Spring-fed stream benthic macroinvertebrate communities as early biological indicators of groundwater tipping points.

Rosemary A. Burk, University of North Texas
Jan Kallberg, University of Texas at Dallas
James H. Kennedy, University of North Texas

Available at: https://works.bepress.com/rosemary_burk/3/
Responding to Global Changes:
The Water Quality Challenge –
Prevention, Wise Use and Abatement
ABSTRACT VOLUME

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Responding to Global Changes:
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Prevention, Wise Use and Abatement
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Ms. N. AbdulRahiman
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Mr. A. Alataway
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Ms. Y. Benitez-Gomez
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Mr. M. Beros
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St. Petersburg’s New Waste Water Treatment Facilities: 
A Major Step for a Cleaner Baltic Sea

Author: Mr. Marco Beros* et al.  
* European Investment Bank, Luxembourg

Keywords: international cooperation, waste water treatment, waste water discharge, eutrophication, HELCOM

Introduction/Problem Identification
The city of St. Petersburg is the biggest point source polluter of the Baltic Sea. The environmental load of waste water discharges to the recipient, the Gulf of Finland and the River Neva, represent approximately 70% of the total point source pollution to the Gulf of Finland. In 2004, about 78% of all wastewater collected in the city was treated in biological waste water treatment plant whereas approximately 22% was discharged without any treatment. The latest major investment, the South West Waste Treatment Plant was completed in autumn 2005. Since then, the percentage of direct discharged waste water has decreased to about 15%. However, in order to comply with the environmental goals of the city of St. Petersburg and to the commitments made under the HELCOM convention, it is necessary to close hundreds of remaining direct discharge points and to reconstruct and enhance waste water treatment plants and the sewer system.

Analysis/Results and Implications for Policy and/or Research
The paper will present the findings of the first five years of operation of the South West wastewater treatment plant, achieved thanks to a strong international partnership. It will then outline the recently started project, set up under a similar partnership of international financing institutions, donors, utilities and Governments. This new investment programme for St. Petersburg encompasses: (i) the completion of the Northern Tunnel Collector (NTC); (ii) pumping stations and buildings; (iii) the connection of current direct discharges of untreated wastewater; (iv) the reconstruction of Central and Northern wastewater treatment plants.

It is a project within the framework of the Northern Dimension Environmental Partnership (NDEP). The project objective is to eliminate discharges of untreated wastewater into the river Neva and enhance wastewater treatment. The total cost will be approximately EUR 560 million.

Through the proposed investment programme, the load of nitrogen and phosphorous to the Gulf of Finland and thus the Baltic Sea is expected to be reduced considerably. The implementation of the proposed programme will promote the fulfilment of the commitments made under the HELCOM convention. As a result the City of St Petersburg will comply with the EU recommendations of 94% efficiency in wastewater treatment.
Eutrophication Dynamics of Lakes and Reservoirs in China: Nutrient Management Strategy

Author: Dr. Nengwang Chen
Xiamen University, China

Co-Author: Prof. Huasheng Hong
Xiamen University, China

Keywords: eutrophication, nutrient enrichment, harmful algal bloom, lakes and reservoirs, management

Introduction/Problem Identification
Excessive nutrient enrichment or eutrophication frequently results in the appearance of harmful algal blooms (HAB) in both freshwater and coastal ecosystems. Eutrophication and HAB has become the primary water quality issue for most of lakes and reservoirs in China. However, trend in eutrophication and associated management strategy was lack of understanding and synthetically design.

Analysis/Results and Implications for Policy and/or Research
A meta-analysis was conducted using extensive published data and case study materials to assess the eutrophication dynamics of lakes and reservoirs in China. Nutrient characteristic and dominant algal species in HAB-easily-occurred lakes and reservoirs were indentified before proposing integrated nutrient management strategy. Analysis results showed that the 5-12 folds increase of external nutrient input (fertilizer consumption, manure and sewage discharge) in recent decades was a key “driver” of water degradation in China. Most of lakes and reservoirs have been encountered nutrient (nitrogen, N and phosphorus, P) enrichment in last 30 years. More than 50 severe HAB events were recorded since mid-1980s, most of which occurred in the receiving waters of developing or developed area, e.g. Tai lake, Dianchi lake, and some coastal rivers. 35 HAB events are caused by blue-green algae; others are diatom, and Pyrrophyta algal bloom. Many reservoirs were hot spots of eutrophication and HAB due to watershed nonpoint source pollution and low flow condition. HAB occurrence is quite frequently since 2000s than that in 1990s. Water bodies during HAB events were characterized as wide range nutrient level (N: 1.00-11.89 mg/L; P: 0.05-1.06 mg/L) and low N/P values (13.5±13.7 in weight). Maximum biomass reached 17-43 million cell/L during HAB events, some of which produced toxin and threatened water supply for large people’s drinking. The recorded HAB events covered a wide range of water temperature (11-26℃), about 70% of HAB events occurred between April and September. However, recently winter and early spring blooms are likely favored by global warming and elevated temperature. Case study of the Jiulong River watershed indicated that shift of nutrient supply ratio (N/P values decline resulting from more inorganic P fertilizers applied to cash crops land since 1990s, and high P excreta discharge from proliferating livestock in recent years) and elevated temperature from 21.09℃ in 1990s to 21.96℃ in 2000s (Xiamen data) are might be closely connected with the recently widespread eutrophication problem both in reservoirs and estuarine waters. Whereas it is thus clear that P should be restricted, controlling the eutrophication of fresh waters will likely require reductions in both N and P. Management strategy should consider land-based best management practices as well as stream restoration. Watershed nutrient budget and distributed dynamic models can be used as useful tools for identifying critical source area and predicting water quality. It is important to prioritize stream restoration sites where potential nutrient loads are large due to significant sources and efficient delivery to streams, and when the majority of nutrient is exported. Potential approaches
for nutrient removal involves increase in-stream carbon availability and favor denitrification process, contact between the water and benthos and riparian vegetations, connections between streams and adjacent terrestrial environments (fishponds or constructed wetlands). We urgently need advances in ability to predict and to prevent the growth of undesirable algae under the interactive effects of human and climatic perturbations. Additionally, long-term ecosystem-scale experiments with P and N is need to better understand the interactions between nutrient enrichment and key physical, chemical and biological characteristics of receiving waters.
Part to Whole Renewable Energy Utilization Concept: Integrated Pollution Prevention and Control

Author: Prof. Udai Kant Choudhary et al.
Banaras Hindu University, India

Keywords: dilution factor, base flow, intake structure, outfall site, renewable energy

Introduction/Problem Identification
Pollutant generated in air, soil and water, finally reaches the river. Dilution factor of river water reduces. Problems become more acute when (i) excess water is being withdrawn (ii) base flow is reduced (iii) STP is wrongly located and is not properly functioning (iv) sites of intake structure and outfall are unscientifically selected (v) renewable energies of river is not used (vi) growth rate of pollutants with increasing population, urbanization and expanding economies are not accounted for. Due to the above reasons, city situated on the bank of the Ganga, India suffer day by day with more and more scarcity of drinking water with its deteriorating quality. Numbers of people suffering from water and airborne diseases increase year after year. The worst sufferers are the villagers in the down stream of the city and people suffer from skin and respiratory diseases over and above other problems. The problem can be controlled, part wise, by additional use of renewable river energy.

Analysis/Results and Implications for Policy and/or Research
The chemicals used in agriculture have their movement towards the river. This depends on the characteristics of ground water table. As the table rises, chemicals get more diluted in ground water reservoir. In this way small quantum of chemicals reach the river with more base flow. This will enhance the dilution factor of river water. This methodology can also reduce the soil pollution. This can be practically achieved by simply enhancing the pressure drag forces of the basin with the bund. Further, the excess withdrawal from a single location of the river decreases the dilution factor. This causes the reduction in dissolved oxygen and rise in BOD. Therefore, the limit of withdrawal needs to be defined. This can be done on the concept of free seepage height. Dilution factor also depends upon location and working of STP. In case of STP located in the flood plain, it has smaller filtering area as compared to STP located in basin. Further, due to frequent break in power supply, STPs are not functioning properly. It results the discharge of untreated effluent in the river. Treatment plants in India are located in the flood plain of concave bank of the river. This is the side where city is also situated. The soil here is fine clay. So it easily gets choked when partially treated effluent is applied in the agricultural field. This creates the problem of effluent logging; choking of soil pores; killing of the soil microbes and finally spreading of the pollutants along the bank region under the action of secondary currents. This pollutant integrally pollutes soil, water and air and affects the villagers in the downstream of Varanasi. This case study shows that the location of treatment plant if is shifted only few kilometers downstream, the scenario would be entirely different. The concave bank is converted into the convex where a huge sand bed is available, the flow streamlines shift from diverging pattern to converging one. This natural energy quantum of river becomes more suitable to manage the pollutants. In this system, it is remarkable to note that the energy required to transport the pollutants from STP is naturally available in the form of hydraulic gradient. This is about 12 m in the critical hour of treatment in the lean period. The sand bed with trickling filter is able to treat organic and microbiological load which are not managed by the STP. In the critical hour of the pollutant load, the sand bed temperature remains about 150°C higher than the atmospheric which will enhance the efficiency of sand bed. The design of the complete system for 1.5 million population of the Varanasi
has revealed that final BOD load of pollutant dispersing in the river water will be in the range of 2-3 ppm only. The other advantages which will be derived is in the form of (i) increase in the river discharge (ii) use of waste land for growing watermelon etc. (iii) managing air pollution (iv) cooling down of atmospheric temperature (v) conserving aquatic life etc. Further, for finding out exact location where pollutants may be discharged for the most efficient dispersion, laboratory and field experiment were conducted. The laboratory curved flow study reveals that the transverse dispersion of pollutant is more needed as compare to the longitudinal dispersion. The best location is decided by the sinuosity and it defines a section where strength of secondary circulation and depth of water are maximum. Now integrating the energy of soil in terms of coefficient of permeability and the energy of the stream at the outfall site in terms of depth of water and energy of the transverse component of velocity, the best outfall site can be selected. Further, experiments were performed to study the impact of filtration on secondary treated effluent by passing through the sand column. The three sand columns were prepared in a different container with the sand collected at three locations of the Ganga at Varanasi. Sand was collected from initial, central and exit sand bed region. With the data it was confirmed that (i) pollutants are removed in the large quantity (ii) filtration mostly occurred in top layers (iii) pollutants removal is function of sand and soil mixture i.e. it is the function of location of sand bed. In the present study it is found that the best suitable site of sand bed for managing soil, water and air pollutants integrally is the downstream exit region of the sand bed. Thus, with the present growth rate of population, industry and economy around Varanasi, the service of sand bed may continue up to 350 years. But as the sand is washed during the flood period therefore it gets renewed every year thus it can be used for infinite years to come. In this way if part to whole renewable river energy concept is utilized, then integrally the soil, water and air pollution of the whole river system can be managed sustainably at the minimum cost.
Provision of Integrated Sanitation and Water Supply:
South Pacific Case Studies

Author: Mr. Andrew J. Dakers* et al.
* ecoEng Ltd, New Zealand

Keywords: integrated infrastructure, water quality, south pacific sanitation, Votua, CIMRIS

Introduction/Problem Identification
This workshop paper describes two projects located in the South Pacific, both focusing on protection of public health and water quality. One project addresses sanitation services while the other addresses both sanitation and water supply. The project teams for each involved international (New Zealand and Australia) and local people from different disciplines of expertise and representing different groups. Both projects have been active since early 2006 and are nearing completion. The Cook Islands project is known as the Cook Islands Marine Resources Institutional Strengthening (CIMRIS) project. The Wai Votua project is based in a Fijian village on the Coral Coast of Viti Levu and is serving as a pilot and demonstration site for this and other initiatives. Both projects are funded by New Zealand and Australian Aid (NZAid and AUSAid) and are focused on achieving sustainable integrated water quality outcomes.

Analysis/Results and Implications for Policy and/or Research
These projects are case studies of different models of integrated approaches for addressing long-term protection of public and private health, maintenance of the ecosystem services provided by land and marine and freshwater environments. They involve the installation and/or upgrade of physical infrastructures that will provide effective and efficient water supply and sanitation amenity services.

Both the Cook Islands and Fiji rely on tourism as a major component of their national economies, and feature attractive coastal tropical landscapes, in particular fringing coral reefs. These easily-accessible reef areas attract tourist as activities such as swimming, snorkeling and other marine recreation activities. They also support important subsistence fisheries and are a part of the indigenous cultural identity. In both countries, research has shown that the marine ecosystems are being degraded by, and are at risk from, land based contaminants. Poor sanitation infrastructure is believed to be one of the key sources of contaminants, and to pose serious risks to community health.

Votua is a moderately-sized coastal village (about 55 dwellings) located on the Coral Coast of Viti Levu, Fiji. Wai Votua is a village-based project which has involved an upgrade of village water supply and the installation of a village wastewater service with final treatment by a wetland and irrigation to land. Expansion of tourist facilities, along with associated immigration and rapid population growth in Fijian villages, is causing increased faecal contamination of coastal waters with attendant health risks for both the local community and tourists. Elevated nutrient concentrations in coastal waters and over-fishing have increased proliferation of macroalgae on adjacent coral reefs, threatening the health and sustainability of the reef. A participatory approach has been utilized during the Wai Votua project which engaged the village community and its leaders enabling the technical team to better understand the local issues and culture, and to support and encourage the villagers to take on new responsibilities that will sustain their upgraded and new services. Wai Votua has not only involved the installation of a physical water supply and sanitation infrastructure, but also involved raising local awareness of issues as well as education and capacity building in water quality and family health issues, basic plumbing maintenance, and ongoing management and self-funding of the services.
The Wai Votua project builds on relationships and awareness developed as part of a community-based integrated coastal management programme supported by the University of the South Pacific (USP) and its collaborators. In addition to the village people themselves, the project involves three NZ agencies, NIWA (National Institute of Water and Atmospheric Research), ESR (Environmental Science and Research), and Christchurch consultancy ecoEng Ltd working in close collaboration with USP’s Institute of Applied Sciences.

The CIMRIS project is a much broader project with a clear requirement to strengthen the institutional component managing and impacting on the marine resources. One component of this focuses on sanitation practices, and it is this component only that is addressed in this paper. The sanitation component has a strong national and institutional focus. Apart from one small community sewage treatment system in Rarotonga, all domestic and commercial wastewater systems are managed by on-site systems. On the volcanic island of Rarotonga, the most populated island, nearly all development is on the coastal areas where free draining coral sands overlay a shallow groundwater table that then drains into an encircling coral lagoon. With development on the coastline, there are now signs of deteriorating coral reef health. There has been an expectation that the technological fix would solve all problems. Recognising that a multi-level integrated approach is required, the project has applied institutional strengthening, training and capacity building, inter-agency co-operation and effort, and community awareness programmes, as well as improved wastewater technologies and systems, research, development and installation of appropriate and innovative field prototypes.

It is critical to understand the operational constraints when planning such projects, both at the village level and at the national level. It is equally critical to establish genuine and mutually respectful partnerships between the key players; for example, the doers, the thinkers, the leaders, the technical experts and the traditional landowners. The interplay between technical and scientific experts and the deeply rooted traditional and local cultural beliefs and practices, has to be sensitively balanced and carefully interpreted if the desired outcomes of the project are to be sustained for present and future generations. No one person can be the overall authority and expert. If well integrated such projects will build capacity at multiple levels and for all key players. This paper will demonstrate these key lessons learnt.
The Salí-Dulce River Basin Commission Management Plan, A New Compact to Address Pollution Prevention and Control

Author: Prof. Lilian del Castillo-Laborde
University of Buenos Aires Law School, Argentina

Keywords: basin commission, management plan, pollution prevention, agro-industrial reconversion, subsidies

Introduction/Problem Identification
The Salí-Dulce river basin, located in the North-West region of Argentina, is the main tributary of South America’s largest saline Mar Chiquita Lake closed basin. The river is highly polluted with wastes dumped from sugarcane industry, the intensive use of pesticides for citrus plantations, and urban drainage with insufficient sanitation nets. Regional economy, mainly in the Tucumán province, rests on the agro-industrial products. The challenge to improve the local economy and to control pollution is in the hands of a Basin Committee, set up in 2007. The new compact involves stakeholders and governmental agencies and started a comprehensive program aiming to tackle urban, industrial and agricultural pollution.

Analysis/Results and Implications for Policy and/or Research
Although there had been previous efforts and understandings aimed at improving the quality of the Salí-Dulce River, these came up against the difficulty that pollution is mainly of industrial and agricultural origin, due to the presence of sugar mills and citrus plantations that belch their wastes into the watercourses in the upper areas of the basin in the Tucumán Province. This polluted water is received by the Río Hondo dam reservoir, which provides water supply to the Tucumán city and its outskirts, and the downstream areas of the provinces of Santiago del Estero and Córdoba. Because of the harm this situation caused, the former even filed legal actions against the Province of Tucumán.

Back in 2004, gauging stations were set up on the tributaries of the Salí-Dulce River and in 2007 a new compact, superseding the old ones, was entered into between the five riparian provinces, namely, Catamarca, Salta, Tucumán, Santiago del Estero and Córdoba, and the national government. This compact, which set up the Salí-Dulce River Basin Committee, entails a qualitative change in attempting to address the Basin’s ongoing water and atmospheric pollution.

The Basin Committee’s main function is to implement the Management Program, which aims to improve social and economic conditions in the region, enhancing production and competitiveness while addressing environmental deterioration. Thus, a new scheme has been established -the Agro–Industrial Reconversion Plan, which proposes the diversification of crops in view of sugarcane prevalence, the modernization of sugar mills, the construction of urban treatment plants and the assessment of the environmental impact of manufacturing sectors. The required funds to implement this project are now in the process of allocation. Within the Reconversion Plan, the “Cleaner Production Program” foresees the adoption and implementation of new environmental standards and regulations by means of economic incentives and subsidies. Hence, a Province Register has been set up for companies showing cleaner manufacturing practices and also a verification and certification of compliance mechanism has been established articulating control and industrial conversion systems. The Reconversion Plan is endorsed by the commerce chambers of sugar and citrus producers and of the agro-industrial sector. Yet it has been difficult to engage producers or industrialists in participating in the pilot project.
scheme. In this regard, it becomes necessary to secure credit facilities in order to assist companies in their compliance with environmental commitments. The Management Plan has neither a full cost evaluation nor budget allocation by jurisdictions and sectors. Moreover, the visible and invisible costs of water pollution have not been assessed yet.

Two areas of the Management Plan, namely Measurement and Monitoring of Water Quality, are now in the stage of implementation, and are being carried out through University programs. The pollution control and reduction program, articulated with the Industrial Reconversion Plan, involves the control of sewage effluents, diffuse sources, the use of indicators and quality standards for the treatment of solid waste, among other aspects.

Through its implementation, the Salí-Dulce River Management Plan is expected to achieve the following: (1) A reduction in industrial and urban pollution affecting the water resources of the Salí-Dulce River, without hampering manufacturing activities or the employment they generate; (2) A curb on erosion and sedimentation processes in the watercourses of the Salí-Dulce River Basin; (3) Reclamation and preservation of environmental conditions in the area of the Basin and related water bodies, protecting biodiversity and human settlements; (4) Restoration of water quality in the Rio Hondo Reservoir, preserving the lowlands on the Río Dulce, the Mar Chiquita Lake and other water bodies in the Basin. The Management Plan also includes the Droughts and Floods Prevention Program. The following stages are under way at present: (1) Basic studies; (2) Assessment of steps to be taken; (3) Selection of intervening entities; (4) Execution Project.

One of the aspects in progress is the educational campaign to foster public participation and to raise awareness about the need to protect the gauging stations and reduce vandalism. Moreover, it is necessary to update and harmonize the laws of the different jurisdictions.
Pollution Prevention Service Learning Education: Case Studies in Transformative Long-Term Impacts on Workplace Behavior

Author: Dr. Bruce Dvorak
University of Nebraska, USA

Co-Author: Dr. Mohamed Dahab
University of Nebraska, USA

Keywords: education, service learning, pollution prevention, water conservation, water quality control

Introduction/Problem Identification
The University of Nebraska Partners in Pollution Prevention (P3) program has provided direct and results-oriented pollution prevention (P2) education to business and industry and hands-on training for students for two decades. Multi-media pollution prevention training with emphasis on water quality and conservation is provided to students before being placed on site at businesses and industries to provide leadership in promoting environmental sustainability. To date, over 500 business and industry projects have been performed by over 150 students. The Nebraska P3 program has amassed data showing measureable change for business clients in terms of implemented pollution prevention practices with substantial cost savings and an increase in business awareness of pollution prevention as the primary environmental management strategy. It has also shown a transformative long-term impact on workplace behavior of past students who are now fully employed in the commercial sector.

Analysis/Results and Implications for Policy and/or Research
In a recent focus group of Nebraska industrial leaders, participants communicated to us that they need students to join their technical ranks who are not necessarily “experts” but who have hands-on training and experience in implementing sustainable practices and applications. The University of Nebraska Partners in Pollution Prevention (P3) program has operated an innovative summer internship program for upper division engineering and environmental science students. These students are provided specific and intensive training in pollution prevention (P2), sustainability, and industrial communications. The students are then placed in Nebraska businesses and industries as summer employees where they provide multi-media P2 assistance.

The P3 program has continuously gathered data from students and clients in order to document its effectiveness and to identify areas of possible improvement. A survey of past clients found that nearly 70% of clients perceived a change in their awareness of pollution prevention as a consideration when making business decisions as a result of their participation in the P3 program.

A survey to measure the educational impact of the P3 service learning experience was distributed to 145 past P3 program students, and to a similar control group of 606 University of Nebraska College of Engineering graduates without the P2 service learning experience. A statistically significant difference between past interns who had gone through the service learning education and the control group was observed for those who reported implementing source reduction changes on the job (67% of past-interns vs. 51% for control), but no difference (53 vs. 51%) occurred between those who reported implementing recycling changes. This result is not surprising since recycling permeates the US education system unlike the more complex concept of source reduction. A further comparison
of the past interns and the control group with a high self-reported environmental ethic showed that despite similarities in consideration of P2 on the job (roughly 75% for both), the past interns applied source reduction at a statistically significant higher rate (78% vs. 59%) than those without a service learning experience. The survey also showed that past interns were more likely to report quantitative impact from on-the-job P2 efforts.

During the past decade, the P3 program has conducted follow-up visits with previous clients to determine the actual impact of the assistance. Based on interviews and reassessments of past clients, 41% of all recommendations made by students were actually implemented and actual implemented recommendations reduced water use by an average of over 50 million L per year, avoided the disposal of over 10 million kg of solid waste into landfills, and saved over US $ 1 million a year.

An example case study from the P3 program focused on a fabrication facility that manufactures metal products for farm and industrial uses. The facility performs many operations including electroplating, conversion coating, machining, impact deformation, welding, blasting, hot-dip galvanizing, painting, and assembly. Many of these operations result in the production of a variety of pollutants that must be handled in an acceptable fashion. For example, the electroplating lines produce acids and rinse water containing zinc and chromium, and the galvanizing line results in the production of acids and rinse water containing zinc and iron. All of these wastes must be treated as hazardous substances. Most of the recommended operational and process modifications were quite simple to implement, and their pay-back periods were short. For example, in the electroplating and galvanizing operations we concentrated on reducing rise water use by using a counter-current process to reduce the amount of wastewater that must be treated. The changes resulted in dramatic decreases in water use amounting to more than 50% in electroplating line and nearly 83% in the galvanizing operation. The process modifications were estimated to have a payback period of about 10 months, with significant improvements in waste management operations. Additionally, other recommended process changes resulted in marked improvements in product quality which were difficult to quantify.

An additional important element that we will focus on in the presentation will be to note the lessons learned from this and other similar U.S. programs. This will be especially beneficial for others who may wish to emulate the program. Among the main lessons are the importance of: 1) carefully developing corporate projects; 2) providing students with realistic and specific applications of P2, from the initial site visit through preparing a business management report; 3) training students how to interact with business people who are either unfamiliar or even hostile to P2 and how to market their ideas to specific clients; and 4) providing adequate mentor guidance to the students.
Water Quality as a Pivotal Aspect of Integrating the Three Axes of Sustainable Water Management – Save Water – Save Harvest – Save Life

Author: Dr. Jochen Froebrich et al.
Alterra, Wageningen UR, the Netherlands

Keywords: water quality, water quantity, water stress, sustainable water management, Africa

Introduction/Problem Identification
Access to water in sufficient quantity and quality is the basis for sustainable development. Water is intrinsically tied to health, food security, poverty eradication and environmental protection. Water is a central component of all 8 Millennium Development Goals, particularly in its link to sustainable development. Nevertheless, single sector approaches are still used too often, which is partly due to the fact that within the “save water – save harvest – save life” triangle water relates to competing objectives.

Analysis/Results and Implications for Policy and/or Research
Save water – Water as an endangered resource base
The term water saving is primarily associated with water quantity – attention to water quantity is certainly critical in semi-arid regions, especially for water scarce regions in Sub-Sahara Africa. However, increased agricultural production and future population growth will lead to increased water stress, which is defined by the European Environmental Agency as the deterioration of usable water resources, both by pollution and overconsumption. Therefore, safeguarding both quantity and quality of water resources is of upmost importance for all future development. Despite investments and progress towards MDG 7, today in 54 countries less than half the population has access to safe water – three quarters of those countries are in sub-Saharan Africa.

Save harvest – Water as a critical factor in assuring food supply
The critical issue for improving food security under limited water resources is to assure that the crop can be harvested and the maximum amount of product is produced per unit of water consumed. Crop losses, and hence losses of resources invested, have to be minimized. This calls for improved irrigation practices and techniques for supplementary irrigation (minimal water use) and more effective nutrient, pest and weed management supported by improved seasonal forecasting capabilities to anticipate extreme weather conditions and climate variability.

The Comprehensive Africa Agriculture Development Program (CAADP; NEPAD, 2003) and the Commission for Africa (2005), among others, call for massive investments in irrigation. Considering the limited availability of blue water resources the Comprehensive Assessment of Water Management in Agriculture (2007) underlined the need to improve water productivity wherever possible. Within the continuum of blue and green water there is an urgent need to integrate the use of rainfall, ground- and surface waters with different techniques into innovation ‘packages’ or ‘baskets’ targeted towards specific user groups and usages of water (e.g. agriculture, fisheries, livestock). While the implication of using agrochemicals is widely understood in large-scale irrigation, especially for smallholder irrigation schemes and ex-situ water harvesting techniques, the impact of increased agricultural productivity on the emission of non-point source pollutions and related water quality needs a much wider investigation.
Save life – Water as a direct threat to people and nature
Hazards of hydrological extremes (flood and drought) and resulting pressure on human life requires increased attention within integrated land and water management. This relates to direct impacts such as environmental refugees, loss of human life and livestock, and the loss of soils and crops. The indirect impacts include the spread of hazardous substances and bacterial contaminations (e.g. from flooded or destroyed sewage systems). The direct and indirect impacts undermine the battles to reduce malaria, diarrhea, HIV/AIDS and undernourishment. Integrated flood management is an option to regenerate temporally overused groundwater resources, but this would require control and monitoring of sufficient water quality as well.

The role of Water Quality
Looking further into the interdependencies, it becomes clear that water quality and water quality protection may play a pivotal role to integrate the described three axes of sustainable water management. Within a river basin, there are multiple water users, most important of which are agriculture and local people, but growing cities and industries are increasingly important users. Increased use of fertilizers and pesticides is widely requested to boost the green revolution in Africa, but relationships to upcoming challenges in water quality protection are less well understood.

Increased use of water resources make the water less usable for following water users, and this reduced quality should be taken into account. It has to be realized that under water scarcity every drop of water is used several times. Except for the most pristine upstream areas the rest of the water in a river is at least second hand.

New agricultural systems will ask for good quality water in order to produce safe food, but also to be able to export safe food. Hence sufficient water quality is not only endangered by intensified production, but intensified production is also endangered by insufficient water quality.
Suitability of Citarum River Water for Supporting the Different Uses and its Aquatic Ecosystem

Author: Dr. Mohamad Ali Fulazzaky
Universiti Tun Hussein Onn Malaysia

Keywords: water quality evaluation, water quality aptitude, Citarum river, pollution, water uses

Introduction/Problem Identification
The Citarum’ river that supports a population of 28 million people, delivers 20% of Indonesia’s gross domestic product, and provides 80% of surface water to Jakarta’s water supply authority, is the most important water sources but is one of the most polluted rivers in Indonesia. Water quality of this river continuously deteriorates due to the increasing of pollution loads particularly releases from Bandung region of the upper river basin into the river. This will be facing the chronic problems of water pollution for supporting the suitability of water for differ uses. This study used Water Quality Evaluation System (WQES) to asses the suitability of water in term of Water Quality Aptitude (WQA) for the different uses. The assessment of 10 locations was verified that WQA ranges from the suitable quality for agriculture and livestock watering uses to the unsuitable for aquatic ecosystem, drinking water production, and leisure activities and sports in the upstream of Saguling reservoir.

Analysis/Results and Implications for Policy and/or Research
The problems of water quality degradation of the Citarum’ river in West Java Indonesia will continuously escalate from the year to year due to the increasing of the pollutants particularly loading from Bandung region in the upper part of basin when released without treatment. The deterioration of water quality in the upstream conspicuously reducing the usability of the resources for the stakeholders of down-stream areas. This may affect the gradual increasing of social costs of the Jakarta’s people due to the risks of waterborne diseases and high cost technology of water treatment since the polluted surface water transfers inter basin from the Citarum to Ciliwung river basin providing 80% sources of raw drinking water for Jakarta’s water supply authority. Integrated water quality management reckoning with the aspiration of stakeholders entire the basin appeals to ensure the best pollution prevention and control of the most important water sources in the country.

The government of Indonesia principally appeals the river basin approach of water management since the enactments of Law No. 7 on water resources (UU No. 7/2004) and Government Regulation No. 82 on water quality management and pollution control (PP No. 8/2001) have been issued. The enactments serve as the legal documents for managers and operators in managing of water quality at the national, provincial and river basin levels. Although the role sharing amongst the stakeholders including technical arrangements of water quality criteria is regulated in the enactments, the operational guideline of specific conditions for each river basin are still not fully understood. WQES has been developed as the tool for assessing stream water quality with two objectives that are: (1) to assess the status of stream water quality and (2) to assess the suitability of water for different uses. This tool promotes a comprehensive approach of aggregate method in evaluating of water quality. For example, the assessment of Citarum river water for 10 selected stations was verified that WQA ranges from the suitable quality for agriculture and livestock watering uses to the unsuitable for biological potential function, drinking water production, and leisure and sport activities in the upstream of Saguling reservoir, generally. The results of water quality analysis using WQES may offer as the decision support system.
(DSS) for formulating the water quality standards and priority of measures to envisage for improving water quality of each river in the country, or anywhere, with its specific local conditions.
Introduction/Problem Identification
A consultancy service on the Kagera River Basin Integrated Water Resource Management and Development Strategy has been carried out by SWECO International. The Kagera Strategy indicates ways in which Burundi, Rwanda, Uganda and Tanzania (acting together) aim to achieve IWRM in the Kagera River Basin. The strategy for preserving quality of the Kagera River dry season flow is one of the outputs.

The Kagera River basin covers the territories of the four riparian. It covers an area of 60,000 km² with a current population of 15 million people that is expected to be about 25 million by the year 2030. The Kagera River is the largest of the 23 rivers that drain into Lake Victoria and it carries 34% of the annual river inflow to the lake.

Analysis/Results and Implications for Policy and/or Research
Although they are limited and highly variable, the basin’s water resources will be sufficient to support social and economic development for the foreseeable future provided they are judiciously managed, and wisely allocated and utilized.

Current development of the Kagera River Basin is very limited. There are no major river flow diversions. In fact the natural flow pattern is essentially intact. However, it is hoped that there will be a significant development pattern in the future.

Various scenarios of Kagera Basin water resources management and development, including seven large-scale and storage-based multipurpose projects, for the coming 20 years have been analyzed.

Domestic water supply and irrigation water demands for the year 2030 were estimated to be about 7 and 19 percent of the current Kagera River flow, respectively. However, it has been possible to limit the lowflow reduction to about 10 percent by arranging adequate river maintenance flow through appropriate reservoir operating rules. The maintenance of the flows on the mainstream were considered by securing acceptable minimum monthly natural flow during each month of the dry season from all reservoirs include in the simulation.

Reservoir releases for river maintenance flows during dry seasons were given a priority next to domestic water supply demand. In other words, any diversion/abstraction for large-scale water consumption such as water use for irrigation purpose will have lesser priority than river maintenance by preserving dry season flow greater or equal to the historical quantity and quality level.
The overall observations that were made for the simulation studies include: (a) the overall character of the hydrograph is maintained; (b) wherever hydropower projects are introduced, low flows are significantly increased and are higher than historically observed range; and (c) high flows are marginally reduced, but within historically observed range.

When river flows experience a dramatic depletion, the main priority is drinking water supply of acceptable quality. As the amount of water diverted (from rivers or groundwater) for domestic water supply, irrigation or other consumptive uses increase the river flows (particularly the dry season flows) decrease. Then the lower quantity results in low quality because dilution of wastewater in the river becomes less than the normal (or historical) flow conditions. The main impact of such water quality deterioration is mainly on domestic water supplies but also affects fishery, irrigation and other uses. In general, deterioration of river water quantity results in poor dilution of the discharged pollutants, and thus a risk of harming human health and aquatic life. Such a situation poses a significant risk not only on human but also the natural ecosystem related to the river flows. Therefore, preserving dry season river flow water quality by supplying adequate river maintenance flow is a vital role of reservoirs.

Constructing dams and creating reservoirs that operates on the basis of clear rules that deals with dry season river flows have clear advantages in preventing pollutions or mitigating their effects and thereby reducing the vulnerability of communities, especially the poor and disadvantaged, to the hazards and threats posed by pollution disasters.
Abatement of Radioactive Flow Beyond the Bounds of the Contaminated Territories: Merits and Demerits of High-Water Dams Construction

Author: Dr. Dmitri Gudkov* et al.
* National Academy of Sciences of Ukraine

Keywords: radioactive contamination, Chernobyl exclusion zone, high-water dams, flood-lands, radionuclide bioavailability

Introduction/Problem Identification
Despite the years since the Chernobyl accident in 1986, the territory of the Exclusion zone (2600 km²) still remains an open source of radioactive contamination with a complex structure of distribution in various landscapes and a dynamic state of radioactive substances, influencing their migration and redistribution in components of ecosystems. The basic problems of radiation safety of the Exclusion zone are connected with radionuclide washout with surface run-off into the river systems, radioactivity carry-over beyond the bounds of the Exclusion zone and sharing in formation of water quality of the Dnieper River – the main waterway of Ukraine. In this connection the radiation condition of surface water of the Exclusion zone has huge importance.

Analysis/Results and Implications for Policy and/or Research
The Pripyat River is the main transport waterway of radioactive substances of Chernobyl origin and its flow into the Dnieper River. During 1986-2009 about 180 TBq of strontium-90 (Sr-90) and 140 TBq of caesium-137 (Cs-137) were flowing into the Dnieper River by the Pripyat River. The maximal flow of radionuclides by the Pripyat River was registered in 1986 – about 66 TBq of Cs-137 and 28 TBq of Sr-90. About 60% of Sr-90 flow by the Pripyat River are formed on the part of catchment basin, which is taking place within territory of the Exclusion zone. Since 1988 the annual flow of Cs-137 rarely exceeded half of Sr-90 flow, and in separate years did not reach also a quarter. About 85-90% of general flow of Cs-137 by the river is formed outside of the exclusion zone. For the postaccident period was observed some crisis situations connected to surface waters. The greatest radionuclide contamination of the Pripyat River in the postaccident period (except for 1986 and 1987) is registered in the end of Jan. – Feb. 1991, when the powerful ice jams were generated, which have caused abrupt flood within the Pripyat River flood-lands in the inner (10-km) Exclusion zone. The flow of Sr-90 by Pripyat River for the period of greatest intensity of display of ice jams (19.01-09.02.1991) has amount 4 TBq. Three quarters of this amount have flow into the river from the territory of left-bank flood-lands. This, unprotected (on that period) from flooding by high waters, territory is characterised by the highest levels of radioactive contamination within Exclusion zone. During 1992-1993 the complex of hydraulic engineering structures as flood protection dams was constructed here, which preventing washing away of radioactive substances from soils and changing a hydrological mode of floodplain flows during a high water. The importance of new dams was most brightly showed in Feb. 1994 during an ice jam on the Pripyat River. The maximal concentration of Sr-90 in the Pripyat River was 6 kBq per cub. m, that is was twice less, than in 1991. After a number of relatively stable years, the spring of 1999 has brought new anxieties connected to a condition of surface waters. In value of the maximal charges and levels, the high water of those year was evaluated as greatest not only for the postaccident period, but also after 1979. In expectation of possible flooding of the unprotected sites of flood-lands, were buildings up existing dams, which block the most contaminated crawls of the Pripyat River and constructed the protective embankment. Due to the carried out measures the direct flow of the Pripyat...
River on the contaminated territory has not taken place. With the subsequent increase of the Pripyat River level the water have flow on the territory of these sites only as filtration through a body of dams. By our estimations, in conditions of the described above crisis situation, the water-protection measure has prevented possible additional flow of Sr-90 with surface waters in amount about 17-20 TBq. On the other hand the construction of dams was by the reason of strengthening of over-moistening and swamping processes within dammed territories. As a result – on a background of the common tendencies of increase of the mobile forms of Sr-90 in soils of catchment territories and bottom sediments of the exclusion zone, there is an increase of humic acids concentrations in waterlogged soils of flood-lands. It is also raises the content of the water-soluble forms of Sr-90 forming with acids the soluble complexes. Thus the increase of concentrations of the mobile radionuclide forms and their inclusion into biotic circulation of aquatic ecosystems during 1999-2009 is observed. It confirms also an increase of Sr-90 specific activity in water, higher aquatic plants, molluscs and fish in lakes within Krasnensky flood-lands, against a background of stabilisation of this parameter for Cs-137 last years. The results of the executed researches confirm the tendency of the further complication of radiation condition of aquatic ecosystems within the Exclusion zone. Swamping of the contaminated territory results in acceleration of mobilisation processes of deposited forms of Sr-90, and also their migration and redistribution in closed aquatic landscapes. Thus there is a formation of the peculiar “depot” of the mobile forms of radioactive substances, which can be a source of increase of Sr-90 carry-over into the Pripyat River and then – beyond the bounds of the Exclusion zone during the high water-level periods. In this connection there are necessities of implementation of hydraulic engineering measures to prevent an underflooding of territories with high density of radioactive contamination, optimisation and perfection of radioecological monitoring system, and also further development of researches of radionuclide behaviour in aquatic ecosystems within the Exclusion zone.
Experience of Integrated Environment Pollution Prevention and Sustainable Rural Water Supply Programme in Sri Lanka

Author: Mr. A.H. Gunapala
National Water Supply & Drainage Board, Sri Lanka

Keywords: water source, ownership, community satisfaction, sustainability, environment

Introduction/Problem Identification

Introduction
Sri Lanka is a small country in the Indian Ocean extending to approx. 64,000 km. Its population is around 20 million. Out of this 72% represent as rural communities. Improved water supply coverage is 78%. Sri Lanka too has been focused to achieve MDG’s for which various programmes have been implemented accordingly. Sustainability is most significant fact. Its main connected areas are; source protection, water supply and sanitation, especially to build up better knowledge as well as implement activities based on integrated environment pollution prevention systems. This paper illustrates experiences on integrated environment pollution prevention sustainable Rural Water Supply (RWS) programme which was implemented under the National Water Supply & Drainage Board (NWSDB) in last five years with the sector partners such as; Health Department, Environment Authority, Local Authorities, Non Government Organizations and Community Based Organizations (CBO).

Analysis/Results and Implications for Policy and/or Research

The NWSDB had addressed this programme to urban and rural communities with especial attention to sustainability. Through this event, we have achieved and build up concrete structure as well as systems to the sector for smooth operation after the programme completion too. Following components were introduced and implemented under the said programme.

- Drinking water supply
- Environment protection and conservation projects
- Household level environment-friendly activities
- Water seal / Ecological sanitation toilets
- Health education and hygiene promotion

Methods
All above activities were planned in collaboration with sector actors and implemented through Demand Responsive Approach (DRA) with beneficiary participation, contribution especially with their decision-making. This is the most important fact, because beneficiaries have their ownership. This is the way to sustainability.

Most of the earlier initiatives on Environment protection/conservation and water supply projects were failed or couldn’t achieved expected out come because “the outside funding” terminates, and communities seemingly not been prepared to sustain the momentum. The said programme has addressed this issue by introducing sustainable system with back up supports. After this programme NWSDB has been established RWS Units and Resource Centers for the main body of the organization in district level for aiming back up supports as well as sustainability of the benefits. Presently 17th RWS District Units were established out of 25 districts and functioning well. At the initial stage, following activities / responsibilities will be undertaken by RWS units.
• Monitoring CBO activities. (Auditing, water quality, preventive maintenance etc.)
• Advice on preparation of water safety plan for CBO schemes
• Providing technical supports to CBO.
• Coordinate water quality problems / pollution of water sources as well as monitoring of surface and ground water quality.
• Rain water harvesting, source protection activities.
• Public awareness training on water sanitation and Hygiene
• Maintain close coordination with all the local authorities in the area with other relevant agencies on RWS method.

The water supply programme main objectives were to transfer the programme ownership and management responsibilities to beneficiaries. The project assistance was maximum of 80% of the total cost of identified Water supply project and beneficiaries were contributed balance requirement as financial or material with labour. All benefited House Holders (HH) were contributed for water supply or sanitation to develop their facilities.

Pilot scale environment protection and conservation projects too were done by with sector partners aiming surface and groundwater source protection in dry zone and water catchments area. In addition selected all sub-projects area for the water supply projects were introduced household level environment activities too. These activities also were helpful mobilization as well as empowerment for the communities to smooth operation and programme sustainability of water supply.

In the mean time the programme was conducted massive community awareness campaign through leaflets, workshops, posters and street dramas to selected area for creating their water supply and sanitation needs as well as environment protection and conservation. Through this event health education, good hygiene habits and environment friendly home garden activities were highlighted and aware its impotency for healthy life to the communities as well.

Drinking water supply facilities were arranged through DRA principles with beneficiary participation and their contribution as a pareral event. These entire rural water supply schemes have been managed by the CBOO.

Results- physical benefits;
• 1000 RWS 47 Small Towns Water supply systems
• 228 school health clubs with water supply and sanitation facilities.
• 27 environmental conservation and protection sites
• Environment friendly HH in each sub projects.
• Pilot level Eco san systems (02 urban/01 rural) and water seal toilets.
• Social benefits;
• Social development and community empowerment
• Community satisfaction
• Ownership of benefits
• Environment friendly Houses
• Health hazard (reduction of water borne deceases and improvement of good health habits and knowledge)
• Strengthening of CBOO
**Recommendation**

Sustainability depends on the ownership. It should be more strengthened and incorporated beneficiary involvement with their participation, contribution as well as decision making. Their capacity and knowledge are to be developed too. The outcome of an environment-friendly sustainable water source protection, water supply and sanitation programme has to be the development of the status of socio-economic and health, together with community satisfaction too.
Water Chemicals and Bacterial Pollution in Central Asia

Author: Prof. Igor Hadjamberdiev et al.
Water, Pollution, Health, Kyrgyzstan

Keywords: pesticides, uranium, chromium, bio-pollution, purification

Introduction/Problem Identification
We have studied pollutant contents in upper, ground, and drinking waters – in six regions of Central Asian (CA) states Tadjikistan, Uzbekistan, Kyrgyzstan, Kazakhstan in 2000-2009 years.

We created maps of each impact by human toxicity 5 rank. It has been offered/improved the water-toxicants alleviation methods.

Analysis/Results and Implications for Policy and/or Research
We have studied pollutant contents in upper, ground, and drinking waters – in six regions of Central Asian (CA) states Tadjikistan, Uzbekistan, Kyrgyzstan, Kazakhstan in 2000-2009 years. The pollutants are: a) hydrocarbons aromatic (formaldehyde, benzene, phenol) – ground and drinking waters in 6 towns, includes 3 capitals; b) uranium, strontium – ground, drinking water and in vegetables in old tailings 3 areas; c) metals (chromium 6, mercury, stibium), pesticides (DDT, lindane, etc), in main rivers of the region (Syr-Darya, Amu-Darya, Naryn, Ak-Buura, Zeravshan); d) bio-pollutants (abdominal typhus, coli bacteria, cholera, 4 helminthes) – in the same main rivers. After studying we created maps of each impact by human toxicity 5 rank. And done common (complex) map by superposition methods, which show scale of water-polluted areas of CA. We have referred created ranks by analysis of base human health markers (immunity level 6 tests, genetic disorder 3 tests). Results of both studies were agree. First consequence of studies is detection of most vulnerable areas in CA that need immediately rescue. It has been offered/improved the water-toxicants alleviation methods: a) twice prolongation of water staying in sediment basin (in water-purified stations); b) protecting 5 tailings from rivers, and we have done project for protecting genetic of vulnerable groups (install 17 updated drinking water filters in schools, nursery, hospitals); c) there are 3 common projects for gathering obsolete pesticides and keep in contemporary warehouses, we created filter system for chromium purify; d) bio-pollutants is a results of human and animals fertilize utilization and toilets absent, we have installed composting toilets in Alpine area.
Integrated Water Pollution Assessment, Prevention and Control

Author: Mr. Kevin Keyser et al.
UNEP-DEWA, Kenya

Keywords: water assessment, sources, measures of prevention, monitoring, incentives enforcement

Introduction/Problem Identification
This abstract explores new approaches to water assessment whereby all different waters are considered. Newly developed methodology guidelines can help assess the condition of rivers, large marine ecosystems, open oceans, lakes and freshwater availability. In providing a case study of the Nairobi River Basin, our project will demonstrate new approaches in water assessment that will help to identify sources and causes of water pollution. We then look into measures and standards for prevention of release and pollution prevention by outlining our results of the Nairobi River water project. Furthermore, we are going to examine new tools in water monitoring and status assessment methods to evaluate water conditions. In addition, we will provide a range of legislative options and procedures to enforce water protecting regulations. Finally, the contribution to this workshop will also consist in an examination of a broad range of incentives to reward less pollution of water resources.

Analysis/Results and Implications for Policy and/or Research
A. Sources, Causes
I) Assessment
Using DEWA Millenium Assessment Scoping Approach through applying a set of four ecosystem services:
1. Regulating Services to sustain human wellbeing
2. Provisioning Services
3. Cultural Services
4. Supporting Services
5. Ecosystem Services will be assessed using State, Stress Reduction, Process and Socio-Economic Indicators

1. Volume, effective or live storage, outflow, retention time, precipitation, evaporation, standard procedures parameters / Freshwater Shortage
2. Biochemistry – Pollution (Bacteria, Organic Substances, Physical Characteristics, Chemical Characteristics), Species diversity and composition
3. Overfishing and other threats to aquatic resources (Overexploitation, destructive fishing practices, impact on biological and genetic diversity)
4. Habitat and Community Modification (Loss of Ecosystems, Modification of Ecosystems), Public Perceptions and behaviors
5. Global Change (Changes in hydrological cycle, Sea Level Change, Increased UV-B radiation, changes in CO₂ source/sink function), Climate, Climate Change

II) Pollutants
a) Airborne Pollutants
* High tropospheric Ozone concentrations
* Acidification
* Long range Transport of hazardous substances
Air Pollution (Causes, Effects and Solutions)
Causes of Air Pollution
Sources of Pollutants
Effects of Air Pollution
Solutions to Air Pollution
b) Land-based activities and sources of pollution affecting the marine environment.
Major environmental problems and issues related to the degradation of the marine and coastal environment resulting from land-based activities (LBA).
Schematic presentation of the DPSIR framework
Water pollution causes
Categories for sources of water pollution:
1. Point source- form of pollution where harmful substances are emitted directly to the water body e.g. industrial pipes emitting wastes directly to rivers.
2. Non-point sources- indirect pollution through transport or environmental change e.g. excessive chemical fertilizers washed away by rain into rivers and lakes.
Specific water pollutants
c) Other diffuse sources
* Microbiological
* Eutrophication
* Chemical Pollution:Shipping, Oil, Sulphur, Aerosols, other hazardous substances/spills, types of hazardous substances
* Industrial Processes, kind of industries in place
* Suspended Solids, Plastics, point source/distributed
* Noise
* Thermal
* Radionuclide
* Invasive Species
* Seafood and pollution, heavy metals
Domestic sewage water
Industrial wastewater
Construction site stormwater
Discharge of toxic chemicals such as motor fuels and concrete washout is prevented by use of: Urban runoff (stormwater)

B. Measures and Standards for Prevention of Release, Pollution Prevention
Preventive Measures / In-house Measures
When and how pollution becomes pollution
Mode of Release: show difference between non-point and point source
Sampling of Water
Integrated Pollution Prevention and Control (IPPC)
Integrated Approach
Prevention
Potential benefits and constraints of IPPC
a) Potential benefits
b) Constraints

C. Monitoring, Control
Different monitoring and status assessment methods that evaluates river conditions:
• Division of the river network for the examination of the river basin
• Monitoring silting of river bottom
• Assessment of water quality by checking on diatom and zoo benthos
• Methods suitable for managing fish stocks and studying the state of the stocks
• Automated monitoring and control system in a river
• Bio tests and other methods for monitoring harmful substances
• Different water parameter analyses and what they tell about the river
• Water pollution control methods to reduce the effects of land use in agriculture, forestry and peat production.

D. Enforcement, Control
Legislation (Components of Legislation: Generator, Transport, Storage, Treatment, Recycling, Disposal)
* What to enforce?
1. Illegal Activities eg dumping, deliberate spills or discharges, non-permitted treatment or recycling, accepting illegal waste, falsifying information
2. Permits eg for sites, storage, transport, treatment, recycling or disposal
3. Information eg declarations of waste generation, results of monitoring results and reporting of incidents
4. Procedures eg monitoring, sampling and reporting
5. responsibilities for operators eg due care, safety, clean-up of spills – for public bodies eg taking action and consulting, keeping records, monitoring and reporting

E. Incentives, Control
These incentives provide monetary and near-monetary rewards for polluting less and impose costs of various types for polluting more, thus supplying the necessary motivation to polluters.

F. Casestudy
Nairobi River
Some Integrated Pollution Control Approaches in the Laurentian Great Lakes of North America

Author: Mr. John Lawrence
Environment Canada

Keywords: lake management, pollution control, Great Lakes water quality, nutrients, contaminants

Introduction/Problem Identification
This presentation will discuss some of the impacts that human activities have had on the Laurentian Great Lakes of North America and some of the integrated pollution control approaches that have been implemented for their management. The lakes were formed by the retreat of the glaciers at the end of the last ice age. The first Europeans found a relatively stable ecosystem which had evolved over thousands of years with only limited disturbance by moderate hunting and agriculture by native peoples. With increasing development and associated agricultural, mining, forestry and industrial activity the lakes were beginning to show signs of deterioration by the early part of the twentieth century. By the 1940s and 1950s serious degradation was reported in the form of extensive fish kills, nuisance algal blooms, anoxia and toxic contamination particularly in areas of rapid urban and industrial expansion in the southern lakes.

Analysis/Results and Implications for Policy and/or Research
Today the Laurentian Great Lakes of North America are home to 10% of the population of the United States and 30% of the population of Canada; they are a source of drinking water for more than 33 million people. Some of the world’s largest concentrations of industrial capacity are located on the shores of these lakes.

By the 1960s scientists were starting to study the causes and effects of the excessive eutrophication and toxic contamination, particularly in Lakes Erie and Ontario. High nutrient levels were quickly identified as the cause of excessive algal growth and oxygen depletion in Lake Erie, which, because of its morphometry, stratifies during the summer months. The notable work of Vollenweider determined that for these lakes phosphorus was the rate limiting nutrient causing excessive eutrophication. At that time, many municipal sewage treatment plants discharging into the lakes had only primary treatment and phosphorus levels in laundry detergents were typically around 50%. In 1972 the Governments of Canada and United States signed the Canada-United States Great Lakes Water Quality Agreement to protect the physical, chemical and biological integrity of the lakes. Since that time, the two countries have collaborated to undertake extensive scientific investigations, and developed rigorous management actions to sustain the health of the lakes.

Initially, phosphorus objectives were developed for the open waters of the lakes and management actions taken to limit the release of nutrients from point sources. By the early 1990, algae growth was much reduced and the extent of summer anoxia was much improved. The lakes were showing significant improvement. However, by the late 1990s, dreissenids (Zebra and Quagga mussels) had been reported in the lower lakes and nearshore waters showed signs of increasing deterioration. Toxic algal blooms reappeared in nearshore regions, odoriferous rotting mats of algae piled up on beaches once again and outbreaks of avian botulism and beach closures became more prevalent. Subsequent studies indicated that colonization by dreissenids changed the nutrient dynamics of the lakes causing increased water clarity and higher nutrient levels in the nearshore waters. The so-called nearshore
shunt mechanism is thought to illustrate how the establishment of dreissenids in nearshore waters have changed nutrient movement direction and quantity and how that influences Cladophora. Non-point sources from agriculture and urban development are now the primary contributors of nutrients to the lakes and are attracting increased attention. Nutrient quality objectives need to be established for the nearshore waters of the lakes as well as for the open waters.

In 1978 and again in 1987 the Great Lakes Water Quality Agreement was revised to focus more on toxic contaminants in the lakes and to introduce a broader ecosystem management approach. The use, direct discharge and atmospheric input of substances such as heavy metals, PCBs, DDT, and other chlorinated compounds have had serious impacts of the ecology of the lakes. Many fish, bird and mammal species were pushed to the edge of extinction. The waters, biota and sediments of the lakes were heavily polluted. Tough regulatory initiatives in both countries have significantly reduced the release of these substances but there are many hot-spots of contaminated sediment that still remain. These are being assessed for appropriate management action which can include dredging and disposal, capping or natural attenuation. Status and trend data spanning several decades will be presented to illustrate the effectiveness of management actions that have been implemented. With the control and virtual elimination of many of these ‘legacy’ substances, attention is now focusing more on chemicals of emerging concern, flame retardants, pharmaceuticals, personal care products, perfluorinated compounds and surfactants. Many of these substances cannot be eliminated by source control so measures must be taken to reduce environmental release as much as possible. Studies are underway to evaluate and enhance the effectiveness of sewage treatment technologies to degrade these compounds and minimize their presence in the effluents.

In 2010, the Governments of Canada and the United States are once again negotiating revisions to the Great lakes Water Quality Agreements to address 21st century issues such as alien invasive species, pathogens as well as new and emerging contaminants.
Ecosystem Recovery of Urban Tidal Flat in Masan Bay, Korea

Author: **Prof. Chan-Won Lee**
Kyungnam University/Coastal Resource and Environment Center, Korea

Co-Author: **Mr. Hong-Pyo Jeon**
Kyungnam University, Korea

Keywords: ecosystem recovery, water quality, sediments, tidal flat, community advisory council

**Introduction/Problem Identification**
A variety of coast usage has caused damage to the fisheries and recreation. A large amount of sewage has been discharged through short streams into the Masan Bay without proper treatment in the period of 1970~80, which led to closure of recreational beaches. The Masan Bay was designated as one of Special Management Area. A large sewage treatment plant was constructed, started its operation in 1994 and upgraded until 2007. Sediment dredging was applied to the bay as a decontamination process from 1990 to 1994. The Korean government has been planning to introduce a total pollution load management (TPLM) system into the coastal environment management regime of the Masan Bay. The urban tidal flat is located at an estuary of Masan Bay in the front of several factories at the entrance of the free trade zone. Restoration efforts were given to the Bongam tidal flat since then. The sediments and bio-species have been monitored since 1988 and the data of deep core sediment samples are available.

**Analysis/Results and Implications for Policy and/or Research**
The ecosystem of Masan Bay became noticeably worse in the summer seasons and reached the highest level of COD. The average COD (Chemical Oxygen Demand) values of surface and bottom waters in Masan Bay at the nearest station from the tidal flat in August 1988 were 3.8±1.50 mg/L and 3.3±1.51 mg/L, respectively. Whereas the average values of COD at the same station in August 2009 were 3.4±1.62 mg/L and 1.88±0.65, respectively. The water quality for PO₄-P was improved from 0.129 mg/L in 1988 to 0.012 mg/L in 2009.

Concentrations of PO₄-P in bottom waters were higher than those in surface waters at all the sampling stations. The results suggest that sediments in Masan Bay are contaminated with organics and these organics are extracted into water column under DO deficient conditions in summer season. The seawater appears not to be mixed vertically or horizontally specially in summer by other seawater parameters like DO and pH.

Monitoring data of streams flowing into Masan Bay through the urban tidal flat since 2005 were collected and analyzed by flow duration curve and load duration curve for TPLM in Masan Bay. The contamination level of sediments in the tidal flat was changed from heavily polluted to non polluted level by the comparison of data between 2005 and 2009. The COD load coming to the tidal flat of Bay mouth through three streams was gradually reduced from 2,267 kg/d to 748 kg/d since 2006. The ecological restoration was also observed in the urban tidal flat as a habitat of otter, birds, fishes, shellfishes, and benthic organisms with recovery of tidal flat sediments.

Masan Bay is a historical harbor in which high quality of iron was transported to neighboring countries 2000 years ago and red tide break was firstly recorded about 600 years ago. A new and well structured harbor was opened in 1899. Samsung founder, Byungchul Lee (1910-1987) was born 100 years ago.
in Gyeongnam Province. Samsung’s history traces back to 1936 in Masan, where he opened a rice mill and grain trade shop at the age of 26. He moved to Daegu to start a business at the edge of a marketplace trading dried fish and fruits naming it Samsung in 1938. In 1970’s large industrial complexes have been built in this area therefore increasing the level of pollutants in coastal waters with a subsequent increase in sediments, especially by heavy metals. Zinc, copper, cadmium, lead, and chromium contamination was revealed at several sites by using metal pair ratios and by the comparison with the background level of deep sediment core. For example, the Zinc concentration in the sediment of tidal flat was gradually decreased from 220 mg/kg in 1988, 182 mg/kg in 2006, and 131 mg/kg in 2009, however, other metal concentrations were not significantly changed through about 20 years. The recovery of fishes, shellfishes, and birds has been quite well recognized in recent years after TPLM implementation even though all the restoration efforts have not been evaluated. It is clear that a close collaboration of stakeholders in this effort is recovering and preserving the bay ecosystem. The Community Advisory Council for Masan Bay, which started in 2005 as a legal organization for Masan Bay’s ecosystem recovery and total pollution load management (TPLM), has answered various issues such as aimed water quality, allocation of load reduction, coastal area reclamation, communication and education, participation, involvement of citizen monitoring, and so on.

Major action plans of TPLM include the regulation of polluted runoff by formulation of natural streams and repair works of sewer lines, increase of removal efficiency in wastewater treatment plant, and control of coastal development in addition to bay clean up activity and many other activities. To raise the public awareness of the importance of the ecosystem, this tidal flat was assigned as an official visit site during the COP10 Ramsar Convention in 2008. The Community Advisory Council established as eco-tour program which provides citizens an opportunity to witness the restoration of the ecosystem and the mudflat service. The Community Advisory Council have experienced that encouraging participation and collaboration was a platform for building capacity, resolving conflicts among them and implementing TPLM in Masan Bay. There should be institutional mechanism applicable on a local base in making decision such as reclamation in coastal seas. Good governance is generally characterized as referring to openness, participation, accountability, predictability, and transparency giving stakeholders the capacity to participate in the decision that affect their lives. There are still conflicts to be resolved in Masan Bay with reclamation pressure even though we learned that stakeholders’ voluntary participation is key success factor in achieving ecosystem recovery. The main effects of governance on ecosystem recovery occur through stakeholders’ collaboration and maturity.
Zero-discharge Treatment Technology Prospects of Tannery Effluent and its Performance Evaluation using Neural Computing Technique

Author: Dr. Veeranagu Nagarajan
Tamilnadu Pollution Control Board, India

Keywords: groundwater, total dissolved solids, reverse osmosis plant, system performance, artificial neural network

Introduction/Problem Identification
Tanning industrial activity along the River course of Upper Palar basin of Vellore District, Tamilnadu, India has been going on for over five decades. The groundwater of Palar basin is the most important source for drinking, agriculture and also for industrial use of this reach. The salt laden effluents with remnants of tanning process were discharged without adequate treatment in the early days intruded into the Palar river aquifer and resulted in deterioration of its groundwater quality. Existing ETPs/CETPs since 1996, do not able to contain the salt content measured as TDS and this discharge of salt laden effluent into the Palar river is continued. In the meantime, the groundwater of this dry tract river has been found to be exceeding the quality norms prescribed for drinking and some of these sources have been even abandoned. The population along this reach is facing eventual extinction and there is a real concern in the future of this population in respect of this vital amenity.

Analysis/Results and Implications for Policy and/or Research
Surface water poorly supports the State of Tamilnadu, India. Owing to the lack of facilities for proper disposal of tannery effluent, serious groundwater pollution in Upper Palar basin of Vellore District have taken place. The tanneries in this regime are adopting Vegetable (or) E.I. Tanning and Chrome tanning. The major pollution emission factors are very high TDS, biodegradable organic, the toxic heavy metal chromium.

The treated wastewater discharge takes place along Upper Palar basin over a distance of 95 km. at five major outlets. The quantity of discharge is ranging from 200 to 4000 KLD and the quality (TDS) is ranging from 10,000 to 18,000 mgl as against the regulatory standards of 2100 mgl. The treatment system installed and operated by the tanneries restrict the discharge of organic and foul smelling matter into Palar river but very little is done on the dissolved solids content which is more than the prescribed standard of 2100 mgl. Given the fact that the discharge of the salt laden treated wastewater flow out on to the dry tracts of the river bed and sink into river aquifer directly, this constitutes a direct increase of the DS in the aquifer. The average DS content of the Palar aquifer is 900 to 3900 mgl as against the statutory drinking standard for DS of 500 mgl. Thus the groundwater cannot be directly distributed into the piped public water supply system without endangering the health of 7.2 million population who are dependent solely on this aquifer water due to absence of surface water for mass scale abstraction and distribution. However, the other major threat i.e emission of chromium either in the liquid or solid state has been prevented as the system for recovery of chrome is in place in all the chrome tanning industries.

The Government of India has constituted the Loss of Ecology (P&PC) Authority. The said authority has assessed that the affected area in Vellore district due to discharge of tannery effluent for the period 12.8.91 to 31.12.98 is 15164.96.76 hec. ac.cents and the amount of compensation payable
for the above period is Rs. 268.2 million. Hence, protection of the groundwater of Palar is highly warranted. Even now, the discharge of salt bearing treated tannery wastewater is being continued in the Palar river. The compelling need is to find out an option to restrain the discharge of salt bearing treated wastewater into the river.

Reverse Osmosis (RO) membrane treatment significantly reduces the salt contents of tannery effluents than the conventional treatment. Implementation of suitable membrane technologies with adequate reject management system for the tannery effluent ensures zero liquid effluent discharge (ZLD) from the CETPs/IETPs.

Selecting the best membrane for the RO process and assess the treatment performance is difficult due to series of controlling parameters like feed water quality, required resulting qualities, operational conditions, flux, and operating pressure head. The methodology adopted to predict system performance is based on the hourly data obtained from the DT-RO system for consecutive three months period after stabilization which is functioning in a Tannery at Ambur, Vellore District. The feed effluent to DT-RO system is secondary treated tannery trade effluent, through ASP, and no pretreatment was provided except pressure sand filter and activated carbon filter. The data collected, i.e performance variables, includes the parameters viz inlet pressure, feed conductivity, feed pH, permeate conductivity, recovery rate, permeate pH, reject pH and reject conductivity. The data for independent variables are collected at the inlet to the DT-RO system and the dependent variables are collected at the outlet of the DT-RO system. Tanneries in Tamilnadu have employed both spiral wound membrane modules and DT-RO system for the treatment of trade effluents. The regulatory authority, Tamil Nadu Pollution Control Board (TNPCB), has been exhorting the tanneries in the study area, in order to avoid further deterioration of the existing condition, to install such RO and RMS to achieve ZLD and progress on implementation by the tanneries is monitored and reviewed periodically by them.

The potential of artificial neural networks (ANN) in estimating the performance of RO plant from limited observed controlling parameter has examined. The unique advantage of the ANN approach in evaluating performance of RO system is that it eliminates the need for identifying a reference system/technique and it requires only limited governing data. The study employed multi layer perceptron (MLP) type ANN for computing the performance. Three MLP networks, each using varied input combinations of controlling variables, have been trained and tested. The model estimates are compared with measured RO performance. The results of the study clearly demonstrate the proficiency of the ANN method in estimating the RO system performance.
Modeling Approach for Lead Pollution Assessment in River Hrazdan Watershed

Author: Prof. Marine Nalbandyan
The Center for Ecological- noosphere Studies, Armenia

Co-Author: Ms. Nelli Ajabyan
The Center for Ecological-noosphere Studies, Armenia

Keywords: lead, pollution, assessment, watershed, model

Introduction/Problem Identification
The watershed of the river Hrazdan is an ecosystem, which is under significant load of different anthropogenic factors. They include sources of industrial and agricultural pollution, as well as domestic drains.

We have focused on greatly urbanized part of watershed, where the impact of industrial throws out or throws off, domestic wastewater in a complex prevails. It is an area of the capital agglomeration. In this paper we concentrate our attention on pollution with heavy metal.

Balance approaches differ with respect to spatial and temporal scale. An important aspect is related to available database. Static balance approaches require detailed data on sites and metals being examined data. Static mass balance studies are aimed at determining important metal input and output fluxes.

The objective of this paper is to present a dynamic mass balance model for a local part of the river watershed and to assess levels of lead in environmental compartments

Analysis/Results and Implications for Policy and/or Research
In this paper balance models of watershed are proposed for one of the most important rivers of Armenia, the river Hrazdan.

Models present the distribution of lead for the parts of watershed covering the territory of Yerevan. The results of different compartments investigations conducted in 2002-2004 are used in elaborated models.

It should be noted scenarios for the northern, central and southern parts of the city are considered separately.

The analysis of situation on lead contents distribution in different districts of the city demonstrates that the contamination of soil is the most in the central part. In surface waters the contents of the metal is higher on outskirts of the city. An increase of pollution in direction from the northern part to southern is specific for sediments.

The increase of heavy-metal flows through the soil and urban land system may cause serious problems for ground water quality and food chains. The model developments for regional ecosystem require that we deal with slow large-scale accumulation of heavy metal in soils to prevent such contamination.
Among environmental compartments being studied the greatest pollution from anthropogenic load is specific to urban soils and bottom sediments of the river Hrazdan.

High concentrations of metals in land and soil in the central part of the city are stipulated by accumulation toxic substances from exhausts of dirty gases by transport and exhausts of industrial sites. The special peculiarities of the city relief make accumulation and retaining the pollutant in the air faster. A large quantity of wastewater exposure in the river without treatment in the southern part of the city leads to accumulation of lead in the bottom silts.

The balance model for this technoeosystem is determined with stronger links between sources of pollution, soils and sediments.

The model is based on aggregated blocks the flows and input, output flows for each component.

Let us denote blocks by numbers, so that 1 is the atmosphere, 2-soil, 3-sediments, 4-river water, 5-hillslope runoff, and 6- groundwater. Let be variables for concentrations in block i, while stand for the flux from and, correspondingly, for the flux from i to j.

The system can be turned to a chain structure by introducing one conditional block, where we have four blocks linked in a hierarchical order.

Then the dynamics chain structure is covered by the following system of ordinary differential equations.

Where is denotation for the flow from external sources to the compartment 2(soil), stand for the part of input that is not solvable and remains in the compartment, functions that can take values depending on some parameters peculiar to the system and stand for the parts that gets lost (either with the wind or water stream).

The Jacobean of system (1) is a three- diagonal matrix; eigenvalues of it can be easily calculated. We can make a change of variables of the form, after which the equilibrium is interpreted as trivial solution of system (1). When the Jacobean has two conjugated imaginary eigenvalues, the system can be reduced to a pair of coupled oscillators. The main point here is that stability of solutions bifurcating from the steady state can be regarded in terms of values the parameters entering in, however we can assume them constants. Resonances in system of coupled oscillators are corresponded with “pumping of energy”, which in the case of study is intensifying of exchange between compartments.
Integrated Pollution Prevention and Control Sources, Pathways, Receptors, Solutions

Author: Mr. John Payne
SNC-Lavalin Inc., Canada

Keywords: watershed, hot spots, pathways, receptors, cleaner production

A watershed or river basin approach, to include the sources, pathways and receptors for pollution and also the solutions, is required for integrated pollution prevention and control. In industrial terms, the source is the process at a plant or facility, the pathway is frequently water either above or below ground, and the receptors may be human or ecological including flora, fauna and sinks, such as lakes and wetlands or large marine ecosystems (LME).

Industry faces significant water issues, including supply and demand, use and consumption, and wastewater discharges, all presenting several key challenges. These include adapting to water scarcity, changing management paradigms and minimizing environmental impacts. Opportunities exist in proactive integrated water management using corporate water strategies that are outward looking and involve a commitment to innovation and implementation. Cleaner production strategies and zero discharge technologies provide the main opportunities and solutions.

Two case studies illustrate this approach to water issues, challenges and responses to them. They involve water, land and air as media and include transboundary effects. While much of the work is technical and scientific, water management and politics are in the background driving the process.

In Ust-Kamenogorsk in eastern Kazakhstan, the groundwater has been severely contaminated from many years of industrial activity, particularly in non-ferrous metal smelting, including rare metals. The situation is now so severe that groundwater supplies are affected and the water in the Irtysh River, and its tributary the Ulba, is deteriorating. The Irtysh is 4248 km long and is one of the biggest rivers in Eurasia flowing north into Russia. Thus a local water issue becomes a transboundary one. An international effort is underway to define the problem and institute remedial measures. Groundwater modelling of the city indicated the flow path and transport migration characteristics in the groundwater and predicted the effects of various remedial options. A plan is in progress to set up a long-term pump-and-treat system to cut off contaminant plumes and contain and improve the groundwater quality. At the same time some of the waste dump sources are being capped. However, airborne contamination emitted from the many stacks in the city adds to the problem by depositing contaminants on the ground surface and contributing to acid rain as a result of the climate conditions. While identifying the pathways and remediating the effects of the sources, long-term measures need to employ cleaner production methods in the many local industries to mitigate and reduce discharges and emissions.

The Dnieper River Basin, comprising large portions of Ukraine, Belarus and Russia is under severe ecological stress resulting in stress to the Black Sea LME. There has been a steady increase in serious environmental impacts to water quality contributing to the deterioration of the overall ecology. More than forty million inhabitants of the Basin rely on the integrity of the water system for potable
water supply, irrigation, transportation, industrial and recreational uses. Sources of pollution include point source hot spots, such as industrial and municipal effluents, and non-point sources, such as agricultural and urban run-off. The Global Environment Facility (GEF) launched the Dnieper River Basin project as part of the GEF Black Sea Basin Regional Waters project to “Remedy the serious environmental effects of pollution and habitat degradation in the Basin, to ensure sustainable use of its resources and to protect biodiversity in the region”.

The UNIDO project on the Identification and Analysis of Sources of Pollution (Hot Spots) provided significant input into the Strategic Action Plan (SAP) and in the core issue of the development of long-term Environmental Quality Objectives. A methodology was developed for the comparative evaluation of hot spots based on impacts to human health, beneficial use of the river basin and environmental features. National Pollution Reduction Reports were produced representing a situational analysis of each country in terms of identification, analysis and prioritization of sources of pollution for the Dnieper River. This step was followed by technical-economic assessments of priority Hot Spots resulting in Priority Investment Portfolios. This, in turn, resulted in the development of pollution mitigation measures for implementation as part of the Strategic Action Programme for the Dnieper Basin. Phase II of the work is about to commence for the introduction of cleaner production methods to small and medium enterprises through the TEST (transfer of environmentally sound technology) methodology.
Agriculture and Water Pollution: A Case Study in Mexico

Author: Dr. Rosario Perez Espejo* et al.
* National Autonomous University of Mexico

Keywords: non-point source pollution, irrigation district, agricultural producers, Mexico, agro-environmental policies

Introduction/Problem Identification
Agricultural diffuse discharges represent a major problem in many countries. Solving it becomes more difficult in developing countries like Mexico, because agriculture is an important and troublesome sector. It only accounts for the 4.6% of the GDP, but it employs about 6 million people and generates income for about 25 million people. Agriculture comprises 67% of the territory, using 78% of water extractions in 86 Irrigation Districts, with an average global efficiency less than 40%. Agriculture is the most vulnerable sector to climate change due to its tropical climate and weak institutions. It is also vulnerable to water pollution, resulting in diminished water availability. Agricultural policy grants huge subsidies, encouraging an intensive use of inputs. In contrast, no agro-environmental policy measures exist in order to alleviate their impact on water quality. Links between agriculture and water/soil pollution are completely neglected by both public policy and academic research.

Analysis/Results and Implications for Policy and/or Research
This paper presents a case study carried out in Irrigation District 011, Guanajuato state, one of the most important agricultural areas in the country. It was conducted by an interdisciplinary team during 2009. The objective of the research was to propose several policy measures in order to reduce the impact of agricultural practices on water quality, and to increase the efficiency of irrigation water. Our results show that: (i) most producers develop unsustainable agricultural practices; (ii) institutions in charge of agriculture and water management, frequently overlap in their activities and programs; (iii) health problems are present due to wrong agrochemicals application; (iv) poor surveillance and enforcement of water use; (v) land fragmentation is a critical problem and estimations indicate that 60% of the Irrigation District 011 land is leased; (vi) low educational level and aging are two major social problems; (vii) water quality analysis showed the presence of lindane and methoxychlor, pesticides of restricted use in Mexico; furthermore, triazines and carbamates were found in some points of the sample; (viii) the price of water for agricultural irrigation is underestimated and electricity for agricultural pumping is subsidized; both measures encourage an inefficient use of water and are the main cause of aquifers overexploitation; (ix) the burning of crop byproducts, although banned, is widely practiced in the region among medium and small farmers, who lack the necessary machinery for practices such as zero tillage.

Other results that can be mentioned are: 1) the need of the modification of the main agricultural policy of subsidies in Mexico: PROCAMPO), in order to encourage fallow areas, which is a sustainable practice needed for soil recovery and water use reduction; Mexican agricultural policy is dispersed in 59 programs and only five (mostly in forest) of them correspond to the environmental area; 2) the identification of cropping patterns in Irrigation Districts according to water availability in reservoirs. Studies on the subject are scarce, but a research conducted at the Irrigation District 076, Valle del Carrizo, Sinaloa, found similar problems in terms of agricultural practices, especially on water, fertilizers and agrochemicals use. In another study related to the efficiency of water use in northern Irrigation Districts, it was found that the problem is due to two main causes: a poor design of irrigation channels, and water flows inconsistent with soil types and available water quantities; 3)
the need of drive a change in producers’ perceptions which, according to our results, consider farming or agricultural practices harmless to water quality. Training should be directed to selected groups of the most influential producers in order to make training more cost-effective, facilitating their replication in other farmers. In fact, assessing producers’ perception towards water quality is one of the first steps required for an effective design of agro-environmental policies. 4) the overuse of pesticides is due to its low price and farmer’s risk-aversion. Using insurance focused on the reduction of pesticide contamination intends to change a “chemical insurance” for a financial one. Such insurance would not guarantee income for the farmer, but would help to avoid early use of pesticides (i.e. before a plague appears in the culture). Thus, we propose a financial instrument which allows the use of pesticides at a lower cost. According to some observations gathered during the investigation, there are notable differences in the costs of implementing the product at different times of cultivation. This fact encourages some producers to apply pesticides in either the very early stages or without having evidence of pest outbreaks. The agricultural green insurance is a subject on which there is little literature and few practical applications.

Author: Dr. Mona Petersson* et al.
* Södertörn University, Sweden

Keywords: river basin, catchment characteristic, ecosystem management, scale, GIS

Introduction/Problem Identification

The EU Water Framework Directive was introduced the year 2000 to protect and secure all water resources within the European Union. The directive is designed to have an ecosystem management approach where the water quality and quantity is administered in relation to the borders of the river basin. During the period from 2000 to 2015 the European countries and their new water authorities are into the implementation process of the directive; classifying the status of their water resources, designing the river basin management plan, as well as the programme of measures. In Sweden five water authorities are responsible for the implementation process, each handling river basins at different scale levels from local to regional size entering the same coastal waters.

Analysis/Results and Implications for Policy and/or Research

In this case study, focusing on the ongoing implementation of the EU Water Framework Directive (WFD) in Sweden, we analyze some of the opportunities and challenges for a sustainable governance of water resources applying an ecosystem management approach. The study area is the Lake Mälaren drainage basin within the Northern Baltic Sea River Basin District in Sweden. This district covers the Lake Mälaren drainage basin and Stockholm archipelago region constituting an ecological and geographic gradient from inland to freshwater archipelago and further to the brackish archipelago in the Baltic Sea. The drainage basin represents an area with a long history both in agricultural as well as mining history, which are quite separated in different sub-catchments. Historic mining remnants from at least the 12th century leaking metals and acid water into rivers and creeks in the western upstream parts of the catchment, and intense agriculture in the lowland areas in the vicinity of the lake in the downstream parts is leaking nutrients adding to the eutrophication. Most rivers within the area have been modified during the history; dammed for mills, rivers straightened and wetlands dredged to increase the land matching the increase of inhabitants. Also the present day situation show differences when it comes to land-use within the catchment, where the north western part is rural and low populated, and at the same time one third of the Swedish population is found within lake Mälaren catchment. The densest population is found in cities at the shore of the lake, with a increasing density towards Stockholm. At regional level future scenarios due to climate change varies, but in some simulations there is an increased precipitation in the area creating a risk scenario of flooding that may result in a transgression in the lowland areas, degraded water quality and increased nutrient levels. Studying the drainage basin of Lake Mälaren therefore makes it possible to compare different water issues between sub-catchments within the same drainage basin, and also at different geographical scales since water quality priorities can be scale related.

The study is based on hydrological data, and data of the physical characteristics of the Lake Mälaren river basin and the different sub-catchments characteristics (area, shape, land use...), and analyzed using GIS techniques. The sub-catchments are compared concerning different scientific aspects as well as issues addressed by the stakeholders. The complexity of large river basins is discussed, and the importance of different solutions in upstream and downstream sub-catchments due to variable
landscape character, land use and history. In the light of the new EU Water Framework Directive the study point to the importance of flexible river basin management from regional to local scale, and vice versa, to create an adaptive ecosystem management where problems can be discussed and solved at a proper scale level.
**Integrated Management of Water Resources and Industrial Effluents. Pantanoso Stream Basin. Montevideo, Uruguay**

**Author:** Ms. Alicia Raffaele et al.
Municipality of Montevideo, Uruguay

**Keywords:** effluents monitoring, stream basin, management, pollution, community

**Introduction/Problem Identification**
Montevideo, capital of the Republic of Uruguay, is home to more than half of the country’s population, nearly 1,500,000 inhabitants, with a population density of 2,650 hab/km². The city is divided into 18 zones covering urban neighborhoods and suburban/rural areas, each of which operates a Community Center (CCZ). These bodies have CCZ local political and Neighborhood Councils as organs of social participation.

Montevideo has a dense watercourse network made up of primarily of low-flow streams, the main ones of which are the Pantanoso and Miguelete rivers flowing into the Bay of Montevideo. The network is closely linked to the human activities associated with the human population and supporting industries.

The three primary sources of watercourse pollution are: discharge of sewage, discharge of industrial effluents and indiscriminate disposal of solid waste.

The impact of human settlement on ecosystems is proportional to the amount of the population.

**Analysis/Results and Implications for Policy and/or Research**
In recent years, the disposal of solid waste into waterways has become an important source of organic pollutants. On the other hand, the discharge of liquid waste into waterways has been partly reversed. Therefore, we must implement measures aimed at the reduction of primarily solid waste. The economic crisis caused an increase in informal human settlements on the banks of rivers, expanding the impact on them and in turn worsening the quality of life for the people. Moreover, for much of this population, the recycling of solid waste is a source of income. This is done on the spot, and what is not marketed is disposed of in the watercourses.

Within this framework we decided to carry out a project that contemplates this situation, involving the residents of the watershed with its problems. We chose as the watershed for this project, the Pantanoso River Basin, which originates in the Pereira Hills, in the central region north of the Department of Montevideo. The river basin drains in a north to south direction into the Bay of Montevideo through rural, semi-urban and urban areas. The length of the basin is 16 km, with slow runoff into the bay because of its low slope. The basin is totally within the Department of Montevideo, and has an area of 70.4 km² within the limits of 5 Community Centers (CCZ: 12,13,14,17,18). Within the river basin there are 207,391 inhabitants (Census 1996), of which, 36,516 people live in temporary settlements (as of 2002).

To carry out the project we considered as a general objective the following aspects:
1) Raising awareness of the population directly or indirectly involved in the issue to be addressed.
2) Encouraging interaction between the various entities and the population of the basin in order to
disseminate the causes of pollution and emphasize that we all have a personal responsibility emanating from our use of water resources.

3) Interacting with teachers in the area, given the potential for replication in educational training.
4) Promote the active participation of women in the field.

The methodology used included the conduct of 2 inspections field all along the basin; 5 workshops to discuss and exchange views (one for each CCZ); and a final day where all issues identified by the workshops were raised.

The workshops were conducted with various stakeholders, where we tried to pose the general concepts of the environmental concerns used in the process of discussion and identification of problems. Worked on at each workshop: causes, consequences and possible solutions to problems identified, and trying to induce a feeling of responsibility and ownership in the participants. To identify the core problems, there was a brainstorming. Then the participants worked in groups to address some of the problems previously recognized, each group then presenting to the workshop participants the result of what had been done and discussed, allowing for feedback from the rest of the workshop participants and their validation.

A focal individual was selected from among the participants, and representing each neighborhood. On the same day in the end, he/she presented the results achieved in the discussion of his/her area. At the same time, we travelled with the commission of the Pantanoso River Basin. The commissions is comprised from various municipal divisions, and is mandated to survey the basic technical information required to draw up a strategic plan for the basin, thus the result of the whole project is an essential input for the design of this Strategic Plan.

The project was implemented in 2006, with a follow-up phase in 2007-2009. Inputs to the project were organized and develop to deliver training materials for the workshops. We also prepared an audio-visual support presentation with photographs taken at the critical points made by travelling members of the CCZ, and a PowerPoint presentation.

The project resulted in the following actions:
1) It generated a diagnostic paper on the problems of the Basin and their possible solutions. It included input from the workshops that emerged from the actors themselves, which better reflects the situation of each sub-area.
2) Workshops were replicated by the local entities.
3) It produced a video including one of the field inspections, work in a factory and opinions of actors who participated in the project.
4) Articles were published in local and national media concerning the project, and interviews were broadcast in the media as part of the final day.

In conclusion, it can be indicated that the conduction of such projects is an innovative action as a tool to detect, resolve and improve environmental problems from the perspective of the community. It also results in a course of action improving public participation in the valuation of natural resources, and in the authorities taking appropriate measures.
Relevance of IWRM Framework in Addressing Water Pollution Issue: The Case of Industrial Pollution in Palar Basin in South India

Author: Dr. Arunachalam Rajagopal
PRIA Foundation for Research and Development, India

Keywords: water pollution by tanneries, common effluent treatment, IWRM for addressing pollution, river basin organisation/board, multi-stakeholders dialogues

Introduction/Problem Identification
This paper is about the importance of the IWRM (Integrated Water Resources Management) approach in addressing the pollution problems in Palar river basin in South India and the lessons learnt from this. The pollution in the basin is caused by tannery industries by discharge of untreated effluents into water sources. This has in turn affected the domestic and irrigation water and made huge negative impact on the health, agriculture, income and overall livelihoods of people in the basin. It is to be noted that the industry is an important source of foreign exchange earning in the country and employment for the local people besides agriculture. The Government and civil society organizations and the World Bank have tried to address the issue under IWRM and River Basin Management Framework but the success is only limited. This paper presents the issues, interventions in addressing the problem and the lessons learnt from this approach.

Analysis/Results and Implications for Policy and/or Research
The Palar Basin is one of the major river basins in Tamilnadu, South India. The river flows only for a few days in a year but recharges enormous ground water sources during its flow season. Ground water is the major source of water supply in the basin for both irrigation and domestic purposes. The area under ground water irrigation has increased quite sharply over a period and hence over exploitation of ground water has been noted already. There are a vast number of tannery industrial units in the basin discharging their effluents into the river, tank and land without treating it and consequently it affected the surface and ground water and soil quality. As water sources were contaminated because of discharge of tannery effluents farmers could not grow food crops like paddy thus affecting food security. As the ground water availability is already less due to over exploitation the pollution impact is severely felt. In some parts of the basin the land has become barren and unsuitable for crop growth affecting small and marginal farmers who depend upon irrigated agriculture significantly for their livelihoods.

Pollution affected farmers have filed cases in the court against the industries and the court has ordered for payment of compensation by them based on an assessment by an authority called ‘Loss of Ecology Authority’. However the compensation arrived by the authority was not accepted by the farmers as they felt that it is not adequate to meet the damages incurred by them. Further based on the court’s intervention, the Pollution Control Board of the Government has ordered installation of Common effluent treatment plants (CETP) for treating the effluents, however many industries have not implemented the order of the court. Thus there was a chaotic situation in the area by the uncoordinated activities of different stakeholders of the basin which have resulted in the conflicts and social unrest.

Under these circumstances some civil society organizations had taken up some initiatives in organizing dialogues among different stakeholders for finding solutions to the problem. This was led by academics,
NGOs, religious organizations, and individual social workers of the area. Though government was initially not participating in the activities but taken up the issue later when there was a programme formulated for this by the World Bank under the auspices of its Water Resources Consolidation Project in the state. As a result there was formation of Palar River Basin Board under the IWRM framework and many pollution control measures including setting up of Common Effluent Treatment Plants (CETP) were taken up. However the programme was not successful due to the following reasons.

1. The costs of treatment of pollution under Reverse Osmosis (RO) technology is formidable for small firms to join the Common Effluent treatment plants (CETPs) and hence they did not cooperate.
2. The monitoring committee formed for the purpose of watching the CETPs was not effective as it was led mainly by government and industries who were not much bothered about the issue. The principle of ‘polluters pay’ was not enforced effectively due to institutional weakness in the implementation of laws on pollution.
3. Adequate representation was not given to farmers in the Palar Basin Board constituted by the government. Similarly civil society organizations who were active in this issue were not fully involved in the board.
4. There is not much coordination among different government departments dealing with water management and pollution.
5. The Basin Board itself was not given adequate authority in the implementation of decisions taken by it regarding water allocation and pollution issues. The decisions by it were not backed by legal authority as it was considered as only advisory by law.

Conclusions

Thus it is seen that though there were many good initiatives taken by different stakeholders in addressing the pollution problem in Palar basin it did not yield much result. This is due to lack of incentives for small industrial units to participate in the effluent treatment due to high costs and less support by government, ineffective monitoring of the treatment plants by government and users group, lack of adequate representation to pollution affected groups (like farmers and general public) in the monitoring mechanism and basin board, lack of legal authority for enforcing decisions taken by the basin board etc. Overall it is seen that though there was an opportunity for addressing the issue of water pollution through IWRM and River basin Management Framework, the actual experience was far from satisfactory due to many reasons discussed earlier. However the IWRM approach / framework continues to be relevant as the pollution issue is related to many social, economical, technical and intuitional aspects and hence requires an integrated approach in finding solutions.
River Restoration Program in Basin Scale

Author: Ms. Nadia Roustaei
Departement of Environment, Iran

Keywords: water quality indices, water quality standards, restoration program, monitoring program, pollution sources

Introduction/Problem Identification
It was the first time in the country that water quality studies were carried out based on integrated water quality management. The main goal of this study was to design and implement the river restoration plan for 9 vital rivers in 18 provinces. The first step was determining the water quality of the rivers in basin scale. Finding the main pollution sources the most deteriorated reaches were identified and the restoration program was prepared for them.

Analysis/Results and Implications for Policy and/or Research
To identify the pollution trend the sampling program was carried out during 4 seasons. The following table shows the name of rivers, their basin area and number of sampling stations.

<table>
<thead>
<tr>
<th>River Basin</th>
<th>Area (km²)</th>
<th>No of sampling stations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sefid rud</td>
<td>59177</td>
<td>94</td>
</tr>
<tr>
<td>Karkhe</td>
<td>50764</td>
<td>85</td>
</tr>
<tr>
<td>Zarine rud</td>
<td>11914</td>
<td>41</td>
</tr>
<tr>
<td>Helle</td>
<td>21212</td>
<td>25</td>
</tr>
<tr>
<td>Zohre</td>
<td>16000</td>
<td>27</td>
</tr>
<tr>
<td>Mond</td>
<td>47854</td>
<td>30</td>
</tr>
<tr>
<td>Gorgan rud</td>
<td>11518</td>
<td>23</td>
</tr>
<tr>
<td>Haraz</td>
<td>4000</td>
<td>20</td>
</tr>
<tr>
<td>Simine rud</td>
<td>3884</td>
<td>15</td>
</tr>
</tbody>
</table>

Main water quality indices including BOD, DO, F coliform, EC, Turbidity, pH, T, nitrate and Phosphate were studied. The water quality standards were adopted from national and international organizations such as Department of Environment in Iran, EAP, FAO, WHO, and some countries such as Canada, Japan.

The results indicated that there was water quality depletion in some river reaches. Water quality modeling were performed for critical reaches and different scenarios were examined to find the best one for designing the restoration program.

To access the effectiveness of this program on pollution reduction in the rivers, monitoring program were designed and suggested.

These two programs will be approved by federal government and will be implemented by local authorities in each province.
Anthropogenic Changes in the Hydrological and Hydrochemical Characteristics of the Delta Rivers Ecosystems of the North-west Coast of the Black Sea

Author: Prof. Sergiy Snizhko
Kiev Shevchenko University, Ukraine

Keywords: hydrology, hydrochemistry, water quality, delta ecosystems, anthropogenic impact

Introduction/Problem Identification
Within the territory of Ukraine on the stretch of coastline of 300 km in the Black Sea flow into the three major rivers – the Danube, Dniester, Southern Bug and Dnieper. These rivers include up to 14% of the area of Europe and 64% of the catchment area of the Black Sea. The volume of runoff of these rivers is 267.7 km$^3$ of water per year, representing 82% of the total runoff into the Black Sea. Therefore, the study of human-induced changes in hydrological and hydrochemical characteristics of these rivers is of great importance for preserving the ecosystem of the Black Sea.

Analysis/Results and Implications for Policy and/or Research
The water of the Danube River is characterized by a predominance of bicarbonate ions from 140 to 200-240 mg/dm$^3$ and calcium (40-75 mg/dm$^3$). The total content of major ions varies throughout the year from 230 to 350-400 mg/dm$^3$. It is very muddy and has a brown undertone (“coffee with milk”), the average values of turbidity in the mouth of the river is 180-190 g/m$^3$. This comes from 20 to 70 million tons of solid suspended matter, and therefore part of the delta of the river is constantly increasing.

The high turbidity of the Danube water determines the environmental condition of the river, in particular its estuaries. It limits the development of algae and bacteria. Suspended particles absorb up to 80-90% of pollutants such as heavy metals, pesticides, oil products, phenols, detergents.

In the delta of the river is the deposition of suspended particles and improve water quality. Simultaneously there is formed a powerful source of secondary pollution of water of the river and the Black Sea ecosystem.

In the sediments of the delta increases the concentration of pollutants in the 100 – 1000 compared with the concentration in the water.

In the Danube and its tributaries coming from many diffuse sources of many heavy metals, of chlorinated hydrocarbons, including dangerous persistent organic pollutants (POP) such as lindane, DDT, DDE, dieldrin, endosulfan and polychlorinated biphenyls (PCB). The content of these substances in sediments and shellfish reflects the level of anthropogenic impact on the ecosystem.

Dniester is the largest river in Western Ukraine and Moldova. Water flow Dniester influenced economic activity declined by 11-18%. Regulation of rivers by reservoirs, the total working capacity of more than 2.7 km$^3$, significantly reduces the water content of the estuaries of the rivers in the spring and summer.

To form the water quality of the river has been of great importance in recent years the passage of natural rain floods. Construction Dubossary hydropower plant (HPP) (1954) and the Dniester...
reservoir with a capacity of 2 km³ led to the stabilization of the hydrological regime of rivers. This event influenced the development of processes of degradation of biodiversity and destruction of the ecosystem of the delta.

If the reduced flow of river water in the mouth that comes salty sea water. This changes the hydro-biological and hydrochemical regime.

The water of the river has a composition of hydrocarbon-calcium with mineralization from 200 (upper) to 700 mg/dm³ (downstream).

In recent decades, the water quality of the Dniester River has declined considerably, the total mineralization during the past 50 years has increased by almost 200 mg/dm³ because the flow of pollutants from the wastewater of industrial enterprises of Ukraine and Moldova has increased significantly.

The most dangerous toxicants for the Lower Dniester are (in decreasing degree of influence): organochlorine pesticides, copper, zinc, phenols. Contamination of water, along with a slow water exchange led to a partial degradation of the ecosystem of the delta, to the deterioration of water quality in estuarine areas.

Dnieper-Bug estuary region includes the combined estuary and the coastal areas of two rivers – the Dnieper and Southern Bug.

All hydrophysical and hydrobiological processes in the Dnieper-Bug estuary region depend on water flow of the Dnieper, as it gives 94% of the total inflow of water in the area.

Hydrological and hydrochemical regime of estuaries of the Dnieper depends on the mode of operation Kakhovska HPP. The influx of water from HPP changed very much in the daily and weekly cycle. In the case of low flow of water (up to 470 m³/s) in the ecosystem increases the concentration of readily available organic matter. Biological oxygen demand (BOD) exceeds 13 gO/m³). At high water flow are dominate self-purification processes (reduction of oxygen demand reaches 4,2 gO / m³).

When mean daily discharges of water flow up to 1500 m³/s maintained a positive balance of production-destruction processes. It ensures the development of the variety of biotopes in reservoirs and streams of different types and species richness of the flora and fauna, great variety and high productivity of plant and animal communities in the Dnieper-Bug estuary region. However, if the volume of releases significantly reduced far below than 500 m³/s, there may be severe consequences for the ecosystem.

In the case of reducing the flow of water in the delta of the Dnieper will take place processes of stalinisation and it will become one of the sea inlets with salinity about 16-18‰.
Water Quality Improvements through Constructed Wetlands: A Case Study from Mexico

Author: Dr. Markus Starkl
University of Natural Resources and Applied Life Sciences, Austria

Co-Author: Dr. Jose Luis Martinez
Instituto Mexicano de Tecnologia del Agua (IMTA), Mexico

Keywords: constructed wetlands, operation, ramsar, sanitation, sustainability

Introduction/Problem Identification
Lake Patzcuaro is situated at an altitude of 2035m above sea level in the State of Michoacan. The southern shore of the lake, which inhabits various plant species, is a Ramsar site since 2005. In the last fifty years, the lake area has suffered from overexploitation of its natural resources and contamination of the lake which lead to severe degradation of environment around the lake. Only few villages can count on sewer networks and septic tanks and latrines are deficient or non-existent. 70% of the wastewater generated by the 120,000 inhabitants in the catchment area of the lake area is not treated. The plan for the recuperation of the Lake Patzcuaro, which was initiated in 2003, envisaged various measures to reduce the contamination of the lake, of which one, the construction of constructed wetlands for small communities will be assessed in this paper.

Analysis/Results and Implications for Policy and/or Research
As there are already some conventional treatment plants around the lake which show weak performance caused by insufficiently trained staff and complicated technologies, constructed wetlands were considered appropriate for smaller communities that used to discharge wastewater untreated in the lake. The benefits of the constructed wetlands that were intended can be summarised as follows:

• treatment of wastewater (that used to discharge untreated in the lake) according to Mexican Norms (NOM 001-SEMARNAT-1996)
• generation of employment during construction and operation of the treatment plants
• income through commercialisation of ornamental flowers that are planted in the treatment units
• income through commercialisation of a variety of bulrush (chuspata) which can be used for handicrafts that are also planted in the treatment units

To evaluate the above mentioned parameters for successful implementation of the constructed wetlands around the lake, two treatment plants around the lake were studied: the wetlands of Cucuchucho and Santa Fe.

Performance of the treatment plants and institutional aspects related to O&M were investigated in detail. Especially the last aspect turned out to be decisive for the functioning of the treatment plants. Therefore, the operators of the treatment plants were interviewed about their daily tasks, the equipment they receive, the support from the responsible municipalities and the problems they face. More opinions from the municipalities, the communities, the health centre and inhabitants of the area were collected and interpreted. The technical performance was evaluated by analysing influent and effluent of the treatment plants accompanied by an expert visit to get a picture of the current condition of the constructed wetlands. During the interviews, information on the benefits concerning flower and plant commercialisation could be gathered.
The two constructed wetlands perform well and accomplish almost all parameters of the Mexicon norm. However, the functioning of the treatment plants is threatened by several issues:

Cucuchucho: The problems of this CW are related to operation and maintenance (O&M) as the operator is changing frequently (already four different persons) and every time has to be trained anew. There are few opportunities to find work in this area, so there are conflicts about getting the job of the operator who is paid by the municipality. The system is still working well, but there is the potential risk of low capacity of O&M staff which could cause other problems.

Santa Fe: The operator receives little support from the municipality, which is formally responsible for organisation of O&M. Material that is needed by the operator (e.g. working clothes, gloves, etc.) is not provided by the municipality, but by Instituto Mexicano de Tecnologí del Agua (IMTA), the cooperating universities or the health centre. The operator tries to use all material and working gear very economically as it is difficult to get new material. In case the support stopped, the functioning of the treatment plant would be highly endangered.

Further, in both villages the sewer is often clogged as people remove sieves and throw garbage (old clothes, plastic bottles, etc.) into the sewer. Another big part of solids that enters the treatment plant is sand, which is getting into the sewer through the rainwater collection systems.

Even though the intended benefits are fulfilled to a big part, the functioning of the treatment plants is not secured for the future. Institutional issues are more complicated than initially imagined as jobs are sought-after in an area with high unemployment. The idea of annual changes of the operator of the treatment plant in Cucuchucho may be reasonable to serve justice, but endangers the functioning of the constructed wetland. Also the treatment plant in Santa Fe is suffering from organisational problems: the well trained operator receives only little support from the responsible municipality and has to rely on external support from IMTA and cooperating universities for his working material.

The problem of clogged sewers was not considered when designing the treatment plant and for future systems, rainwater drainage and sewer should be separated. The practice of people to throw garbage into the sewer is already counteracted, but maybe awareness campaigns are not enough to persuade people to refrain from this already accustomed habit.

Still, both treatment plants contribute to the protection of the Lake Patzcuaro and confirm that constructed wetlands are an appropriate technology for treating domestic wastewater of small communities.
Evaluation of Industrial Water Saving/Management Options – Example from the Steel Industry

Author: Ms. Katharina Tarnacki
RWTH Aachen University, Germany

Co-Author: Prof. Thomas Melin
RWTH Aachen University, Germany

Keywords: industrial water management, IPPC, water saving, steel industry, water management

Introduction/Problem Identification
In Europe many regions suffer from poor water quality and water stress due to high water abstractions and discharge of not adequately treated wastewater into the surface water bodies. Among the drivers for water stress industry has been identified to be often a point and/or diffuse pollution source. The industrial sector, including cooling is the largest water user in Europe but also a major water polluter. Many investigations have already taken place to reduce water demand in industrial plants, to improve wastewater treatment in order to increase recycling rates and to increase discharge water quality. There is a wide variety of water saving and water management options which reveal different advantages and disadvantages (costs, energy requirement, use of chemicals, large equipment etc.) and the comparison between options is very complex. In this study water management options for the steel industry have been compiled and evaluated according to a multi-criteria approach.

Analysis/Results and Implications for Policy and/or Research
The high water demand in the steel industry and the complex water systems of integrated steelworks offer a wide platform for water use optimisation and application of advanced wastewater treatment technologies in order to increase recycling rates in the plant and save freshwater abstracted from the environment. In the various plants (e.g. coke plant, sinter plant, rolling mills) different wastewater streams are generated and require adequate treatment. A centralised wastewater treatment is in many cases not useful due to the complex composition of the wastewater which poses high challenge to the treatment. Therefore, many investigations focus on advanced treatment of specific wastewater streams (phenol-containing wastewater from the coke plant, emulsions from rolling mills, wastewater from gas treatment etc.) in order to decrease their pollution loads and consequently enable reuse in the process or the direct discharge into the environment. However, also general process integrated water management options such as cascade water use in the plant (good knowledge on the water quality requirements of the plants necessary), optimisation of cooling water cycles or operation of pumps lead to considerable water savings within those industrial plants.

In this study publications and studies on water management improvement in the steel industry have been screened, options have been compiled, categorised, evaluation criteria have been selected and determined in order to evaluate all those options which are often not easily comparable.

Of course, not all treatment technologies or water management options are adequate for all different wastewater streams and can be applied in all plants, but the generic multi-criteria based approach with the wide range of criteria is a methodology which can be applied also for other sectors and is a tool to evaluate this kind of diverse water management options.
The selected criteria consider the impact scale of the options, costs, maintenance efforts, other emissions etc. They reveal which disadvantages and other bottlenecks concerning environmental impacts occur (e.g. shift of environmental burden to other compartments as it is in case of chemical use, or generation of sludge or concentrates or other emissions) and are often not taken into account by engineers and water managers (except costs) who deal in the first range with the water management problems.

The results of the study give an overview about the variety of opportunities to mitigate water stress in catchments with strong impact of the steel industry. The first results show that many studies deal with advanced treatment technologies including chemical addition and considerable energy demand (e.g. application of membrane technology for treatment of emulsions, biological treatment for phenol wastewater etc) in order to enable water recycling in other processes. Many very satisfying results can be found in publications and the technologies are promoted. However, among those options many have high environmental impact on other environmental compartments and impact categories (e.g. global warming) and have a negative life cycle assessment (LCA) balance comparing to the status quo of the water management in the plant. They help only to shift the problem from the aquatic to other parts of the environment which is from the integrated pollution prevention and control approach point of view not the required and desirable objective. There is also a range of process integrated, sometimes even non-technical options (e.g. raising awareness of staff to spillage of water) which require previous performance of detailed water balances of the whole industrial site to discover bottlenecks in the water management achieving high water savings but are often not considered since end-of-pipe solutions are often favoured.

For the selected criteria indicators are determined for all options and an overall evaluation under consideration of possible scenarios and weighting factors is performed. The study is not still ongoing and the final results will be available for the conference.
New Methods of Xenobiotics Bioidentification as a Part of Pollution Control

Author: Prof. Valerii Tonkopii
Russian Academy of Sciences

Keywords: xenobiotics, Daphnia magna, bioidentification, toxicity, pollution control

Introduction/Problem Identification
In view of the fact that chemical analyses require special equipment, they are expensive to perform and do not allow to evaluate the general toxicity during the recent decade large scale investigations have been performed to study various test-objects for biotesting. To assess toxicity integrally, biotesting plays an important role in the system of water quality control. We have been developing non-traditional methods of the identification of pollutants, using various hydrobionts as biological objects and the study of the mechanism of toxic action of xenobiotics. The experiments were carried out with using of Daphnia magna. Daphnia magna is a Crustacean in the order of Cladocera. This aquatic animal extensively used as a test organism in aquatic toxicology due to their small size, short life cycle and amenability to lab culture.

Analysis/Results and Implications for Policy and/or Research
Experiments were performed with a 2-days old culture of Daphnia magna. The toxicity of pesticides was determined by the value of LC50, a concentration of the compounds causing death to 50% of hydrobionts during incubation with toxicants for 24 hours. In the first stage of the work, toxicity of organophosphates (Dipterex, DFP, DDVP, Paraoxon, Malathion, Malaoxon), heavy metals ions (Hg, Pb, Cu, Co, Cd, Cr, As, Al), organochlorines (Aldrin, Dieldrin, Endrin, Aroclor, DDT, Lindane, PCBs etc.), cyanides (sodium cyanide) and pyrethroids (Cypermethrin, Fenvalerate, Deltamethrin, Permethrin, Allethrin, Resmethrin, Phenothrin, Kadethrin, Cyphenothrin) was determined. The effects of a number of antagonists on the toxicity of pesticides were studied. We discovered that in experiments to Daphnia magna some muscarinic cholinoreceptor blockers (atropine, amyzil etc.) reduced a toxic the effect of organophosphates. In the case of heavy metals the chelating agents (EDTA, Dithioethylcarbamate, Unithiolum, Sodium thiosulphuricum, L-Aspartic acid) were effective, for certain organochlorine poisonings – anticonvulsive drugs (diazepam, phenobarbital), for cyanide poisoning – sodium nitrite and anticyane were effective. In the case of pyrethroid’s poisonings the antagonists of glutamate (ketamine), DOPA (haloperidole) receptors and blockers of calcium channel (nimodipine) reduced the toxicity of of pesticides. As far as these antidotes have a specific treatment action only against definite classes of pollutants, we have elaborated the sensitive express-methods of bioidentification of pollutants.
Role of Pallikaranai Marsh in Moderating the Flood

Author: Ms. Sujatha Vijayaraghavan
Anna University, India

Co-Author: Mr. Mudgal B V
Anna University, India

Keywords: flood moderation, marshland, ecosystem, restoration, social impact of flooding

Introduction/Problem Identification
Marshlands are the lifeline of any ecosystem, contributing healthy environment to society in many ways. They retain water during the dry periods, keeping the water table high and relatively stable. They reduce flood levels and trap suspended solids and attached nutrients during the heavy monsoon seasons. Pallikaranai Marsh in Tamil Nadu was no exception in providing these services, but slowly now it has lost its ability to control the severity of floods and erosion because of the systematic annihilation of the entire marshland system. In this study, an attempt will be made to assess the status of the Pallikaranai marsh. Satellite imagery and Survey of India Toposheets give copious information for this assessment. This would be complemented well by using Participatory Research and Analysis (PRA) tools. These tools would help to understand the social and economic impact of flooding in those areas. This study aims at making the public aware of the importance of the marsh for their sustainable life.

Analysis/Results and Implications for Policy and/or Research
The marsh area was digitized using ArcGIS Desktop from the 1970 Survey of India Toposheet as well as from modern satellite imagery (ArcGIS World Imagery service). Using the 2 meter contour data, digital elevation model (DEM) of the terrain around the marsh was created. Consequently Flow direction raster was created with the DEM. The rainfall data is incorporated into the calculation by creating Thiessen polygon rasters from the meteorological station point locations in and around the marsh area. The polygons were given the annual values of rainfall for the years 1984, 1994, 2004 and 2008 and were used as weight rasters for flow accumulation calculation for their corresponding marsh area. Using ArcGIS model builder, a flow accumulation assessment tool was created by which the flow accumulation for the marsh area was determined for the different years. A Sensitivity Analysis was performed to analyse the effects of the variations in the rainfall data and the area of the marsh on the marsh storage capacity.

This tool was built using ArcGIS model builder. With this tool the marsh storage capacity for various years can be calculated. This tool assumes that all rain became runoff and there was no interception, evapotranspiration, or loss to groundwater. First the meteorological stations are located and plotted as point data in ArcMap and the data about the total annual rainfall of those stations for the various years is joined with the respective stations. Now theissen polygons are created such that the area inside the polygons represents the station lying inside it. Now these vector polygons are converted into raster to facilitate the calculation. The raster value is based on the total annual rainfall data for a year. Meanwhile ‘Flow direction raster’ is created from the Digital elevation model (DEM) created from the 2-meter contour data. Flow direction creates a raster of flow direction from each cell to its steepest down slope neighbor. The output of Flow Accumulation would represent the amount of rain that would flow through each cell. To find the flow accumulation, the rainfall raster is used as the weight raster. Now we can find the storage capacity of the marsh by taking the sum of all the pixel values falling inside the marsh area. The tool is run in batch mode to perform sensitivity analysis as mentioned earlier.
The information of the temporal degradation of the marsh over the decades is also obtained from the residents there through PRA tools and semi-structured interviews, and also through the analysis of temporal depletion, the status of the marsh is determined.

The objective of finding the socio-economic impacts of the flooding in the surrounding areas of Pallikaranai marsh is carried out by the PRA tools, Focus Group Discussions and the Semi-structured Interviews. The questionnaire is prepared to understand the impacts (social and economic) of flooding and the constraints faced by the public during flooding. The population data obtained from the Department of Economics and statistics helped in sampling the informants. The sampled population is interviewed individually so that they can share their personal views. The personnel from NGO’s which were working for the improvement of Pallikaranai Marsh like CARE EARTH, SAVE PALLIKARANAI FORUM, EXNORA etc were also interviewed.

The 317 ha of the marsh was announced as a reserve forest only by the tireless effort of the NGO’s, and some welfare organization working for the improvement of the Pallikaranai marsh. The awareness about the importance of the marsh and its effect in controlling the flood is given to the residents by convincing them about the results obtained from the project. They should be convinced that the floods are occurring not due to the excess rainfall, but due to the improper use of the ecosystem which moderated the floods earlier. The government and people must realize that the misappropriation of the marsh has in turn led to several social and economic impacts to the residents near the marsh. The residents and the government should work hand in hand to preserve the marsh from further deterioration.
Workshop 2: Shortcutting Historical Pollution Trends

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Turkish-Dutch Cooperation to Enhance Organization and (Energy) Efficiency in the Turkish Waste Water Treatment Sector

Author: Mr. Marcel De Ruijter* et al.
* Unie van Waterschappen, The Netherlands

Keywords: g to g cooperation, wastewater treatment, organization models, energy efficiency, financial models

Introduction/Problem Identification
Waste water treatment is often a collection of energy intensive processes. Treatment plants designed in the past decades with its low energy prices are not always (energy) efficient. Today's challenge is to introduce energy efficient waste water treatment concepts aiming the goals:

1. clean water
2. combat climate change
3. save energy and costs

In the Turkish situation it is expected that approximately 2,500 new urban waste water treatment facilities are required to comply with the EU Waste Water Directive. This means that large number of facilities have to be started from a green field situation where no facilities are available yet. This provides the opportunity to tackle all three goals at once.

Dutch experience and knowledge in the field of (energy) efficiency policy has recently been extended by Dutch regional water authorities. Since 2009 the Dutch and the Turkish government are working together to put this Dutch experience to practice in the Turkish situation.

Analysis/Results and Implications for Policy and/or Research
Not available yet but to be expected in June 2010. The result will be a written guideline on (energy) efficiency in the waste water treatment sector along with appropriate new organizationale and financial models.
Lake Dryness and Its Impact on Biodiversity: A Case Study of Bhoj Wetland of India, a Ramsar Site

Author: Dr. Mukesh Dixit* et al.
* Government of Madhya Pradesh, India

Keywords: lake, dryness, biodiversity, conservation, management

Introduction/Problem Identification
The Upper Lake, popularly known as Bhoj wetland is the life line of Bhopal. The Lake has a special significance since it has been a source of piped water supply to the city of Bhopal for over 75 years. Even now, the lake accounts for some 40% of the city’s water supply. Until 1947 the water quality of Upper Lake was so good that it required no treatment before being supplied to the public. However, tremendous population growth of the city (about 70,000 in 1951 to about 1.8 million in 2010) and rapid urban development on the eastern and northern fringes of the Upper Lake (especially during second half of the last century) compounded various environmental problems resulting in deterioration of water quality mainly due to inflow of untreated sewage as well as unpredicted scanty rainfall. In last two years, a major portion of the Lake has dried up and about 70% of the lake bed has been exposed.

Analysis/Results and Implications for Policy and/or Research
Thus to evaluate the impact of acute draught on available flora and fauna, water quality monitoring were done at monthly intervals during the period 2008-2009. Water samples were collected from 18 different sampling points of the lake, both from surface and bottom.

The two years study reveals a drastic reduction (60%) in total number of species both of flora and fauna especially in the group, Chlorophyceae and Bacillariophyceae in phytoplankton community and Cladocera in zooplankton community. More over a succession in number of macrophytic species has been recorded due to dryness and fluctuation in the water level. The dryness has also affected the availability of migratory birds. The paper presents the impact of draught on biodiversity of the lake and the conservation measures being adopted for rejuvenation of the lake ecosystem.

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Resource Dynamics, Pollution Trends and Compatible Groundwater Use and Environmental Conservation through use of Decision Support System in India

Author: Prof. A. K. Gosain
Indian Institute of Technology Delhi, India

Co-Author: Dr. Kapil K Narula
Columbia University, India

Keywords: groundwater, depletion, pollution, decision support system, environment

Introduction/Problem Identification
Agriculture sector in India accounts for more than 85 percent of the total water use. Of this, the share of groundwater is around 50 percent and is responsible for two-thirds of the total agricultural produce. The aim of this sector is to ensure food security. The challenge is to ensure food security under limited land and water availability conditions. This requires intensification which is possible through introduction of high-yielding varieties of crops and multi-cropping systems. This, in turn, requires greater inputs of both irrigation water and fertilizers. Groundwater resources are experiencing over-abstraction. Excessive use of nitrogenous fertilizer such as urea results in its leaching to groundwater due to rainfall and irrigation water inputs. Thus groundwater is under huge threat on account of pollution and depletion. This study tries to demonstrate the use of a decision-support system that aims to make groundwater use and environmental conservation more compatible in India.

Analysis/Results and Implications for Policy and/or Research
Increases in agriculture production in last 5 decades have come about through intensification of agriculture and efforts at enhancing agricultural productivity rather than increasing the area under cultivation. With agriculture continuing to be the single largest component of India’s GDP and production from irrigated lands claiming the major share in it, a large percentage of India’s GDP could actually be therefore seen to be closely tied to future intensification in the sector which would require assured supplies of water and increased fertilizer application. Implications of the diminishing availability of fresh groundwater for sustainable agriculture become clear when we consider that the regions currently facing water stress, both on account of depletion and deterioration, are also India’s agriculturally important regions.

Analysis of India’s agriculturally important regions reveals that groundwater tables have continued to decline typically at a rate of 0.2 – 0.5 m per year with locally higher rates in the range of 1- 3 meter per year. Groundwater use is mostly between 70 – >100 percent of its annual recharge capacity. Fertilizer use, in absolute terms, has increased from 0.07 million tonnes (MT) in 1950s to around 25 MT annually in last decade. Fertilizer application per unit area has also increased from 0.5 kilograms per hectare (kg ha-1) to around 100 kg ha-1. Excessive use of nitrogenous fertilizer vis-à-vis phosphatic and potassium fertilizers has resulted in a shift of NPK ratio from an optimal value of 4:2:1 to a distorted 7.9:2.9:1. Urea is the most common type of nitrate fertilizer used in India. Urea’s hydrolysing property is high and hence is not retained by the soil. It gets leached to groundwater due to rainfall and irrigation water inputs.
In brief, groundwater is under increasing threat from inadequately-regulated pumping and pollution that arises from agricultural land use. The research question is: what efforts are needed to make groundwater use and environmental conservation more compatible? And, to what extent does institutional responsibility for control of groundwater abstraction and protection against pollution need to be strengthened?

To accomplish the research questions mentioned above, use of decision-support-systems (DSS) that are comprehensive, continuous in time, conceptual, backed by strong science and have the capability to integrate land use with groundwater and environmental considerations are explored in this study. Attention has to be given to use of such a GIS based decision-support system, for example visualisation techniques that try to strengthen institutional responsibility for designing strategies for control of groundwater abstraction and protection against pollution. Such DSS aims to make groundwater use and environmental conservation more compatible in India.

Soil and Water Assessment Tool (SWAT ArcView GIS version), a physically-based, time continuous model has been used to integrate land use with groundwater and environmental considerations. The DSS simulates the land phase of the hydrological cycle, to obtain groundwater aquifer recharge and nitrate loadings in various components of runoff from rural – especially agriculture dominated – watersheds. Residence time based groundwater quality module has been integrated to simulate groundwater quality and nitrate concentrations. Sensitivity analysis has been performed with regard to factors that determine transport and fate of nitrates in groundwater.

The validation of the various modules of DSS has been done for agricultural regions of the Upper Yamuna catchment located in north of India. Results on surface runoff, groundwater levels, and pollutant loadings obtained as outputs from SWAT simulation show a good comparison with the observed stream flow and groundwater levels. This was followed by nitrate modeling in aquifers. Results for nitrate modeling in deep groundwater aquifers were compared with observed nitrate concentration in aquifers as well as the results and are found to be in good agreement.

The study recommends the use of such tools, which have strong visualization capabilities, by decision makers for designing groundwater protection strategies. User friendly map based outputs have the capability to generate greater awareness that is required to bring about a balance in the exploitation of groundwater with the increasing demands of water and land users who can pose a threat to its availability and quality.
On-site System for Domestic Wastewater Pollution Control in the Developing World

Author: Dr. Nurudeen Oladoja
Adekunle Ajasin University, Nigeria, NIGERIA

Keywords: domestic, wastewater, on-site, pollution, low cost

Introduction/Problem Identification
Centralized wastewater treatment system is the conventional waste management practice, but the construction and operation are associated with high cost, intensive energy requirement, complex technology and high level skilled operator. These characteristics have made it an exclusive preserve of the developed world, where the basic operational requirements of these systems abound. On-site treatment of waste is a decentralized wastewater treatment system that requires simple, reliable, low – energy consuming and low-cost technologies that private owners with little skills for operations can afford. Gravity percolation of wastewater through one kind or another of percolator material is a common on-site wastewater treatment technology that fulfills these criteria. During transit through the percolator, the wastewater is purified by physicochemical (filtration, adsorption) and biological (microbial degradation) process.

Analysis/Results and Implications for Policy and/or Research
The indispensable and foremost position of water in man’s daily operations has left him with no options other than to recycle such waters for reuse and this has culminated in the development of varying sophisticated wastewater treatment processes to cater for his water needs. Decentralized wastewater management employs all available treatment and disposal technologies. The appropriate technologies in a measure that meets current needs and takes into consideration future growth, are matched with the treatment and disposal requirement that have been identified. Using decentralized wastewater treatment system, saves money, protects the home owners’ investment, promotes better water shed management, offers an appropriate solution for low density communities, provides suitable alternative for varying site conditions and furnishes effective solutions for ecologically sensitive areas. The developing world with its maligned economy suffers from decaying and moribund social infrastructures. The Gross National Product of most developing countries are far below that of developed countries and this makes investment in social infrastructure to be very low so that there is a shortage of investment in the construction, operation and management of wastewater technologies. Consequent upon the limiting investment potential, the danger inherent in access to unsafe water and poor sanitation abound in these countries. In order to assuage the scourge resulting from the lack of adequate and sustainable wastewater treatment system, the developing nations require the use of high – performance, low-cost, technologically simple, reliable, low-energy consuming, decentralized wastewater treatment technology to control pollution in the water environment and to alleviate the serious escalating water shortages that have been caused by water pollution in recent years. Consequently, a wide range of materials has been introduced in the on-site wastewater treatment of primary and secondary sewage in percolator systems. Amongst which are; slag and ground stones (Oleszkiewicz, 1981; Bishop and Kinner, 1986), soil materials such as sands (Pell et al, 1984) and organic materials like Bambo (Kirchof, 1989) and straw (Lowengart et al, 1993). Combinations of materials like soil and peat; sand and gravel (Faraham and Brown, 1972; Nicholas and Boelter, 1982) were shown to improve the treatment capacity of percolator systems. It has been reported that peat is very effective in the removal of textile dyes (Pools et al, 1975; Stephen et al, 1988); Pesticides (Brown et al 1979, Williams and Crawfold,
1983; Cloutier et al, 1984); heavy metals (Coupal and Lanlancete, 1976; Smith et al 1977; Chan-
geny and Hundemann, 1979); oily compounds (Mathavan and Viraraghavan, 1989); and radioactive
materials (Belanger et al., 1987). Besides this, peat has been proven to be an effective material for the
biological treatment of presetttled domestic wastewater (Nicholas and Boetler, 1982; Rock et al, 1984;
Brooks et al, 1984). Oladoja et al., (2005, 2006a and b) has also reported the ability of different clay
minerals, fortified with gravel pebbles, to treat domestic and industrial wastewater. The application
of wastewater to organic soil system is an alternative method of treatment and disposal that is also
receiving increasing attention.
The 1st National Pollution Census of China: Lesson Learned and Its Implication on Water Pollution Control

Author: Dr. Fang Qinhua  
Coastal and Ocean Management Institute, Xiamen University, China

Co-Author: Mr. Yifan Zhang  
Environmental Science Research Center, China

Keywords: water pollution sources, census, comparison, Jiulong River Waters, China

Introduction/Problem Identification
The first national census on pollution sources of China was just released in early February of 2010, regarded as an important step of governmental efforts to assess pollution problems, the issued bulletin profiles the general water, air and solid waste pollution of China in the year of 2007. This bulletin includes general results on the quantity of the discharged water pollutants including chemical oxygen demand (COD), ammonia nitrogen, oil, volatile phenol, and heavy metals from different sources covering industrial, agricultural, domestic, and treatment utilities, among different industrial sectors and provincial or basin areas.

Analysis/Results and Implications for Policy and/or Research
In this paper, these results were compared with 1) the literatures, 2) annually China’s Environmental Bulletin of 2007, and 3) a specific case of Jiulong River Watershed in Fujian Province, to examine the disparity; and the main causes to the disparity were also analyzed. Recommendations to water pollution control were also proposed based on the issued pollution sources census results.
How Big are the Societal Benefits of Improving Water Quality?

Author:  **Dr. Elisabeth Ruijgrok**  
Witteveen and Bos, The Netherlands

Co-Author:  **Dr. Rob Nieuwkamer**  
Witteveen en Bos, The Netherlands

Keywords: economic benefits, water system analysis, Water Framework Directive, water quality, CBA

**Introduction/Problem Identification**

The European Water Framework Directive (WFD) aims to improve the quality of all surface waters and ground water bodies throughout Europe. On the basis of this directive all European countries formulate water quality ambitions and measures to actually realize these ambitions. Since measures to improve water quality entail high socio-economic costs, particularly for developed countries where the quality has already been improved a lot the last decades by means of the easiest e.g. cheapest measures, the question rises whether there are sufficient socio-economic benefits of a (further) water quality improvement. In other words: do the benefits of WFD-measures surpass the costs?

**Analysis/Results and Implications for Policy and/or Research**

Determining the costs of an improved water quality is relatively easy, since costs are directly linked to the measures taken. Benefits, however, cannot be directly linked to the measures taken, because welfare is not derived from the measures, but from the induced changes in the chemical and ecological state of the water body. In essence the following theoretical framework is used to determine water quality benefits: water quality measures → changes in the chemical and ecological state of the water body → changes in human welfare i.e. societal benefits.

On the basis of this framework a calculation model was developed for the Netherlands. This model includes Measure Effect Relations to predict the effect of measures on the chemical state (e.g. concentration of heavy metals and pesticides etc.) and on the ecological state (e.g. chloride, turbidity, oxygen, morphological state, biological class etc.). The model also includes Dose Effect Relations linking the welfare effects, such as extra fish harvest, extra fresh water for agriculture, less sick swimmers, less costs in drinking water purification etc. to the relevant chemical and ecological state parameters.

By means of the model the costs and benefits of the various WFD-ambitions were calculated for the seven catchment areas of the Netherlands. The results show that the benefits are EUR 1 to EUR 6 billion for the whole country. Another interesting finding was that from a perspective of societal benefits, one would choose other measures than the presently proposed ones. For example no measures were proposed on bacteriological contents, thought these would lead to health benefits.
The Crucial Link between Water Quantity and Quality: The Scope of the Problem and Implications for Solutions

Author: Mr. Daniel Stellar et al.
Columbia University, USA

Keywords: groundwater, quantity, supply, India, Brazil

Introduction/Problem Identification
Water quantity and quality are generally considered to be separate issues, requiring separate baskets of solutions. Upon analysis, however, there is revealed to be a close link between the two. In many ways, water scarcity (either absolute or relative) actually drives problems relating to water quality. When water supplies are greatly diminished, most often the remaining water is of only marginal quality. Further, when water supplies are depleted from a watercourse, the pollutants that may have accumulated there over time are likely to be more concentrated, thereby exacerbating the pollution crisis.

Creative solutions to challenges of water quality (for example, providing safe drinking water) can be found by innovations which are primarily focused on water quantity. Columbia Water Center’s work in this area will be discussed, with an emphasis on projects in India and Brazil.

Analysis/Results and Implications for Policy and/or Research
The relationship between water quantity and quality can be seen in two distinct ways. First, in cases where water resources are being overexploited, the remaining water is, by definition, often of marginal quality. This dynamic can frequently be seen in regard to groundwater. As groundwater aquifers are drawn ever deeper, salinity becomes a greater issue, particularly in coastal areas. In some regions, the constant drilling to greater depths places entire aquifers at risk of saltwater intrusion. While agricultural use is primarily responsible for the exploitation of groundwater reserves, it is household users who bear the brunt of the crises once saltwater intrudes into an aquifer.

In regard to surface water, as formerly mighty rivers are depleted they simply have less and less of an ability to dilute pollutants. This dynamic is exacerbated by the fact that, at least in the developing world, pollutant loads have increased at the same time that flows have diminished. In this case, both industry and agriculture are primarily responsible, yet it is again household users, and typically poor ones, who bear the impact.

The connection between water scarcity and pollution can, in turn, lead to problems of water access. For example, municipal water supply systems can face increased treatment costs when reservoirs or stream flows are low because pollutant concentrations increase in the water they must treat. Water scarcity not only makes it more difficult to get adequate and clean water to meet human needs, but also harms aquatic habitats and species downstream. Similarly, water supply reservoirs may be used to mitigate drought impacts on irrigated agriculture and municipal and industrial use, but are subject to high evaporation and water quality degradation under drought situations.

In addition to water quantity, a related issue is reliability of supply. By improving allocation procedures, not only can “more” water be made available in raw numbers, but reliability can be improved. In addition to the benefit this provides in itself, particularly for vulnerable populations, there is also
a related improvement in water quality. As reliability of high-quality water increases, better decisions can be made, ensuring that the highest quality water can be provided for household use.

Work done by the Columbia Water Center in India and Brazil has emphasized the first order problem of water scarcity. This work has focused on improving efficiency in water use in the agricultural sector, which is responsible for over 70% of global water use and significantly more (upwards of 90%) in developing countries. In addition, agricultural water use is characterized by inefficiency, so it is in this sector that the greatest gains can be made. While the work has focused primarily on increasing the volume and reliability of water available in various settings, an important byproduct has been an improvement in water quality, particularly water made available for household use.

Two project sites will be examined. In the first, in Gujarat, India, project work has focused primarily on policy changes which can reduce groundwater depletion. In Ceará, Brazil, work has focused on reservoir allocation procedures. Here, the work has improved both volume and reliability of surface water. Work at both sites will be summarized, and the benefit to water quality will be analyzed.
An Integrated Water Quality Management Model for South Africa: A New Mindset

Author: Ms. Robyn Tompkins* et al.
* Jeffares & Green Consulting Engineers, South Africa

Keywords: water resource quality, drinking water quality, integrated water quality mgt, water use, management model

Introduction/Problem Identification
The aim of the project was to develop a conceptual model for aligning the management of the quality of water resources with that of drinking water quality in order to support the effective management of water use in the interest of all water users. In other words, to ensure management of water in the context of the integrated water use cycle in South Africa. The approach developed in this project has given rise to the integrated water quality management conceptual model (IWQMCM).

A literature review was undertaken to identify international integration mechanisms, as well as to identify gaps in the current South African water quality management framework. The literature review considered the current water policy and related legislation in terms of its compatibility for use in an aligned water quality management approach.

Analysis/Results and Implications for Policy and/or Research
A consultative process was followed throughout the project, through a series of focussed workshops around South Africa. The attendees included a wide range of water sector professionals as well as a broader set of stakeholders. Initially the World Health Organisation Water Safety Plan, which is currently being contextualised for South Africa as the Water Safety and Security Plan, was seen to be the primary mechanism for implementation of integrated water quality management. As the project developed, however, the approach has changed.

Issues raised in the first round of workshops were categorised into defining principles, background conditions and catchment to consumer cycle elements. Defining principles include fundamentals such as: water must be properly valued; institutions responsible for managing water must be accountable for water quality, and water quantity and quality are inextricably linked. Background conditions are defined as those conditions external to water quality and quantity which support the implementation of the framework and therefore indirectly impact on water quality such as management systems and tools. They are: communication; public access to information; accountability including aspects such as polluter pays, enforcement and the implementation of a government watchdog; and institutional capacity. Considering that the catchment to consumer approach recognises that the management of water resource quality and that of drinking water quality are inextricable, legislative instruments, institutional frameworks and management processes must also be fully integrated to achieve integrated water quality management. This was identified as a gap that currently exists in the South African legislation. The model that is summarised below and will described more fully in the paper allows for IWQM either within a formal legislative framework or external to it.

Assimilation of workshop feedback highlighted the need for an amendment to the fundamental catchment to consumer cycle. The catchment to consumer approach was therefore changed to reflect land-use impacts as well as the impacts of raw water abstraction and untreated discharge, all of which
are significant in risk assessment. This water use cycle, as it is referred to in the paper, is the basis of the IWQMCM.

The IWQMCM allows for the establishment of management units (MUs) at various levels, which may for example, community level (made up of various types of management units), municipal of local government level, catchment level and regional level. The main issue will be to manage the interface between the various management units through a structured, generic business process. This process monitors the implementation of effective communication mechanisms and reporting strategies around the pivotal business process element, which is, the establishment of performance targets for each critical control point.

The management mechanism for the IWQMCM business process that would be followed for each MU includes the key elements of hazard/risk assessment to identify critical control points. Risk management includes the setting of performance targets and contingency planning to address potential failure at each point. Of importance at each MU is the need to identify existing skills and needs in order to implement relevant awareness and training programmes. Each MU will need to identify a tool such as the Water Safety Plan, an Integrated Water and Waste Management Plan or an even simpler tool that encompasses the key elements mentioned above and to allow for adequate information flow, an accountability trail and external auditing and enforcement.

In many countries improved water quality is only achieved through stringent enforcement. In the South African context, and no doubt in many other countries, while stringent legislation exists, the capacity to enforce is limited, consequently the ‘do nothing’ approach is often adopted by many direct water users, or users who impact the water resource indirectly, because the chance of prosecution is minimal. In this respect the IWQMCM described will require champions for each MU and a mind-set change, since the model is based on voluntary accountability at each MU. It must be noted that the accountability mentioned above refers to other management units in the framework, and therefore institutionalised accountability (i.e. the accountability of managers of water quality to the users of the water, through the legislative and regulatory framework) still applies.

The results of the project were the development of the water use cycle, as a context for the model, and the development of the basic integrated water quality management model itself. The case study currently underway in the Breede Catchment of the Western Cape Province of South Africa will refine and complete the model.
Improving Health at Schools through Franchising of Water and Sanitation Services

Author: Dr. Kevin Wall* et al.
* CSIR, South Africa

Keywords: water, sanitation, operation and maintenance, franchising partnerships, South Africa

Introduction/Problem Identification
Some areas of the developing world have seen an increasingly poor and often unacceptable quality of water and sanitation service. The reason for this is invariably inadequate arrangements and incentives for operation and maintenance (O&M) -- including not just skills shortfalls, budget shortfalls and sometimes inadequate design and/or construction, but weak institutional arrangements, and unwillingness, or inability, to change.

Improved institutional and financial mechanisms, where corporate, social and ethical responsibilities are given due attention, are needed. An important aspect would be how to increase positive incentives – part of this must be the measurement of performance, and a system for rewarding on the basis of that performance.

A franchising partnership model for the planned maintenance of water services infrastructure is now being tested and evaluated in South Africa.

Analysis/Results and Implications for Policy and/or Research
Ongoing work by the Water Research Commission (WRC) of South Africa and the Council for Scientific and Industrial Research (CSIR) finds that franchising partnerships for operation and maintenance could alleviate and address many challenges in the management of water and sanitation services. Generically, franchising:

• transfers appropriate skills transfer to local personnel,
• brings ongoing performance measurement and support, and mentoring and quality control, and
• provides backup at-a-distance skills together with the incentive, on the part of the local microenterprise (franchisee) personnel, to call for those at-a-distance skills and, on the part of the franchisor, to make them available, because there is a binding contract between them and a shared reputation.

The partnerships would involve three parties -- that is, franchisor, franchisee and the owner of the water services infrastructure. The main incentive of the franchisor and franchisee to perform is, frankly, that their livelihood depends on it.

Many opportunities lie in the franchising of parts of the water and sanitation services value chain -- of activities suitable for microenterprises inter alia in that they can be readily systematised. A selection of these has been modeled by WRC and CSIR, and is being made available to emerging entrepreneurs as the basis of viable businesses.

The water services and health environment of many schools in South Africa is very poor. Interventions at schools not only lead to safer environment for pupils, but are investments -- pupils at schools with good water supply and sanitation are sick less often than those without, and are thus able to
attend school more regularly. But, also, pupils take back to their homes the good practices they have learned at school.

An innovative programme whereby emergent microenterprises are trained and mentored to clean and maintain water and sanitation facilities at schools is being piloted in the Eastern Cape province of South Africa. The programme is one of partnerships founded on skills and incentives principles akin to those of franchising.

This pilot got under way early in 2009. The CSIR and the East London-based Amanz’abantu Services (Pty) Ltd, funded by Irish Aid through the WRC, are providing policy, technical and other assistance necessary to facilitate the pilot programme. Locally-based microenterprises -- trainee franchisees -- are working in partnership with the franchisor Impilo Yabantu which has been set up by Amanz’abantu. Impilo Yabantu has provided training and has assisted the microenterprises with setting up their businesses. It is now mentoring them, and will offer further training as and when necessary.

The services which the franchisees are providing to the schools are being paid for by the schools from their budgets annually allocated for operation and maintenance of infrastructure.

Progress with cleaner sanitation facilities and improved hygiene in the schools that form part of the pilot project is already evident. Emphasis is on the quality and reliability of the service, and the viability of the franchisor and franchisees.

The CSIR is monitoring the progress of the pilot, and will in due course disseminate results with a view to replication of the franchising partnerships concept in the operation and maintenance of other types of water and sanitation facilities.

Water services infrastructure owned by municipalities offers many opportunities. The incentive to municipalities to reform their current often inadequate provision for quality service delivery is the increasing pressure from the South African national Department of Water Affairs, which is threatening to prosecute authorities that do not comply with the legislated requirements for safe drinking water and adequate sanitation.

In a franchising partnership setup, the help of the franchisor would be of particular value away from the major urban centres. For example -- few rural municipalities in South Africa can afford to employ competent qualified staff, and this directly results in periodic unreliability of supply and frequent non-compliance with national standards relating to, for example, wastewater treatment works effluent quality. Significant improvements would soon be seen if the generally under-qualified and under-resourced water and sanitation services staff could have this ongoing support, mentoring and quality control -- or if the municipality could partner with microenterprises and/or community-based organisations which would, through franchising partnerships, enjoy the necessary ongoing support, mentoring and quality control from the franchisor, and would have quick access to skilled assistance when they needed it.
Historical Trends in Restoration of Nairobi River Basin

Author: Prof. Shem Wandiga
University of Nairobi, Kenya

Co-Author: Dr. Fredrick Oduor
University of Nairobi, Kenya

Keywords: Nairobi river basin, water quality, water quantity, restoration, sustainability

Introduction/Problem Identification
Although originally known as a place of cool waters ‘Nairobi’, with adequate water resources for human and livestock consumption, the physical environment of the Nairobi City has changed significantly due to poorly controlled commercial and industrials activities that have grown overtime. Established in 1890 as a village town the City has expanded in size and population to about 4 million, and become a regional hub for industrial and commercial activities. The conglomeration of abiotic, anthropogenic and biotic factors has negatively altered the quantity and quality of the basin water as well as the composition of riverine ecosystems. The negative impacts on the catchment have lead to drastic decline in biodiversity and ecosystem health. Although many initiatives have been put in place, this paper discusses the success of the Nairobi River Basin Programme which was initiated in 1999 with the sponsorship of UNEP, the Government of Kenya and other partners to restore the basin ecosystem.

Analysis/Results and Implications for Policy and/or Research
The rapid expansion of industrial and commercial activities in Nairobi City compared to infrastructure planning and development have contributed to deterioration of water quantity and quality standards. Most of these industries consume large volumes of water and have caused significant impact on the general water supply system of the city. In addition most industries discharge their used water in form of effluents that is not well managed causining adverse effects on the sustainability of the riverine ecosystems as well as on human health. As a consequence, both the quantity and quality of water consumed and released by the industries have significant impact on the society.

Industries in the Nairobi River Basin have not been adequately documented. The data analysed is based on environmental audit reports from various administrative units within the City revealed that the water quality parameters of some effluents discharged into the rivers were beyond the recommended guidelines. In addition, inconsistencies in the use of analytical methods, parameters reported and sampling periods had adverse effects on the water quality data generated and hence reliability.

The analytical capacity of most of the laboratories is still weak and needs support to enhance reliability, quality and reporting of most water quality parameters. The data collected showed that most industries mainly reported physicochemical parameters, and to a limited extent chemical, heavy metals, organic, and microbial parameters. Data gaps in the submitted reports due to lack of consistency in terms of omissions of parameters analysed as well as harmony among industries in the selection of parameters. This could be improved by training on the use of a standardised monitoring protocol that includes sample collection, time of sampling, sites, transportation, handling, storage, preservation, analytical methods and data storage and interpretation. It would also contribute to equitable apportioning and utilisation of the existing facilities and resources, and the building of a reliable database that can be used for policy formulation and in the predicting of temporal and spatial trends in water quality and quantity.
The findings from the desktop study lead to development of the Nairobi River Basin water quality monitoring protocol. Water quality monitoring protocol was developed for the Nairobi River Basin Programme under the project funded by the UNEP Regional Office for Africa. The goal of the protocol manual is to provide quality data that inform policy through guidance to the many volunteers, researchers, and agency personnel who analyse water quality of the Nairobi River Basin Rivers. In this regard, all national institutions and laboratory conducting water quality analysis would be training using the harmonised protocol using similar methodologies and procedures to ensure comparability of the data. The protocol addresses standards on data collection, quality control procedures, analytical methodologies, data storage and interpretation.

Using the harmonised protocol, preliminary monitoring studies have established that levels of BOD, COD, TDS, TSS and electrical conductivity were higher during the dry season than the wet season, whereas pH and concentrations of dissolved oxygen were lower during the wet season than the dry season. The levels of some heavy metals such as cadmium were not detected in all the three rivers for both dry and wet seasons, whereas concentrations of lead and chromium are higher in the dry season than the wet season for all the sites.

The NRBP database provides an easy way to view, update and modify parameters data received from different laboratories. This allows the database administrator to define different roles for different users.

Consistency is the data currently generated using the protocol gives a suitable background on which appropriate policy decisions can be made.
Impact of Urbanization on Ground Water Resource Management in Tirumanimuttar Watershed, Tamil Nadu, India

Author: Dr. Nallathambi Varadaraj
Central Ground Water Board, India

Co-Author: Dr. John Franchis Lawerence
University of Madras, India

Keywords: Tirumanimutar water shed, hydrochemical studies, water level monitoring, water quality zonation, management strategies

Introduction/Problem Identification
Urbanization results in rapid changes in the land and water environment. Also, the disposal of untreated industrial effluents on land and/or on surface water bodies makes water resources unsuitable for other uses. Continuous irrigation using even treated effluents may lead to degradation of ground water and soil through the accumulation of pollutants. There are many pockets affected by multiple sources of pollution. Tirumanimuttar water shed in Tamil Nadu is one such area, in which, the author has carried out the impact of urbanization and industrialization on water resources. Gross ground water potential is 1823 MCM while draft is 926 MCM. The estimated regeneration from domestic use may be around 241 MCM. The ground water recharge from various sources has resulted in complex hydrochemical regime of the sub-basin. The ground water sources are not fit for beneficial use in larger part of the watershed resulting in drinking water scarcity and reduction in food productivity.

Analysis/Results and Implications for Policy and/or Research
The hydrogeological studies in Tirumanimuttar water shed, Tamil Nadu, India is carried to find out the nature of the hard rock formations and its ground water potential. The localised higher mineralization in ground water due to the geogenic origin is inferred from the primary and secondary data collection. The water samples collected from a network of 53 wells during May-June 2002 has been subjected to detailed analysis of basic parameters like EC, pH, Ca, Mg, Na, K, CaCO₃, CO₃, HCO₃, Cl, SO₄, NO₃ and F. In order to get realistic micro level information on water level and water quality changes with time in Salem Urban area, its downstream area with sewerage flow is selected and all the dug wells and bore wells are inventoried. Network stations for base line, trend and trend cum surveillance purpose are established and urban pollution coupled with industrial contamination is studied by monitoring water quality from select 13 wells including one bore well in the part of Tirumanimuttar sub basin. The data indicates the general increase in the chemical parameters with time indicative of the deterioration in water quality. The seasonal dilution of surface run off by rainfall and incremental salinity in surface and ground water is rather complicated.

The presence of heavy metals in this area is studied for Cu, Pb, Zn, Ni, Cd, Mn, and Fe and As at 5 surface water bodies and 15 ground water sources. The analytical results also indicate the presence of heavy metals which is marginally higher than permissible limits. The surface water samples also show the presence of pesticides like DDT in all five samples varying from 0.000024 to 0.0394 PPB and Heptachlor at 3 locations in the range of 0.001 to 0.0018 PPB.

The irrigation wells are having better yield along the river with direct recharge conditions, while the uplands controlled by regional rainfall recharge is devoid of water sources. This is having direct impact
on drinking water scarcity and the areas having fresh water in the basin is shrinking with time. Few lands are also lost due to water logging condition and resultant alkalinity in soil. Dug wells near river are generally used for irrigating Sugarcane and Paddy as well as coconut gardens. The water quality Zonation map of the study area taking the geogenic contamination and manmade pollution affected areas is prepared to evaluate the extent of groundwater quality deterioration with time.

The studies indicated the influence of surface water in ground water in terms of quantity and quality. Also, applied fertilizers, pesticides and industrial wastes are degrading more and more land and water resources with time. The vulnerability of the water quality deterioration in major part of the watershed with time due to multiple source of pollution is brought out and need for regulation of untreated waste water disposal is highlighted.

Tirumanimuttar is presently acts as open drain with more bed load of pollutants from houses as well as small-scale industries. This flux of water is normally stored in system tanks along the river for a length of about 20-km length of river. The recharge and draft from ground water system is reflected in the water level changes observed from monitoring wells located in the entire watershed. The distinct variation in the depth to water level and fluctuation pattern is noticed between the surface water influence sectors, where the levels are shallow and long-term decline in level is not visible. Obviously, the polluted surface water results in contaminated ground water and in turn impact on the irrigated land.

There is an increased disuse of dug wells due to direct contamination of water by the sewerage from open drains and river. The basic and trace element analysis of the water samples indicate the seasonal changes, selective increase of contaminants in November period after rains and general increase in chemical concentration between May 2003 and May 2006. The presence of heavy metals are in traces and but for very localised areas, the concentration levels are within limits.

With the physical impurities and colour and odour as well as the presence of high concentration of few parameters, ground water is found to be unfit for drinking purpose along the Tirumanimuttar River and the areas having highly contaminated water is demarcated.

The toxicity of small scale dyeing, bleaching industries and other handloom activities is known and their impact in surface water and in turn, in ground water quality is seen from the presence of toxic elements at select water samples. Also the environmental threat from the mortality of fishes is to be considered as warning bell for taking up remedial measures.

It is high time to plan a centralised sewerage collection and treatment plant for the Salem urban area. Existing fresh water pockets are to be protected by proper legal measures.
Sustainable Water Management in Response to Global Changes

Author: Prof. Peter A. Wilderer
Technical University Munich, Germany

Keywords: demographic growth; global trends; lifestyle; sustainability; urbanization

In the current debate global changes are very often narrowed down to climate change and global warming. Excessive emission of carbon dioxide is considered the major reason for the problems we are facing on Earth, and reduction of carbon dioxide emission is considered the “knight in shining armor”. In reality, however, we are confronted with a multitude of challenges, most of them tightly interconnected. Climate change is just one of the hazards threatening mankind. The overarching problem is – on the one hand side – the rapidly growing demand of the global human society for energy, water, food, raw materials and land. Among the main drivers of the vital challenges of mankind are demographic growth, urbanization and globalization of the lifestyle prevalent in the industrialized countries of the world. On the other side, livelihood is on stake in many regions of the world, in high and low income countries alike, because of the massive overuse of water, land and air as sinks of all kinds of solid, liquid and gaseous wastes. The unprecedented acceleration of the demand for basic goods, and the unprecedented acceleration disposal of waste materials make it extremely difficult to maintain conditions on Earth favoring well-being and prosperity for all. Economic and societal stability is at risk. The traditional concepts of problem solving are insufficient as they were developed under totally different ambient conditions. They are to be supplemented by methods which respond to magnitude and speed of global changes, and which are long lasting in effect, sustainable, in other words.

Sustainable water management is assumed to be one element in the overall network of rescue measures because water plays a decisive role in all sectors of life on Earth. It is an element equally important compared to, and tightly interconnected with sustainable energy, food production and land management. On the first place, water is required to maintain existence and the self-regulating capacity of ecosystems. Large-scale ecosystem restoration is assumed to play a vital role in all attempts to keep the basic functions of anthroposphere, litho-, hydro- and atmosphere in balance. Establishment of sustainable water management is the starting point of a healthy economy growth. It enables unfolding job opportunities, income, and happiness – in summary: economic and societal stability. Taking this in perspective it appears highly important to intensify efforts to raise the issue of sustainable water management to the state of priority it deserves.
Improving Water Quality in Economically Developing Countries through Equal Partnership Collaboration

Author: Dr. Cecilia Öman* et al.
* International Foundation for Science (IFS), Sweden

Keywords: equal partnership, water pollution, scientific capacity, local stakeholders, project evaluation

Introduction/Problem Identification
This paper emphasizes the shift from traditional development support to equal partnership. Historically, obstacles to equal partnership include that cooperation revolves too much around money, and that Northern organisations do not always seem to trust their Southern partners and take on too big a role for themselves. There is a growing trend for donors to insist that Southern partners meet increasingly high administrative and financial standards, demands that are not necessarily asked of Northern partners. In addition, Northern partners tend to work in a universally prescribed way regardless of the local context, thus the agenda is usually determined by the priorities of Northern donors. Many Northern partners take a narrow instrumental view of capacity building, which is limited to improving the capacity of organisations to deliver more effective programmes for the donor rather than increasing the Southern partner’s organisational strength.

Analysis/Results and Implications for Policy and/or Research
Surveys have found that Northern collaborators see partnership as moving to working with Southern Partners, developing systematic policies and moving towards a strategic results-oriented way of working. On the other hand the Southern partners wish partnership to be based on genuine dialogue, where their own expertise is valued and where the decision making processes of Northern partners are transparent.

When it comes to identifying ways to achieve better partnership between Northern and Southern organisations it is required that help from Northern partners does not contain too many conditions and does not hold onto a project management role when that role is better placed at a Southern local organisation. The partnership must build on an open dialogue; face to face discussions; shared trust and values in general and trust built between key individuals; mutual learning, sharing and support; equal involvement in project design and evaluation.

Method
A project team was developed of eight developmental organisations addressing water pollution and related topics in a project called Scientific Capacity Strengthening for Long-term Development in the area of Water Resources (SCALE). The organisations represents different regions; IFS Water in Europe; CRPML in Latin America, CREPA in West and Central Africa, Maji na Ufanisi in East Africa, INWRDAM in the Middle East, BCAS and DNet in South Asia, and CENTEMA in South East Asia. Since 2005, 52 joint workshops have been held on water resources and water pollution thematic topics, scientific methodology issues and networking between local stakeholders. The events held 1000 participants from 65 economically developing countries. In addition five universities have been equipped with scientific equipment and structures for having the equipment working properly.

The project team is investing time and resources in building a more genuine form of partnership than what was historically common. The partnership builds on a two way continuous transfer of
skills, information and support as well as financial resources. Passionate efforts are put into creating a genuine form of partnership of equals with a high level of trust. The partnership builds on seven cornerstones:

1. Balanced requirements on fundraising and reporting
2. Shared project management
3. Open dialogue
4. Equal involvement in project design and evaluation
5. Mutual learning, support and knowledge sharing
6. Mutual trust and shared values
7. Respect for local society and its culture

The partners fundraise and support each others in delivering financial and program reports to donors. Each partner manages the share of the collaboration where they have the largest experience, knowledge and capacity. Open dialogue and transparency is key for the partnership. Documents are shared openly, e-mails copied to all and “skype” is frequently used for open discussions. Unfortunately budget constraints hinder frequent meetings of the full group, but the project team meets in different constellations during joint events. One workshop was held with a professional trainer on Outcome Mapping for team members to jointly develop the project design, and such workshops will be continuous. The project has a focus on equal involvement in evaluation, learning and knowledge sharing which is addressed through open dialogue, joint events and Outcome Mapping workshops. The issue of mutual trust and shared values is thoroughly addressed. All partners believe in this and have the capacity and motivation to address it strongly. Trust is continuously built between key individuals through transparency and a willingness to support. Local stakeholders such as academia, government, private sector, local communities and media are involved in the activities. Through local stakeholders and local partners the respect for the local society and its culture is strengthened.

Results and conclusions
It was concluded that the project was successful. Indicators showed that i) the training courses were appreciated by researchers and local stakeholders, ii) the researchers increased knowledge on water pollution issues and scientific methodology, iii) local stakeholders increase awareness of scientific findings, iv) workshops in combination with local support enabled researchers to develop projects that could attract funds from international organisations, v) 200 new scientific projects in 53 countries were initiated, vi) training events required follow-up support to generate good outcome, and vii) equal partnership was crucial for the success.
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Mapping Water Quality and Water-Related Diseases in a Context of IWRM for the Inner Niger Delta of Mali (West Africa)

Author: Mr. Jan Cools* et al.
* SORESMA, Belgium

Keywords: water quality, water-related diseases, river basin management, GIS, Mali

Introduction/Problem Identification
Human health in the Inner Niger Delta of Mali is strongly linked to water management. The bacteriological contamination of surface water with faeces and dead animals is a major cause of diarrhoea, whereas stagnant water and improper drainage have a high risk for the transmission of schistosomiasis and malaria. Global change, including climate change, demographic growth and economic development may increase the transmission of diseases since they create new vector breeding habitats (e.g. dam reservoirs, irrigated fields) and increase the domestic and agricultural waste water load. Integrated river basin management has been identified as promising and cost-effective for diseases regulation, e.g. in the Millennium Ecosystem assessment (2005) and the UNEP Global Environmental Outlook. It is expected that ecosystems in good condition and well managed river basins minimize the transmission of diseases. Yet, few quantitative evidence exist. This paper will contribute to this challenge.

Analysis/Results and Implications for Policy and/or Research
This paper is developed under the European 7FP project WETwin which works on the role of wetlands in integrated water resources management for twinned river basins in EU, Africa and South America. WETwin follows the assumption that adequate and integrated river basin management maintains/improves the ecosystem services that wetlands contribute to human well-being. Wetlands are key elements in river basins and provide important services for local communities including the provisioning of food, drinking water, wild products, etc. and water regulation, water purification and disease regulation (Millennium Ecosystem Assessment, 2005). Many wetlands however lack sustainable management and are currently being threatened by human activities within and upstream of the wetlands. As a result, the ecosystem services which they are providing are challenged. This degradation can partly be attributed to a lack of knowledge about the functioning of the wetland ecosystems and their relationships with the river-basin and a lack of adequate valuation methods for the ecosystem services wetlands provide. Evidence furthermore exists that wetlands are sensitive towards future pressures such as climate change, demographic growth, land use change and economic developments. This paper focuses on the relationships and trade-offs that exist between the ecosystem service ‘disease regulation’ and human waste disposal for the city of Mopti, centrally located in the Inner Niger Delta wetland in Mali.

We will present at the one hand side, a spatially distributed system analysis of the sanitation systems and water cycles of the region of Mopti, within the Inner Niger Delta of Mali and at the other hand a map of the spread and occurrence of three water-related diseases, being diarrhoea, schistosomiasis and malaria. In a next step, we will present the observed relationships between water quantity, water quality and human health. We will do so by estimating and visualising (in GIS), firstly the urban waste water load, flood extent and frequency, presences of stagnant water (puddles, reservoirs, pools, ...), facilities for drainage and the status of sanitation and drinking water supply. Secondly, the spread and occurrence of diseases is visualised based on existing work of the National Public Health Institute (INRSP), logbooks of the regional health centres and interviews. The latter GIS maps are then com-
combined into a map showing the vulnerabilities of communities for pollution and water-related diseases as well as the critical points for water quality pollution and disease transmission. Next, promising management options are proposed. Beside classical community-based approaches evidence is provided for integrated river basin and wetland management as a promising and cost-effective solution for disease regulation.

In addition, the impact of global change scenarios on the water quality, quantity and disease prevalence is assessed as well. Downscaled regional scenarios for climate change, demographic growth, economic development (dams and irrigation) are developed based on three global change scenarios. They describe possible future developments of the world and are basically in line with the IPCC-SRES scenarios (Nakicenovic & Swart, 2000). The scenarios are complemented by two sources: 1) “new” future demographic trends and economic growth at the country level with respect to new insights (Van Vuuren et al., 2007) and 2) insights of local field experts and stakeholders.

The presented results can help both local practitioners and communities and the international community. Maps are proven instruments to facilitate a stakeholder dialogue, to discuss conflicting issues and to inform decision-makers. The presented results can furthermore help to set-up local development plans (including local water safety and sanitation plans) to focus on certain priorities for environmental management. For the different measures that will be listed in the project to reduce disease transmission, the cost effectiveness together with an acceptance evaluation, will make sure that the best solution will be chosen under specific circumstances. The international community will benefit from this paper through our contribution for the analysis of the pathways, extent and cost-effectiveness of environmental solutions for disease regulation.

Author: Mr. Kamal Dahanayake  
Rural Water Supply and Sanitation Division, Sri Lanka

Keywords: water quality, rural water, community based organizations, regulation, surveillance

Introduction/Problem Identification
As rural folk comprise 78% of the Sri Lanka’s 20 million population, they represent a large, needy and often difficult-to-access, constituency. Since 1993 over 4,500 rural water supply (RWS) schemes serving approximately 4 million people have been constructed. These schemes are managed by Community Based Organizations (CBOs) with little support from the government. The communities have normally contributed appreciably to initial capital costs and the CBOs are expected to recover full O&M costs through their respective tariff schemes.

Because of cost and operational difficulties in these poor and remote communities, formal water treatment is not provided, reliance being placed on hygiene training, including knowledge of chlorine disinfection, and boiling of drinking water. Although government has recognized monitoring water quality is critical to minimize health risks, ensuring water quality standards has become a major challenge in CBO managed RWS Schemes.

Analysis/Results and Implications for Policy and/or Research
International practice asserts that if water quality is not at an accepted standard, the service will not achieve desired health benefits and could in fact be detrimental to consumers’ health. Accordingly the government has acknowledged that only by monitoring the water quality of these schemes can the communities understand the sort of health risks that may be present and therefore the corrective actions needed to minimize such risks. Monitoring also helps government to gauge the efficacy of their investments in the sector and to better plan future sector assistance. The Government of Sri Lanka has thus recently introduced a National Water Quality Surveillance System (NWQSS) with the main objective of enhancing the safety and acceptability of drinking water for both urban and rural consumers.

The governing principle of the NWQSS is that service providers are responsible for the safety of the water. Therefore, service providers are required to check that systems they administer are capable of, and are, delivering safe water. The Ministry of Health is supposed to conduct independent surveillance through periodic monitoring of all aspects of safety and verification testing. Under the NWQSS, each service provider is required to prepare a Water Safety Plan (WSP) for each piped water supply scheme.

Although this surveillance system is notionally in place, there are many challenges in achieving water quality targets, particularly in CBO-managed systems. The Ministry of Urban Development recently conducted a study of water quality monitoring aspects of CBO-managed schemes. The study’s key findings are:

1. Coliform bacteria were present in 49% of tap points surveyed; few schemes disinfect their water supply. Water in several schemes was found to exceed quality standards for turbidity, pH, iron, color and fluoride.
2. Only 20% of CBOs had undertaken any water quality testing subsequent to initial design-stage source testing.

Regular water quality testing is expensive for CBOs. Furthermore, laboratories are located in district capitals, distant from remote rural villages. CBOs, which act as both service providers and consumers, have little interest in water quality testing, unless a local water-borne disease outbreak occurs.

In rural Sri Lanka people commonly place greater emphasis on water quantity and reliability than on water quality. Having usually experienced past hardships due to water shortages, the mere availability of water is seen to be “enough”. Although the CBOs now reasonably successfully undertake the O&M of rural water supply systems, their performance on water quality monitoring still lags well behind other operational aspects.

Sophisticated water treatment processes are not encouraged as they are simply not financially feasible due to the investment ceilings and/or high operational costs. Neither the Donor agencies, nor the Government, have insisted on ensuring water quality in RWS schemes. According to WHO guidelines, water quality may be controlled through a combination of protection of water sources, treatment processes and handling of the water. This spectrum of activities is not fully incorporated in most RWS projects. Therefore, CBOs established by rural communities are incapable of managing water quality.

One of the rural water supply sector’s key challenges in developing countries is to incorporate measures to ensure drinking water quality in community-based RWS schemes. Capital and scheme management costs will be substantially higher if water treatment and disinfection facilities are installed in RWS systems. With the limited funds available, coverage targets would have to be reduced if this criterion is to be met. Also, some of the technical options currently available for rural areas, such as open protected wells and domestic rain water harvesting systems, would no longer be appropriate as safe water source options. If regulating authorities become very strict on drinking water quality, it could reach the point where many CBO-managed water systems would have to suspend operation, forcing rural communities to perhaps revert to even more polluted alternative water sources.

Under these circumstances, it is high time that the vexed question of providing safe water to small, poor, rural communities was more openly discussed. For example, perhaps a step-by-step approach would be appropriate, with strict water quality as the last target, with access to water and reliability of the service being the initial priorities? It is suggested that, in the rural sector, water regulation should be sensibly aligned to the availability of resources and ability to pay, and accompanied by an integrated approach incorporating hygiene promotion, sanitation and source protection programs. It is important that RWS project developers consider these aspects from initial project formulation stage as the present system is patently not working.
Using Water Quality and Hand Contamination Test Results as Informational Interventions: Experience from Peri-Urban Tanzania

Author: Prof. Jennifer Davis et al.
Stanford University, USA

Keywords: water quality, diarrheal disease, hygiene, fecal indicator bacteria, Sub-Saharan Africa

Introduction/Problem Identification
Efforts are being made to develop simple, low-cost water quality diagnostic tests for use by households in developing countries, but little is known about how test result data influence households’ behavior. We compared the effects of providing households with individualized water quality and hand contamination test results to providing nonspecific messages about water, hygiene, and health. We visited 334 households in Dar es Salaam, Tanzania, four times each over a period of 11 weeks. During each visit we interviewed the female head of household and took stored water and hand rinse samples. Four cohorts subsequently received (1) general health information about safe water storage and hand hygiene; (2) information and water test results, (3) information and hand rinse test results, and (4) information and water and hand rinse test results. Changes in behaviors, contamination levels and prevalence of water- and sanitation-related illness were assessed in two subsequent visits.

Analysis/Results and Implications for Policy and/or Research
At baseline, each study participant was asked about her knowledge of water treatment practices, causes of diarrheal and respiratory illness, as well as her family’s behaviors vis-à-vis hand hygiene, sanitation, and water storage. No significant differences across cohort were detected at baseline. Similarly, cohorts were found to be equivalent, on average, in terms of baseline levels of E. coli contamination on mothers’ hands and in stored drinking water. Contamination of mothers’ hands ranged between 3.0 and 3.3 log CFU / 2 hands across the four cohorts (ANOVA test of means across cohorts: F=1.04, df=3, 117; p=0.38). Contamination of respondents’ stored drinking water with E. coli ranged between 1.2 and 1.6 log CFU /100 mL at baseline (ANOVA test of means: F=1.35, df = 2, 165; p=0.26).

At the second visit, all participants received general health information regarding the links between water, sanitation, hand hygiene and health. Members of three cohorts also received test results for their stored drinking water, hand rinse samples, or both. Overall, respondents who received test results indicating “high” levels of water and hand contamination made greater improvements over the course of the study, in terms of knowledge gains, reported behavior change, and water and hand contamination, as compared to those who received “low” or “medium” contamination results. For example, the estimated marginal mean water contamination level for water cohort households that received “high” test results decreased from 2.60 log CFU/100mL at baseline to 1.60 log CFU / 100mL in the first follow-up visit and 1.59 log CFU/100 mL in the second follow-up visit (Wilks’ Lambda F=2.50, df=14, 314, p=0.002). These findings are consistent with health behavior theories that postulate that greater perceived risk stimulates more behavioral intentions.

In some cases, it appears that outcome variables were more strongly influenced by whether respondents were surprised by the level of contamination of their hands and stored water than the test result content itself. For example, all else held constant, respondents who received a “high” water contamination test result were 2.3 times more likely to report having made some improvement in household water storage and hand hygiene practices over the course of the study.
management as compared to those who received either a “medium” or “low” test result, or no water test result at all (Wald $\chi^2=3.86$, 1 df, $p=0.05$). Those who received a water test result that showed their stored drinking water to be more contaminated than they expected (regardless of whether it was “low,” “medium,” or “high”) were 5.6 times more likely to report having increased usage of chlorine disinfection products (Wald $\chi^2=3.16$, 1 df, $p=0.07$). Respondents who received these “surprising” water contamination test results were also 1.9 times more likely to report having made a change in water treatment practices that required cash expenditures (Wald $\chi^2=2.95$, df=1, $p=0.09$). Surprising results may help health messages “stick” longer than test results that are consistent with respondents’ expectations. Given the limited duration of this study, additional research is needed to investigate the degree of persistence of this effect.

Equally important is the finding that, just as bad news appears to motivate intention for behavior change, good news appears to be associated with a subsequent decline in stored water quality and hand cleanliness. For example, the estimated marginal mean of mothers in the hand test cohort who received a “low” or “medium” result increased from 1.54 log CFU / 2 hands at baseline to 3.02 log CFU / 2 hands in the first follow-up visit and 2.57 log CFU / 2 hands in the second follow-up visit (Wilks’ Lambda $F=3.38$, df=14, 314, $p<0.001$). This so-called “boomerang effect” has been documented in a variety of environmental health settings. Informing households about their low levels of water and hand contamination could inadvertently attenuate their perceived risk or vulnerability to water- and sanitation-related disease, possibly leading to reduced effort in safe water management and hygiene.

Finally, for several outcomes of interest (e.g., gains in knowledge about water treatment methods, contamination of mothers’ hands), members of the information cohort made improvements that were comparable to those who received “high” test results. Because this study did not include a true control group, i.e., households from whom information and samples were obtained without the provision of either health information or test results, the impact of the household visit itself cannot be distinguished from that of the health message intervention. Given that the cost and logistical demands of a campaign to improve household water management and hand hygiene would be greatly influenced by the incorporation of household visits and/or FIB testing, additional research is needed to elucidate the conditions under which each of these elements delivers cost-effective results.
Roof Water Harvesting and Its Quality for Domestic Used - A Case Study

Author: Mr. P.K. Wilbert De Silva
World Bank Assisted 02nd Community Water Supply and Sanitation Project, Sri Lanka

Keywords: rain, water, collection, quality, domestic

Introduction/Problem Identification
Rainwater harvesting is an ancient practice widely used around the globe for human consumption. The growing needs of population, the rapid growth of urbanization, the gradual depletion of groundwater, water pollution and altered climatic conditions have regenerated the past practice of Rain Water Harvesting (RWH) as a pressing need of the hour. In the present context, rainwater harvesting is being seriously considered as an alternative option for rural water supply in Sri Lanka and the Government of Sri Lanka is acknowledged the practice through formulation of national policy for RWH. At present there are over 30,000 RWH systems in the country and its development and improvement of technology has resulted in more affordable and better water quality design which is more acceptable to the community.

Analysis/Results and Implications for Policy and/or Research

A Case Study – Enasalmada Village
The village call Enasalmada is situated few miles away from the Matale town. Existence of poverty among villagers is very significant and availability of infrastructure facilities in the village is also extremely poor. Potable water is the major issue faced by the majority of people in this village. A common well situated in lower terrain in the village was the only water source available for the community and during drought seasons peoples used to walk long distance to collect water for their daily requirement. Considering this severe hardship faced by the people in this village in obtaining drinking water, the Community Water Supply and Sanitation Project has stepped into the village to assist them in creating their own water supply system. Many options of providing water to this village were consider at the initial stages of the program. Finally, with all possible regular options failing due to various reasons, rain water harvesting from roof catchments was decided as the option available. However, at the end project has able to construct 134 RWH tanks for selected house holders through comprehensive awareness program. Initially the rain water option was rejected by the majority due to health and various social issues. Perception of most rural people is rainwater is unfit to drink, more so when is collected from roof catchments, it is totally unfit for consumption. Incidentally, this perceptional attitude is the driving force for RWH in future. However recent test conducted on quality of water indicate that it is fit to drink after boiling. Result of the quality of the collected rainwater from various RWH project sites in several districts reveals following results:
WHO recommended standards on conductivity of drinking water were maintained in all rainwater harvesting tanks

WHO recommended standards on total hardness of drinking water were maintained all rainwater tanks

All rainwater harvesting tanks passed WHO recommendation on turbidity for drinking water

Overall 40% of the tested rain water tanks records No-E-coli, which is the WHO recommended
value for drinking water. In more than 55% of the rain water tanks the E. coli level are less than ten in 100 ml of water, WHO low risk value.

Having a simple charcoal and gravel filter and first flush system reduce the contamination levels in the tanks markedly.

E. coli levels in the tanks receiving rain water from G.I roof is less than from other roof due to heating of the G.I roof which result in perishing of E.coli in the roof.

Mosquitoes breeding are reported in some tanks. Experience of village has shown that mosquito breeding could be prevented raring fish in these tanks. Or else, if the tanks is tightly sealed, it serves both in preventing the breeding of mosquito larvae and the growth of algae and thereby improves the quality of the harvested rainwater.

Earlier studies have shown on an average of 10-15 % of beneficiaries use rainwater for drinking purposes. One of the reasons for the non-acceptability of rainwater for drinking purposes was the peoples perception of quality. Presence of leaves and other materials, presence of mosquito larvae and other insects, rodents, color and taste are the major parameters they use to perceive quality. Improvement in technology and more effective awareness has brought about increase in use of rainwater for drinking. Recent studies have shown that up to 80 – 90 % of the beneficiaries use rainwater for drinking.

Conclusion
Project believed that RWH is the most suitable technology for drinking water supply to rural areas and make arrangements to popular that technology among project beneficiaries through very intensive awareness campaign. This paper described the acceptability of RWH facilities in the rural areas and how it has promoted as an alternative option for provision of drinking water among deprived rural community in all over the country. It was observed that effective public awareness program has to be placed before the implementation commenced to obtain a desired result which is the acceptance of RWH system as an equal technical option in solving their water supply issue by rural communities. This has endorsed by the Rural Water Supply and Sanitation Projects and reached the recorded progress in RWH implementation through collective action.
Development of The Healthy River Ecosystem Assessment (THREATS) for Integrated Change Assessments of Water Quality in Canadian Watersheds

Author: Dr. Monique Dube* et al.
* University of Saskatchewan, Canada

Keywords: water quality assessment, IWRM, watershed change assessment, THREATS, watershed management planning

Introduction/Problem Identification

Canada is not a stranger to the linkages between source water contamination and consequences to human health. In Walkerton, Ontario seven people died and more than 2000 became violently ill as a result of microbial contamination of drinking water supplies. The Walkerton tragedy, while incalculable in its human effects, was estimated to have cost the community $64 million Canadian dollars. In 2001, in North Battleford, Saskatchewan up to 7100 local residents and hundreds of travelers to the area became ill due to drinking water contamination. In the latter example, a downstream community’s drinking water intake was affected by the upstream discharge of municipal sewage. In Canada as in many other parts of the world, we are hindered by our abilities to integrate information on change and risk in an efficient, effective, and scientifically defensible manner. This hindrance has had consequences to both human and ecological health.

Analysis/Results and Implications for Policy and/or Research

Our team at the University of Saskatchewan has developed a system-based integrated assessment approach for application at watershed scales that integrates water quality and quantity metrics to measure changes over broad temporal and spatial scales. This provides an understanding of where changes have occurred, the magnitude of the changes and the direction of the changes. All changes in parameters are evaluated against “reference” benchmarks determined from natural variability using a statistically rigorous and quantifiable approach. The THREATS approach identifies “hotspots” for assessing and managing Canadian watersheds towards sustainability and has been applied to large watersheds in Saskatchewan including the Quapelle River Basin and the South Saskatchewan River Basin. Most importantly the scientific change assessments are reported in a risk-based context and made available through our THREATS software as a legacy instrument for ongoing assessment, adaptive management, knowledge translation and education. The approach will be extended to other Canadian watersheds as well as global watersheds based on water quality information submitted through the UNEP Global Environmental Monitoring System (GEMS/Water). Our success has been founded in understanding that irrespective of the watershed examined, core commonalities in water quality assessment exist and must be built into a decision-making framework for consistent application over time within a watershed and across different watersheds. It is only in this manner that a scientifically rigorous process can be consistently developed over the temporal and spatial scales required. We will illustrate how these change assessments can be linked into adaptive management frameworks and watershed management plans.

Implementation of IWRM in the interest of human and ecological health has proven to be difficult. Certainly presentations at World Water Week in Stockholm in 2009 illustrated the complexities and challenges of practically implementing the concepts. The spatial scale of the watersheds in Canada mandates development of an integrated approach. The innovation of our approach lies in how highly
complicated statistical results on water quality changes are rolled into simplified risk-based assessments for decision-makers. The novelty also lies in how we have developed a core and transferrable approach so assessments can be built consistently over time and space; a crucial element for IWRM and to reduce the fragmentation that currently exists in understanding water quality changes overtime and space and their potential effects to human and ecological health. Finally, we find novelty and innovation in how we have developed benchmarks to determine changes in water quality parameters that lie outside of natural variability. Collection of data in the absence of benchmarks holds little value for decision-makers and managers of the resource. These novel elements are then combined into a user friendly decision-support software tool.
Prevention of Water Related Diseases by Designing and Implementing Sanitary Safety Measures as Key Components of IWRM in Dniester River Basin

Author: Prof. Tetiana Galushkina
National Academy of Sciences of Ukraine

Co-Author: Ms. Svitlana Slesarenok
National Academy of Sciences of Ukraine

Keywords: water & health protocol, sanitary safety measures, IWRM & sanitary cooperation, sanitary regulations for basin, prevention of water deseases

Introduction/Problem Identification
The Dniester River (1,380 km) has its source in the Carpathian Mountains in Ukraine, flowing south and east along the territory of Moldova, and re-entering Ukraine near the Black Sea coast. The population of the Dniester Basin is about 8 million people. The Dniester is the main source of drinking water in Moldova and is no less important for a significant part of Ukraine, particularly the Odessa Region. Water pollution and modified river flow regime are major environmental problems in the Dniester Basin. The Dniester Estuary is an area of special concern in terms of its sanitary and epidemiological situation. The river water in this section is characterized by elevated levels of pollution, especially with regard to bacterial contaminants. The antigens (indicator organisms) of various pathogenic viruses (hepatitis A virus, rotavirus, rheovirus, and adenovirus) were regularly recorded in the Dniester water samples in the period of 1996-2002.

Analysis/Results and Implications for Policy and/or Research
The total population of the Dniester River basin in Ukraine and Moldova is about 8 million people, but in the same time the Dniester River is alone source of drinking water for 2.5 million people living out of the basin, using water mainly from the most polluted estuary part. It should be noted in this respect that the higher numbers of rotaviruses, recorded in the river Dniester water samples in 1998, remained stable in 1999-2000. This data correlate well with the results of tap water analyses in Odessa, suggesting that the presence of viruses in the water supplied was the major cause of enteric disease outbreak in 2000. A particularly challenging issue relates to the presence of hepatitis A virus in water sampled in various locations. The evidence provided in by scientists and medical statistics indicates that the growing frequency of hepatitis A incidence, recorded in Odessa in 2000-2002, was caused by poor quality of raw and tap water, and low efficiency of wastewater treatment, especially with respect to virology. According to data done by scientists and medical statistics the Cryptosporidia oocyst was found to have been present in surface water and effluent samples taken in the City of Odessa and Odessa Oblast (1% of surface water samples taken from the Category 1 water sources, 6% of samples taken from the Category 2 water sources, and 14% of sewage effluent samples). In view of the close relationship between the river and tap water quality, the best way of improving the situation would be to address the issue of drinking water quality and public health by designing and implementing the most urgent sanitary safety measures in parallel with actions designed to improve the ecological state of the Basin’s water resources. In the design and development of these measures, account should be taken of current status of water supplies in the Basin, and greater emphasis placed upon the improvement/modernization of the water treatment process. The transboundary status of existing environmental issues is graphically illustrated.
by the fact that the river flows into the territory of Moldova from Ukraine, then reenters Ukraine
to drain to the Black Sea south-west of Odessa.

Downstream populations of river Dniester (Odessa region) are exposed to water pollution from up-
stream activities. The increasing use of wastewater and heavily polluted surface water for agricultural
production exposes humans to multiple microbial and virus threats through the food chain. During
the Soviet era, the Dniester Basin was managed as a single system, i.e. on a catchment basis. Since
1991, Moldova and Ukraine have managed those parts of the river basin that lie within their respec-
tive territorial jurisdictions. As both Ukraine and Moldova aim to become members of the European
Union, the EU Water Framework Directive is important as a guideline for future developments, both
are parties of The 1992 Convention of the protection and use of transboundary watercourses and in-
ternational lakes, both ratified Protocol on Water and Health. Regarding to this the inter governmental
working group, working in framework of OSCE/ UNECE project “Transboundary cooperation and
sustainable management in the Dniester River basin” took decision to facilitate cooperation between
sanitary-epidemiological services of the two states in Dniester basin by developing the “Draft regulation
on cooperation on sanitary epidemiological control of water quality in the transboundary Moldovan-
Ukrainian section of the Dniester River basin and the transboundary rivers of the Black Sea basin”. The
process on drafting Regulation was initiated by NGOs, the Odessa Oblast sanitary-epidemiological
service and the Ministry of Health of Moldova. The document aims at resuming (after the break-up of
the Soviet Union) Moldovan-Ukrainian cooperation on sanitary-epidemiological water quality issues.
A programme for systematic monitoring, methods, and modalities for the working group are presented
in the document. The present Regulation on trans boundary water quality assessment are based on
Article 6 of the Agreement between the Cabinet of Ministers of Ukraine and the Government of the
Republic of Moldova on the Joint Management and Protection of the Cross-Border Waters signed on
October 19, 1994, the Convention on the Protection and Use of Trans boundary Watercourses and

Currently there is no systematic solution for the joint water management of the river basin including
7 oblasts of Ukraine, and half of the territory of Moldova. Unresolved political status of the Transd-
niestrian region makes the task even more complicated, but common work on developing Sanitary
Regulation, improved the exchanging of the sanitary information between Moldova, Ukraine and
not recognized Transdniestrian region. Also it was established the tradition of common samples in
time of extreme pollution.
300in6. Safer Water for 300 Million People in 6 Years with HWTS

Author: Mr. Urs Heierli
MSD Consulting, Switzerland

Keywords: home water treatment, safe storage, safe drinking water, business development, 300in6

Introduction/Problem Identification
There are still some 880 million people worldwide without access to safe water sources. Millions drink water from unreliable piped water systems. Water from safe water tap points often becomes recontaminated during transport or in storage at the house due to poor hygiene. Experiences indicate that treatment of water at the point of use with HWT (Home Water Treatment and safe storage) options, can drastically improve water quality, reduce child mortality and increase health. For several reasons the dissemination of HWT options as chlorine, SODIS, Flocculants/desinfectants, and filters is going (to) slow. To double the speed the 300in6 initiative was launched at the World Water Forum 5 with the objective that 300 million people will have safer water in 6 years with new effective low cost HWTs, lessons learned and innovative business approaches. Providing HWT options is seen as a commercial marketing challenge rather than a charity operation, as it is often done now.

Analysis/Results and Implications for Policy and/or Research

Reasons for scaling up HWT
• In many rural areas it is the only way to get safe drinking water
• It is a very cost-effective option to improve health
• It has benefits of up 60 x the investment costs (WHO 2008)
• Investing in safe drinking water maybe the most effective single action to reduce poverty. (UN university 2008)

Solutions are there
Innovations have made HWTs more effective en more affordable
For example disinfection options as Aguatabs, Watasol, Silvertubes Cost $0.1 – $1/yr/person. New filter options as Potfilter, LifeStraw family or Siphon filter Cost $10 – $20. The solutions are there, the challenge now is……scaling up.

Actual situation
At this moment (excluding boiling), there are some 40 million people using the newer Home Water Treatment options as Waterguard and Aguatabs, Solar disinfection, and types of filters (Potfilters, Biosand sandfilters, Candle filters, Life straw family etc) With the actual speed an estimated 150 million people will use these HWTs by the end of 2015.

300in6 intends to double the speed with:
1 Business approach: identify and replicate successful business approaches and delivery models for the BOP (Base Of the Pyramid) customers. Some organizations are piloting interesting business models that are both sustainable and replicable
2 Private sector: Both the international and local private sector are essential for scaling up with innovative new and affordable products.
3 Social marketing: Customers who are most in need often lack awareness about the importance and economic benefits of safe water. Scaling-up initiatives need substantial social marketing support to reach those target groups. Social marketing activities and hygiene awareness campaigns are a public sector and not a private sector task.

4 Research: R&D and monitoring activities of 300 in 6 will focus on marketing and dissemination aspects and work in close cooperation with the R&D activities of for instance the HWTS network of WHO where significant breakthroughs have been achieved.

5 Policy dialogue and advocacy: safe water has been only a marginal topic in the international water policy dialogue. 300in6 aims at bringing the topic high on the international water agenda.

6 Alliance: 300 in 6 is an alliance of like-minded organizations with a small core-group. Implementing organizations work with Governments, Multi-lateral organizations, NGOs, Research organizations and individuals as partners and observers.

Strategy and approaches of 300 in 6

1 It is the belief of 300 in 6 that free delivery of safe water is – except in emergencies – not a sustainable solution and people should whenever possible, pay for products and services. Subsidies may be needed in some circumstances, but the products and services should be cheap and supply chains profitable so costs can be covered. If people cannot afford to pay a product in one time, subsidies should be used to create payment options.

2 Social marketing are an important element of a scaling-up strategy. Poor families are often the least aware of the dangers of drinking unsafe water. Social marketing campaigns can be linked to other initiatives such as hand-washing promotion, hygiene education. Examples are the Blue bus campaign in Nicaragua by the J. Hopkins University. Social marketing is not the responsibility of the private sector but a public health task.

Marketing BOP products: Base of the Pyramid
The recent entry of large companies in the HWT market such as Unilever with the Pureit filter and Tata with Swach filter in India indicate that they see a future market of 800 million customers. There are other filters such as the Tulip filter that are effective cheap and nicely designed and microfinance packages are gradually becoming available. Giving free filters to schools and other strategic early adopters can stimulate the creation of a market. Involving communities or women’s groups in the supply chain can combine the social marketing with the creation of jobs and apply “Tupperware marketing approaches” (women convince their peers).

Marketing BOP services
Business models are tested in India such as selling water in kiosks or chlorine delivered from house to house. In order to involve small enterprises from the informal sector the delivery models need to be well structured, branded and finally franchised, so that proven approaches can be replicated in large numbers. Branded water vendors that would ensure the delivery of safe water would be a considerable improvement over the present situation. Over 25’000 water kiosks operating in India have shown that there is considerable potential in such models.
Fluoride Distribution and Occurrence of Fluorosis in Central Rajasthan (India) and Developing an Alternative Low Cost Defluoridation Technique

Author: Dr. Jakir Hussain  
National River Water Quality Laboratory, Central Water Commission, India

Co-Author: Mr. R.C. Jha  
Central Water Commission, Ministry of Water Resources, India

Keywords: fluoride, fluorosis, defluoridation, Rajasthan, India

Introduction/Problem Identification

India is among the 23 nations around the globe where health problems occur due to excess ingestion of fluoride (>1.5 mg/l) by drinking water. In India, 15 states are endemic for fluorosis. Out of these states, only 5 states may be categorized as hyper endemic for fluorosis including Rajasthan. In Rajasthan, 18 out of 32 districts are fluorotic. Many workers have reported the level of fluoride concentration in different districts of Rajasthan; however, the Bhilwara District, a centrally located district yet no studies have been undertaken in the study area with regard to fluoride and fluorosis problem. So the objective of this study was to investigate the concentration of fluoride in some rural habitations of Central Rajasthan. Various methods proposed for defluoridation are not in general practice due to either complication or high costing; therefore, it is planned to investigate an effective defluoridation technique using low cost and easy available material like marble slurry.

Analysis/Results and Implications for Policy and/or Research

An exploratory qualitative survey was conducted to describe perception of the community regarding fluoride and related health problems in Central Rajasthan. A study on distribution and health hazards by fluoride contaminate in groundwater was performed in 1,030 villages of Bhilwara district of Central Rajasthan. One thousand thirty water samples were collected and analyzed for fluoride concentration. Fluoride concentration in these villages varies from 0.2 to 13.0 mg/l. Seven hundred fifty-six (73.4%) villages have fluoride concentration above 1.0 mg/l. Sixty (5.83%) villages have fluoride concentration above 5.0 mg/l with maximum numbers (24, 19.5%) from Shahpura tehsil. A detailed fluorosis study was carried out in 41 villages out of 60 villages having fluoride above 5.0 mg/l in the study age, sex, and occupation data were also collected. Four thousand, two hundred fifty-two individuals above 5 years age were examined for the evidence of dental fluorosis, while 1998 individuals above 21 years were examined for the evidence of skeletal fluorosis. The overall prevalence of dental and skeletal fluorosis was found to be 3,270/4,252 (76.9%) and 949/1,998 (47.5%), respectively. Maximum of 23.9% (1,016) individuals have mild grade of Dean’s classification. Three hundred seventy-four (8.8%) individuals have severe type of dental fluorosis. The Dean’s Community Fluorosis Index for the studied area in total is 1.62. Maximum CFI 3.0 was recorded from Surajpura of Banera Tehsil. Five hundred sixty-six (28.3%) individuals have Grade I type of skeletal fluorosis while only 0.6% (12) individuals have Grade III skeletal fluorosis. In conclusion, the prevalence and severity of fluorosis increased with increasing fluoride concentration. It was interesting to note that in some villages, the prevalence and severity of fluorosis were highest in subjects belonging to the economically poor community. Similarly, male laborers showed highest prevalence of fluorosis. Prevalence and severity of fluorosis were observed higher in subjects using tobacco, bettle nuts, and alcoholic drinks. In contrast, subjects using citrus fruits and having good nutritional status showed low prevalence.
In coping with the problem of fluoride-contaminated water, various methods were introduced for defluoridation. However, because of cost factors or complexity, these methods could not gain momentum. The research paper deals with an alternative, low-cost method of defluoridation using marble slurry. The method is based on the fact that calcium carbonate, magnesium carbonate, and zeolite have compact crystalline structures, showing large calcium and magnesium ion surroundings by small oxygen and carbon atoms. Packing efficiency of such crystals is less with large empty spaces. Similarly, zeolite has a sieve structure and is a well-known ion exchanger. Also, fluoride ions are small in size and are a hard base. Calcium ions and magnesium ions are hard acids, which explain high stability of calcium and magnesium fluoride. These minerals can easily exchange fluoride. Fluoride can also be accumulated as interstitial ions in these crystalline compounds. In the present studies, marble slurry was found to be effective in the removal of fluoride ions from water. In Rajasthan, there are huge deposits of marble slurry. It is very cheap and found as a good fluoride remover from drinking water. Marble slurry may easily trap fluoride ions inside their crystalline structure. As it is well known that "Pitcher filtration technique" is used by humans for purification of water, since long times. The principle of marble slurry can be successfully used as an effective fluoride remover. Results obtained will give us a cheaper and effective method for fluoride removal. The adsorbent, which is marble slurry, was found to adsorb fluoride rapidly and effectively. The effect of various parameters such as contact time, initial concentration, pH, and adsorbent dose on adsorption efficiency was investigated. The fluoride concentration of 5 mg/l was reduced to 2.1 mg/l by the use of marble slurry. In another experiment, fluoride concentration reduced to 1.85 mg/l from an initial concentration of 3.9 mg/l. This reduction comes near the tolerable concentration of fluoride in water. The adsorption occurred within the first 5–10 min. Adsorption efficiency was found to be dependent on the initial fluoride concentration and adsorption behavior followed the Langmuir adsorption model. The optimum pH was found to be about 6.5. The presence of other ions such as nitrate and sulphate did not affect the adsorption of fluoride significantly. This study clearly shows the applicability of naturally occurring marble slurry as a selective adsorbent for fluoride from solutions.
Small Supplies: From Microbial Risk Analysis to Risk Management

Author: Ms. Severine Jacob
ASTEE, France

Co-Author: Mr. Dominique Gatel
Veolia Water, France

Keywords: risk analysis, microbiology, water safety plan, HACCP, water treatment

Introduction/Problem Identification
Risk analysis and risk management are now the recommended approach to complement the Risk analysis and risk management are now the recommended approach to complement the analytical evaluation of drinking water against parametric values. The WHO has adopted this view under the “Water Safety Plan” approach. Such a methodology is due to deliver considerable benefits for the society at large, but seems to be out of reach of many utilities supplying less than 5,000 inhabitants. This situation contrasts with the higher rates of non-compliance observed in small supplies.

The French Association ASTEE decided to develop a specific approach for such supplies, which could be freely accessible and easily implemented in remote areas, simply using a spreadsheet or equivalent. Microbiological risks, being the first to address, are at the heart of this approach.

Analysis/Results and Implications for Policy and/or Research
The bibliography enabled identifying a number of methodologies and tools available at the international level, confirming that the subject is a matter for numerous projects. The Montana Microbial Risk Assessment Tool (Butterfield, 2004) raised the attention: presented as questionnaire under Excel, it addresses all steps from resource to tap in a user-friendly manner, then calculating the risks of microbiological contamination of the drinking water.

The analysis of the tool against the expectation of the users revealed a need for an adaptation of the risk weights: an example is the reliance on chlorination, which in some countries is the main driver, but in France is of a lesser importance compared to other risk mitigation steps. It was also felt that the number of question needed to be adapted to best describe each of the supply chain elements. Finally, it was decided that the risk analysis would be complemented by the edition of recommendation (in the form of priority for action) and checking forms to facilitate follow-up.

In concrete terms, the questionnaire walks the operator through an initial list of 200 questions, with a possibility to refine the description of the treatment steps and supply systems, up to more than 500 individual questions. The water resource types which are considered in the tool are rivers, lakes, boreholes and springs. The treatment steps considered are chlorination, chlorine dioxide, ozone, UV, Flocculation & decantation, sand filtration, aeration & stripping, membrane or cartridge filtration.

A group of 16 experts of ministries, local health agencies and operators was formed to evaluate the weight of the different control steps in the final risk. The set of weights was entered in the remodelled tool, which was subsequently tested in 5 pilot sites, to assess the reliability of the risk calculation versus the expert judgement.
The main areas where changes had to be brought are the refinement of the questions dealing with the resource protection, the analysis of the network risks, and the balance between the two, necessitating an iterative process.

10 other sites were then proposed for a validation of the tool with several objectives: ensuring the validity of the calculation for different supply types; checking the acceptability of the tool by the end-users; evaluating the time needed. At this stage, the weights did not necessitate major adjustment, whereas the subsequent recommendation & action prioritisation were subject to some rewriting. It was found that local operators accepted well the tool, and needed 1-2 days to answer all questions.
Emergency Sanitation: A Window of Opportunity for Better Water and Sanitation Standards

Author: Ms. Åse Johannessen* et al.
* International Water Association (IWA), Sweden

Keywords: emergency sanitation, post-disaster interventions, innovative technologies, sustainable systems, case studies

Introduction/Problem Identification

Natural and human-driven forces can generate events to which the poor are ultimately the most vulnerable. Earthquakes, tsunamis, floods, land-slides, droughts, and wars are examples of events that tend to exacerbate the risks threatening the poor’s health and livelihoods.

The combination between the magnitude of an event and the vulnerability of the affected population will determine whether a disaster has occurred, and ultimately if an emergency intervention is required. Emergency situations provide challenging environments for intervening agencies with regards to water management and sanitation.

Traditionally understood as comprising the efforts related to the phase immediately after a disaster, emergency interventions can also be understood as embracing a broader spectrum of actions oriented to reconstruction and disaster prevention. In all phases, the choice of sanitation technology plays a major role in determining the impacts on the lives of the affected population.

Analysis/Results and Implications for Policy and/or Research

Our work is done as a collaboration between the International Water Association (Åse Johannessen), the Stockholm Environment Institute (Elisabeth Kvarnström), and Stockholm University (Juliana Porsani, and Olivia Puill). It consists of the compilation of case studies in which some type of innovative and productive sanitation technology has been implemented in one of the emergency intervention phases. These cases point to the benefits of introducing a system that not only meets the basic international recommendations, but also brings to the picture innovative reuse and recycling possibilities of water, waste, and sanitized excreta.

The relevance of including emergency situations in the discussion derives from their ability of testing and displaying the functionality of water and sanitation systems during extreme events. Considering the recurrence of such events and the fact that they normally lead to the worsening of the health and livelihoods of the most vulnerable, it becomes extra significant to improve systems that were unreliable and unsustainable in the first place.

Emergency interventions constitute a concrete opportunity for change as in their immediate phase, enormous amounts of funds are directed to the affected region. Many times, funds are used to address immediate and crucial priorities, but without considerations to long-term implications. The concern is that quick fix emergency solutions for sanitation may not be sustainable in the long term, while many emergency interventions and their humanitarian efforts can often last for many years. Thus, in places where choices during an immediate emergency phase may impact the long term sustainability of a system, considerations for alternatives to conventional sanitation technologies are necessary. If sustainable sanitation systems exist and can also provide more benefits in the emergency phase, the win-win situation is apparent.
For example, a problem often encountered in emergencies is that latrines fill up too quickly, where urine separation (urine-diverting dry toilets – UDDTs) could dramatically reduce the volume and thus prolong the life of a latrine. At the same time urine separation also provides for quicker decomposition of excreta. This technology in combination with using raised latrines is especially suitable for environments susceptible to floods or with high water tables, as it can prevent ground and surface water contamination, and thus contribute again to the populations’ current and future health. In addition, when the immediate emergency phase is over, UDDTs can offer future productive and economic benefits to the affected population. In this way environmental long term benefits are balanced with priorities of containing excreta in the fastest possible time in an emergency.

Our presentation will portray a number of sanitation cases covering the continuum from emergency to development interventions that have taken place in diverse socio-environmental conditions. It will highlight where alternative approaches to sanitation have been used, and thus point to the window of opportunity that sustainable emergency sanitation systems constitutes not only in alleviating immediate burdens, but also in constructing more sustainable and socio-ecological trajectories for the affected population to avoid future slow and silent disasters.

Our case studies will become part of a toolbox on WASH (Water, Sanitation and Hygiene) which aims at providing a bridge and repository of information between the development and emergency communities. A working group exists on sustainable sanitation technologies in emergencies, consisting of these two communities, and this study will further contribute to its continued dialogue, and knowledge base. They will serve these both communities with the state-of-the-art solutions available in sustainable sanitation for the immediate emergency as well as for the transition to more permanent and sustainable alternatives.

We hope that this presentation will contribute to the open discussion about alternative sanitation interventions in emergencies, and advance our understanding on the viability of these systems becoming more available, tested, evaluated and hence adapted properly to an emergency situation.
Introduction/Problem Identification
In Nepal three types of system exist, from the water safety point of view. First: Water is safe at source but like to contaminate at intake needing protection. Second: Source is bacteriologically contaminated at source requiring seasonal or all year round chlorination. Third: Source is heavily contaminated (presence of physical, chemical and bacteriological contaminants) requiring treatment plants.

In Nepal 50% population people have access to piped water system of which about 80% systems come under first two categories. Except few projects in large towns, all water supply systems are managed by users committee. Water Safety plan was practiced in 10 projects in rural settings and 4 projects in urban settings during year 2008-9. Projects include small to large gravity system and town small town’s settings with pumping schemes and treatment. Purpose of this paper is to share experiences of WSP in different settings and project types as case study, lesson learned, and challenges.

Analysis/Results and Implications for Policy and/or Research
One of the pilot project was Sisuwa Badahare Water Supply project. Project is located in Western region in Pokhre represents one of large size rural project. Source is located far away from the village. It takes about 4 hours to walk from community. Users had feeling that their water is safe. Knowing that source is contaminated with 50 Ecoli/100 ml they corrected source to protect from local contamination. After correction Source became 4 Ecoli/100ml. At the same time Colera out break took place in other part of the Nepal that killed more that 300 over 11 districts. Their consciousness for water safety and this incidence changed them to go for alternate treatment at HH level for drinking water even with this low contamination. Now they have feeling that this much contamination is due to open defecation in the village over upstream of the source. Now they are intensively working for declaring that village for Open defecation free with all king support. They have regular monitoring plan.

WSP starts from developing an effective WSP team. Team analyzed their systems, contamination points, control measures. They carry out urgent corrections needed and validate that the control system works to prevent contamination especially E-Coli and makes a monitoring plan to ensure that the system is continuously protected. As result of piloting WSP working modalities for Nepal has been developed. Lesson learned from this pilot works will help improve policy and guideline for WSP mainstreaming.
Water Quality for Human Health and New Approaches to Disinfection of Drinking and Waste Water

Author: Dr. Vladimir Malyshev* et al.
* Saint-Petersburg Pasteur’s Institute, Russia

Keywords: contaminants, water quality, human health, DEZAVID, antichlorine

Introduction/Problem Identification
The problem of surface and underground water pollution by bacterial, viral and parasitic contaminants is a global one. Up to now, water chlorination has been the main method of water disinfection all over the world. More than 90 % of water supply plants in the world disinfect and decolorize water with the aid of chlorine or its derivatives consuming about two million tons of this reactant annually. We offer DEZAVID®, the disinfectant of a new generation, as an alternative to chlorine and chlorine containing preparations. It consists of a kation-type organic polymer (guanidine compound) with addition of a synergist substance (quaternary ammonium compound)It is registered as a disinfectant for decontamination of waste and recycling waters, recycling waters in equipment cooling systems, water in secured service water systems of enterprises, for disinfection of drinking water including prolongation of the ultraviolet decontaminating effect.

Analysis/Results and Implications for Policy and/or Research
In the Russian Federation, where more than 70 % of water intake facilities are supplied from surface water sources, practically, 100 % of wastewaters are discharged into these water sources. It becomes clear how important the wastewater disinfection stage is. The quality of potable water is vastly dependent on how and by what means wastewater disinfection will be performed. Rotavirus infection (RVI) is one of the main reasons for occurrence of diarrhea of children and adults. According to some assessments, every year 125 million people become infected with rotaviruses. In average, 6 % of lethal cases among children of up to 5 years old are caused by this infection. According to WHO, every year up to 500 000 children die of RVI. Rotavirus transfer by water is one of the leading ways of dissemination of this infection as a marker of water viral contamination. Application of chlorine-based preparation is rather not ideal for human health due to formation of chlororganic compounds and absence of viricidal action (the bactericidal effect is available). Therefore, use of chlorine and chlorine-based preparations is not an efficient method of disinfection of treated wastewaters. The hardware methods of water disinfection (ultraviolet, ozonization) require high investments and considerable expenses in the process of operation.

DEZAVID® produces harmful effect on spores, bacteria, viruses, fungi, protozoa and helmints. So, as to the E.coli indicators, the reduction of concentration by 10(4) BOD is observed. Whereas as to the enteroviruses, 100-% virulicidal action is possible only when the concentration reaches 10(8) viral particles. DEZAVID® dosed as 8mg/L (0.256 mg/ active substance) fully suppresses the infection activity of rotaviruses, contained in wastewater during 30 minutes. Detection was effected by ELISA and PCR real-time.

A serious approbation of DEZAVID® in laboratory and production conditions shows that 1 liter of disinfectant (with the concentration of 6 to 8 mg/L) is able to disinfect 170 m³ water. However the preparation is safe if ingested. The disinfectant is non-toxic and does not feature a mutagenic and carcinogenic activity. It reduces efficiently turbidity, chromaticity, improves organoleptic properties
of water being disinfected. And in addition, DEZAVID® does not contain active chlorine, phenols, aldehydes, it is stable and its pot life is up to 3 years.

Using and electronic microscopy method we have found out that the charged polyatomic kation polyhexamethylene guanidine PHMG) and QAC, which are the components of the DEZAVID® preparation, interact electrostatically with the norovirus particles. Interaction begins with the external negatively charged P-domains and then involves hydrophobic S-domains, which results in dissociation of the core protein molecules and thus in destruction of viral particles. In the absence of receptor proteins, the norovirus RNA is not able to contaminate; moreover, it is also destroyed and inactivated by the components of the disinfectant. Further on, the destroyed viral particles turn into conglomerates of denaturated proteins, which coagulate with the lapse of time, precipitate and are subjected to biodegradation.

Application of the DEZAVID® preparation for decontamination of water does not require capital investments in water treatment facilities. The DEZAVID® disinfectant is simple in use and highly efficient in controlling waterborne infections. This makes it possible to draw a conclusion on economic efficiency of application of the DEZAVID® disinfectant in the different regions of the world.
Water Quality for Human Health in Poor Urban Areas of Latin America

Author: Ms. Maria Onestini
Centro de Estudios Ambientales (CEDEA), Argentina

Keywords: health, poverty, latinamerica, integrated, development

Introduction/Problem Identification
The health impact of environmental degradation associated to water in poor urban areas of Latin America is a critical issue from many points of view. For equity reasons, environmental grounds, or as a policy rationale (as well as for any combination of these factors), the matter is a vital one. Water-related matters within this broad outlook are key. The paper proposed for presentation draws comparative, integral and wide-ranging conclusions related to water issues from a series of case studies carried out in several Latin America that examined (from an integrated perspective) the inter-connected issues of health, environment, and poverty in these urban areas. A series of policy and general recommendations from a systems perspective do also emerge from the comparison of the case situations and progress identified in several specific situations.

Analysis/Results and Implications for Policy and/or Research
The paper proposed for presentation draws comparative and wide-ranging conclusions related to water problems from a series of case studies carried out in the cities of Lima (Peru), Cochabamba (Bolivia), Sao Paulo (Brazil), and Moreno (Argentina) that examined (from an integrated and systems perspective) the inter-connected issues of water, health, environment, and poverty in these cities. A series of policy and general recommendations do also emerge from the comparison of the case situations and progress has been identified in several specific situations.

The case studies point to new and crucial problems related to water and health in Latin America's poor urban areas, with the evident divergences between and among different urban configurations within the metropolitan areas that have been analyzed. The general conclusion, however, remains that environmental burden of disease for the poor is very high and growing in Latin America. Of this, a great deal is related to the access (or lack of access) to safe water and of water-borne illnesses and lack of integrated systems perspective in water management issues.

Concrete evidence of these links is illustrated in the following data:

The lack of safe water in Lima is linked to diseases associated to this matter have increased to reach an estimated 22 percent in the last few years.

In several cases in Argentina it has been found that even water provided by municipal systems is non-potable due to a high content of arsenic and nitrates, among other contaminants, as well as bacteria in unsafe water. Specifically in Moreno (Argentina) water-related gastrointestinal pathologies represent nearly 40% of all pathologies reported within the municipal health system.

In Cochabamba, the case study also identified the perception of illness by the urban poor related to the lack of safe water, indicating that 63 percent of the poor (with a slight gender differential) perceive that the lack of safe water is associated to illness.
And in Sao Paulo, a tendency of poor urban settlements budding close to highly contaminated courses of water is highly visible, with health issues associated to this adjacency.

The case studies have also analyzed the issue of water, health and poverty from an equity point of view. With concrete data from Cochabamba and Lima, it has been found that water provided by informal means (for example, through water cistern trucks) is not only highly contaminated but also it costs the poor more than eight times than water provided by municipal systems.

Some general conclusions vis-à-vis the knowledge that links issues such as water, health and poverty in urban Latin America can be schematized as follows (following the findings in the aforementioned case studies). Under reporting of water-related illnesses for the poor is a weighty issue, not only from a research point of view, but (importantly) from an equity and policy standpoint. It is recommended that progress in this matter be pressed by analysis to be carried out that confronts under reporting as well as unreliable official data in many circumstances.

Lack of holistic and integrated urban planning continues to plague the poorer urban regions in Latin American cities, increasing informality, meager infrastructure and their associated health problems. It is recommended that proactive policy alternatives that link health issues for the poor as related to water problems be furthered.

Lack of safe water provision has been associated in many cities with the informal property rights on land, and that progress is evident when tenure is secured. It has been recommended that a move forward to more formal situations of land tenure can lead to better water provision infrastructures and (as a result) to situations where access to safe water is also improved and progress evidenced.

Positive experiences and progress have also been identified in the case studies, and it is suggested that several of these experiences (programs of infrastructure in shanty towns, community projects, health vigilance programs, and systematic management and urbanization plans, etc.) should also be analyzed in the future as to recognize the opportunities that these experiences bring to better provide for water-related issues in relation with health as well as their possible replication in other urban areas.
Introduction/Problem Identification

The Philippine Department of Health (DOH) has the mandate to issue standards and guidelines for regulating drinking water safety based primarily from the provisions of two Philippine laws: Sanitation Code (1975) and the Clean Water Act (2004). Despite such regulations, however, outbreaks of gastro-intestinal diseases in different parts of the country have occurred. Prominent incidences were the cholera outbreak in Pangasinan province (2004) that affected nearly 10,000 people and the typhoid outbreak in Laguna province (2008) which victimized more than 2,000 people. The DOH reports revealed presence of contamination at different points of the water systems. It is in this context that the DOH has strongly supported the application of water safety plan (WSP) as an approach to address water-related outbreaks. With the complex institutional set up of the sector, the DOH was challenged on what strategy to adopt in scaling up WSP for water systems that are not under its direct supervision.

Analysis/Results and Implications for Policy and/or Research

When the World Health Organization (WHO) published in 2004 its 3rd edition of the Guidelines for Drinking Water Quality (GDWQ), the concept of water safety plan was included. This publication became useful for the DOH as a major reference in which during that time was updating its national standards for drinking water. In 2006, WHO introduced to the Philippines the new GDWQ with detailed discussion on water safety plan concept.

With fund assistance from AusAID, WHO pursued its assistance to the Philippine Department of Health by piloting water safety plan in a very large water supply utility, i.e. Maynilad Water Services, Incorporated in 2006. This activity underwent a series of in-house consultations with technical assistance from local and international consultants before it was finalized. It took nearly one year to complete the first WSP in the Philippines. The experience of piloting WSP was documented and lessons learned were inputted to the next stage of scaling up.

With the desire to roll out lessons learned from the pilot stage, WHO and DOH partnered with Philippine Waterworks Association (PWWA) in 2008 to conduct a series of nationwide training on water safety plan. PWWA established a core of trainers that served as resource persons. These trainers underwent WSP training in Singapore Public Utilities Board. At the end of 2009, about 135 water districts participated in the PWWA water safety plan training which covered 472 participants. From the series of trainings conducted in 3 batches, about 16 water safety plans were drafted. Six (6) modules were developed and utilized in the training-workshops. These modules contain concepts, procedures, and group exercises for developing a water safety plan. The training-workshops identified several issues that affect water supply provision, such as: multi-use of watersheds, uncontrolled water pollution from industries, inadequate capacity of water laboratories, leaks and illegal connection,
unregular calibration of equipment, flexibility to the effects of climate change, and difficulty to fully comply with drinking water standards. These issues will be addressed by water utilities in the design of their WSP with support from the DOH and other partners.

During the training-workshops, the “big brother” approach was conceptualized to be applied in future WSP activities. This means a big water utility in the same water catchment will mentor a small water utility in developing and implementing their WSP. The approach promotes inter-water utility cooperation and coordination in addressing common problems of the watershed.

The WSP initiative has obtained the attention of major donors in the Philippines. The World Bank and Asian Development Bank (ADB) have considered WSP as a part of their on-going or pipeline projects. The Sustainable Sanitation in East Asia Project of World Bank piloted water safety plan in a rural municipality in 2009 while ADB will integrate WSP in their Water District Development Sector Project which is targeted to commence by 2012.

In some national fora, the WSP topic has been included, such as in the PWWA conventions (2007-2009), Sanitation Summit (2008) and Philippine Society of Sanitary Engineers conference (2006). During such fora, issues were raised whether water safety plan should become part of government regulation and how this approach could be sustained. Consensus obtained from consultations with key stakeholders point to the inclusion of WSP in government regulation with a condition that adequate systems and procedures should be in place to legitimatize all activities related to WSP towards sustainability.

The DOH is ready to lead a vigorous national program using its mandate derived from the Sanitation Code and Clean Water Act to scale up WSP application beyond the partial number of water districts which participated in the 2008-2009 activities. To support such program, systems and procedures that are needed to be in place would be as follows:

1 Institutional: technical assistance team; monitoring system; surveillance agency; and policy issuance for WSP implementation
2 Financial: costing template; financial assistance mechanism
3 Capacity building: human resource development to prepare, review and audit WSP; accreditation of training institutions; laboratory improvement; inter-calibration of equipment and quality measurements; certification systems for WSP competencies; and human resource performance appraisal
4 Technical: priority health-based parameters in specific areas; WSP templates for different water sources; guidelines for WSP preparation, review and audit; integration of WSP in the business plan of Water Districts; WSP linkage in Integrated Water Resource Management and Water Quality Management Area

With the support of the international community, WHO and DOH envision that the identified systems and procedures for WSP implementation will be accomplished to bolster further scale up.
Involving Schools in Developing Water Safety Plans for Small-scale Water Supply Systems; Experiences from Romania

Author:  
Ms. Margriet Samwel  
Women in Europe for a Common Future (WECF), The Netherlands

Keywords:  water safety plans, anthropogenic pollution, nitrate monitoring, involving schools, community mobilisation

Introduction/Problem Identification
Since several years, Women in Europe for a Common Future, in cooperation with local partners, has been monitoring water pollution of small-scale water supply systems such as dug wells in rural areas of several countries. Romania, an EU member state is one of the countries facing substantial problems in water protection. 7 million people in rural areas of Romania obtain their drinking water mostly from wells. Poor sanitary conditions and mismanagement of human and agricultural waste cause anthropogenic (man-made) water pollution with nitrates, faecal bacteria. Despite the evidence provided, this has NOT triggered any action by local or regional authorities to start water protection measures. Among the rural citizens and local authorities low awareness exists on the relation of anthropogenic pollution, water quality and related diseases. In villages with small-scale water supply systems, financial mechanisms or structures for water and sanitation are often not available.

Analysis/Results and Implications for Policy and/or Research

Developing Water Safety Plans involving schools

Study area
Eight Romanian villages were selected in the county Teleorman, Mehedinti, Giurgiu and Ialomita. None of the target villages is served by a central water supply network or sewerage system. Beside the individual wells the dwellers of 3 villages use partly public taps.

Methods
To address the above-mentioned problems WECF created an educational package (WSP toolbox) for schools to develop community based Water Safety Plans (WSP) for local small-scale water supply systems such as dug wells, boreholes and public taps.

The aim of the WSP toolbox was, building local capacity and mobilising the community for improved access to safe drinking water. The WSP toolbox provides schools with a WSP manual with background information about the aims of the WSP, about properties of drinking water and sources of pollution and related health risks. Three different questionnaires were prepared for the schools: one for citizens, one for the local medical staff and one for the authority responsible for the local water supply. Based on the sanitary inspection forms of the World Health Organisation WHO, checklists for the risk assessment of water sources were adapted to the local circumstances.

Two teachers per participating school were trained by WECF on how to develop with the involvement of their pupils a WSP for their local community. The schools were provided with materials for carrying out nitrate quick tests and organo-leptic observations, and were motivated to analyse local water sources and to do longitudinal nitrate monitoring of selected drinking water sources.
Implementation
In autumn 2008, school staff of 8 Romanian schools developed and started a WSP programme for their pupils. Teachers and the pupils of the participating schools were very motivated and enthusiastic about the activities, because the activities were experienced as practical, educative and relevant to the local environment. Approximately 500 water samples were tested for nitrate and other simple tests were carried out. The schools interviewed several stakeholders and formulated conclusions and recommendations.

Results of interviews with the local water responsible authorities
One of the results of the interviews was that in one out of the 3 communities with public taps the wells and the water quality was seldom monitored; for the other 2 communities with public taps regularly water quality controls were carried out. Citizens have to pay little money for water delivered by public taps, water from public wells is for free. The respondents said that the communes do not have additional budget.

Hence in the target villages water protection measures or maintenance of the water sources was very poor.

Results of interviews with the local health authorities
As a main problem concerning local drinking water, doctors mentioned the pollution via animal droppings, septic tanks, lack of sewerage and the fact that water is not tested or protected. In three villages partly served with partly public taps, the main problem mentioned was partial or a total lack of water supply. Regarding the water quality, the doctors of the four villages mentioned the high nitrates and water infected with Giardia. Most interviewed doctors of the target villages were aware of the lack of access to safe water and related health problems.

Monitoring results
Most of the tested water sources exceeded the EU nitrate limit of 50 mg/l, locally the nitrate concentration in water exceeded up to 9 times the EU limit. Even drinking waters in deeper aquifers are endangered by nitrate pollution. Locally the nitrate concentration in wells were fluctuating tremendously. The pupils identified a relation between precipitation events, the seasons and the observed nitrate concentrations. The very high nitrate levels of 150, 200, 250 mg/l found in the month December, decreased during the months of January and February. However in the month March – April nitrate levels increased again. In only one of the target villages is served by a 30 – 50 meter deep aquifer, nitrate test showed concentration of 25 mg/l to 50 mg/l without any fluctuations.

The results of the interviews showed low awareness among the rural citizens on the causes of water pollution. Based on the checklist for the sanitary inspection and interviews with citizens the pupils concluded water pollution occurs at local level due to unsealed pit latrines, keeping livestock, lack of safe waste disposals and uncovered wells. In the final reports and in community meetings, the pupils proposed plans for improving the situation, which were related to the observed sources of pollution. The WSP programme proved to be good tool for community mobilisation, raising awareness among the citizens about water quality and causes of water pollution. However, the available time frame of 7 months was too short for implementing local actions, but sufficient to identify needed local actions.
Water Safety Plans – Not a ‘Panacea’, but a ‘Door Opener’
Towards More Effective Resourcing

Author: Mr. Oliver Schmoll
Federal Environment Agency, WHO Collaborating Centre for Research on Drinking Water Hygiene, Germany

The World Health Organization (WHO) Guidelines for Drinking-water Quality provide the international point of reference for the majority of drinking-water regulations. The third edition of the Guidelines launched in 2004 establishes a “Framework for Safe Drinking-water”. It encompasses health-based target setting, a risk assessment and risk management approach called Water Safety Plan (WSP), and a system of independent surveillance.

WSP take an integrated systems approach, aiming to minimize risks in the water supply chain from catchment to consumer through the systematic identification of hazards, prioritization of risks and implementation and monitoring of control measures. WSP provides a means for enhancing the quality of drinking-water by complementing “traditional” compliance monitoring by a risk-based approach in day-to-day management routines of water suppliers.

So far, there has been significant international momentum and increasing policy recognition of the WSP approach in response to the WHO Guidelines. An increasing number of countries have either revised, or plan to revise, their drinking-water regulations to require WSP implementation.

Accumulating experience reveals that water safety planning provides a range of benefits for water suppliers, including: a sounder information basis for water suppliers’ strategic decisions; investment and business planning; improved operational delivery and maintenance schemes; and better relationships with other stakeholders. Taken together this will lead to reduction of incidents and improved water safety.

Discussions about the need for a supporting environment tend to revolve around the need for regulatory requirement of WSP implementation. This is surely an important impetus. However, experience shows the prime importance of a careful national advocacy process for the concept – one which fully acknowledges and integrates local success stories. WSP implementation is most successful if it is flexibly adapted to local and national conditions – this proves a prerequisite for it to be fully embraced by supply management rather than being perceived as an ‘annoying’ duty or formality leading to token implementation. Other important elements in the broad suite of accompanying measures include widespread education and capacity building initiatives, WSP incentive programmes, model projects and in some settings the establishment of entities capable and mandated to review and audit WSP.

The role of adequate resourcing as a critical success factor for sustainable WSP development, particularly in less well developed socio-economic contexts is highlighted by the example of post-Soviet countries: even “improved source” piped water supplies in the UNICEF and WHO Joint Monitoring Programme (JMP) classification rely on aged or disrupted supply infrastructures, face irregular electricity supply or limited access to disinfection or treatment chemicals – all in all leading to intermittent water supply and poor drinking-water quality. In such situations, the suite of improvement and upgrade needs that require investment may seem obvious, but in practice, developmental aid often is not based on priority-setting driven by public health targets. A water safety planning process, through hazard analysis...
and risk assessment, could prove very useful for setting health-based priorities for investment, and this is particularly important where resources are scarce.

WSP is not a panacea for long prevailing funding and resourcing problems in the short-term. However, through its commitment to WSP the utility demonstrates a progressive and pro-active approach to water safety, and makes transparent current shortcomings and critical improvement needs. For national or international finance institutions and donor agencies, WSP provide opportunity for strengthening the sustainability of their investments in improved service levels, increased coverage or construction of new water supplies. Thus, both the supplier’s and the funding provider’s demands can meet at WSP: the supplier can rationalise and substantiate its resourcing requirements for improvements in water safety and service level – the funding provider can use WSP as ‘benchmark’ for any of their water programmes. There is a clear need for it.
Worsening Water Quality of Kathmandu Valley, Its Impacts on Health and Alternatives

Author: Mr. Anuj Sitoula  
Water and Energy Users’ Federation-Nepal (WAFED)

Co-Author: Mr. Ratan Bhandari  
Water and Energy Users’ Federation-Nepal (WAFED)

Keywords: Kathmandu, water, quality, health, alternatives

Introduction/Problem Identification
Kathmandu Valley has become the most populated city in Nepal in recent years with an estimated population of some 4 millions. One main reason behind this is the lack of insecurity in all parts of Nepal as a result of the 10 years’ of Maoist insurgency and continuing instability even after the 2006 peace accord. However, the overall infrastructure of the city remains the same as it was some 60 years ago, including water infrastructure, planned for a population of about 1 million population.

The water and drainage pipelines run through virtually in parallel causing water-born diseases serious and health hazards, particularly during the rainy season. The scarcity of water has become another major problem during the dry season. The better and cheaper local options of ground, surface and rain waters are largely ignored. The high level of leakage is another serious problem. The most expensive ADB-funded Melamchi Water Supply Project is preventing these alternatives to explore.

Analysis/Results and Implications for Policy and/or Research
The research over the past five years conducted by WAFED has found that one of the main problems of the permanent health hazards in Kathmandu Valley is the water-born diseases, particularly among the children, the landless and homeless poor, and the people living on the streets. The problems are caused both by the lack of adequate amount of clean and safe drinking water supply and very poor sanitation system. The drainage system is virtually blocked all over the Kathmandu Valley due to the uncontrolled use of plastic bags and plastic wastes. As a result, the drainage waste mixes up into the drinking water pipes and other drinking water sources causing huge amount of water pollution.

The second finding of the research is that the Kathmandu Valley is not affordable for more than 2 million people if the availability of the most fertile agricultural land is to be preserved, if the small river ecosystem is to be maintained and if the city is to be kept socially, culturally and environmentally clean and safe. Kathmandu Valley has seven UNESCO world heritage sites -- now in serious danger due to over population, haphazard urbanisation and environmental pollutions.

The third finding is that even the public and private hospitals lack the basic supply of clean and safe water in an adequate quantity. Treatment of these diseases for the majority of the public is very poor in public hospitals and the same treatment in private hospitals is simply unaffordable due to the high cost.

The fourth finding is that the cost of investment in drinking water supply is much more cheaper than the cost of public health disaster -- both at the cost of finance in hospital facilities and medicines as well as the human health and the human lives. But the government has not done any comparative study in this regard so as the donors who are funding in health and infrastructure sectors in Nepal.
The fifth finding is that the population of Kathmandu Valley can get the drinking water supply in a much more cheaper, better and faster manner if the priority is given to the conservation of local watersheds and the local water resources (groundwater, rainwater-harvesting and collection of waters from traditional lakes, ponds and streams) which are totally ignored, poorly maintained and underutilised. The supply of water from the Melamchi River through the 27-long kilometer tunnel once it is constructed in the next 5-10 years at the cost of local lives and ecosystem in Kathmandu Valley is not the best and immediate option. Funded by the Asian Development Bank (ADB)-- the Melamchi project has been in controversy, corruption and delay all the time over the past 20 years. To make it worse, it has a lending condition for the privatisation of Kathmandu water supply already making the water supply, quality and quantity system worse than before when it was under the public authority of Nepal Water Supply Corporation.

The sixth finding is that the water-related health hazardous will become worse in the next five years and after if some emergency measures are not undertaken for the immediate utilisation of local water alternatives available in Kathmandu Valley even if the Melamchi project is to continue.

The seventh finding is that Kathmandhu will have no capacity to sustain if the pattern of centralised development and the uncontrolled growth of Kathmandu population from all over Nepal is not regulated, revised and decentralised even with the water supply from the costly Melamchi River.

The eighth finding is that the donors and the international financial institutions such as the World Bank and the ADB must review their existing funding policy and give priority to locally available cheaper and better alternatives to water management, water supply and preventing health hazards.
Social Vulnerability to the Risk of Water Pollution: Mayotte’s Case Study

Author: **Ms. Aude Sturma**  
LMTG – CNRS (French National Center for Scientific Research), France  
Co-Author: **Mr. Matthias Mailliard**  
IRIT – UT1, France  
Keywords: sanitation, waste water treatment, health and environmental risk, social vulnerability, Mayotte

**Introduction/Problem Identification**
Sanitation, has been raised recently by the UN as a major concern for the millennium. However, so far, sociological analysis on water management have focused on problems of scarcity, distribution and supply of water at the expense of the major problem of sanitation and its alarming consequences on health and environment. Our study will focus on sanitation through the analysis of social change in the French island of Mayotte. This overseas territory is undergoing an increasing social and demographic changes since the last two decades, leading public agencies to develop a supply of drinking water. The establishment of waste water treatment remains still difficult, although the environmental and health issues are a great concern for institutional authorities. Our presentation leaves off the prism of technicity, to consider social, cultural, and economic factors, which are the underlying processes of social and institutional vulnerability.

**Analysis/Results and Implications for Policy and/or Research**
It is very difficult to obtain accurate data on the social use of water in Mayotte. Initially, our research focused on the use of water in Mayotte regarding the study of social vulnerability conducive to water pollution threat. We define social vulnerability as the insufficient capacity to cope with a risk, in this context, the risk associated with water pollution (disease with faeces, environmental pollution). We have therefore developed a methodology aimed at identifies the different situations related to lack of sanitation that can be encountered on the island. We thus have selected 6 typical sites characterising these situations. (in partnership with agents of SIEAM water agency)

These sites include the following issues:
Isolation: with the selection of villages being isolated in the south and affected by a strong unhealthiness, their WWTP are not functional, the sludge overflows from manholes, and residents are facing a daily situation of faecal peril accentuated on rainy season

Lack of space: some villages have suffered uncontrolled urbanization, the development of water pipeline between houses is impossible.

Experimental WWTP: in a village’s suburb where water waste are partially treated and are then transported into the mangrove. Where a CNRS’s (French National Center for Scientific Research) team is thus testing the purifying capabilities of mangrove regarding waterwaste for the domestic pollution. The acceptability of such alternative procedures is crucial and would allow the lowering of price water.
Social injustice caused by the housing situation: we wanted to focus on a difficult situation that people have to live in. They have their own traditional sanitary, but they have to endure the consequences of malfunctioning devices from nearby residential houses. This situation often leads to tensions and a rise in claims.

Village rivalries: land’s issues are very important in Mayotte due to lack of available space to construct WWTP, local officials do not agree on the choices of implantation sites, which slows down the establishment of sanitation.

Urban issues: the county town, Mamoudzou, regroups key areas of economic activities and has a very important demographic pressure. The treatment plant was undersized and the resulting olfactory nuisances have strongly lead to the bad reputation of such devices for a long time.

We have carried out 1000 questionnaires with the population on these 6 sites. The statistical treatment allows us to make an inventory of the worrisome situation. Our questionnaire comprising 70 questions covers many aspects of sanitation. Here, we present only two aspects of our research, namely the impact of the sanitation representations and the economical sanitation cost for habitants.

Firstly, there is an important lack of information and awareness about sanitation, aiming at the understanding regarding the difficulties encountered with the problem of sanitation. This lack of knowledge is double as it concerns both people and local officials.

According to our statistical analysis it appears that people are not aware of the causal link between the diseases they contracted, and water pollution. (for a given disease, 41% do not know its causes …). It appears that they put it down on fatality and religion plays a part in it. Also, when asked about the usefulness of sanitation, the second most cited response was “to charge users”.

This misunderstanding of sanitation is also present among local politicians, and it puts them in a logic of effluent removal and not in a processing one.

Secondly, the economic situation remains very worrying if one looks at the impact of water price on family budgets. Indeed, we have demonstrated that water is a strong and expensive social challenge for Mayotte. Thus, 20% of the population pays a bill which corresponds to at least 20% of household incomes. The average family spends 17% of its budget for its water bills.

Given this situation, our research seeks to provide a core local factual knowledge to allow a less technocratic political actions, by figuring out these local characteristics.
Using a Risk Based Strategic Self-assessment of Local Government’s Capacity to Guide Sustainable Municipal Water Quality Management

Author: Mr. Allestair Wensley* et al.
* Department of Water Affairs, South Africa

Keywords: municipal water quality, municipal services, performance management, risk management, self-assessment

Introduction/Problem Identification
South Africa, as many developing countries, faces challenges in the sustainable provision of adequate and safe municipal water services. In recent years considerable progress has been made in progressing municipal water quality management (WQM). These include the extremely successful national deployment of a Municipal WQM Performance Management System (winner of the IWA’s Global Project Innovation Award in 2008), and the subsequent deployment of the “Blue Drop / Green Drop” incentive based regulation programme in which Blue and/or Green Drop status is awarded to municipal systems compliant with drinking water and wastewater regulatory and best practice requirements.

Nevertheless, the challenge of sustainable municipal WQM remains. Each municipality has its own unique challenges. To support sustainable WQM a risk based Decision Support Tool, which provides a strategic assessment of each municipality via a simple self-assessment, has been deployed and is presented below.

Analysis/Results and Implications for Policy and/or Research
South African municipalities have responsibilities including the protection and management of water resources, provision of adequate and sustainable water services, operation and maintenance of water services infrastructure, monitoring and management of municipal water quality to regulatory requirements, reporting to the Department of Water Affairs (DWA) with regards to the aforementioned, etc.

In order to ensure an effective and sustainable water service, the above mentioned aspects must be satisfactorily addressed by municipalities. The national “Blue Drop/Green Drop” Regulatory System approaches municipal water systems in a manner closely aligned to the IWA’s Water Safety Plan oriented approach. Further there to, and in support thereof, an annual facilitated municipal self-assessment, looking at the overall “business status” of the municipality and the impact thereof on the sustainability of municipal WQM, is carried out by DWA. This “business status” assessment helps to identify areas of vulnerability (threats) to the sustainable services provision per municipality, and to develop local, regional and national strategies as to what measures should be put in place to close these municipal “sustainability gaps”. The municipal self assessment based “Strategic Gap Analysis of Water Quality Management” therefor compliments the regulatory based Blue Drop / Water Safety Plan oriented approach, by assisting municipalities, water services sector partners, and DWA to identify critical municipal areas requiring support.

The Strategic Gap Analysis of Water Quality Management is carried out via the national municipal WQM tool, the web-enabled electronic Water Quality Management System (eWQMS) which is
accessible to all municipalities. The Survey Tool incorporates a series of simple key questions which indicate the status of both drinking water and wastewater services. Each municipality is taken through a structured “self-assessment” interview process to capture the performance of the municipality as regards to six key areas of performance necessary to attain sustainable WQM.

The Six “Legs of Sustainable WQM” comprise the following:
- Water Legislation, Policies and Regulations;
- Water Resources and Water System Infrastructure;
- Water Quality Monitoring, Laboratories and Logistics;
- Human Resources;
- Management; and
- Finances.

The survey has been facilitated via DWA for the last 4 years, and over the last 2 years 100% participation was achieved – a close to unique achievement in terms of South African municipal participation in self-assessments.

Outputs of the municipal self-assessments are presented to individual municipalities in easy to use colour coded “Spider Diagrams” indicating clearly the risk/vulnerability status of each “Leg of Sustainable WQM”. These simple summaries have been found to be particularly effective in assisting technical and management staff to convey to non-technical, elected municipal councillors those areas of the municipalities operation which requiring their prioritised attention and assistance.

Outputs are rolled up into regional views which assist risk/vulnerability benchmarking between municipalities across each of South Africa’s nine provincial regions. This assists in regional supportive interventions by provincial and national departments, both in terms of identifying most vulnerable municipalities and in addressing regional themes.

Finally, outputs are rolled up into national views and used for national information, planning and business intelligence purposes. A recent example is the use of the Strategic Gap Analysis of Municipal WQM data to inform the high priority “Local Government Turnaround Strategy” in terms of (i) confirming high risk municipalities, (ii) providing specific details on those areas of high risk weakness within weak municipalities.

The following key points of the approach and progress todate are noted:
- The web-based municipal WQM tool, eWQMS, has been rolled-out by DWA to all municipalities in South Africa, who are familiar with its accessibility, features and functions.
- Municipalities can update their Strategic Gap Analysis status at any stage and are therefore empowered to conduct self-assessments and self-manage themselves more effectively.
- The data is securely stored on an appropriate national database.
- The current outputs generated via the eWQMS can also be updated to include any other required survey/assessment outputs.
- The current approach has significant cost savings (consolidation of surveys, largely a desk-top based assessment – no or limited site visits).
- As the data/information is electronically available and can be uploaded into the National Information System (NIS) at any stage, DWA National and DWA Regions are able to perform strategic analyses of data at any time.
• Municipal confidence in DWA increases due to consolidation of questionnaires, minimisation of duplication, effective use of data, etc
Workshop 4: Improved Water Use Efficiency through Recycling and Reuse

Experience with Agricultural Reuse of Treated Wastewater in Jordan: Focusing Water Scarcity, Risks of Climate Change and CO2-Reduction
Study on Water Conservation Policy Package Including Wastewater Recycling in Tokyo and the Applicability in Selangor, Malaysia
Quantitative Microbial Risk Assessment for Wastewater Reuse in Irrigation and Survey Public Attitude towards Wastewater Reuses in Saudi Arabia
The Dole Banana New Millennium Packing System: A Breakthrough in Optimizing Water Use in the Fresh Fruit Industry
Performance Evaluation of Decentralized Treatment & Recycling of Wastewater – An Integrated Approach to Water Management at in Auroville (India)
Role of Water Reclamation and Reuse in Water Resources Management
Future Water- Reuse and Exchange of Wastewater for Irrigation in the City of Durango
Incorporation of Water Recycling and Reuse into Regional Water Supply Strategies – An Integrated Water Management Policy from Queensland, Australia
Sustainable Sanitation for the 21st Century: A Source Book for Capacity Building
Water Reuse in the End Point of Nile Basin: The Risks and Opportunities
Water Resources Management Efficiency in Uzbekistan
The Removal of Pharmaceuticals, Endocrine Disrupting Chemicals and Microbial Pathogens for Water Re-use Purposes: A Groundwater Recharge Case Study
Problems and Potentials of the Waste Water of Oworonshoki, Lagos-Nigeria
Importance of Wastewater Reuse as Management Strategy in the Basin of Mexico
Technological Solutions to Improve Water Use Efficiency in Delta Areas Prone to Salinization
Recycling and Reuse of Wastewater on the Maintenance Lines of Indian Railways
Present Situation on the Reuse of Wastewater for Irrigation in Developing Countries
Characterization of Grey Water and its Implication for Reuse, the Case of Kigogo Peri-Urban in Dar Es Salaam, Tanzania
Water Reuse and Recycling: Emerging Options and Their Policy Implications
Pharmaceuticals in the Environment: Carbamazepine in Wastewater, Irrigated Soil and Groundwater in a Tunisian Reclaimed Water Irrigated Area
Sustainability of Wastewater Collection, Natural Treatment and Reuse for Food Production and Carbon Capture
Improved Water Efficiency Through Recycling and Reuse: The Success Story of Singapore
Demanding Reuse at Wastewater Treatment Plants: A Case of the Private Sector
Helping to Pay for Sanitation
Community Based Initiatives to Exploit Untapped Run Off Water for Enhanced Nutrition and Sanitation
Environmental Impact for Reused Agricultural Rainage Water in Egypt
GCW's 4Rs of Sustainable Water Management: Reduce, Recycle, Recover and Release
Environmentally Friendly Technology for Water Conservation, Consumption and Sanitation in Tanzania – What Can We Learn?
Treatment for Water Reuse in Eucalyptus Nursery
Safe Reuse of Treated Wastewater in Large Residential Estates
Irrigation Water Re-use: Harnessing Water for Development by Re-thinking Traditional Concepts of Efficiency and Wastage
SINBAD – Système INtégré de gestion du BAassin pour la réutilisation Des eaux usées pour l'agriculture
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The Impact of Mandatory 40% Water Reduction and Recycling Targets for New Dwellings in New South Wales, Australia 203
Water Tariff, a Tool for Improving Water Use Efficiency through Recycling & Reuse 205
An Analysis of Regulatory and Institutional Economics of Water Use Efficiency in India 207
Investigations into the Role of Land Drainage and Monsoonal Rains in Promoting Waste Water Use in Arid Regions 208
Drought Response – Where Regulation Meets Implementation 210
Experience with Agricultural Reuse of Treated Wastewater in Jordan: Focusing Water Scarcity, Risks of Climate Change and CO2-Reduction

Author: Mr. Sameer Abdel-Jabbar* et al.
* German Technical Cooperation (GTZ), Jordan

Keywords: Jordan, risk monitoring, quality standards, climate change, energy

Introduction/Problem Identification
Jordan is one of the most water scarce countries with appr. 120 m³/a water resources per capita (in comparison to e.g. USA with 6800 m³/a). That results in a serious overuse of the water resources. E.g. the groundwater abstraction is with 400 MCM/a clearly higher than the sustainable rate (appr. 280 MCM/a), what leads to a very serious drop of the groundwater levels. For the future development, the population development (appr. 2.5 %/a = 64% in 20a) will worsen the situation.

Climate change aspects are relevant in two ways: Re-use is an essential adaptation method to tackle the high risk of reduced water availability through effects of climate change (as stated by research projects, e.g. through the so-called “GLOWA Jordan”). On the other hand re-use reduces CO₂-emissions through the reduction of energy-intensive fertilizer-production and electricity generation.

Analysis/Results and Implications for Policy and/or Research
In this situation, the re-use of treated wastewater is an essential method to tackle the problem of water scarcity. Therefore the Hashemite Kingdom of Jordan and the Federal Republic of Germany work together in this field in form of the Development Co-Operation via the German Federal Ministry for Economic Cooperation and Development (BMZ) through KfW-Development Bank and the German Technical Cooperation (GTZ).

Sustainable use of reclaimed water can not be achieved by working on a one-level approach; therefore, a multilevel approach has to be followed to induce change. Levels of interventions address legal, institutional, technical and economic aspects of reuse of treated wastewater in Jordan.

Regarding the technical and economic level, a new project is to highlight, which will enable to re-use the water of three wastewater treatment plants. The decision about the financing (Jordan, Germany through KfW-Development Bank) has been taken and the design is currently under preparation. A new transport line, a final treatment station, instalments for the blending of the treated wastewater, and a hydropower station (for electricity generation) will be constructed.

As main result of the project, additional 15-20 MCM/a (2025) will be available for irrigation in the Northern Jordan Valley. It is planned that the water resource which is currently used for irrigation, then will be used for the supply of Amman – which would lead to additional 20 l/cap/d (2015).

In addition, it is possible to generate electricity: appr. 12 million kWh/a (2015), which represents the electricity consumption of around 10,000 people (equivalent to appr. 9 million kg CO₂/a).

The investment cost is estimated to be appr. 30 million €. Integrating the O/M-cost this results in prime cost of 0.15-0.2 €/m³. In comparison to other Jordanian projects with the goal to generate additional water, re-use can be considered as very cost-effective: The use of the fossil water Disi aquifer...
(currently under construction) leads to m³-cost (investment and O/M) in the dimension of 1 €/m³. Also the use of desalinated water of the Red Sea (currently the Feasibility Study for the so called Red-Sea-Dead-Sea-project is under preparation) is estimated to be clearly over 1 €/m³.

Complementary to the “hardware”, gtz in collaboration with Jordanian partners (JVA, MoA, Universities) have developed agricultural guidelines for farmers and extension workers through which farmers can adjust their fertigation programme to consider the nutrients in treated wastewater. The impact of nutrient content on reducing fertilization cost was assessed by the German-Jordanian water programme through practical demonstration trials with farmers. The results revealed that average farmers can save up to 60% of fertilization cost which in monetary terms is equivalent to 333 €/ha/a (in total 5.6 million €/a) and represents 20% of his yearly net profit. This reduction of approx. 6000 t/a mixed fertilizer equals to the saving of 86 million kWh/a production energy (about 1% of the current Jordan electricity consumption) and a reduction of 11 million kg of CO₂/a emission.

Moreover, and in order to mitigate the impact of health and environmental risks, gtz started by multidisciplinary working team involving all stakeholders in the development of a comprehensive risk monitoring and risk management system aims at identifying not only risks but also effective ways of mitigating adverse impacts of the risks. The anticipated impact of creating this system is efficient and effective monitoring that would prevent the duplication of work which currently exists in overlapping monitoring programmes.

On the legal level, gtz, the Jordanian partners started working on the development of national quality standard for irrigation water that is in line with international criteria to govern the use of reclaimed water. In Jordan there is no standard for irrigation water quality. The proposed standard is in line with the new edition of WHO guidelines issued in 2006 which is more understanding of the socioeconomic situation of developing countries, more flexible and less stringent. The Jordan Valley Authority as the responsible organization for irrigation is supporting issuing the standard that specifies irrigation water quality according to WHO guidelines.

On the institutional level, gtz, the Jordanian partners have succeeded in institutionalization of an effective state crop monitoring system within the Jordan Food and Drug Administration (JFDA) to assure crop safety. This programme will provide an irrefutable proof for decision makers and public alike that reuse of treated wastewater in agriculture has no adverse health impacts and no additional disease burden as it was confirmed by results of crop monitoring. In addition to this it acts as an alert system in case of crop contamination and improves the reputation of Jordanian agricultural produce.
Study on Water Conservation Policy Package Including Wastewater Recycling in Tokyo and the Applicability in Selangor, Malaysia

Author: Ms. Nafisah AbdulRahiman  
Shibaura Institute of Technology, Japan

Co-Author: Prof. Matsushita Jun  
Shibaura Institute of Technology, Japan

Keywords: water conservation package, supply side control, demand side control, analysis on conservation rate, total water resources management

Introduction/Problem Identification

In major cities, rapid urbanization due to population and economic growth generally cause increase in water supply/demand. Furthermore, life-style change encourages per capita water consumption to increase. Governance tends to have policy that support increasing capacity to response to increasing demand. But this requires huge funding and several other problems such as opposition by environmentalist. To overcome the problem, water demand should decrease especially by decreasing per capita water consumption by water conservation. On such basis, this paper focuses on ‘Water Conservation Policy Package’ including Wastewater Recycling (WWR) implemented in Tokyo by Tokyo Metropolitan Government as a ‘universal tool’ to promote water conservation particularly for developing Asian countries. Tokyo is taken as reference as Tokyo had undergone the experience earlier than other major cities in the world which might be a good lesson for policy makers of other nations undergoing rapid urbanization.

Analysis/Results and Implications for Policy and/or Research

Analysis/Results

The ‘Water Conservation Policy Package’ was introduced in Tokyo in 1973 during stabilized economic growth period in Phase 2, where 3 major periods of economic growth in Tokyo that corresponds to water consumption pattern are as follows:

Phase 1 = High Economic-Growth Period (H.E.G.P) – 1965 to 1972: water consumption increasing period
Phase 2 = Stabilized Economic-Growth Period (S.E.G.P) – 1973 to 1992: water consumption stabilizing period
Phase 3 = Low Economic-Growth Period (L.E.G.P) – 1993 to 2007: water consumption decreasing period

The policy package are shown in Annex 1. It indicates that every measures contributes significant amount of water conservation. In total about 81 l/p/d of water consumption reduction in 30 years is realized. Indeed, per capita water consumption reduction could stand at 215 l/p/d or more by the implementation of the policy package which serves as pushing down factors. But due to pushing up factors composed by change of life-style and family structure, contributing 66.8 l/p/d of increment, the actual reduction declined as stated. The relationship of pushing up (P.U) and pushing down (P.D) factors related to water consumption are as follows:

Phase 1: P.U > P.D
Tokyo faced various challenges to implement each measure, however successfully manage to tackle it. Experiences of TMG are as follows:

Due to high water cost, wastewater recycling is successfully implemented in Tokyo especially by industrial sector to reduce cost. After overcoming the people’s perception barrier towards the WWR, Tokyo has advanced system and technology together with subsidy system for WWR. Currently, new building development with area >10,000sq.m must have WWR or RWH, however WWR is preferred by developers except in Sumida-ku as it is more reliable.

The success introduction of SWT devices is due to encouragement and request by TMG to makers to produce such products. TMG also provide their own models base on experiments as guidance for the makers. Thus, makers consider the challenge as their business strategy to produce most efficient type of device in term of water consumption.

For the introduction of cumulative charging system, it involves time barrier where up to 7 years are needed to realize such system as capitalist party during the time are against it due to the worry on effects of it on the economy because the big companies might be affected as they have to pay more corresponds to the water consumption.

For public relation or promotion activities, TMG actively distributes brochures and held campaign to promote water conservation.

From Tokyo’s experience, although they introduced such tool, however they cannot forecast the future of water consumption and have no confident on the success of such tool. Thus, the governance tend to increase water supply capacity corresponds to water demand. Accordingly, Tokyo currently have excess water supply which is waste of government fund.

Annex 1
The ‘Water Conservation Policy Package’ in Tokyo consists of measures from supply and demand side controls together with the amount of conservation are as follows:

Supply side measures:
- leakage reduction (55 l/p/d)
- other non-effective water reduction (20 l/p/d)

Demand side measures:
- introduction of save-water type (SWT) devices – SWT flushing toilet (11.1 l/p/d) & SWT washing machine (20.4 l/p/d)
- effective water usage – in-house WWR (6.7 l/p/d), in-house rainwater harvesting (0.03 l/p/d) and in-factory reduction (8 l/p/d)
- other control measures including public relation and promotion activities such as introduction of cumulative charging system, campaign, etc. (26.6 l/p/d)

Implication of Tokyo’s Policy Package for Selangor (Applicability Analysis)
Leakage reduction and other non-revenue water reduction have been practiced in Selangor but in small scale due to funding problems. WWR has not been practiced so far. This might be due to people’s perception that recycled water is dirty, harmful etc. Moreover, cost constraint could be a barrier as
well. Practice of WWR in Muslim countries such as in the middle-east should be relevant to promote WWR in Selangor. Tokyo’s know-how on WWR also might help.

RWH is preferable in Selangor however the practice is still largely under pilot projects. Tokyo’s know-how could be lesson for Selangor.

For the introduction of SWT device, unlike Tokyo, there is rich-poor gap diversity. The affordability by people to buy SWT devices mainly will depend on the cost. Thus, low-cost devices could be appropriate. Targeting to promote such device to high-income group could be considered.

Cumulative charging system was already introduced, however the cumulative increment are relatively small, thus big consumers still pay less. Such increment should be steeper.

Promotion activities and public relation has been carried out since 2006. The outcomes are still under investigation.
Quantitative Microbial Risk Assessment for Wastewater Reuse in Irrigation and Survey Public Attitude towards Wastewater Reuses in Saudi Arabia

Author: Mr. Abed Alataway
Newcastle University, UK

Keywords: wastewater, risk assessment, microbiology, agriculture, attitude

Introduction/Problem Identification
Many parts of the world face shortage of fresh water. Saudi Arabia (SA) is no exception. Most of the SA is arid and freshwater resources are limited. The annual rainfall is less than 150 mm in most parts of the country. The national water balance estimated for 2010 indicates that demand will be approximately 18 billion m³. Only 4 billion m³ will be available from natural and other renewable resources. More than 80% of water consumed is in the agricultural sector. Therefore, wastewater reuse (WWR) for irrigated practices, contributes as a means of integrated water resources management and also in order to cope with unforeseen future critical conditions that might affect food production. The WWR in agriculture is receiving increased attention in SA due to the scarcity of fresh water. However, wastewater generally contains high levels of microorganisms, which may have adverse health effects on farmers and consumers in addition to public perception of risk associated with the WWR.

Analysis/Results and Implications for Policy and/or Research
The construction of a QMRA model is an essential component of risk management for any recycled water irrigation scheme. The study carried out in Al-Hassa, Saudi Arabia where is a projected wastewater reuse for unrestricted-irrigation to supply farms with irrigated water by opened canals. A decision support tool, which is Recycled water Irrigation Risk Analysis (RIRA), was used to conduct QMRA for recycled water irrigation (Hamilton et al., 2007). The preliminary objective of this study was to determine the concentration of Escherichia Coli and helminth eggs along part irrigation canals. E coli water analysis results for samples that were collected from inlet flow point into the canal do meet the Saudi Water Quality Standards (SWQS). The parameter for the E coli should not exceed 23 colony forming units (CFU)/100 mL for unrestricted irrigation. However, E coli concentration increased with distance and travel time along the main and sub-main canals, and exceed the SWQS. Although the E coli concentrations exceeded the SWQS, The RIRA software indicated that E coli parameters were in the range of acceptable risk according to 1 in 10,000 annual infections. Contrary to the E coli counts, helminth eggs decreased with travel distance in all investigated canals. Helminth eggs results exceeded the SWQS for helminth eggs concentration at the flow discharge point. Helminth eggs results were more than 1 egg/L, and exceeded the probability benchmark for annual infections risk acceptance.

On the other hand, evaluate the perceived risk to farmers and consumers. Two communities have been chosen to conduct questionnaires. One of these community experienced WWR and the other one is not. 500 farmers and 400 consumers from both communities were participated in the questionnaires. Questionnaires revealed that they were not well informed regarding knowledge for nature of wastewater. Although they were in general positive towards WWR, however, their attitude was negative when food related applications were mentioned.
The Dole Banana New Millennium Packing System: A Breakthrough in Optimizing Water Use in the Fresh Fruit Industry

Author: Mr. Rudy Amador* et al.
* Dole Fresh Fruit International Ltd., Costa Rica

Keywords: banana packing, climate change, water reuse, farming community, process redesign

Introduction/Problem Identification

In the past year, Dole/Standard Fruit Company of Costa Rica has been developing an innovative system that is set to revolutionize the process of banana-packing and reduce the use of water by a factor of 10. This document summarizes the evolving process undertaken by the Company to reduce water use, as well as provide a general perspective regarding the importance of these new techniques for water use reduction in an industry that is vital to the economies in dozens of developing countries. Nations throughout the world will need to work together to address adaptation to a changing climate and ever scarcer natural resources. The survival of the fresh fruit industry in the developing world is set to depend on technological innovations such as those developed by Dole and the extension of these techniques to farmers on a global scale.

Analysis/Results and Implications for Policy and/or Research

Developing countries account for virtually all exports of bananas and tropical fruits. The banana is the second largest export fruit product in the world accounting for nearly 20% of fruit exports (nearly 15 million tons) slightly less than citrus. Over 80% of the banana world trade is of Latin American origin with the remainder being produced in Asia, Africa, and the Caribbean. The largest exporters are Ecuador, Costa Rica, Colombia, and the Philippines.

In Latin America, Dole Fresh Fruit International Ltd, a subsidiary of Dole Food Company, Inc., the global leader in fruit and vegetable production and distribution, operates in seven countries producing and sourcing fresh fruit products for export to markets in the United States and Europe. In Costa Rica, the Dole/Standard Fruit Company has pioneered efforts to manage water use in the banana packing process through the development of the New Millennium water project, now transitioning from pilot to commercial implementation.

Bananas are generally a high yield crop with important advantages for producing countries: a year-round crop and a labor-intensive, excellent source of employment. However, bananas can also be a very resource-intensive and are highly dependent on the availability of a key natural resource: water. With few exceptions banana production is undertaken in areas that are water scarce and suffer from aquifer depletion.

Bananas, which are harvested green, are normally subjected to a packing process that requires extensive water use for: cleaning to remove debris and insects from the fruit; a holding medium while the bananas await cluster formation and selection; and to provide a residence time for latex removal, which can seriously threaten the quality of the final product.

Throughout the years the banana packing process and facilities at Dole have undergone important changes. In the past ten years the Company’s assessment of environmental impacts has led to clear
efforts to address the use of water in banana packing, as well as to work with growers to improve water management. The fruit packing process has been evolving and new technologies are currently being implemented that are poised to reduce water use to a bare minimum. This evolution can be grouped into four general technology levels.

Traditional Banana Packing Plant. This system is resource intensive. The packing process is supported throughout by the use of two large pools of water: the de-handing and latex removal tanks, which require a continuous flow of water during a 10-hour period. This can lead to the daily extraction of over 400,000 liters of water from the aquifer or 120 to 150 liters to pack just one banana box, the equivalent of 1 to 1.5 liters of water per banana!

Partial Recirculation. In the early nineties, Dole engineers designed a system (gravel and sand) to filter water from the de-handing tanks and then return the water for reuse. This system saves 30% of the water used in packing, but still requires approximately 100 liters for a banana box or somewhat less than a liter of water per banana.

Full Recirculation. In the late nineties, Dole’s Ecuadorian operation designed a system that allows for full re-use of the packing water after a latex removal, filtration, and chlorination process. This can reduce water use by approximately 80%. Dole financed full water recirculation systems for its grower base leading to the installation of over 120 systems in Ecuador. The concept has been extended to growers in water scarce areas in Colombia, Honduras, and Costa Rica. Results: 18 liters of water per banana box packed, or less than 200 ml of water per banana!

New Millennium Packing System. In 2009, Dole/Standard Fruit Company of Costa Rica completely redesigned the banana packing process with the help of an interdisciplinary team comprised of farm workers, farm coordinators, industrial engineers, and production and quality personnel. A holistic analysis was done focusing not only on packing, but beginning with the actual harvest of the bananas in the field. Ergonomically-designed carts and cleaning tables with a manual water spray system now perform many of the tasks that were undertaken in the traditional packing facilities. The fruit is put upside down on specially-designed latex-removal trays that fit onto a rack which is transported using the traditional cable way system. By the time the fruit reaches the packing location, approximately half the activities required to prepare the bananas for packing have already occurred, dramatically reducing the need for water. Results: just over 8 liters of water to produce a box of bananas, or less than 100 ml of water per banana! Energy use is reduced by over 50%. The total impact of this system if implemented on a regional level: nearly sixty million cubic meters of water used for banana packing could be redirected to provide drinking water to a population of over 30,000 people per year.
Performance Evaluation of Decentralized Treatment & Recycling of Wastewater – An Integrated Approach to Water Management at in Auroville (India)

Author: Dr. Khan Anwar Ali
Government of Uttrakhand, India

Keywords: multi chambered OHT, root zone treatment, up-flow anaerobic treatment, recycle, decentralized treatment

Introduction/Problem Identification
The Sangamam community housing project in Aurovi sets an example of innovative use of water within the community through recycling the wastewater. 3chambers OHT is built to store and supply UG water, recycled w.w and harvested rainwater. Potable water is pumped from a bore well to the topmost container of capacity 50KL. Treated w.w from the STP is pumped to middle container of capacity 15KL. Harvested rainwater from the rooftop surfaces is collected into an over ground lined pond and pumped into the bottom most container of the tank, capacity 15KL. Houses are connected with three separate pipelines one for the supply of UG water and the rest for harvested rain water and treated wastewater. Treated w.w & Harvested rainwater & from the middle and bottom container is used for flushing the toilet, gardening. Rainwater from the roof surfaces is transferred to lined storage pond. STP consists of anaerobic up-flow reactor as a PT and Root Zone Treatment (RTZ) as ST. Maturation pond is for TT.

Analysis/Results and Implications for Policy and/or Research

Results and Discussion
In general the samples for analysis of raw sewage and treated wastewater have been taken every month. Both grab & composite sampling methods were adopted during the period of study & analysis. Also, for several months wastewater samples were collected on weekly basis for analysis by volumetric composite method with respect to the flow.

Tested Parameters were; pH, Total Suspended Solids (mg/L), Total Kjeldahl Nitrogen (mg/L) Chemical Oxygen Demand (mg/L), Biochemical Oxygen Demand (mg/L), Fecal Coliforms (MPN/100 ml).

At the same time, supply & consumption of potable water, treated wastewater and harvested rainwater is also recorded to study the actual water balance Characteristics of raw sewage has been analyzed for both morning and afternoon hours.

Water Balance Study
The supply of potable water and reuse of treated wastewater & harvested rainwater has been recorded to study the actual water balance.
Scenario 1: Before commissioning of recycling system
Scenario 2: After commissioning of recycling system

Before commissioning of Recycling System
As per the actual readings recorded on the Overhead Tank a total consumption of potable water for 30 PE, person equivalent is 6635 lts/day which indicates that the consumption of potable water per person per day is 221 lts/day.
After commissioning of Recycling System
Water has been supplied in two different combinations;

1. Potable water and treated wastewater
   • Potable water supply – 3017 lts/day
   • Treated wastewater supply – 2304 lts/day
   • Total volume supplied = 5321 lts/day for 30 PE

2. Potable water, harvested rain water and treated wastewater
   • Potable water supply – 2836 lts/day
   • Treated wastewater supply – 1170 lts/day
   • Harvested rain water supply – 680 lts/day
   • Total volume supplied = 4686 lts/day for 30 PE

Result – Water Balance Study
• Potable water consumption before commissioning of recycling system is about 221 LPCD
• Potable water consumption after commissioning of recycling system is about 101 LPCD
• Ultimate saving in potable water uses 120 LPCD

The study revealed that the quality of treated waste water from Root Zone treatment system is good enough to directly pump in the Overhead Tank for supply to be reused. Also, if the treated waste water from secondary is allowed to pass into the maturation pond and left for few days before being pumped into the OHT, the color of treated water changes to green due to algal growth.

In this study project, the treated wastewater from secondary treatment unit (Root Zone system) has been directly pumped into OHT for recycling. The average tested quality of treated wastewater from the maturation pond is for pH 7.4, TSS 72 mg/l, TKN 12 mg/l, COD 37 mg/l, BOD 13 mg/l and Fecal Coliform is 1.58 X10^4 MPN.

By recycling of treated wastewater & harvested rainwater consumption of fresh water has been reduced from 221 lpcd to 101 lpcd thus reducing the consumption of fresh water by 45.7%. The cost of monitoring, operation & maintenance of the treatment system has been about 500 US$ per annum which is quite reasonable and affordable to the dwelling population.

The detailed paper will discuss about the design, performance and evaluation of the rainwater harvesting structures, sewage treatment plant units, its efficiency and cost benefit analysis and its acceptability.
Role of Water Reclamation and Reuse in Water Resources Management

Author: Prof. Takashi Asano
University of California at Davis, USA

Keywords: public acceptance, public health, water reuse, water resources management, wastewater treatment

Water reclamation and reuse provides a unique and viable option to augment traditional water supplies. As a multiple-disciplined and important element of integrated regional water resources management, water reclamation and reuse can help to close the loop between water supply and wastewater disposal as well as integrating water and reclaimed water supply functions. More specifically, water reuse accomplishes two important functions: (1) the treated effluent (reclaimed water) is used as a water resource for beneficial purposes, and (2) the effluent is kept out of streams, lakes, and beaches; thus, reducing pollution of surface water and groundwater.

The foundation of water reuse is built upon three major principles: (1) providing reliable treatment of municipal wastewater to meet strict water quality requirements for the intended water reuse application, (2) protecting public health, and (3) gaining public support and acceptance. Whether water reuse is appropriate for a specific locale depends upon careful economic considerations, potential uses for the reclaimed water, and the relative stringency of waste discharge requirements. Public policies can be implemented that promote water conservation and reuse rather than the costly development of additional water resources with considerable environmental expenditures. Through integrated regional water resources planning, the use of reclaimed water provide sufficient flexibility to allow a water agency to respond to short-term needs as well as increase the reliability of long-term water supplies in the region.

The discussions will include water quality changes as shown in Fig. 1 as well as the future of indirect potable reuse with respect to appropriate technologies and public acceptance.

Fig. 1. Water quality changes during municipal uses of water and treatment in a time sequence
Future Water- Reuse and Exchange of Wastewater for Irrigation in the City of Durango

Author: Mr. Miguel Calderon Arambula  
State Water Commission of Durango, Mexico

Co-Author: Mr. Francisco Javier Hernandez Flores  
State Water Commission of Durango, Mexico

Keywords: wastewater, reuse, irrigation, Mexico, water saving

Introduction/Problem Identification

The semi-desertic characteristics of the municipality of Durango and increasingly prolonged drought, have forced state and local governments to generate actions to ensuring drinking water in our city, at least for the next 100 years.

In 2007 the green area of square meters per capita was only 2.6, equivalent to an area of one million 245 thousand 996 m². 75% of this area, was watered by the authority, an annual total of five million 6 thousand 428 m³ and the remaining 25% was irrigated by the inhabitants with drinking water. 12.52 litres per square meter of green area were use daily, only 5% of treated water was used.

Today, this has changed, the “Future Water” and “Durango Green” programmes were designed, programmes aimed at substantially and in a sustainable manner improving the environment. On the one hand an ambitious water infrastructure and sanitation programme was designed, on the other it was linked to a programme to increasing green area that had a guaranteed survival.

Analysis/Results and Implications for Policy and/or Research

The combination of these programmes led to encouraging results. In order to give sustainability to these green areas, the following actions were taken.

1. Construction of automated irrigation systems:

An increase from 5 irrigation systems in 2007 to 35 in September 2009 has been achieved, representing a 700% increase, from supplying to an area of 74 thousand 100 m² to an area of 183 thousand m², which represents an increase of 147%. Today the 35 systems use 403 thousand 862 m³ of treated water per year, a significant drinking water saving. In 2007, there were 18 thousand 339 linear meters of hydraulic infrastructure of irrigation systems, 87 thousand 265 meters linear were added by September 2009, an increase of 476%.

This infrastructure has brought major benefits:

- Savings of up to 60%, in the amount used compared to traditional hose irrigation.
- Automated irrigation is done during the hours of greater usage, resulting in greater efficiency.
- Soil erosion has substantially decreased.
- Life of plants is prolonged.
- Better usage of human and material resources.
- Unprecedented increase of green areas in the City of Durango, from 2.6 m² per capita in 2007 to 4.26 in September 2009.
2. Irrigation capacity increased through water tank trucks.
One of the traditional ways for irrigating green areas of the city has been through water tank trucks. In 2007 the installed irrigation capacity through this scheme was an annual 236 thousand 799 m³ through 7 water tank trucks. By September 2009, the capacity was of 611 thousand 493 m³ per year, through 15 water tank trucks. Acquisition of 8 water tank trucks of different capacities, leading to an increased irrigation of 374 thousand 694 m³ per year, an increase of 158%. It is important to note that today all the water tank trucks irrigate with treated water, representing a significant water use saving. A fundamental aspect of the water tank trucks operation is the filling of tanks for irrigation systems. The increase in water tank trucks made possible the construction of irrigation systems using treated water, besides fountains being filled with non-drinking water.

The city of Durango has 60 fountains, with an annual water expenditure of 32 thousand 136 m³. Eight of the 60 fountains no longer use drinking water, representing a saving of 10 thousand 504 m³, a saving of 33%, as the fountains of greater capacity were selected. This improvement started in 2008, has led to a change in the citizen awareness, citizens have modified their habits on water use.

4. Fountain water reuse.
Thanks to the modernisation of water infrastructure for irrigation, a constructive practice with environmental impact has started by interconnecting the existing fountains, in gardens and avenues, to the irrigation systems, which allow removing when needed, the water from the fountains to be conducted to the irrigation systems in order to prevent this water to be wasted in the sewage. Of the annual 32 thousand 552 m³ of water used for the fountains, 19% has been incorporated under this scheme, representing six thousand 84 m³ per year. Moreover, 91% of the drinking water used in the fountains is equivalent to 29 thousand 622 m³ per year and reused for urban irrigation, it is not sent to the sewerage but extracted by the water tank trucks and used for landscape irrigation.

5. Reuse of treated water from Wastewater Treatment Plants (WWTP) located in boroughs.
There are 5 treatment plants providing service in 5 boroughs. These plants have an installed capacity of wastewater treatment of 114 thousand 272 million m³ per year, 34% equivalent to 382 thousand 608 m³ per year. All this in an area of 9.2 hectares. The remaining 731 thousand 664 m³ are used for agricultural irrigation, which finally results in a substantial drinking water saving.

6. Artificial lakes and fountains water use for green areas irrigation.
The city has three public parks with a total area of 85 hectares of which 65 thousand m² of green area is irrigated once a week with 25 thousand 800 m³ of water annually, from a artificial lake as well as from 15 fountains and 5 pools, this with the aim of reusing this water. This water saving has enabled to start an ambitious reforestation project in 81 acres of these parks, where it is intended to plant along the year, four thousand pinaceas trees endogenous of the region.

7. Treated water reuse for agricultural irrigation.
Of the 654 thousand received at the WWTP, one thousand 550 are for the Irrigation District 052 and used in agricultural irrigation thousand 500 hectares, generating drinking water savings of 42 million 573 thousand 600 m³ per year, that are prevented from being extracted from the aquifer of the Valle del Guadiana, based on the agreement with the members of the Irrigation District. Benefits to both reducing the overexploitation of the aquifer and for the rural development in the state.
Incorporation of Water Recycling and Reuse into Regional Water Supply Strategies – An Integrated Water Management Policy from Queensland, Australia

Author: Ms. Carolina Casaril
Queensland Department of Environment and Resource Management, Australia

Co-Author: Mr. Richard Priman
Queensland Department of Environment and Resource Management, Australia

Keywords: strategy, policy, reuse, security, climate variability

Introduction/Problem Identification
Water quality and water use are inextricably linked. This is recognised worldwide through the application of total water cycle planning concepts to water resource management, water quality frameworks and the provision of water services including water supply, wastewater, recycled water and stormwater. This paper highlights how Regional Water Supply Strategies in Queensland, Australia, incorporate the total water cycle planning concept and face the challenge of integrating the management of water quality with water quantity.

Regional Water Supply Strategies (RWSS) are currently being developed for 7 regions in Queensland to meet water needs until the 2050s. RWSS look at rural, urban, industrial and environmental water needs; including all aspects of the water cycle: surface water, groundwater, storages, runoff and discharge, recycled and greywater and desalinated water.

Analysis/Results and Implications for Policy and/or Research
RWSS analyse future water demand and supply, identify risks and shortfalls and provide solutions for implementation including guiding new policy. Recent changes in climatic trends have severely impacted water security in QLD. Long term increases in temperature and evaporation, overlayed with variability beyond the historical record, has put strain on water supplies compromising our ability to manage our aquatic ecosystems sustainably. Previous water reliability indicators have failed to adequately represent water supply security and environmental needs. The management frameworks and tools surrounding water allocation, environmental flows and reliability measures, are being influenced by the need for a new performance indicator: the Level of Service (LoS). Inclusion of LoS considerations will potentially enhance the allocation and management framework and our ability to maintain high water quality and ecosystem health while providing safe and secure water supplies for the future.

Advanced characterisation of the reliability of water resources is pushing innovation in modelling the highly variable inflows of Australian rivers. An improved understanding of the likely statistical performance of storage behaviour beyond historical experience is being achieved using innovative combinations of stochastic modelling techniques, downscaled climate change factors and trigger levels for drought response. Recent achievements include collaboration with CSIRO and QCCCE to downscale climate change projections by region, and feed this into Integrated Quality and Quantity Models (IQQM) to determine potential impacts of climate change on future end-of-system flows and runoff into streams and storages.

This information is being used to guide water supply security assessments when formulating Water
Resource Plans (WRP) and to assist derivation of operating rules incorporated into Resource Operations Plans (ROP), which dictate the day to day operation of rural and urban water users. Comprehensive assessments of river system health and potential impacts of increased water extractions guide the preparation of WRPs and ROPs, which underpin water allocation and seek to balance environmental, social and economic outcomes. Impact assessments include water quality, aquatic biodiversity and potential climate change impacts on stream flows. WRPs and ROPs are the foundation upon which water use efficiency, recycling and reuse can be used to increase water security and maintain water quality.

In RWSS, sustainability is promoted through water reuse/recycling and water demand management in rural and urban water use efficiency initiatives. A recent achievement for QLD is the completion of the SEQ water grid; a concept that will be expanded across the state. It embodies the saying ‘turn the rivers around’ by linking existing storages as well as returning wastewater and desalinated water to the head of the catchment. The SEQ grid involved the construction of the 125ML/day Tugun desalination plant, an extensive pipe network linking existing and new impoundments, and Advanced Water Treatment Plants for purification of wastewater. Recycled water is taken to power stations and other clients, after being treated on a fit-for-purpose basis. Desalinated water supplements the system and, in case of severe drought, purified recycled water can be added to potable water supplies via a 7-step barrier process. New legislation was developed to ensure water treatment reaches the highest possible standard. The management of the water grid includes triggers for restrictions and other drought response measures. During the Millennium Drought, residential water usage was cut from over 300L/p/d to less than 130L/p/d. Permanent water saving measures are now widely accepted, and community education and cooperation was central to this success.

In collaboration with local government, stakeholders and industry groups, RWSS are also exploring solutions in demand management. Analyses of current water consumption patterns allow region specific scenarios of demand management measures to be developed. Other advantages are also weighed, such as greenhouse gas emission reduction. Important management initiatives focus on water recycling and reuse at a variety of scales. Away from the urban umbrella, important new thinking is occurring in rural water use efficiency, from research into evaporation reduction to innovative crop management techniques and technologies.

RWSS undertake a broad number of assessments, collaborate with scientific bodies, promote innovation in water efficiency management, and foster community involvement in securing clean water at an acceptable Level of Service. This is improving the way water is allocated and managed and benefits water quality and ecosystem health. Where the quality and the quantity of water resources are so inextricably linked, maintaining a healthy water cycle is the only way of ensuring sustainability in water management.
Sustainable Sanitation for the 21st Century: A Source Book for Capacity Building

Author: Dr. Jan-Olof Drangert* et al.
* Linköping University, Sweden

Keywords: capacity building, sustainable sanitation, reuse, futures research, recirculation

Introduction/Problem Identification
Urbanisation, population increase and expanded production place improved sanitation in the lead of recirculation of used matter. The source book addresses the fundamental links between sanitation, water, agriculture, energy and climate in response to present global changes. It provides new ways of thinking about sustainability and material flows through society. The focus is on the urban household sector.

Analysis/Results and Implications for Policy and/or Research
The potential to increase recirculation involves a combination of activities: to encourage non-polluting content of products, keeping flows separated, and treating each flow close to the place of use. This short-loop approach identifies possible improvement in the life-cycle of materials from cradle to grave. Best-practice methods are suggested to address strategic and project-level implementation options. The aim is to expose professionals to a wide range of sanitation options. The source book gives input to a problem-based learning.

The leading idea is to achieve sustainable sanitation solutions to protect the environment and human health. The positive message is that there is no scarcity of urban water or nutrient resources for food production – only poor management of the available resources.
Water Reuse in the End Point of Nile Basin: The Risks and Opportunities

Author: Ms. Nagwa ElNwishy
Biotechnology Research Center, Egypt

Keywords: water management, recycling, fish, affordable technologies, integrative farming

Introduction/Problem Identification
In Egypt, irrigation represents up to 95% of water uses and plays a major role in the national food security. Meanwhile, being the end point of the Nile Basin gives Egypt limited share of Nile water which varies annually. Thus, national strategies emphasize the possibility to maintain, improve water resources use. Some strategies may generate tensions among Nile basin countries down and upstream. Thus, water reuse approaches and policies were encouraged.

One of these approaches is recycling water. Farmers indigenously practiced water recycling by reuse of agriculture wastewater in/with fish farming, but it lead to environmental risks and human health problems. Currently, it is developed by biotechnology and biochemistry involvement.

Yet, for a small stockholder like farmers, such technologies are unaffordable. For such farmers, the concept of environment protection and climate change mitigations becomes insignificant if it affects the farmer’s financial stability.

Analysis/Results and Implications for Policy and/or Research
The objective of this work was to develop a simple affordable method for waste water recycling in integrative agriculture – aquaculture. A methodology which can be economically applied mainly by small stakeholders like farmers. This can enforce its wider application and ensure economical and environmental benefits.

A micro climate experiment was designed; tilapia fish (Oreochromis niloticus) of 3.3 ± 0.6 g were stoked in an aquarium (Q1) with a stock rate 611/m³. It was provided with water. Other tilapia 20.3 ± 0.53 g were stoked in two glass aquaria to 185 tilapia fish/m³ stock rate; One aquarium (Q2) was provided with the waste water of (Q1), another aquaculture (Q3) was provided with the waste water of (Q2). Finally 110 ±11.2 g catfish (Claris gariepinus) were stoked in another aquarium (Q4) and was provided with the waste water of (Q3). Fish were brought from “Fish Research Center of Suez Canal University” and fed according to Eurell et al., 1978. Oxygen was maintained in all aquaria by aeration pumps, water temperature was adjusted at 28 ºC, and water was changed each 10 days. 4 different plants have been irrigated with the final filtered waste water (F1) and other replicates of the plants were irrigated with the collected filtrates of all waste waters (F2). Plantation period was 4 months. Analysis of water (Q1, Q2, Q3 and Q4) and soil in all irrigated plants were made; Ammonia content according to (Page et al., 1982), Total Nitrogen and Organic matter content according to (Richards, 1954) and statistically analyzed by Statistical analysis of results by multivariate ANOVA SPSS 13 at (P <0.05) revealed remarkable significant increase in organic matter content, total nitrogen, and (NPK) in (F1) and in the irrigated soils. The increase of the water and soil content were higher than those reported by ElNwishy (2008) where water was recycled twice in two fish species. The production was significantly higher in all plant species irrigated with F1 than the ones irrigated with unrecycled water. Fish did not show any negative behavior or appetite. Growth was in the normal averages. No diseases
or death of fish was observed when reared in the recycled water. However, fish in Q3 showed less appetite, they were seen at the surface of the water occasionally. This indicted a lack of respiration ability, mostly as the amounts of ammonia in the water were higher than standard. The occasional surface swimming was not observed any longer when the aeration was increased in the aquaria.

Increasing the number of recycles may cause potential diseases and decrease of fish production and quality. Additional recycling process may require chemical and/or biological treatments.
Water Resources Management Efficiency in Uzbekistan

Author:  Dr. Abror Gadaev* et al.
*Samarkand State Architectural and Civil Engineering Institute, Uzbekistan

Keywords:  water resources, ground waters, Aral Sea issues, irrigation and water supply, water reusing technologies

Introduction/Problem Identification
Uzbekistan and other Central Asian countries are struggling to come to terms with an ecological disaster affecting the Aral Sea. The crisis has been brought about by the mismanagement of water resources from the Aral’s main tributaries, the Amudarya and the Sirdarya rivers. Agricultural irrigation systems have caused high pollution levels in the region’s (unevenly distributed) surface waters. Historically water flow the Aral Sea was 56 km³ per year, which decreased to 47 km³ between 1966 and 1970. Water flow plummeted to 2 km³ between 1981 and 1983, and now stands at less than 1.8 km³. A key question is how to balance social and economic development with natural resource protection. Central Asian Republics utilize the same watersheds and share many water management issues in common.

Analysis/Results and Implications for Policy and/or Research
The Central Asian region has been designated in recent years as an ecological and social disaster zone because of Aral Sea situation. Although water resources are not a new issue, this problem can be traced back to the beginning of civilization for a number of reasons. The growth in water consumption is connected to cultivation of new irrigated territories, where mainly cotton and rice are grown. That issue combined with the increase in the population and employment in agriculture, the flow of water to the sea from the two major river systems -the Amu Darya and Syr Darya – completely stopped. By the beginning of the 20th century, 7-8 million people lived in the region. Irrigated lands made up about 3.5 million hectares and had irrigation networks of different levels. It was the foundation of society’s economic base. At present the population of the region has increased 7 times, exceeding 50 million people. In response to the increase in population, irrigated lands have doubled (7.5-7.9 million hectares). In the climate of the Aral Sea region, 60 cubic km per year would be needed to keep the surface. Area of the Aral Sea at approximately 60 000 square km. The water has stopped completely. From 1930 to 1960 there has been a sharp increase in water usage from 25 km³ to 103 km³ a year. The quantitative facts alone show the high usage rates for improper reasons coupled with less potable water for health incentives. The improper use of the water taken from the Aral Sea has led to many consequences that the interstate commission is trying to resolve. Unfortunately since the departure of the USSR, central Asian economies have not been strong enough to rehabilitate the productivity of the territory. Socially these include protecting the population from adverse impacts of desertification, creating new workplaces and job markets and trying to improve the economic and social conditions by introducing new water efficient technology. Ecologically, each country must implement new plans for the restoration of flora and fauna diversity and the prevention of any further degradation of the Aral Sea. In particular, improving irrigation efficiency, water supply development, waste water treatment and watershed management are critical needs throughout Uzbekistan and Central Asia. An additional problem is the regular failure of the region’s groundwater systems during the summer (when the demand sharply increases), so that the population is left to consume poor quality surface water. In jeopardy is the health of the region’s entire population. Infectious intestinal diseases, often caused by the contaminated drinking water, are a primary challenge facing water specialists is to balance the competing demands of sending more water to the Aral Sea and simultaneously meeting the water
supply and quality needs of a developing economy and growing population. The proposed program delivers advanced operational training via activities which develop self-initiative and problem solving skills to prepare students and industry professionals for meeting these needs.

What is the conclusion: Improving the situation in the region is possible by increasing water resources management efficiency with the main focus on ground waters. This option is more realistic by ground waters purification and demineralization because the quality doesn’t meet official water standards. The second option involves the implementation of more modern irrigation techniques. Although modern irrigation technology would be a positive, financial resources tend to hold this project back. In addition because of this, the training of people would be difficult to provide. Researchers estimate that complete renovation of irrigation systems on 6 million hectares could save about 12 cubic kilometers a year but would cost about 16 billion in US dollars. Although water is conserved, the funding is far beyond state and international funding. The third option is reusing traded water. This would also include additional resources because all participating countries would need to develop several wastewater treatment plants. Most rural populations do not have access to safe water; water treatment plants would indefinitely aid many citizens. This would help with water supply and irrigation. The first plan of prevention would be to take away certain government monopolies on items such as cotton, gold, oil and silk. Although there have been improvements made such as the creation of the Water Users Association in 2003, there are still disagreements on the water policy. These agreements between farmers and the government only perpetuate the issue of water resources. These agreements are at the heart of water resource issues and should be addressed. In addition, there needs to be improvement on the interstate cooperation of water management.
The Removal of Pharmaceuticals, Endocrine Disrupting Chemicals and Microbial Pathogens for Water Re-use Purposes: A Groundwater Recharge Case Study

Author: Ms. Bettina Genthe
CSIR, South Africa

Co-Author: Ms. Maronel Steyn
CSIR, South Africa

Keywords: groundwater recharge, removal of emerging pollutants, risk assessment, wastewater reuse for drinking, water management tool

Introduction/Problem Identification
In South Africa, the semi arid conditions together with a lack of major surface water systems makes the reuse of wastewater for potable purposes essential. Of growing global concern is that re-use of wastewater does not cause harm to human or environmental health. The town of Atlantis (50 km north of Cape Town in the Western Cape, South Africa) augments its water supply with an artificial recharge scheme. This scheme pioneered the application of artificial groundwater recharge as a water management tool for bulk water supply in southern Africa. After secondary treatment of domestic wastewater, the effluent is polished in a series of maturation ponds and blended with the urban storm-water runoff before being discharged into the main recharge basins. Since its inception over thirty years ago the groundwater has been monitored for the typical water quality indicators used internationally. This study examined the removal of emerging pollutants in the water treatment and recharge chain.

Analysis/Results and Implications for Policy and/or Research
This is the first study to examine the removal of both pharmaceutical and endocrine disruptors in the water treatment and recharge chain as well as pathogen removal and to carry out a risk assessment on the process.

A number of commonly used drugs were tested for in the process chain using solid phase extraction methods. These drugs include antibiotics, psychoactive drugs and X-Ray contrast medium, and more specifically: sulfamethoxazole, carbamazepine, dihydrodihydroxy, iopromid, iohexol, ibuprofen, diclofenac, temazepam, codeine, oxazepam, and diazepam. Oestrogen mimicking activity making use of the Yeast Estrogen Screening test was also measured along the process chain, as well as microbial pathogens.

Microbial water analysis was done for selected indicator as well as pathogenic microorganism groups. The human health risk assessment and management study made use of actual pathogen removal results as well as surrogate indicator microorganism removal to understand how to best manage the recharge scheme to protect human health. The selected indicators included: E. coli, Total coliforms, total bacterial counts. Surrogate pathogen counts, namely E coli representing bacterial pathogens, Clostridium representing parasite pathogens and coliphages representing viral pathogens, were used in addition to the analysis for actual pathogens for the risk assessment process.

The bacterial counts at the various points in the system illustrate the importance of the subsurface passage as a safety barrier in the system. It was found that not only the indicator organisms follow
this pattern but also the pathogens, including viruses follow a similar pattern of log-reductions to provide the necessary safety margins for the recycling system. The highest counts were observed in the winter which is the rainy season in Atlantis.

Maximum total coliforms were in the order of 105/100 mL. The absence of microbes or low microbial numbers found in the groundwater may be as a result of filtration of the poorer quality recharge water. It may also be as a result of natural die-off of the microorganisms.

Another important factor is that the storm water tended to have higher microbial counts than the treated wastewater effluent. This has implications for the management of the water scheme.

The trace organic compounds and pharmaceuticals show a significant decrease through the treatment system and the subsurface passage. Although some degree of degradation or adsorption on the geological material in the subsurface is expected it would seem that most of the reduction could be ascribed to dilution, particularly in the case of sulphamethoxazole, carbamazepine, dihydro-dihydroxy-carbamazepine, and ibuprofen. All of these are present at low levels in the abstracted groundwater. In contrast, the compounds iopromide, iohexol, and diclofenac, are not present at measurable levels in the abstracted water. Artificial groundwater recharge ensured the sustainability of the Atlantis water supply over nearly three decades and will continue to play a key role.

The Atlantis wastewater and storm water recycling system seems to be quite robust from a water quality point of view. Indirect recycling of storm water and treated domestic wastewater augments the limited groundwater supplies in a publicly acceptable manner. Water quality management remains the dominant issue regarding water supply at Atlantis. Separation of source water into different fractions allowed recharge of the highest quality water in the areas of importance for the production well field. The final water following artificial recharge with wastewater was found to be of good quality with no pathogens, and no oestrogen mimicking activity detected and most chemicals at below the detection level. A quantitative risk assessment was carried out to assess the existing barriers and identify weak links within the system. This risk assessment process allowed the identification of the importance of the aquifer in the re-use treatment chain.
Problems and Potentials of the Waste Water of Oworonshoki, Lagos-Nigeria

Author: Mr. Chinemerem Godwin
Ebonyi State University, Nigeria

Co-Author: Mr. Chidubem Uchechukwu
Ebonyi State University, Nigeria

Keywords: Oworonshoki, pathogenic organism, irrigational farming, water analysis, nutrient

Introduction/Problem Identification
Oworonshoki waste water, notorious for its characteristic brownish-black colour and uninviting appearance, is daily polluted with human wastes, industrial wastes and refuse. The people around depend on it for their fishing, irrigational farming and transportation activities as they are mostly fishermen, farmers, canoe paddlers and traders. The water is very important as it extends to the Lagos Lagoon which empties into the Atlantic Ocean. It is also associated with the Lagos Third Mainland Bridge, the longest bridge in West Africa.

Analysis/Results and Implications for Policy and/or Research
Analysis conducted on the water revealed that it contains a high load of pathogenic organisms (helminthes and bacteria) and it is very rich in nutrients (nitrogen, potassium, phosphorus, sulphur, calcium, magnesium, sodium and chloride), zooplankton and phytoplankton. The use of the water in its untreated form for irrigational farming expose agricultural workers and consumers to various infections like helminthiasis, bacterial diarrhea, dysentery, typhoid, cholera and hepatitis. The water been rich in nutrients, serves as fertilizer to the irrigated soil hence, the farmers have no need for fertilizer. Also the water been rich in biodiversity, provide a wide range of sea foods for the people. The water was found to be suitable for the commercial cultivation of economic important algae which can be used in the production of biofuel, drugs, cosmetics and other chemicals. Establishing close collaboration between the public health authority and resource management agency, will greatly assist in mitigating the problems and maximizing the potentials of Oworoshoki waste water.
Importance of Wastewater Reuse as Management Strategy in the Basin of Mexico

Author: Dr. Eugenio Gomez-Reyes
Metropolitan University, Mexico

Keywords: management, method, balance, metropolitan, policy

Introduction/Problem Identification
The rapid rate of urbanization has far exceeded the management and financial capacities of all levels of governments of the Basin of Mexico. Water availability has become a growing threat to achieve sustainable development of one of the most population density centers of the word, the Mexico City Metropolitan Area. Hence there is a need for an effective water management strategy to increase availability. Accordingly, water authorities are looking and pursuing several options to augment water supply, including wastewater treatment and reuse. Since it is considered these strategies of the same relevance for a substantial increase of water availability, application of a variety of water management policies are are resulting in a serious adverse economic, social and environmental impacts on the region. Unless there is an identified strategy that concentrates water authority efforts to improve water availability, present water management policies will continue demand higher investment costs.

Analysis/Results and Implications for Policy and/or Research
In this paper is presented a method that aids to identify the most significant strategy to improve water availability in the Basin of Mexico. It turns that wastewater reuse became an essential component of basin strategies for integrated water resource management whilst securing water for population growth and economic development. Once the main strategy to improve water availability is identified, it became clear the priority order applications of water management policies to achieve sustainable development in the Basin of Mexico.

The method consists in considering all input, output and internal rates of hydrological processes that take place on the surface water basin, and to establish a relationship for these processes that allows assessing the relevance of terms associated to water resources management. The relationship came through the principle of mass conservation and the algebraic handling reveals expressions which can be used to evaluate water management strategies and to address questions such as: To what extent can wastewater reuse be incorporated into integrated water resources management strategies?

The method can be applied to any water basin. In the case of the Basin of Mexico it was found that importation vs. exportation of water from and to other neighbor basins can accounts for the deficit of water supply to the Mexico City Metropolitan Area, and for much of the water volume required to compensate the large extractions rates of water from the aquifer system. Hence, the balance of water fluxes across the boundary basin becomes a crucial strategy to achieve sustainable development in the Basin of Mexico.

Importation of water to the Basin of Mexico is achieved through an aqueduct that brings water from two southwestern neighbor basins the Lerma River and Cutzamala System. The exportation is accomplished through the basin’s drainage system that delivers water to the northern neighbor basin of Tula River. Hence, a reduction of the wastewater transported to the Basin of Tula River ought to be conducted to achieve the balance of water fluxes across the boundary basin. Consequently, a strategy...
to improve water availability in the Basin of Mexico derived from this analysis consists of the reten-
tion and reuse of wastewater in the basin.

Specific water management policies may be instrumented attending the characteristics of the com-
bined drainage system of the Mexico City Metropolitan Area: (1) 100% of sewerage treatment, and
(2) 100% harvesting of rain water. Further water management policies are to be related to the reuse
of the treated wastewater to achieve sustainable development in the Basin of Mexico, v.gr., enhance
aquifer recharge, replacement of drinking water for irrigation and industrial use.
Technological Solutions to Improve Water Use Efficiency in Delta Areas Prone to Salinization

Author: Mr. Jan A.M.H. Hofman* et al.
* KWR Watercycle Research Institute, The Netherlands

Keywords: wastewater reuse, desalination, salt sensitive crops, water use efficiency, deltaic areas

Introduction/Problem Identification
Deltaic areas have provided fertile grounds for food production for many ages. Increasing population requires increased crop yields leading to increasing water demand in these areas. At the same time, climate change will increase the salinization rate of these areas. Increasing sea levels will lead to seawater intrusion via river mouths, and to increased seepage of brackish or saline groundwater.

To reduce the effects of salinization, fresh water is required to flush the water system and dilute chloride concentrations in the surface waters used for crop irrigation. In many cases the salinity of the surface systems is controlled by flushing with fresh water, supplied by upstream rivers. Increasing seawater intrusion in the river branches in the delta will enhance salinization and reduce options for flushing the local water system (external salinization). In other cases e.g. the Nile River, almost all fresh water provided by the river is directly used for irrigation.

Analysis/Results and Implications for Policy and/or Research
In the Southwestern delta area of the Netherlands a similar situation is present. However, after a catastrophic storm surge and flooding in 1953, most sea branches were closed by dikes for flood protection. The sea branches were converted to fresh water lakes, used to flush the local water system on the islands in the delta. But, although sufficient fresh water is available at the moment, this situation is not very efficient in water use: less than 5% of the water used to keep the water system fresh is used for agriculture. Because the lake areas in the delta are suffering from algal blooms (cyanobacteria), it was decided to turn most of the lakes into salt water systems again. Also due to land subsidence and sea level rise, internal salinization is expected to increase. To keep the possibilities to grow salt sensitive crops in the area, new fresh water sources have to be found or desalination has to be applied.

In the paper a case study of the island Goeree-Overflakkee is presented. The major salt sensitive crops on the island are cichory roots and flower bulbs. These crops rotate annually on the island to prevent soil exhaustion. The growth season of these crops is between March and June. In that period, spray irrigation is applied, taking water from the local water system. Progressing salinization would require increased flushing of the local water system, further reducing the water use efficiency. As alternative solutions for local freshwater supply, the following options have been considered:
- Sewage Treatment Plants (STP) effluent reuse
- Local desalination
- Import river water from upstream through an aqueduct

The annual production of sewage effluent (6 million m$^3$/y) on Goeree-Overflakkee is almost equal to the water demand of the cichory and flower bulbs (5 million m$^3$/y). However, since the growth season is only 3 to 4 months, a large storage facility and local distribution of the water stored to the crop fields is required. Storage tanks for this huge amount of water are extremely expensive and not feasible. Water storage in underground aquifers however could be an economically feasible solution.
An additional advantage of using STP effluent is that the organic load (COD) in the sewage water can be used to produce energy. Also phosphate recovery from the wastewater is possible. Estimations show that more than sufficient phosphate is present in the wastewater to support the growth of the cichory and flower bulbs. This means that a self-sufficient situation can be created in terms of water use, nutrients and energy demand.

A second alternative is local desalination. In this situation, a mobile desalination unit placed in a container can provide water to the fields, using water from local (brackish or saline) sources (surface water or groundwater). The advantage is that fresh water can be used for other applications as it is no longer required to flush the water system. This will increase water use efficiency. By making the desalination units mobile, the system can move along with the crop rotation. By using wind or solar power supply to the units a sustainable solution can be created. The membrane concentrate will be disposed of in the local (brackish) water system. If the recovery of the desalination unit can be kept low, which is no problem if sustainable energy is used; the chloride concentration in the brine solution will have no significant effect on the surface water quality.

The third alternative would be to import fresh water from upstream by a large pipeline or aquaduct. Financial and spatial considerations make this option less attractive.

The paper will provide more detailed information about the three options and their feasibility.
Recycling and Reuse of Wastewater on the Maintenance Lines of Indian Railways

Author: Mr. Anshuman Jaiswal
The Energy & Resources Institute (TERI), India

Keywords: conservation, railways, recycling, water demand, wastewater

Introduction/Problem Identification
India stands ‘water stressed’ and is already near to being categorized as ‘water scarce’. Uneven distribution, inadequate supplies and increasing demand from various sectors (viz. agriculture, industry, domestic) along with pollution has put tremendous pressure on the water resources in various parts of the country including the National Capital Territory of Delhi that faces a crisis of water availability with significant depletion of its groundwater.

In the prevalent water stress, Indian Railway’s New Delhi Railway Station faces a major challenge of availability & quality of fresh water needed to cater the rising fresh water demand of over 208 trains, 400 thousand daily passengers, platforms, maintenance yards and washing lines. This paper seeks to highlight opportunities for conservation and efficient management of fresh water at railway stations by designing a model for recycling and reuse of wastewater with a potential for replicability.

Analysis/Results and Implications for Policy and/or Research
The New Delhi Railway Station (NDLS) had consumption of about 1.15 MLD of freshwater at its washing lines for washing purposes and the generated wastewater was mixed with the sewage and drained as waste. Primary aim of this project was to assess the amount of wastewater being discharged at these washing lines and design an appropriate recycling system to conserve and utilize this water otherwise being discharged as waste.

The project approach involved:
• Estimation of the present & future water demand and the gap within.
• Estimation of wastewater generation at washing line
• Assessment of water quality for wastewater and freshwater streams
• Identification & designing of appropriate and cost effective wastewater treatment & recycling system for selected washing lines.

Identification of Demand Supply Gap
The primary flow monitoring, secondary data and the demand supply situation analysis showed that NDLS had a supply of 5.6 MLD as against the demand of 8.5 MLD leading to a demand-supply gap of 2.9 MLD which was expected to rise further to 4.6 MLD in the future, due to expansion activities. Thus the fresh water demand far exceeded the availability at NDLS.

Proposed solution: Wastewater recycling system
Various options were evaluated for fresh water management and wastewater recycling was found to be a viable option to reduce the fresh water demand supply gap since the water use at washing lines was as much as 25% of the total fresh water use at NDLS.

It was proposed to set up a pilot recycling system at a cluster of washing lines (namely 3, 4 and 5) which
could be later replicated for other washing lines at NDLS. The scheme broadly included tapping the wastewater generated from washing lines before it falls and mixes with sewage, treating it to desired quality and choosing cost effective technology to recycle & reuse about 85-90% of wastewater.

**Design considerations:**
Capacity: Through the detailed primary flow monitoring at the selected cluster of washing lines, the per unit water consumption was estimated (1870 litres per coach), and using the maximum utilisation capacity of washing lines (170 coaches) the design capacity was estimated to be 0.3 MLD.

Wastewater quality: Wastewater samples were collected and analysed for essential parameters such as pH, COD, BOD, TSS, TDS, Nitrate-Nitrogen, Oil & Grease and Detergents using standard methods. Further, considering the critical parameters (such as BOD, COD, TSS and Oil & Grease) appropriate treatment technology for wastewater recycling and reuse was selected.

**Treatment options:**
With an objective to choose a technology that ensured higher number of cycles of concentration, less maintenance and financial prudence, several technologies were evaluated for the selected washing lines. These included the
- Biological treatment-Activated Sludge Process: with potential for recycling about 85 to 90% of water with 6 to 7 cycles of concentration and a capital & annual recurring cost of INR 41 Lakhs and 8.97 Lakhs respectively.
- Membrane Bio-Reactor: with potential for recycling about 95% of water with 6 to 7 cycles of concentration and a capital & annual recurring cost of INR 70 Lakhs and 16.36 Lakhs respectively.
- Physiochemical Treatment: with potential for recycling about 50% of water with 2 cycles of concentration and a capital & annual recurring cost of INR 35 Lakhs and 5.5 Lakhs respectively.

Of the above mentioned treatment options, the biological activated sludge process, which had the desired high recycling potential yet financially most attractive, was adopted for NDLS.

**Cost benefit analysis:**
The cost benefit analysis was conducted by comparing the cost for procuring water from Ranney well and from the wastewater recycling system taking into account the annualised capital cost and running/O&M costs. This revealed that sourcing water from Ranney well was not a sustainable option. Further, the per kilo litre cost of water falls from INR 11 to INR 7 when the size of the water recycling plant is increased from 0.3 MLD to 2.5 MLD which is the required capacity of recycling system for the entire washing lines of NDLS. Hence the wastewater recycling option emerged as both technically and financially sound alternative.

It was estimated that implementation of the recycling system will lead to saving of around 0.23 MLD of water at one cluster of washing line (when operated at 80% capacity) alone. Further, recycling the wastewater from all washing lines would save about 1 to 2 MLD of water which can meet almost 45%-60% of the demand supply gap for potable water by reducing fresh water requirements.

Wastewater recycling at washing lines has a huge potential to reduce water demand in Indian railways and has not been explored and practiced across India as yet. Utilizing such model across the country would improve the water situation across the sector and strengthen the water policy of India that promotes water conservation through recycling and reuse.
Present Situation on the Reuse of Wastewater for Irrigation in Developing Countries

Author: Dr. Blanca Jimenez* et al.
* National Autonomous University of Mexico

Keywords: wastewater reuse, food security, nutrient recovery, livelihoods, policies

Introduction/Problem Identification

This paper presents a summary of information collected from different countries in the developing world where wastewater reuse is either controlled or non-controlled. It describes the advantages and disadvantages of both situations. The paper also contains the official perception of the use of wastewater and guidance is presented for the development of proper policies in different developing countries.

Analysis/Results and Implications for Policy and/or Research

Present situation on the reuse of Wastewater for irrigation in Developing Countries
Blanca Jiménez(1), Pay Drechsel(2), Doulaye Koné(3), Akiça Bahri(2), Liqa Raschid-Sally(2) and Manzoor Qadir(3)(4)
(1) MEXICO
(2) IWMI
(3) Water Operators Partnership (WOP-Africa) African Water Association (AfWA)
(4) International Center for Agricultural Research in the Dry Ares

This paper presents a summary of information collected from different countries in the developing world where wastewater reuse is either controlled or non-controlled. It describes the advantages and disadvantages of both situations. Historically, the use of wastewater (and even excreta) has been a widespread practice in many countries. For some developing countries it continues to be common practice as a result of cultural background, while in others it simply results from a combination of factors, notably the lack of sanitation and water availability.

In the literature, there is no comprehensive global inventory of the extent of the use of non-treated wastewater for irrigation. This is mainly due the fear of publicly recognizing what is perceived as an objectionable practice; However, WHO (2006) indicates that there are at least 20 million ha irrigated in this manner globally. This area is equivalent to 7 per cent of the total irrigated land in the world and is 10 times greater than that irrigated using treated wastewater. In order to reduce the risks created by the uncontrolled reuse of wastewater for irrigation, greater attention needs to be given to developing public programmes to progressively move from an uncontrolled situation to a controlled one. In doing so the advantages already observed by numerous users of wastewater must be preserved. Although there are distinct advantages, many of them are unknown by most policy makers.

In order to contribute to a better understanding of the reuse of wastewater for agricultural purposes, this paper describes its drivers in urban versus rural and water scarce versus water rich regions. From this analysis a classification of how wastewater is being reused is proposed. This considers the direct or indirect use of wastewater and differentiates between planned and unplanned practices. In applying these concepts, it is evident that the reuse of wastewater or polluted water is not limited to low-income countries that have no capacity to collect and treat wastewater comprehensively, but occurs also in
fast-growing economies such as China, the Middle East and the North African region.

The paper proceeds to describe – using data from around the world – the advantages and disadvantages of reusing wastewater. The advantages listed include the link to food security in deprived areas, its reliability as water source and its potential use as a fertilizer. All these advantages reflect economic benefits. Some studies have quantified the aggregate contribution of wastewater to food supply. In Pakistan, about 26 per cent of national vegetable production is irrigated with wastewater (Ensink et al., 2004), while in Hanoi, Vietnam, which is much wetter than Pakistan, about 80 per cent of vegetable production is in urban and peri-urban areas irrigated with diluted wastewater (Lai, 2002). Across major cities in West Africa, between 50 and 90 per cent of vegetables consumed by urban dwellers are produced within or close to the city (Drechsel et al., 2006) where much of the water used for irrigation is polluted. Some data on the economic benefits is presented for Ghana, India, Kenya, Mexico, Pakistan and Senegal. With regard to disadvantages, naturally, the health problem is highlighted and discussed, and recommendations to deal with this using the new WHO (2006) guidelines are presented.

In the third section of the paper, the official perception of the use of wastewater is commented on and some guidance is presented for the development of proper policies in different developing countries. The paper recognizes that policies to control the unplanned reuse of wastewater where it is an ongoing practice are not only hard to implement but are even difficult to develop (Drechsel et al., 2002). This occurs because governments are faced with a trade-off between public health protection and the ethical question of whether to prevent farmers from cultivating with the only source of water that is accessible to them (Jiménez and Garduño, 2001). To assist in this decision-making process, the advantages and limitations of using the WHO (2006) wastewater reuse guidelines are discussed. This highlights the challenges for developing countries to set-up their own norms when there is a lack of reliable data at the national level concerning both the health conditions associated to the practice of the use of polluted wastewater for irrigation and – more simply – on the extent of the practice.

The paper concludes by presenting the view that with an increasing world population and improving living standards, domestic water use will increase and so will the production of wastewater. Since, simultaneously, there are many regions facing severe freshwater shortages, water scarcity will continue to be a key driver for recycling wastewater. Even if sanitation conditions are, hopefully, improved, this cannot be achieved instantaneously, and hence the reuse of polluted water or non-treated wastewater for irrigation will increase independently of the increase in the global reuse of water. Under these conditions it is important to study, promote and communicate appropriately for developing countries suitable and feasible treatment alternatives in combination with ‘non-treatment’ interventions applied at different entry points along the production and consumption chain. This paper clearly states that there is an opportunity for urban planners and policy-makers to reinvent the role of wastewater management by linking the efficient use of water, the food security agenda and the recovery of water and other resources.
Constructed Wetlands for Treatment of Grey Water for Domestic Reuse

Author: Dr. Shiromi Karunaratne
University of Moratuwa, Sri Lanka

Keywords: BOD, pretreatment, removal efficiency, subsurface flow, wetland plants

Introduction/Problem Identification
Properly managed grey water can be a valuable resource which agricultural and horticultural growers as well as home gardeners can benefit from. It can also be valuable to landscape planners, builders, developers and contractors because of the design and landscaping advantages of on-site grey water treatment/management. Treatment systems based on natural degradation processes, such as stabilization ponds and constructed wetlands, are particularly suited for domestic wastewater treatment where sufficient land is available, because they require little or no energy, are relatively simple to operate, and show reliable treatment performance. Therefore the objectives of the study are:
• To provide a demonstration on a low-cost, grey water treatment system that could serve as a model in a typical Sri Lanka community.
• To promote reuse and recycling water for home gardening/irrigation and flushing purposes. The target group is specially those who are living in semi-urban areas.

Analysis/Results and Implications for Policy and/or Research
With the earlier mentioned objectives, a subsurface horizontal flow constructed wetland was designed at University of Moratuwa. The system is comprised of 5 principal components such as Pre Treatment (settling and oil trap), Treatment Cell (waterproof basin), Filter Material, Wetland Plants, Inlet and Outlet Structures.

Pretreatment
Since the model plant is established to treat grey water from a non domestic set up (staff canteen of University of Moratuwa), an extra step of pretreatment (two-120 l tanks for settling/screening) was introduced to reduce the possible additional load of particles to the grease trap and subsequently the treatment cell, to prevent creating unnecessary clogging problems. However, in a usual domestic environment, this can be completely omitted. The objective of tank 1 is primarily the screening of large particles that escape from the kitchen sink while settling of particles that escape the 2 mm wire mesh screen (basket). The waste coupling of the kitchen sink has holes of 10 mm diameter. The particles that escape tank 1 is screened with a 1 mm wire mesh screen (basket) at tank 2 while settling of remaining heavy particles will take place.

Grease Trap
Grease trap is designed for a retention time of 1 day. This will promote the separation of grease from the grey water and will be accumulated on the top while any heavy particles will be settled at the bottom. Accumulated grease will be skimmed periodically while the settled matter (which will be collected on the settling tray) be removed manually.

Treatment Cell (Waterproof basin)
The total volume of the cell is approximately 8000 l. and Four meter (4.0 m) long 1.8 m wide (at the top level) cell was divided longitudinally at the center while vertical baffles are provided at approximately 590 mm intervals, running through the entire vertical depth (0.75 m) of the wetland cell with an opening
of 270 – 380 mm. Considering the middle separation, the effective average width and the length of the treatment cell is 0.75 m and 8.0 m, respectively. The wetland cell was completely lined with 1:2:4 concrete (50 mm thick with 50x50 mm wire mesh as reinforcement) (with cement rendered bottom)

Filter Material
The filter material fulfills a variety of essential functions. Because of its wide availability in Sri Lanka crushed stones (construction aggregates) are the most widely used filter material for constructed wetlands. However, use of broken roof tiles (40 mm) has also been tested as alternative substrate material and proved to be a good option to reduce the high costs.

Wetland Plants
It is recommended that locally available emergent plant species that can tolerate stagnant water conditions be used. Common reed (Phragmites australis), Cat tail (Thypa Latifolia) are widely used because of its general availability. In the present model, Cat tail (Thypa Latifolia) was planted at a density of 6-8 plants per m².

Inlet and Outlet Structures
The first and last 400 mm distance of the cell was filled with 40 mm dia. aggregates (remains after screening through a 25 mm sieve) while the rest was filled with 20 mm aggregates (remains after screening through a 15 mm sieve) after washing to remove fine particles. A 5 mm PVC wire mesh separated the two types of material. Inlet and outlet structures are required for wastewater distribution and collection, respectively. Inlet structures include distribution pipes, which were installed across the entire width of the wetland’s inlet area with a 10 mm diameter PVC pipe. 3 mm diameter holes were drilled at 25 mm intervals along the 10 mm pipe. The outlet structure for the recollection of the treated wastewater consists of a drainage pipe laid at the bottom of the outlet area and raised to a level 75 -100 mm below (adjustable) the top level of the filter material.

Wetland cell (sizing)
Average daily flow (average grey water flow + maximum daily average rain fall)* factor of safety (1.5) = (280 + 92) l/d *1.5=558 l/d
Therefore design daily flow (Q) – 560 l/d
Assuming a porosity of 0.5
Effective volume of the treatment cell (V) – (8000 * 0.5) = 4000 l
Hydraulic retention time (H)= V/Q = 7.14 days (WHO recommends at least a 6 day retention time to minimize the possible health risks due to pathogen contamination)
Ideal effective depth of the substrate should be more than 600 mm.
Operational conditions (optimum) and efficiency
Flow (L/d) – 560
Hydraulic retention time (d) -7
Influent COD concentration (mg/L) – 650
Surface loading rate (g COD/m² d) – 0.075
Hydraulic loading rate (m/d)- 0.065

The pretreatment removed 80-90% of oil and grease while the removal of BOD and COD was in the range of 85 to 95% during the early stages of the treatment plant. N and P removal rates were relatively low being in the range of 30-60%. However, the retention of N and P in the effluent is highly desirable as the treated water is used for growing vegetables. The project is still ongoing.
Characterization of Grey Water and its Implication for Reuse, the Case of Kigogo Peri-Urban in Dar Es Salaam, Tanzania

Author: Dr. Richard Kimwaga
University of Dar es Salaam, Tanzania

Co-Author: Mr. Yustin Kabuli
Tanzania

Keywords: grey water, re-use, characteristics, recycle, efficiency

Introduction/Problem Identification
The situation of water supply services in Kigogo (a peri-urban and unplanned area) in Dar es Salaam, Tanzania is poor. The area is served by water operator in Dar es Salaam, DAWASCO only twice a week. As a result, people find other alternative sources of water like boreholes and shallow wells. Grey water (GW) re-use is increasingly seen as an alternative to water saving in household especially in water shortage/scarcie areas of peri-urban and unplanned areas, like Kigogo area. Since GW re-use has potential in reducing the water consumption and therefore bringing about efficiency in the household level, despite of its high production in Kigogo area, there is no study on GW re-use that has been done so far. The study was therefore conducted with specific objectives; to characterize (quantity and quality) of GW with view of it’s re-use and explore its implication for re-us.

Analysis/Results and Implications for Policy and/or Research
The GW quantity was obtained by using direct interview method. 40 households were selected where members of households were interviewed on their water consumption per day which had ultimate direct GW production. The GW samples were analyzed for pH, Electrical Conductivity (EC), Dissolved Oxygen (DO), 5 day Biochemical Oxygen Demand (BOD5), Total Suspended Solids (TSS), Total Nitrogen (TN) and Facal Coliform (FC) in accordance to the Standards Methods for Water and Wastewater Examination.

Grey water Quantity
The GW quantity was from three sources, namely bathrooms, laundry and the kitchen. Quantities varied from 95l/day (40l/ca.d) for a 3 members household (water consumption 120l/d) to 530 l/d (30l/ca. d) for a 17members household (water consumption 600l/day). The significant contribution of GW was from the bathrooms and laundry. The kitchen contributed only about 5% while the bathrooms and laundry contributed 45% and 50% respectively. The average quantity of the GW produced at Kigogo is 76.78% of water consumed. This water volume is large hence if properly managed it can be re-used and hence bring about efficiency.

Grey water Quality
The quality of the GW varied depending on its source. The pH values varied as follows; kitchen pH 7, laundry pH 8.4 and bathroom pH 8.1. The higher pH for laundry could be attributed to the use of the soaps. All the three sources of GW had acceptable pH values when compared to the Tanzania Water Quality Standards which stipulates the values to be between 6.5 and 8.5. The Electrical Conductivity (EC) of GW also varied depending on the source. Kitchen had the highest EC 2530µs/cm, bathroom the lowest value of EC 1038 µs/cm while that of the laundry had EC 2066 µs/cm. The kitchen had a lot of salts which could be the cause of high EC value. The GW from each source had
different DO values. The kitchen had the lowest amount of the DO (1.2mg/l) probably due to having materials of organic origin. The other sources of GW had high values of the DO (laundry 3.5mg/l and bathroom 4.0mg/l) because they are not subjected to higher organic pollutants. The TSS also varied from one source to another. The kitchen had higher value of the TSS than other sources. The kitchen had 3800mg/l, laundry had 1900mg/l and bathroom had 152mg/l. The kitchen had high values because there is organic matter. The laundry had BOD5 460mg/l while the kitchen had high 409mg/l and bathroom had lower than the other 295mg/l. The kitchen had high BOD5 probably due to high foods remains dissolved which are organic in nature. Results from the study shows that the GW from the kitchen had lower nitrogen content (0.146mg/l) than the other sources. Nitrogen contents for laundry and bathrooms are 0.16mg/l and 0.174mg/l respectively. There is no significant difference among these different sources. The results for FC also showed variation from these sources. Laundry had the highest FC 6 x 10^4 no/100ml, kitchen 2.5 x104 no/100ml and bathroom 3 x 10^4no/100ml. The high values for FC in laundry may be caused by washing kid nappies which contained the faeces in families having children since FC is the indicator of the bacteria present in human intestine and are always present in human faeces. The presence of the FC from the kitchen and bathroom is indicating that the people from Kigogo are using water which is contaminated with faeces. The water used over the area is from the shallow wells and according to the soil characteristic of the area (sand in nature) and the type of toilets they are using (pit latrines) water from the latrines might have percolated to the shallow wells. Despite their variation in the FC content, the GW from different sources is very high from the standard required with specific reuse. For vegetable irrigation the standard allows the maximum FC of 1000no/100ml and for lawn irrigation it requires the water with FC not more than 5000 no/100ml.

**Implication for Re-use**

The important aspect of GW re-use is quantity and quality. The study shows that about 77% of the water consumed in the household is produced as GW. Therefore going for GW reuse will bring about water efficiency for in house water use which can save much of the income as well as to the environment. However, on the other aspect of GW re-use, i.e. quality, the study has found out that GW from Kigogo is not good enough for re-use; as it has higher FC than the required for reuse in irrigation. According to WHO guidelines, GW can be used for irrigation without restriction if the BOD is less than 25mg/l, TSS is less than 50mg/l and FC is less than 1000 no/100ml. The barriers to re-use of GW from Kigogo area is its quality. To a great extent, because of its large quantity, GW can be incorporated into climate change adaptation and integrated water resources management strategies by its re-use once treated adequately. The study recommends treatment of GW prior to re-use by grey water towers, constructed wetlands or any other low cost treatment system.
Water Reuse and Recycling: Emerging Options and Their Policy Implications

Author: Dr. Xavier Leflaive
OECD, France

Keywords: water reuse, distributed infrastructure, urban water supply, alternative business models, environment-related innovation

Introduction/Problem Identification
To address the challenges of urban water supply, OECD countries would benefit from exploring the potential of water systems which use rainwater or reuse grey or reclaimed water. Such systems are not a panacea, but in a number of contexts, they could be articulated with existing infrastructures. In order to optimize the benefits of such systems, it is vital to reform water-related regulations and institutions.

Analysis/Results and Implications for Policy and/or Research
It is not clear how prevailing water systems in OECD countries will adjust to urban water challenges. These systems are based on piped water supply in centralized systems using a series of accepted technologies. They consume a lot of fresh water and energy.

Alternative water systems exist, which use alternative sources of water: rain water, (treated or not treated) grey or reclaimed water. They can be organised at different scales. Such systems are deployed in Australia, Spain, some states in the US, which are aware of the price of water scarcity. Markets for water reuse are booming: according to market insight from Global Water Intelligence, half of the world’s major industrial companies and one quarter of major cities will consider water reuse in the decade from 2005 to 2015. However, most OECD countries implicitly block their deployment in urban areas.

Alternative water systems are neither systematically better, nor worse than central infrastructures. Central and local governments would benefit from considering their deployment and articulation with existing infrastructures. This is particularly the case in new urban areas where no central infrastructure exists; in city centres with decaying water infrastructure or with infrastructures meeting diseconomies of scale or capacity constraints; in projects of urban renewal; in unstable contexts, where flexibility, resilience and adaptation are valuable (i.e. contexts created by climate change); in projects where property developers operate the buildings they invest in (to recoup investment costs).

To realise the full benefits of alternative water systems and to mitigate the risks they generate, water-related regulations and institutions have to be reformed. In particular:
• The public has to be involved, as populations tend to balk at the idea of water reuse;
• Regulation should be made technology-neutral;
• Water sector regulators will have to monitor water quality from a variety of sources;
• The price of water ought to reflect real (environmental) costs;
• The articulation of central and distributed systems has to be planned, as it challenges the business model of existing (public or private) operators.

An increasing array of experience accumulates. An informed policy dialogue on the available options, in a context that favours innovation and adaptation, is the best way forward.
Pharmaceuticals in the Environment: Carbamazepine in Wastewater, Irrigated Soil and Groundwater in a Tunisian Reclaimed Water Irrigated Area

Author: Ms. Olfa Mahjoub* et al.
* National Research Institute for Agricultural Engineering, Water, and Forestry, Tunisia

Keywords: reclaimed water, irrigation, carbamazepine, soil, groundwater

Introduction/Problem Identification
In scarce water resources countries, reclaimed water is reused to grow foods and save conventional water for more appropriate uses. Nowadays, new concern has been raised about trace organic pollutants for which no guidelines exist yet (Weber et al., 2006). Pharmaceuticals are trace compounds, excreted and discharged with urine and feces in sewage network. In the last decade, pharmaceuticals have received particular attention because of their detection in water bodies (Andreozzi et al., 2002). Since few data exist on their behaviour and fate in the environment (Oppel et al., 2004), long term health risks are not well addressed yet. The scope of this paper is to underscore the growing need to carry out studies in order to prevent environment and public health problems. It outlines the main results of the first Tunisian case study to have dealt with pharmaceuticals in a scheme irrigated with reclaimed water reused effluent, soil and groundwater.

Analysis/Results and Implications for Policy and/or Research
In areas where reuse is regularly practiced, the scarce research works dealing with pharmaceuticals gave evidence of contamination of soils and groundwater through various routes, mainly long term effluent reuse (Duran-Alvarez et al., 2009). More than 80 compounds and their metabolites were detected in effluent in Austria, Brazil, Canada, United Kingdom, Germany, Italy, Spain, Switzerland, USA, Deutschland, etc. (Heberer, 2002). For instance, clofibric acid, a metabolite of a lipid-lowering agent was detected in soil and groundwater beneath a 100 years effluent irrigated area in Germany (Scheytt et al., 2004) and in a 80 years irrigated area in Egypt (Elgala et al., 2003). It was also found in artificial aquifer recharge site in Germany (Heberer et al., 2001).

Carbamazepine (Cbz) is an antiseizure detected in effluents and receiving waters (Ollers et al., 2001) owing to its little degradation after secondary treatment (Paxéus, 2004). Due to its persistence in the environment, several scientists suggested to use it as a potential tracer of effluent contamination (Clara et al., 2004). After a large study on effluent reuse in European countries, discharge of Cbz was proposed to be controlled and concentration limited in reclaimed water according to reuse (Salgot et al., 2006). In soil, Cbz was shown to accumulate in effluent irrigated soils in USA, and to migrate to groundwater (Kinney et al., 2006). Aquifers in Long Island and Western Montana (USA) were contaminated by Cbz following a septic tank seepage (Benotti et al., 2006; Godfrey et al., 2007). Cbz was also found in the groundwater of a 45 year-effluent irrigated area in Germany (Ternes et al., 2007). Artificial recharge may also cause groundwater contamination (Drewes et al., 2003). In France, Cbz was detected at 43.2 and 13.9 ng/L in wells used for water supply (Rabiet et al., 2006). In Germany, potable water contamination by Cbz was noticed after groundwater recharge (Massmann et al., 2008). Several other examples can be cited in these countries, but very few exist in developing countries.

In Tunisia, a 30 year-irrigated plot was investigated for Cbz (Mahjoub, 2009). In a citrus cultivated plot located in Oued Souhil, in Nabeul region (North-East of Tunisia) irrigated from June to Oc-
ober with an activated sludge effluent, irrigation water was sampled in July and September 2008. Analysis showed average concentrations of Cbz of 133.7 ng/L in July and 235.7 ng/L in September. Similar values were observed in effluents by (Leclercq et al., 2008) and (Spongberg and Witter, 2008). Taking into account the 4000 m³/year used for irrigation of the plot, about 0.74 g Cbz/year may be transferred to soil. Assuming that the compound is distributed evenly on the soil surface, an amount of 1.1 g/m² can be found. Soil samples from 0-10 cm horizon were collected in June 16th (before irrigation), July 1st, July 23rd, August 26th, September 15th, and October 7th. Results showed Cbz content of 0.28 ng/g in the first sample, which confirms Cbz persistence 8 months after irrigation. During irrigation, Cbz concentrations increased in soil up to 0.94 ng/g. Since the only source of Cbz is the reclaimed water, each irrigation seems to bring 0.1 to 0.3 ng/g of Cbz to the 10 cm surface layer. In a 90 year-irrigated soil, (Duran-Alvarez et al., 2009) estimated that about 0.2 ng/g were brought up per irrigation event. Taking into consideration the soil properties, the 10 cm layer contained 37.5 to 109.9 µg/m² of Cbz. Comparing these values to the load estimated above (1.1 g/m²), we can bring out that concentrations at the soil surface can go 10⁻⁶ to 10⁻⁵ lower through infiltration and other mechanisms like degradation. Since Cbz has affinity with organic matter (Stamatelatou et al., 2003), as organic matter content is decreasing with depth in the studied sandy soil, mobility of Cbz may increase. Groundwater samples collected in two wells located near the infiltration basins of a groundwater recharge site showed the presence of Cbz. Concentrations of Cbz comparable to values detected in irrigation water were found in samples taken in February (245.5 ng/l and 209 ng/l). Cbz contents of 19 ng/l and 33 ng/l were detected in September indicating a likely mitigation through dilution; spatial and temporal studies are needed to better explain these observations. The present trend shows that groundwater is subject to variable contamination (and not only by Cbz) through both irrigation and artificial recharge. However, no data are available on contaminant sources upstream that allow assessment of the contribution of each practice and its impact on the agricultural environment. In Tunisia, new projects are planned to develop water reuse through expanding irrigated areas and replenishing aquifers, it is therefore important to assess and control upstream contamination of wastewater in order to prevent environmental and health problems.
Sustainability of Wastewater Collection, Natural Treatment and Reuse for Food Production and Carbon Capture

Author: Prof. Duncan Mara
University of Leeds, UK

Keywords: carbon, collection, reuse, treatment, wastewater

Introduction/Problem Identification
In 2006, according to the 2008 report of the Joint Monitoring Programme of WHO and UNICEF, there were some 2.5 billion people in the world without access to improved sanitation. Of these, some 660 million were in urban areas. The proportion of people living in large cities in developing countries and who had a sewer connection was 15–45% in 2000. Wastewater from sewered urban areas needs to be collected, treated and reused (or disposed of in an environmentally neutral way). The Hashimoto Action Plan II (released in January 2010) includes a new focus on “Building new impetus for wastewater collection, treatment and reuse”. However, there has hitherto been little incentive to treat wastewater – for example, in 2000 WHO/UNICEF reported that the percentage of wastewater effectively treated in Africa was zero (presumably less than 1%). This work demonstrates that a financial incentive to treat wastewater is to be found in carbon capture and the Clean Development Mechanism.

Analysis/Results and Implications for Policy and/or Research
Simplified/condominial sewerage is the only means of providing adequate sanitation in high-density low-income urban areas in developing-country cities. The wastewater so collected has to be treated and this analysis demonstrates a novel means of how wastewater treatment costs can be substantially reduced.

It is well known and well appreciated that ‘natural’ wastewater treatment (NWT) processes, such as waste stabilization ponds and constructed wetlands, do not require any electrical energy for their operation. Thus, in the global effort to reduce greenhouse gas (GHG) emissions, natural wastewater treatment is already ‘ahead of the game’. But more needs to be done: natural wastewater treatment and reuse systems need to be widely used not only to reduce the consumption of electrical energy and its associated GHG emissions, but also – and more creatively – to generate electricity and capture carbon. This is termed ‘natural wastewater treatment and carbon capture’.

Energy generation. Methane is produced in anaerobic ponds and most commonly this methane escapes to the atmosphere. Methane is a very powerful GHG: a tonne of CH₄ is equivalent to ~21 tonnes of CO₂. Allowing the free discharge of methane from anaerobic ponds is not only very ‘climate-damaging’, but it is also a huge waste. The biogas from anaerobic ponds should be collected and used to generate electricity, but this is likely to be feasible only at large works such as the Western Treatment Plant in Melbourne, Australia. However, the recent development in Colombia of high-rate anaerobic ponds (HRAnP) is extremely important as they not only combine the high-performance advantages of UASBs and the simplicity of conventional anaerobic ponds, but they also provide an easy means of capturing biogas at relatively small works – for example, at El Cerrito in Valle del Cauca, southwest Colombia, which has a population of only 50,000 (and currently the only HRAnP). Even if the biogas is not used to generate electricity it should be collected and burnt in order to emit CO₂ rather than CH₄, and this could earn carbon credits at the rate of 20 credits per tonne of methane burnt.
Carbon capture. The HRAnP effluent can be treated in a secondary facultative pond (as at El Cerrito) and its effluent used to irrigate a plant that is able to sequester large amounts of carbon. An ideal candidate plant is bamboo and one example would be Guadua angustifolia which is the one of the most important species of bamboo in Latin America. It has many high-value uses – for example, as scaffolding, for building and bridge construction, and in furniture manufacture. More importantly it has an extremely high carbon capture, ~35 t C per ha per year, equivalent to a CO₂ sequestration of ~130 t per ha per year.

The clean development mechanism. The real purpose of carbon capture through NWT is to earn and sell carbon credits through the Clean Development Mechanism. One carbon credit is equal to one tonne of CO₂ captured, so 1 ha of G. angustifolia could earn ~130 carbon credits per year – i.e., the generation of a net tradable value of around USD 1000 per ha per year (at a net “rate of exchange”, after brokerage fees, of USD 7.5 per carbon credit). In the case of El Cerrito, where the design effluent wastewater flow is ~7500 m³/day, ~20 ha of G. angustifolia could be irrigated at a rate of 35 mm/day, so earning a net tradable carbon credit value of some USD 20,000 per year, which would make a substantial contribution to the cost of wastewater treatment.
Introduction/Problem Identification
Singapore is a city state with land area of 700 km², twice of Stockholm, but population of 4.6 million, 6 times of Stockholm’s. With no natural groundwater, it has depended on imports from Malaysia and rainwater for its water needs. Rainfall is 2400 mm per year, but there is a very limited catchment area. This poster discusses some lessons for planners and policy makers, in how Singapore has continuously increased its water efficiency through recycling and reuse of wastewater.

Presently Singapore’s Public Utility Board (PUB) can supply up to 15% of the water needs of the city-state by recycling wastewater. Currently most high quality treated water (known as NEWater) is sold for high-end industrial use; small portion (1%) is added to the reservoirs for indirect potable use. With a new higher capacity recycling plant, capacity may rise to 30% by August 2010. Singapore may be self-reliant in all her water needs before the water import treaty with Malaysia expires in 2061.

Analysis/Results and Implications for Policy and/or Research
Singapore has a long history of incremental developments in increasing its water use efficiency by reclaiming used water. PUB describes this short circuiting of water cycle as ‘closing the water loop’. The high quality water reclaimed from used water using microfiltration and reverse osmosis is branded NEWater.

Closing the Water Loop
In 1915 attempts were made to reuse industrial waste water for cleaning tanks and landscaping. In 1960s the effluent treatments plants experimented and used chemical processes of industrial wastewater for reuse. In 1974 there was a bigger leap in used water reuse using state-of-the-art technology of ion-exchange, reverse osmosis, and electrodialysis, in combination with chemical treatment to achieve good quality water from industrial affluent. In 1998, learning from the works in USA, the Ministry of Environment and PUB started a new reclamation plant to produce potable quality water using new technologies of dual membrane (microfiltration and reverse osmosis) and UV disinfection. In 2002 Singapore closed the water loop when its reclaimed used water, NEWater, was ready to become a source of potable water: a ‘National Tap.’

Holistic Approach
Other than using the learning newest technology in used water treatment, one of the successes of PUB is in its approach to the challenge in many different fronts simultaneously.

Since 1970s a comprehensive sewerage system was built to keep the used water separate from the storm water. The initial motivation for this was hygiene and increased catchment of storm water, but this paved the way forward for tapping used water.

Other than building the infrastructure, since 1970s, Singapore also built legislation around planning and design of sewage systems of houses and industries to preventing adverse impact of industrial and
domestic discharges on water quality. This legislation has been successfully implemented, keeping the Singapore waters clean and safe.

To reduced land used for collection and treatment of wastewater, Singapore undertook the engineering of Deep Tunnel Sewerage System (DTSS). DTSS comprises of a network of wide tunnels, up to 6m in diameter, 20 – 50 meters beneath the ground. This makes the expansion of water reclaiming viable and sustainable keeping in mind the limited land available.

The Singapore government also undertook institutional restructuring to ensure that the whole water cycle, from sourcing of water to end use, and then reclaiming, was managed by PUB. This restructuring allowed for rapid expansion of the NEWater facilities in early 2000.

Public education and communication strategies
NEWater has gone under rigorous testing under international standards to win confidence: more than 20,000 assays on 190 parameters to ensure quality and stability over long periods. Nevertheless, it was not enough to only harness latest technology of making potable water from used water; NEWater posed the challenge of convincing people to overcome possible reservations against reclaimed water for drinking. PUB and Ministry of Environment have managed a successful communication and educational campaign to this end. PUB has also partnered with television and print media to generate confidence and pride in NEWater. For instance, during the Independence Day parade of 2004, more than 60,000 people, including prime minister, minister mentor and other officials, tasted NEWater.

A part of the brand campaign is in choosing the nomenclature wisely. Small changes such as using ‘used water’ instead of waste water, and ‘reclamation plants’ instead of sewage treatment plants can go a long way in changing mental attitudes.

Conclusion
This case study presents a good example of the reusing and recycling wastewater as part of an overall social, economic and environmental strategy for the city-state. From being ‘water stressed’ in terms of access to freshwater sources, Singapore is moving towards water independence by increasing its water-use efficiency, based mainly on water reuse and recycling practices. The PUB plans to increase its water reuse to a level that it will not have to import any water. Depending on rain water, desalination and treatment of used waters, Singapore may be self-sufficient in all her water needs before 2061.

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Demanding Reuse at Wastewater Treatment Plants: A Case of the Private Sector Helping to Pay for Sanitation

Author: Dr. Ashley Murray
Waste Enterprisers Ltd., Ghana

Co-Author: Mr. Frederick Tettey-Lowow
Waste Enterprisers Ltd., Ghana

Keywords: aquaculture, Ghana, public-private partnership, operation and maintenance, fish farming

Introduction/Problem Identification
A public-private-partnership (PPP) is underway in Ghana to combat the inefficiency of disposal-oriented sanitation, while simultaneously transforming the weak financial model that governs sanitation facilities. The developing world is replete with examples of failed and failing wastewater (WW) and fecal sludge (FS) treatment plants (TPs). The reasons for this are manifold (see e.g., Murray and Drechsel under review [1]); however, the absence of adequate financial resources to cover the on-going costs of operation and maintenance (O&M) is not least among them. Household willingness to pay for sanitation is notoriously low; however, annual government investments in the capital and O&M of sanitation systems amount to only 8% of the more than $30 billion necessary to achieve the Millennium Development Goal for sanitation [2].

Analysis/Results and Implications for Policy and/or Research
The PPP project will turn WW treatment and discharge plants into multiple-use WW treatment and production facilities. Specifically, a private company, Waste Enterprisers Ltd. (WE), has entered an agreement with the Kumasi Municipal Assembly (KMA), according to which they will farm catfish in the maturation ponds of a community-scale waste stabilization pond system in the city. Gross profits from the sales of the fish will be shared between the company and the KMA; the KMA’s portion is explicitly designated for O&M activities at the WWTP. Projected revenues from the project are promising for both WE and the KMA (Table 1); thus demonstrating that sanitation can be a profitable business for the private sector while also improving the delivery of sanitation services and making beneficial use of the resources embodied in WW and FS.

WW-fed aquaculture is a common practice around the world, particularly in Asian countries where its history dates back centuries [3]. The city of Calcutta in India began using its wastewater to fertilize fish ponds in the 1930s, and the city’s system is now considered the largest wastewater-fed aquaculture scheme in the world [4]. However, the project in Ghana is a rare example of a WWTP benefiting from the profits generated by aquaculture; typically, wastewater is discharged and freely accessed by farmers or other end users with no compensation to the TP. Furthermore, this project showcases a novel role for the private sector in sanitation; being profit-motivated, they will ensure the longevity of the project and will optimize the resource utilization, benefiting themselves, the TP, and the community at-large.

Throughout the world, and particularly in developing countries, aquaculture is a lucrative and increasingly important sector. In Africa for example, to maintain the present per capita consumption of fish, aquaculture will have to expand by 250% in the next 10 years. Ghana’s per capita fish consumption is approximately 24 kg – 16% higher than the world average – making it the most important source
of animal protein in the local diet [5]. However, wild fish capture in Ghana has been declining for nearly a decade, and today approximately 44% of fish are imported (FAO 2009). Designing multiple use WW treatment and fish farming facilities has great potential for improving the financial sustainability of sanitation while also improving urban food security and the productive use of the resources embodied in WW.

Table 1. Economic projections for an aquaculture project at a waste stabilization pond system in Kumasi, Ghana. The project is a public-private partnership between Waste Enterprisers Ltd. (WE) and the Kumasi Municipal Assembly (KMA).

<table>
<thead>
<tr>
<th>Unit Cost (GHc(a))</th>
<th>Total Cost (GHc)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>WE start-up costs</strong></td>
<td></td>
</tr>
<tr>
<td>Aquaculture equipment 700</td>
<td>700</td>
</tr>
<tr>
<td>(e.g., barrels, boots, nets)</td>
<td></td>
</tr>
<tr>
<td>Water quality testing 276</td>
<td>276</td>
</tr>
<tr>
<td><strong>WE direct operating costs</strong></td>
<td></td>
</tr>
<tr>
<td>Catfish fingerlings 0.25 each 3600(b)</td>
<td></td>
</tr>
<tr>
<td>Fish feed (agricultural byproducts) 3000</td>
<td></td>
</tr>
<tr>
<td>Operations manager 120/month 720</td>
<td></td>
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<tr>
<td>Water quality analysis 75</td>
<td>900</td>
</tr>
<tr>
<td><strong>WE indirect operating expenses</strong></td>
<td></td>
</tr>
<tr>
<td>Overhead 15% of net profits 2700</td>
<td></td>
</tr>
<tr>
<td><strong>WE net profits</strong></td>
<td></td>
</tr>
<tr>
<td>Catfish sales 3.5/ kg fish 32,760(c)</td>
<td></td>
</tr>
<tr>
<td>Net Profit 32,800</td>
<td></td>
</tr>
<tr>
<td>Gross Profit 6 month cultivation 18,700</td>
<td></td>
</tr>
<tr>
<td>Estimated Payment to KMA toward WWTP O&amp;M 50% gross profit 9,300</td>
<td></td>
</tr>
</tbody>
</table>

(a)1 GHc (Ghana cedi) = 1.45 USD. (b)Assumes stocking density of 3 fish/m². (c)Assumes 65% survival; average weight 1 kg/fish.

Literature Cited
Community Based Initiatives to Exploit Untapped Run Off Water for Enhanced Nutrition and Sanitation

Author: Ms. Rosemary Nambooze
Kagoma Women Initiative Group, Uganda

Keywords: untapped water, run off, nutrition, sanitation, livestock

Introduction/Problem Identification
The millennium Development goal (MDGS) of reducing poverty and increasing access to safe water and sanitation half of the population by 2015, will not be possible if the run-off water from water springs, rain water harvesting is not channeled into income generation activities. Harvesting of run off water from rain water and well drained ordinary spring channels has proven to be a potential for improving crop, livestock and fisheries production for rural communities in Wakiso district.

Wakiso district comprises of Maganjo Parish and Nabweru sub-county and is the operation area for Kagoma Women Initiative Group. KWI is a Community Based Organization that has empowered rural Women into sustainable management of natural resources for the last 8 years. As one of its objectives, it seeks to contribute to poverty alleviation for poor rural peasant communities through sustainable management of water resources, to increase community access to safe water for improved quality of lives.

Analysis/Results and Implications for Policy and/or Research
Water which is not absorbed by the soil and flows to lower ground, eventually draining into a stream, river, or other body of water. Rainwater harvesting is simple concept; collect and capture rain as it falls and store it in basins or tanks so that it can be used when demand arises. There are numerous, innovative methods for capturing, storing, and delivering rainwater to farmers’ fields or underground aquifers. Many harvesters simply tailor their systems to the unique environmental conditions at hand. Some large-scale collection plans are designed to take advantage of the topographical conditions that produce rainwater runoff. Where rainwater naturally collects in runoff channels, these flows are intercepted with dikes, dams, and other structures that can capture water before it enters the ground or evaporates.

Rain water and ordinary springs run-off water have been utilized by the communities in which KWI works to engage in various economic activities which improve incomes, diets and general livelihoods more still ensuring functional eco- systems.

Fish farming/aquaculture has been adopted in low lands of various villages. Run-off water from well drained ordinary spring channels and rain water have channeled to swampy areas and have supported aquaculture. Poor farmers have been able to harvest fish for sale, improve incomes as well as improve diets through increased households consumption and access to fish.

Run-off water from rain water and ordinary springs has through communal collaboration been channeled to man made ponds thus livestock has able to access enough drinking water, besides increasing milk and meat productivity for improved household nutrition and incomes. Thus animals and communities stop sharing water.
Local and traditional irrigation schemes have successfully sprung up and this has enabled farmers channel harvested rain water to their gardens with lowland growing fruits, vegetables and other crops for example sugar canes rich in potassium, zinc and glucose have been grown, both for home consumption and sale; besides tomatoes, cabbages and other green vegetables have been grown for sale and household consumption. This has improved incomes, nutrition and enhanced availability of pastures for livestock in critical dry seasons and further utilization of land which wouldn’t other wise be utilized towards improvement of community livelihoods.

Watershed management is one key way that communities have improved the quality, quantity, and reliability of their water resources. Controlling erosion and runoff are always central to good watershed management. This has been done in a variety of ways. Contour farming and terracing among KWI women.

Putting the global factor into consideration, availability of this common good in some parts of the continent which are so dry and the surface water is scarce, the run off water provides a water source where ground water is un available. This technology can further address the issue of equity. Due to its low costs for construction, every household can afford to put up in order to enjoy this common.

However, there is a need to increase the capacity of the poor rural communities to manage the available run-off water sustainable for increased incomes to improve quality of life. This can be done through effective means to deal with the climatic variability and community conflict resolution after communal collaboration. In some seasons there are prolonged draughts, this owes to the fact that climatic variability and communal conflicts have hampered effective functionality towards such initiatives and in some areas complete failure.
Environmental Impact for Reused Agricultural Rainage Water in Egypt

Author: Dr. Magdy Nasralla
National Water Research Center, Egypt

Keywords: reused drainage water, environmental impacts, side effects, drainage burden, pollutions

Introduction/Problem Identification
In Egypt, the introduction of drainage system has conserved or improved millions of hectares of land for agriculture or other purposes. The benefits of drainage include the gain in land, better quality land, and the sustainability of irrigated land use. However, the benefits are associated with certain disadvantages. Sometimes, the gain in one location is associated with a loss in the same area. More commonly, improvement or gain in one place leads to a burden in another place. At present, the drainage water is reused for irrigation purposes either directly or after blending with fresh water to adjust the salinity to normal acceptable limits. The Egyptian government plan to reuse about 4.8 billion cubic meter/year of agricultural drainage water where it represents about 30% of the applied irrigation water. It was found that this quantity could be increased to 8.5 billion m³/year without affecting the environmental equilibrium and fish wealth in the northern lakes.

Analysis/Results and Implications for Policy and/or Research
The study was carried out in Mit Kenana Pilot Area as a representative area of the Nile Delta of Egypt. The main objective of this study is to conduct an extensive study to determine the positive and negative impacts of the reuse of agricultural water drainage. The impacts could be physical, chemical, biological or hydrological. In this study, it will be focus mainly on the environmental side effects of agricultural land drainage mentioning the other aspects only occasionally.

The drainage system has positive effects in removal the salts away to the root-zone of plants but in the other way it has a negative effect as a result of the movement of the salts at the sub-soil. Before installation of subsurface drainage for Mit Kenana Pilot Area, the average water table is equal to 0.6 m from the ground surface and in the lower parts, it is found at the surface. After drainage, the water table depth is fluctuating between 0.80 to 1.40 m from the soil surface and also there is no surface water problems happen in the lower part area. Although the crop yield has generally increased after drainage, the amount of increase was not the same for each crop. This is due to the different tolerance levels of crops to salinity and excessive moisture. It can also be attributed to other agricultural inputs. Under the specific conditions of Mit Kenana Pilot area, wheat and rice had apparently the highest increase in yield. Water can act as a vehicle for all kinds of soluble elements that are stored in the soil. These elements are nutrients; herbicides, pesticide, organic matter, salts and toxic trace elements which could be leached from the soil and it are polluting the drainage effluent. Generally, it could be concluded that the reuse of drainage water is a national policy to meet present and planned future water demands in Egypt. It could be used under control.

To investigate the influence of reused drainage water into the soil pollution. An area of three feddans (1 fed. = 0.42 ha) in Mit Kenana Pilot Area was selected. It was irrigated by drainage water. The area was controlled under the current farming conditions for one year (2005–2006) to apply the data measurement program. Soil and water samples were collected from 7 locations of sandy soil. It was collected for each 0.5 m up to 2.0 m depth to determine the degree of pollutant for each depth of the
soil. Water samples were collected from application drainage water and renovated groundwater to verify the soil aquifer pollutant impact on water quality. The samples were analyzed in the Drainage Research Institute (DRI) laboratory to determine the selected investigated quality parameters including Total Dissolved Salts (TDS), Fecal Coliform, Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Nitrate (N-NO$_3$), Ammonia (N-NH$_4$), Phosphates (PO$_4$) and Sulfates (SO$_4$). The results revealed that the pollutants removal percentages for Fecal Coliform, BOD5, COD, N-NO$_3$, N-NH$_4$ and PO$_4$ are 47.2%, 63.43%, 63.43%, 63.43%, 52.3% and 48.8% respectively. It is also observed that the maximum polluted process occurred at soil depth of 2.0 m for Fecal Coliform, at 1.0 m for Organic Matter, at 1.5 m for nitrate-nitrogen, at 1.0 m for ammonia-nitrogen and at 1.5 m for phosphate and Sulphates.

The results of this study indicated that, although there are major benefits of drainage projects, it must be take into consideration its side effects especially the ones related to the hazards and the environment.
GCW’s 4Rs of Sustainable Water Management: Reduce, Recycle, Recover and Release

Author: Mr. Pat Nixon
Sinclair Knight Merz, Australia

Keywords: recycled water, wastewater, management, planning, communication

Introduction/Problem Identification
The consequences of climate change and reduced rainfall are overturning traditional water and wastewater management paradigms. In the city of the Gold Coast, Australia, the record-breaking ‘Millennium Drought’, combined with rapid population growth, were opportunistic drivers for the creation of sustainable and innovative water management solutions.

Over the past decade, Gold Coast City’s local water authority, Gold Coast Water (GCW), has directed a shift to more sustainable management of the city’s water, particularly wastewater and recycled water services and assets.

Analysis/Results and Implications for Policy and/or Research
Through the evolution of wastewater and recycled water policy, GCW has developed an integrated approach to long term planning and management to optimise the use of recycled water resources and produce effective and sustainable wastewater management outcomes. This approach has culminated in the innovative reapplication of the 3Rs of waste management to a water context – creating a hierarchy of actions to govern recycled water management – The 4Rs of Sustainable Water Management: Reduce, Recycle, Recover and Release.

- Reduce the generation of wastewater, through water conservation and prevention of stormwater infiltration into the wastewater network.
- Recycle water where possible, to replace potable water for fit-for-purpose uses, such as toilet flushing and outdoor use (Class A+), and beneficial non-contact uses, such as irrigation and industry process water (Class C).
- Recover recycled water from storage to balance excess recycled water production with shortfalls in demand. This avoids the unnecessary release of recycled water to waterways and prevents the use of potable water for non-potable water needs.
- Release unavoidable excess recycled water using optimal timing and positioning of release which takes advantage of ebb tide flows to maximise mixing with the receiving waters.

This hierarchical approach identifies and directs a planning focus on more sustainable water options before proceeding to less preferred options. The 4Rs approach thereby aims to generate the maximum amount of benefit and use from water resources, while minimising the extent of impact of recycled water released to the receiving environment.

The 4Rs has now been comprehensively applied to all recycled water infrastructure and initiatives on the northern Gold Coast to create a strategic integrated planning system. The planning process involved identification of where wastewater and recycled water infrastructure and programmes within the region fit into the 4Rs hierarchy. This included identification of timing of initiatives, including previously implemented actions and long-term future goals.
The scheme also involved community engagement through information brochures and an online interactive map which outlines GCW initiatives and timing of implementation. In this way, the 4Rs approach makes use of a well known maxim to foster understanding and generate community support for the scheme and its outcomes.

The following provides an overview of how current GCW initiatives fit into the 4Rs hierarchy:

**REDUCE:**
1. Water conservation measures and education programs to minimise wastewater reduction but also minimising potable water use (thereby creating multiple beneficial outcomes). These have included free services to improve domestic water efficiency, rebates on water efficient appliances and curriculum packages for primary and secondary education.
2. Prevention and minimisation of infiltration and inflow into the wastewater network from groundwater and stormwater sources (also reduces pumping and treatment costs, and improves treatment plant performance).

**RECYCLE:**
Recycled water use is underpinned by stringent quality control procedures to maintain public health and safety as a priority at all times. This element includes operation, maintenance and augmentation of the wastewater treatment plants, recycled water distribution network and water carriers.
3. Recycling of lower quality recycled water (Class C) for fit-for-purpose uses, e.g. highly controlled irrigation and dust suppression, which reappllies maximum nutrient mass for beneficial purposes while minimising treatment costs.
4. Recycling of high quality recycled water (Class A+) for fit-for purpose uses, e.g. dual reticulation, fire fighting and less controlled irrigation (domestic / municipal gardens and lawns) which requires further treatment and is therefore more energy intensive than Class C.

**RECOVER:**
5. Storage and recovery of Class C recycled water in open storage facilities for later use. Facilities require stringent monitoring and control of water quality. Storage of recycled water allows seasonal balance of demand, which is highly influenced by weather and climate, particularly for outdoor use.
6. Storage and recovery of Class A+ recycled water in closed storages, particularly aquifers (Aquifer Storage and Recovery) for later use. Closed storage provides a more controlled environment to help ensure quality control of Class A+ recycled water for customers.

**RELEASE:**
7. Determination of the lowest impact methods of release. This approach is underpinned by extensive monitoring and modelling of the receiving environment to understand the mixing characteristics and their influence on the behaviour of released recycled water. GCW is in the development phase of a new release system (SmartRelease) for its largest wastewater treatment plant which measures prevailing tidal, meteorological and oceanographic conditions to fine-tune release timing.
Environmentally Friendly Technology for Water Conservation, Consumption and Sanitation in Tanzania – What Can We Learn?

Author: Ms. Lina Nordlund
Chumbe Island Coral Park Ldt, Tanzania

Co-Author: Ms. Karlyn Langjahr
Chumbe Island Coral Park, Tanzania

Keywords: rainwater harvesting, environmental technology, sanitation, water scarcity, Tanzania

Introduction/Problem Identification
Developing countries often face the problem of poor and inadequate water resource management causing eutrophication of coastal waters and depletion of limited fresh water aquifers. Zanzibar, Tanzania, is a water deficient area with extremely high population growth rates and an exploding tourism industry. Zanzibar's freshwater resources are to a large extent dependant on seasonal rains stored in limited aquifers prone to saltwater intrusion. There is a need to improve the efficiency of water use in these areas. Chumbe Island Coral Park Ltd is a private company with not-for-profit objectives managing a fully protected marine and terrestrial reserve. Since 1998 the eco-lodge on Chumbe Island has introduced a variety of sustainable and eco-friendly technologies for water and sanitation suitable for tropical conditions. To minimize environmental impacts, Chumbe harvests rainwater, employs shower heads with a switch, has natural grey water filters, and utilizes composting toilets etc.

Analysis/Results and Implications for Policy and/or Research
The eco-lodge on Chumbe Island was constructed between 1994-1998 using state of the art eco-technologies such as rainwater harvesting systems on all roofs. The roofs are designed with maximum surface area shaped to funnel the seasonal rains through sand and gravel filters into large enclosed cisterns combined with hand pumps to provide fresh water for showers and washbasins. The closed systems are particularly important in tropical areas to avoid providing breeding grounds for disease vectors such as mosquitoes. Most of the Zanzibari population lacks a good fresh water supply. Rainwater harvesting is an unusual sight on Zanzibar, perhaps due to its expense and investment for the very the poor; however most people who can afford building a house could make this investment because it is equal to the cost of the normal water tower and cistern. A major obstacle might be the lack of local expertise, even though a rainwater system is fairly simple.

To reduce water consumption all shower heads on Chumbe are equipped with a switch for releasing water. Many households could save great amount of water with this simple and cheap solution. On Zanzibar abolition is practiced and these kinds of shower heads are readily available.

Untreated sewage threatens sensitive coral reefs and pollutes coastal waters worldwide. To avoid introducing unwanted nutrients into the surrounding environment, waste waters from the showers, washbasins and kitchen pass through artificial wetland systems prior to being released. The waste water from the bungalows passes through gravel and sand filters before entering a sealed vegetation bed containing plants absorbing large amounts of phosphates and nitrates. The kitchen grey water system removes nutrients through three steps; a manual grease trap, an artificial wetland, and a final step where surplus water irrigates plant beds. These systems make high-energy and industrially manufactured technologies, products and services for water purification unnecessary. With the right
information, the local community could plant vegetation with high capacity to absorb nutrients in areas where waste water is often discarded. Further, the grey water system reuses kitchen water for their plants.

The lodge on Chumbe uses sealed composting toilet systems to avoid fresh water consumption and to avoid sewage production. The organic waste is turned into nutrient rich dry matter of a sixth of its original volume over time. The introduction of composting toilets was a real challenge for Chumbe, as local people commonly practice abolition and have cultural resistance towards touching the compost produced by human feces. This challenge has been overcome through training and experience. In areas with scarce water, flushing toilets are wasteful and unnecessary given the availability of clever composting toilet technology today.

On Chumbe renewable energy from the sun is used to heat water, provide energy for lights and freezer as well as sockets for recharging batteries. Solar powered solutions are still expensive, but in areas with fluctuating power supply and extensive use of generators, the investment of solar power will give a reliable source of energy. After the expensive initial investment, running costs are very low not forgetting the environmental benefits.

Chumbe was the first eco-lodge of its kind in East Africa. This innovative project with its locally adapted environmental technologies has been working for over 10 years. Chumbe Island has a large environmental education program where local students are brought free of charge to the island while learning about eco-technologies, environmental issues, the coral reef, etc. It is time to further share these environmental friendly solutions at the international level. There are many good ideas out there but are often unheard of. If governments and/or other organizations could be involved in disseminate information about sustainable (well-tested) solutions in ways suitable for their specific community, a possible improvement in water management could be expected. In Zanzibar community based peer education is a possible way of introducing environmental friendly technologies to the local community.

For people to use more environmental friendly options there must be a gain or incentive for the individual. One example is the shower head with a switch whereby the amount of water used during the shower is greatly reduced, delaying the need to purchase another water load or prolonging the time needed to collect new water. This provides a direct feedback to the consumer with an environmental improvement. For most people the likelihood switching to a more environmental friendly alternative is based on the perception that the individual will experience greater benefits, typically economic benefits (i.e. money saved). To be able to enforce more environmental friendly alternatives, alternatives must be thought through highlighting the individual benefits.
Treatment for Water Reuse in Eucalyptus Nursery

Author: Mr. Jorge Oliveira et al.
Federal University of Rio de Janeiro, Brazil

Keywords: water, reuse, treatment, eucalyptus, nursery

Introduction/Problem Identification
The purpose of this project was to investigate water reuse with emphasis on a cost-saving, natural water reclaim method. Eucalyptus nurseries have a medium operation cost with low profit, due to the high-level maintenance associated with the water irrigation process and challenges connected to low education levels of employees in the operation area. The goal of this project was to meet the qualitative requirements of a low cost investment, non-intensive operation and maintenance functions, and a low analytical control wastewater treatment system. A long-term field test was conducted to analyze the physical, chemical, and microbiological properties of wastewater from a nursery in Pindamonhangaba, SP, Brazil.

Analysis/Results and Implications for Policy and/or Research
Researchers were developed in a projected and installed pilot scale treatment system for nine months. The sequential method of wastewater treatment, included an insertion of a submerged fixed-bed anaerobic bioreactor, followed by granular activated carbon – GAC reactor, and sand filtration. Existing literature discussing good water quality informed analysis parameters for irrigating the eucalyptus nursery. Analysis of pH, temperature, turbidity, apparent color, electrical conductivity, total suspended solids – TSS were done hourly/daily in the field. The more complex parameters, like COD, BOD, ammoniac nitrogen, phosphorus and total organic carbon – TOC were analyzed weekly / monthly in an external Lab. Results suggested that the wastewater treatment, using the bioreactor, was very important to produce appropriate water to be reclaimed. On the other hand, the results showed that the sand filter used in the study did not show relevance, when the previous GAC reactor was being used. On average, 86% COD, 27% BOD, 27% ammoniac nitrogen, 20% phosphorus, 19% electrical conductivity, 86% turbidity, 28% TSS and 15% of the apparent color of the wastewater were removed.
Safe Reuse of Treated Wastewater in Large Residential Estates

Author: Prof. Subir Paul  
Eco Group, India

Keywords: life style, user acceptance, cost effective, ecological engineering options, impact on water quality

Introduction/Problem Identification
Rapid growth in drawing of water by Urban settlements, in India; creating acute water stress in it’s hinterland. Over 80% of urban water demand, is for domestic consumption caused by 1) Change in the life style, 2) mega housing projects etc. Large industries, hotels and hospitals etc. have initiated Water conservation through wastewater reuse – through expensive treatment/recycling plants too high for domestic application. Cities urgently need ‘concept of water demand management’ and evolve appropriate strategy for Water Demand Management as a correction to ‘Water Stress’ created and associated water quality deterioration of water sources. Water conservation through safe Reuse of treated wastewater has significant potential in reducing water demand in cities by about 50% or to a level of 65 litres per capita per day (lpcd) – shall deliver significant impact on water quality of natural water sources.

Analysis/Results and Implications for Policy and/or Research

Analysis
Status of surface water quality in populous states of India – analysis of water quality deterioration arising out of excessive water demand and water stress.

Cities are without adequate coverage by Sewerage system, most underground sewer lines are leaking and quality performance of city run STP treated effluent are poor – these conditions can not deliver ‘reuse of treated wastewater’ by urban local bodies. Delhi undertook a feasibility of reuse of treated wastewater and found the cost prohibitive.

Water quality criteria for safe reuse of treated waste water for secondary purposes (toilet flushing and landscape irrigation – excluding potable water) – Reuse of wastewater at project level through on site treatment shall be cost effective and have significant impact on water quality of natural water bodies.

Reuse potential of sewage/treated waste water can be classified in the following ways:

a) Inter Sectoral – domestic to industrial, domestic to agriculture, domestic to recreational, – examples Chennai, Delhi power plants, and water exchange between Delhi-Haryana.
b) Intra Sectoral – in domestic sector, treated Wastewater reuse can be planned at various scales including at project level like in hotels, hospitals, industries etc.

Evaluation of on-site waste water Treatment options:
a) RO & Membrane
b) Package units (Rotating Biological Filter)

d) Soil filtration

Ecological Engineering Options – pre-treatment in Anaerobic Baffle Reactor followed by
Evolving ‘Wastewater reuse models’ based on Ecological Engineering Options – Protocols – CPCB norms for discharge of treated sewage/wastewater not appropriate – Reuse of treated Wastewater is consistent with NBC 2005 – User satisfaction and acceptance

Implications of research

Performance Assessment
1) Water loss in processing – quantity of raw wastewater and net quantity of processed wastewater for reuse
2) Quantity and quality of reject water produced, if any.
3) Space Requirement
4) Power requirement
5) Cost (Life cycle cost) of treatment
6) Scale of treatment – city level/sub-city level, project level, household level etc.
7) Who delivers Safe Reuse of Treated Waste water?
Irrigation Water Re-use: Harnessing Water for Development by Re-thinking Traditional Concepts of Efficiency and Wastage

Author: Mr. Rahul Pillai Sivashanmugham
University of Bonn, Germany

Co-Author: Dr. Peter Mollinga
University of Bonn, Germany

Keywords: irrigation water re-use, canal irrigation, rain-fed agriculture, water-use efficiency, seepage losses

Introduction/Problem Identification
Water in the case of canal irrigation is often seen in isolation by the state and decision-makers, who often tend to have divergent policies regarding agriculture and developmental activities in the canal command area, and the areas excluded from it; which in the context of many developing countries would be rain-fed. This article strives to produce examples of interconnectedness of these supposedly separate worlds through the fieldwork executed to detect the prevalence of irrigation water re-use in the borderlands of canal command and rain-fed areas in Andhra Pradesh, India. The conventional statistics on the perception of loss and efficiency in a canal irrigation system is based on the idea that irrigated agriculture being an unattached entity to the surrounding environs. This paper argues that in a holistic policy approach will have the capacity to better address the problems arising out of drought and climate change, while also achieving the goals of IWRM.

Analysis/Results and Implications for Policy and/or Research
In many environments, irrigation is an advantage, if not an essential pre-requisite to agricultural practices. A popular method worldwide is the method of canal irrigation. The conception of an irrigation system, which may look simplistic is never actually so in practice. The very feasibility of an irrigation system is bound by geological, ecological, climatic and social constrains, the world over. Even provided situations where most or all of this have been settled at a satisfactory level, the issue of irrigation water efficiency is an oft repeated complaint.

Canal systems are often long and winding, and may not provide itself easily to maintenance. The water, transported over longer distances is bound to have losses through evaporation, and more importantly seepage. The efforts towards limiting seepage losses are mainly in the cement-lining of the canals, thus preventing water from percolating down. But being a costly procedure, and one that requires constant upkeeps and maintenance, it does not offer a fool-proof solution. What would be the next reaction? The governments, acting through engineers and officials at the irrigation department and similar bodies, decry wastage and endeavor to spend more funds towards physical measures to stop seepage, and thereby to enable more water to reach the intended beneficiaries.

Here, let us make a deviation to clarify some of the major ideas driving this way of thinking. The intended beneficiary here refers to a farmer, whose lands are within the pre-delineated canal command area. Irrigation canal panning and construction is not just vital for the agricultural economy of an area, but often is also an important factor in determining land value and holds potentials for obtaining continued future benefits and contracts. Thus, the planning of the canal involves involvement by powerful individuals and political pressure groups. But even considering that irrigation canal
construction is a purely logical decision innocent of personal or political clout, it will only mean that
the question of whose land receives water from the canal is a matter of sheer accident. This would also
automatically ensure that there are much larger numbers of individuals in the vicinity who have equally
pressing need for more water, but simply have the land outside the command area of the irrigation
canal. Thus, while thinking along the lines of providing more water to the intended beneficiaries, the
authorities simply are not getting a holistic picture of the scenario.

But the story does not end here. The water that is lost from the irrigation canal need not actually be
wasted. How? Water, once out of a guided and controlled system reverts to following the local natural
drainage, which usually the irrigation system juggernauts over. Thus following the topography, this
water would tend to move towards the lowest gradient, following contours of the land. This usually
leads to small brooks, where this water may appear as surface flows or continue as sub-surface flows.
It is from such sources that farmers, often subsistence or small holding individuals, try to obtain
water to irrigate their crops, which are otherwise almost exclusively rain-fed. This water can often
be the difference between a successful harvest and crop failure, especially in the event of droughts
or erratic rainfall.

These outcomes were arrived at by the author based on the fieldwork conducted in the province of
Andhra Pradesh, southern India. The rural areas chosen for the study had both irrigated canal com-
mand area, and the rain-fed agricultural lands in juxtaposition. The area received only a moderate
amount of rainfall, which too was concentrated during the monsoon season. Variations in and failures
of these rainfall patterns had disastrous consequences for agriculture, most of which was rain-fed. It
was however observed that water was available in the non-perennial streambed well outside the mon-
soon period. This could only imply seepage water from the irrigation canals and the irrigated fields
in the canal command area, using irrigation water. This “stream” water was being used by farmers in
the lands designated as rain-fed, for agricultural purposes. In an effort to understand the mechanism
better, surveys about motor-pumps along the natural drainage was conducted during the dry season
in the study area, and the locations were digitized into the topographic sheet of the area, giving a clear
idea of the extent of irrigation water re-use.

The conclusions arrived at in this paper are just an effort to take forward the understanding of the
interconnectedness of irrigation, agriculture and the whole livelihoods system, which we often del-
egate as separate worlds. The understanding and acknowledgement of such a scenario is essential to
formulate laws and rules that are sensitized to the idea of interdependence, and more importantly for
a developing a better measure towards calculating efficiency and wastage.
SINBAD – Système INtégré de gestion du BAssin pour la réutilisation Des eaux usées pour l’agriculture

Author: Mr. Augusto Pretner
SGI Studio galli Ingegneria SpA, Italy

Keywords: water reuse, irrigation, integrated wastewater modelin, sanitation, pollution abatement

Introduction/Problem Identification
The overall objective of SINBAD is to improve water use efficiency in Algeria by promoting an integrated wastewater management approach and reusing (treated) wastewater in irrigated agriculture. Two pilot areas were selected for the project implementation: the hydrological basin draining to Lake Réghaïa, situated on the Algerian Mediterranean coast, and the city of Constantine in the north-east. To achieve this goal the project has built an integrated mathematical model of the wastewater cycle (sewer networks and Wastewater Treatment Plant – WWTP) of the target areas. Alternative waste-water treatment options are simulated to identify the most cost-effective one that is engineered in the master plan for the wastewater management of the two pilot sites. 2 training sessions were carried out to build the modelling capacities of Algerian experts from the Ministry of Water Resources involved with the operation of the WWTP in Réghaïa and Constantine.

Analysis/Results and Implications for Policy and/or Research
The early stage of the project was characterized by data gathering and analysis. Population, point and diffuse pollution sources, hydrological data, features and drawings of sewerage and irrigation networks and WWTPs, industrial areas, data on wastewater quality, location of outlets, general data on receiving water bodies (rivers, lake, sea) were inventoried and implemented into a GIS. The existing wastewater management process was analysed using a combination of models to simulate the processes taking place in the wastewater cycle, from the time pollution loads are generated in urban areas or in the watershed, until they enter into the sewer network, processed in the WWTP and discharged into the receiving water bodies (rivers, lake, sea).

Different treatment scenarios were simulated to assess impacts on the environment and human health, cost-effectiveness, requirements in terms of legislation and local stakeholders’ institutional and managerial capacities as well as affordability, with the final goal to reuse treated wastewater for agriculture in Constantine and in Réghaïa areas, taking into account the environmental boundary conditions (restoration of the degraded lake of Réghaïa). Treatment options include: centralized-combined treatment for municipal and industrial sewage; centralized/decentralized treatment of industrial sewage; treatment processes for irrigation purposes (i.e. aiming at abating microbiological pollution and TDS and using sludge as fertiliser). A bi-dimensional hydrodynamic model of the lake simulates water quality patterns depending on the efficiency of wastewater treatment works.

The results of the simulations of integrated models support the preparation of the master plan of the best scheme for wastewater management and reuse in agriculture. The master plan embodies: the upgrading of the water quality and quantity monitoring system, the integration and rehabilitation of the sewerage network, the upgrading of the WWTP and a new laboratory for water analysis, the uprising of the current irrigation system to account for the reuse of treated water. The master plan also evaluates the most suitable irrigation technologies (e.g. drop, furrow, sprinkler, shallow flooding irrigation etc.) depending on specific chemical, biological and physical conditions of water and soil in
the two pilot areas (e.g. stability, salinity, nutrient content, microbiological contamination etc.), and types of cultivated crops (e.g. from the perspective of nutrient demand, yields and nutrition values, vulnerability to microbiological contamination etc.). Capital and operational expenditures, estimated revenues, assessment of affordability by customers are included in the financial and economic analysis to support the project viability.

The project has included a capacity building program for the staff of the Algerian Ministry of Water Resources. 2 specific training sessions were carried out, one in Algeria at the Ministry of Water Resources (AMWR) and the other in Italy at SGI’s. The training courses addressed the following topics: integrated wastewater management modelling, with special focus on the management of the Constantine and Réghaia wastewater treatment plants, wastewater treatment technologies, modelling of the irrigation networks in Constantine and Réghaia, efficient use of water in agriculture, quality standards, contamination processes and classes of pollutants. Detailed tasks and financial plans to develop sustainable infrastructures are prepared, taking into account cost recovery and operation issues and avoiding unrealistic expectations.

SINBAD is developed in the framework of the Water Programme for Africa funded by the Ministry of Environment, Land and Sea of Italy and implemented by UNESCO-IHP. Ms Lamia Lehtihet and Mr Ben Aissa Mokrane, respectively Deputy Director and Director of AMWR DG for non conventional water resources, coordinate the project at the national level on behalf of the Algerian Ministry of Water Resources.
Towards Effective Institutional and Financial Frameworks for Waste-water Recycling & Re-use: Perspectives on Systemic Reforms & Innovation from India

Author: Ms. Supriya Sahai
ICRA Management Consulting Services Limited (IMaCS), India

Co-Author: Mr. Sunder Subramanian
ICRA Management Consulting Services Limited (IMaCS), India

Keywords: wastewater, re-use/recycling, India, institutional frameworks, reforms and innovation

Introduction/Problem Identification
Indian towns and cities treat less than 30% of their sewage, allowing a staggering 26.5 billion litres of untreated wastewater to be discharged into water bodies, rivers and coastal waters every day, and very little is recycled or reused. With very few STPs meeting discharge standards and failure to address systemic problems leading to significant infrastructure deficits, there is a widening gap between sewage generation and existing treatment facilities. India has thus seen increasing levels of pollution of water bodies and courses which also has implications for long term water security. Populist pressures, deteriorating fixed facilities and equipment, lack of focus on O&M and poor cost recovery are often cited as the underlying reasons for such low service levels. While government is aware of its limitations, there is a latent acceptance for the vital role of the private sector in addressing the needs of the public sector to achieve better service delivery results.

Analysis/Results and Implications for Policy and/or Research
Given the above context, we will discuss the limitations that public utilities in India typically face which act as barriers for water recycle and reuse. Broadly classifying these into policy gaps, technological adequacy, institutional limitations, economic feasibility, market dynamics, political considerations, capacity constraints, etc., we will create analytical schema constructs to identify the various factors that limit the promotion of water use efficiency by the public sector. These will then be used develop the framework conditions that will help understand and address such hurdles.

In the light of the above, we will examine how private sector participation in water recycling and reuse projects can help address these framework conditions as also the question of what will be the supporting mechanisms that are needed in each of these conditions that will help in development of appropriate institutional arrangements, project formats and financial structures which will incorporate all concerned risks and returns in a comprehensive way. We will then create a basket of optional policy responses by government such as, the development of various fiscal support systems including in the form of Viability Gap Funding, subsidies (including transitional incentive structures) to moderate any financial or project financing shortfalls faced by the private sector.

Using the results of the above schema constructs, we will study these conditions in the first of its kind, recently bid out waste-water recycling project in the city of Surat, India where private sector would be responsible for constructing and operating a tertiary treatment plant for a period of 20 years to supply Industrial grade water to the numerous industrial units in the city. We will present this as a case example of an effort by the city’s utilities and municipal administration towards water conservation and recycling to free up potable grade water (that was otherwise used by the industrial units).
We will argue that how adequate political will and sincere project development efforts could perhaps result in promoting the concept of water recycling and reuse and yet attain the commercial objectives, overcoming the paradigm of systemic deficiencies identified in the introduction.
Recycling of Drainage Water Residual in Closed Basin

Author: Dr. Gehan Sallam
National Water Research Center, Egypt

Co-Author: Dr. Magdy Nasralla
National Water Research Center, Egypt

Keywords: recycle, reuse, closed basins, oasis, drainage water

Introduction/Problem Identification
Water management has been identified as one of the elements of sustainable development. In Egypt, increasing demands for food production to face the fast increase in population requires more attention for reclamation and cultivation of more agricultural areas. However, uncontrolled or poorly planned expansion of reclamation projects has led to critical situations in disposal of drainage water residual. Drainage systems produce poor quality drainage waters and disposal of such waters is a serious problem in the absence of natural outlets like in closed basin areas. So disposal of drainage water residual of closed basins (Oasis) in the west desert of Egypt is a major concern due to the deterioration of water quality in the drainage network and the need for safe disposal of this water. Therefore, recycling of drainage water residual is a safe alternative to keep drainage effluents strictly separate in order to prevent environmental pollution.

Analysis/Results and Implications for Policy and/or Research
The various ways to manage and recycle of drainage water to reduce the impact of drainage water flows on the environment are including conventional techniques and non-conventional techniques. Therefore, the main objective of this study is to investigate the potentials of the different techniques for reuse and recycle of drainage water in closed basins (Oasis) in Egypt. To achieve this objective, it was necessary to conduct a monitoring system to assess the volume and quality of drainage effluent produced in the reclamation areas in closed basins and also monitors groundwater quality. The most conventional technique that was experienced by Ministry of Agriculture is disposal of drainage water residual in evaporation ponds (or lake) for evaporation. However, this alternative causes a lot of problems because of the high water levels in the evaporation ponds due to uncontrolled springs and wells causing water logging and salinity problems especially in the lower depressions. This could be attributed to the increasing in the input quantity of drainage for the evaporation ponds than the output due to evaporation rate in the area. It was found that the average annual maximum temperature is 31.4°C and the overall annual average temperature is 14.9°C, while the average daily evaporation losses differ between 3.95 mm/day in winter season to 6.9 mm/day in summer. So, it was important to investigate the other unconventional techniques to face this problem. The first alternative is the intermediate reuse of drainage water in cultivation after remixing with irrigation water at the inlet of the secondary or tertiary irrigation canals. But this alternative, on the long term, may cause increase of soil salinity due to the high salinity of drainage water. Therefore, it was proposed to apply natural (biological) treatment for drainage water before reused by using in-stream wetlands or constructed wetlands. The wetland is defined as land that is saturated with water long enough to promote wetland or aquatic processes as indicated by poorly drained soils, hydrophytic vegetation, and various kinds of biological activity which are adapted to the wet environment. It was found that the in-stream wetland is more economical than the constructed one because the treatment process completed in the drains system itself without need to construct engineering wetland. Another unconventional technique is to reuse drainage water in fishery farms. On the other hand, the biological drainage could be applied...
by using drainage water for forestation in desert areas or cultivation of special salt tolerant crops that
could be used as fodder crops. In the case of forestation, the safety requirements must be taken into
consideration. For the fodder crops some critical points must be taken into consideration like the effect
of using these crops on the growing rate, health, and thirst and water consumption for the cattle. All
of these alternatives are suitable for recycling of drainage water in closed basins and oasis in Egypt
but it must be evaluated and ranking for each area separately to find the most suitable and applicable
alternative for the different cases according to its special conditions and characteristics.
Improving Efficiency in Irrigation Water Use

Author: Mr. J.W.M.Ranjith Thomas Seimon
Ministry of Urban Development & Acred Area Development, Sri Lanka

Keywords: irrigation, efficiency, return flow, losses, scarcity

Introduction/Problem Identification
Traditionally, the term “irrigation water use efficiency” has been used to mean the ratio between water delivered and water consumed by crops within an irrigation system. The residual water is considered as losses while this traditional concept of efficiency may still be valid for planning, developing and operating irrigation systems. It can be misleading for understanding the issues related to managing water as a resource.

The conventional concept of irrigation efficiency ignores the integrated nature of water resource systems and the potential re-use of irrigation return flows. This could lead to erroneous conclusions and serious misallocation and mismanagement of water resources. With recent advances in the understanding of water in river basins, there has been a noticeable shift in the perception about irrigation performance.

Analysis/Results and Implications for Policy and/or Research
The irrigation systems of Sri Lanka consist of major, medium and minor irrigation schemes which are categorized according to the command area. Schemes which have more than 600 hectares of command area fall into the major category, between 80 hectares and 600 hectares are categorized as medium irrigation schemes and minor schemes have less than 80 hectares of irrigable area.

In Sri Lanka, the irrigation schemes are normally conventional gravity irrigation systems. The application efficiency of a conventional gravity irrigation system is only 45 percent on the average, while high efficiency systems such as sprinkler, drip and trickle systems attain application efficiencies of 70 to 90 percent.

For most irrigation schemes during the past, only about 25 percent of the tank storage was made use of to meet the irrigation demand. The loss of 75 percent of the tank storage was due to evaporation from the tank water surface and canal water surface, seepage and percolation, conveyance losses and application losses at the field level. With the type of structures presently available and better operation and maintenance, effective utilization of rainfall, adhering to the cultivation calendar, adopting rotational water issues and avoiding high ponding of water when irrigating high spots by proper land levelling it is possible to increase the above usage to 35 percent. These corrective measures could be easily adopted when the number of cultivators are not large, or the extent cultivated by each individual is sufficiently large.

Sri Lanka’s water resources situation at least when considered in terms of national level aggregated statistics, does not appear to experience scarcity at present, or into the first quarter of this century. Yet districts in the country’s dry zone are facing water scare situations. At present, the agriculture sector accounts for most of the total water withdrawals. But there will be increased competition for scarce water resources from the domestic, industry and environment sectors in the future. Indeed, as the country aspires to a greater degree of industrialization, the availability of water in adequate quantities...
and of acceptable quality could well become a key determinant in the location of major industrial development schemes. Also, water scarcities, especially in the rice producing districts in the dry zone could have a significant impact on Sri Lanka’s food production potential, meeting increasing competing demands will require innovative technical and organizational approaches to water resources management, backed by an effective institutional and policy environment.

Water like air, is vital for life. Like air, water has tended to be considered by Sri Lankans as a readily available free good. The government has reinforced this conviction, bolstered no doubt by the relevant abundance to water in the South Western region of the country. Furthermore, it has taken the responsibility over several decades of providing irrigation water free in the drier regions of the country and for domestic use in many parts of the country. This distorts the economic value of a valuable resource and neglects the costs that have to be incurred to make it available at the desired location in the required quality and quantity. In reality, shouldn’t the value of water determine its supply and demand as in the case of other scarce commodities?

These aspects become particularly crucial as population increases, but water availability remains finite. There is an urgent need for an emphasis that shifts from the question “how much water do we need and where do we get it?” to the more productivity oriented “how much water is there and how we best benefit from that amount?”
Reuse of Water to Improve Water Supply and Dry Zone Population in Sri Lanka

Author: Mr. Lakshmane Wickreme Seneviratne
Institution of Engineers, Sri Lanka

Keywords: dry zone development, pumped reservoirs, population growth, drought relief work, climate change

Introduction/Problem Identification
Sri Lanka is a tropical island in the Indian Ocean lying between 6-10 N latitude and 80-82.5 E Longitude with 65519 sq km in area. The Northeastern part of the island is dry and receives about 2000mm to 1100mm annual rainfall and possess 65% of the land area. Only one river passes through the dry zone –Mahaweli-. Mahaweli water is diverted into dry zone through canals for irrigation and hydropower and other uses. Reservoirs traditionally built in ancient Sri Lanka cater to rice irrigation and maintain local population up to a limit. Water is the key limiting factor in dry zone. We need to make reservoirs and pump water to satisfy the future needs of dry zone. Attempts are made to tap the excess drainage and brown water reuse in all basins. Jaffna lagoon is converted in to a fresh water body. Freshwater is a need.

Analysis/Results and Implications for Policy and/or Research
Gravity irrigation needs storage reservoir or a feeder canal to irrigate rice fields using surface water. But any deficiency in supply in the absence of rainfall almost kills the crop. In such a situation farmers try to extract all available means of ground water and pumps are used to lift the water. If the cost is very high we abandon that idea. Any drought period is hazardous in crop failure and habitat collapses. 2010 year is predicted by the author as a drought year and all tropical countries are affected by this climate change. We have to take steps to minimize the damage to civilians. Jaffna, Mannar, Hambanthota districts are affected by terrorism and now liberated. Development activities are planned for the resettlement of refugees and encourage economic activity in the destroyed coastal belt. Fresh water is the most valued commodity in the colonies. Action is taken to restore all possible means of fresh water storages. River for Jaffna project makes the 1000ha lagoon a freshwater body by closing all sea outfalls at Wadamarachchi, Thondamanar and Punerin. The spill water from Iranamadu tank is directed to the lagoon. Suitable populated areas from Jaffna peninsular are selected to promote cultivation using pumped water collected at surface or elevated tanks. This project increases the population and encourages people to concentrate around irrigated areas. Slowly brackish water lagoon converts into a fresh water body but precautions are needed to control pollution from the return flows. Limestone base of Jaffna has a 30m deep pool of freshwater used by farmers using pumps or manual means. Most of the deep wells are very old and possess sludge deposits to reduce the water quality. Cleaning of this sludge is very costly.

Giant’s Tank in Mannar District is badly affected by war-now renovated to serve more command and the return flow is stored and used for expanded irrigation. Mannar has a high fertility soil regime.

Hambanthota District in south is fed by Walawe River and the Liyangasthota 6000ha irrigation project is the lowest in the cascade. Town supply intake to Ambalanthota and Hambanthota is at Bolana but it is possible to extract 45MCM from this location annually without allowing that water wasted by draining to sea. Pump capacity of 4.4 cumeck running continuously during floods can store 24MCM.
in the lower Sittarakala and upper Sittarakala newly designed tanks. This enhances the water supply needed for future population. New air port and sea port brings a new set of industries which increase the demand of water. A series of newly designed tanks are constructed to collect drainage brown water from Kirindioya project using pumps. This reduces the soft water content in the Bundala and Malala lagoons. Softness reduces the shrimp catch in lagoons. Proposed Bundala tank and Weligatta tank are operated under pumps for the drainage season. Kachchigal ara basin is improved by new Mamadala tank and improved Deniya tank. Hanguna ara of Menik Ganga basin is proposing a new tank of 20MCM. All these new developments supply 105MCM to new Ruhunupura demand in 1930. Ground water is pumped up to 10MCM.

All Srilankan projects are designed for gravity drainage. That has no procedure to reuse water other than the cascade flow of all basins. 65% run off drains to sea but due to low head it needs a series of pumping during the high run off. It is possible to design new tanks closer to the coastal belt. New industries are associated with the sea. There is a possibility of pumping water from an upstream location to a new canal and extend that supply to a new command area. This situation is planned only where water is found in excess. The designed new projects are subjected to further study to satisfy the donor conditions and foreign aid is sought. The pumped water needs more economic handling than traditional irrigation.
The Impact of Mandatory 40% Water Reduction and Recycling Targets for New Dwellings in New South Wales, Australia

Author: Mr. Aaron Smith
Sinclair Knight Merz, Australia

Keywords: BASIX, mandatory, reduction, affordability, ownership

Introduction/Problem Identification

What is Building Assessment Sustainable Index

In 2004 the New South Wales (NSW) state government introduced the Building Assessment Sustainable Index (BASIX). Under this system all new dwellings must comply with minimum reductions of 40% in water and electricity consumption and a minimum thermal comfort rating. Compliance must be through devices and environmental design, not through the individual practices of the residents.

This paper investigates the impact of mandatory water efficiency at a customer based level. In this assessment it will look at the water reuse and saving option adopted by the public and some of the social impacts of the program.

Analysis/Results and Implications for Policy and/or Research

The Physical Impact of BASIX on Water Saving and Reuse in NSW

In terms of volume the 40% reduction means a saving of 35,960 litres per person per year, equal in volume to a 4m by 4m room of potable water.

The impacts of BASIX can be seen in the data from its first years. By forcing new homeowners to look at their future water usage through a cumulative reduction target people see that water management make economic, social and environmental sense.

The 40% means that while individuals are free to devise their own reduction system they cannot reach compliance without a recycling or reuse element. This is a fundamental change from the previous centralised urban water system of NSW and has had a dynamic impact on how water is viewed at a customer level. While before BASIX, only 5% of households typically installing an alternative to mains supply, in 04/05 installation had grown to 99%, (BASIX 04/05 Outcomes, 2007). This resulted in despite an increase in urbanization an increased level in water efficiency throughout the state.

The Cost Implication of Mandatory Water Management Devices

The importance of having economic benefits to promote a water reduction process can be seen in what reuse system is typically selected. Despite a huge range of options on the market today rainwater tanks, being flexible and cheap have been selection for 80.4% of all new homes under BASIX.

This economic thinking behind BASIX is partial attributed to the rapid increase in housing prices in NSW. This has lead to questions of how much should be paid to reduce our water demand.

In its development BASIX was planned to bring about major consumer change by providing a system of mandatory targets with financial savings. Despite these aims the reverse has occurred. Mainly attributed to the large developers new homebuyers are being charge 8,000 to 10,000 dollars for the
required devices while the direct installation price would be only $2,000. This act mitigates the financial savings of the reduced water bill reversing the economic benefit BASIX can promote.

**Conclusion**
Overall BASIX’s water saving program is effective because it provide flexibility way to individually reach clear goals. Through this despite, the additional cost, people are seeing the long-term economic and social benefits of water reuse and reduction. In fact analysis of the options has shown the most economical level of reduction is a larger 56% water saving.

Most important BASIX is getting people talking about water usage. NSW resident no longer now see their water as an end of tap supply but an integrated resource. Attributed mainly to the presents of rainwater tanks people have a physical and visual reference to understand their water usage. Even existing homes, exempt from BASIX, are even installed water reuse system because of the social awareness BASIX is promoting. It is this community ownership of water as a resource that will outlast the taps, tanks and legislations.
Water Tariff, a Tool for Improving Water Use Efficiency through Recycling & Reuse

Author: Mr. Suresh Vithal Sodal  
Maharashtra Water Resources Regulatory, India

Keywords: recycle, reuse, efficiency, affordable, sustainable

Introduction/Problem Identification

Management of water is an economic, social & political issue encompassing all sectors of an economy. Water resources are increasingly becoming a limiting factor for economic growth & human development. The consequences of population explosion coupled with the demands of unbridled consumerism have converted what was once an abundant resource into what is now a scarce resource. This is the main reason for a worldwide movement pushing governments towards policy reform in the water sector. The focus has to not only sharpen on supply side management but also include demand side management through improving & incentivizing water use efficiency & water conservation. Water use efficiency & conditions of water delivery system in most municipal & irrigation water services fall far short of satisfactory levels of performance, financing of these services & recovery of at least the O & M costs of the delivery system has emerged as a key factor for performance improvement.

Analysis/Results and Implications for Policy and/or Research

The Maharashtra Water Resources Regulatory Authority (MWRRA) was set up in August 2005 under the MWRRA Act. Its main function is to regulate the water resources of the State. It is required to ensure that the management of these resources & the allocation & utilization of water from them is done in a, judicious, equitable & sustainable manner & to fix the rates for use of water for agriculture, industrial, drinking & other purposes keeping these parameters in mind. Thus fixing bulk water tariffs for the three main user categories is one of the important functions of the Authority. Under the various sections of the Act, the Authority is required to fix the criteria for water charges at sub-basin, river basin & state level after ascertaining the views of the beneficiary public based on the principle that water charges shall reflect the full recovery of the cost of the irrigation management, administration, operation & maintenance of water resources projects. The Authority is also required to review and revise the water charges after every 3 years

The Authority is the first of its kind in the country & criteria based water tariff fixation by a third party regulator has never been attempted anywhere else to date. Thus developing criteria for bulk water tariffs, based on sound economic principles & informed economic choices, was a challenging task before the Authority.

The proposed allocation of O&M costs to the three categories of users, considering 3 factors viz. affordability, accessibility & quantity & timeliness of supply.

As per the Maharashtra Water Resources Regulatory Authority Act, bulk water tariffs in the state are required to recover the O&M costs of the irrigation system. The criteria for fixing tariffs for this purpose are to be determined in consultation with the beneficiary public. However water pricing remains a complex process & is required to meet diverging financial, economic, environmental & social objectives. A major challenge therefore is designing tariffs in a way that strikes an appropriate balance among competing objectives.
Users are, however, not absolved from the responsibility of ensuring efficient use of water & discharging, after use, water of prescribed quality. These objectives are to be enforced through a system of penalties & incentives in the tariff structure. Thus the tariff structure for the state as a whole will not only need to recover O & M costs while assuring affordability & accessibility but also promote efficiency of water use & environmental sustainability through such a system. Other characteristics of a successful tariff plan are simplicity (tariff plan should be understandable and straight forward) & transparency (tariff plan should be evolved through a consultative process) & these characteristics will have to inform the tariff structure as it seeks to achieve its multiple objectives.

A slew of incentives / concessions have been proposed to the three sectors to improve water use efficiency, (i) In irrigation – incentives for using micro irrigation techniques such as drip & sprinkler systems: 50% of the basic tariff. (ii) In drinking water – if the Municipality reduces its demand by recycling, tariff may be lowered to 70% of basic rate for reduced demand. If municipality makes available treated sewage effluent for irrigation/gardening tariff for the volume of such treated effluent will be 50% of water supply tariff & also the municipality will be allowed to retain the revenue earned from sale of treated effluent. Higher rate of water tariff by way of penalty may be considered for Municipal Corporations/ Municipalities who do not show adequate progress in setting up Sanitation Treatment Plants (STPs). (iii) In Industry – if service providers reduce their demand by recycling or promoting recycling in their units the tariff may be lowered to 70% of basic tariff on reduced demand. (iv) to encourage adoption of recycling by industries & usage of treated effluent for irrigation. The “polluter pays” principle has been introduced for errant industries. Every industry is expected to treat effluent to desired standard before release into the natural water course. In such case, basic rate will be charged. If effluent is not treated to required Maharashtra Pollution Control Board (MPCB) standard, rate will be twice basic rate.

While residential users have little freedom of choice for waste water disposal & for altering the composition of their effluents commercial & industrial users have a wide range of technology input & project choices that affect their water borne waste loads. Industrial water use is most amenable to recycling & effluent treatment & hence a system of incentives / disincentives needs to be incorporated in the tariff structure to encourage industries to recycle & dissuade them from polluting water bodies. Charging waste water dischargers according to the strength & quantity of waste water will motivate them to reuse or recycle water & switch to cleaner production processes. Where sewerage service costs rise high then industries find that public sewerage is not the most cost effective means of disposal. Instead in-house treatment recycling & re use emerge as more economical options & industries choose to switch to more self treatment & effluent re use.

Today every industry is expected to treat effluent & bring its discharge to the desired standard before release into the natural water course. In such case, basic rate can be charged. If effluent is not treated to revised MPCB standards a rate equal to twice the basic rate can be charged.

The Authority is also required to address the issue of low water use efficiencies especially in the agriculture sector. The service provider viz. WRD has been now entrusted with some degree of responsibility for asset management, equity in supplies between head & tail enders with the concept of entitlement & ushering in improved water use efficiency.
An Analysis of Regulatory and Institutional Economics of Water Use Efficiency in India

Author: Dr. Piyush Tiwari
IDFC, India

Co-Author: Mrs. Manisha Gulati
IDFC, India

Keywords: institutional economics, water efficiency, case analysis, recycle and reuse, role of water pricing

Introduction/Problem Identification
India is facing increasing scarcity of water. Rapid urbanization and changing demand patterns would extenuate the problem further. The question about how the water requirements of the future are to be met is increasingly taking the country towards options such as water conservation by way of increasing user efficiency and decreasing the demand on existing water resources; adoption of innovative technologies that reduce water consumption; and recycling and reusing water. Several initiatives towards improving efficiency of use, and recycling and reuse of water can be found in India. However, these initiatives remain sporadic and are yet to gather mass momentum – the kind that would make a visible impact on the availability of water in future. The reasons for this are not hard to find. The absence of a well-defined strategy that identifies and promotes alternative uses for recycled water, the lack of economic incentivizes and institutional barriers are some of them.

Analysis/Results and Implications for Policy and/or Research
Enabling efficiency improvements, recycling and reuse of water will require a concerted action oriented approach to mainstream such considerations in the actions of various institutions in India. In this context, this paper will critically analyse initiatives that have been taken in order to improve water use efficiency and promotes recycle and reuse of water in India from the perspective of their overall impact on water consumption, coverage, quality and cost economics. In doing so, authors also look at the role of regulatory and institutional structures to facilitate behavioural changes that enable efficiency in water consumption. Given that behavioural changes as well as technological choices in water are a function of economic instruments, this paper will also dwell on how the tendency to price water below economic value is posing a barrier to improving efficiency in use of water, and undertaking its reuse.

Based on an analysis of cases where institutional and economic reforms have taken place in India, authors analyze the efficiency, efficacy and replicability of such measures.
Investigations into the Role of Land Drainage and Monsoonal Rains in Promoting Waste Water Use in Arid Regions

Author: Dr. Narendra Kumar Tyagi
Agricultural Scientists Recruitment Board, India

Keywords: aquifers, salinity, monsoon, drainage, productivity

Introduction/Problem Identification
In north-west India, the productivity of agricultural lands is severely constrained by inadequate surface water supplies, presence of saline/sodic aquifers and water logging induced secondary salinization. Development of salty waters through various techniques, including horizontal drainage, skimming wells and shallow tube wells, and cycles of monsoonal rains offer opportunities of ameliorating salinity and generating additional irrigation supplies. The extent to which the differential salt tolerance of the crops is exploited, can further improve the chances of successful saline/sodic water reuse. Several variants of this model have been implemented in northwest India. The important outputs of waste water use projects in the form of increased crop productivity, water use efficiency and farm income; resulting from physical and biological interventions as moderated by monsoon rains and drainage; are presented.

Analysis/Results and Implications for Policy and/or Research
Recent researches on nature and properties of salty wastewaters and their interaction with plants and soil systems have led development of technologies that permit profitable use of these waters for crop production. A number of projects on reclamation of waterlogged saline lands and reuse of drainage effluents were implemented in north-western India over a period of two decades (1985-2004). Analysis of data from these projects operated under varying agro-climatic situations provide valuable information in respect of technical and policy options for generating and practicing wastewater use in agriculture.

The three important techniques of abstraction of salty waters include horizontal drainage in high water table areas, skimming wells in situations where marginal quality water floats over higher salinity water and shallow tube wells in low table conditions could helped ameliorating water logging and salinity and was providing. The quality of drainage effluents extracted through horizontal subsurface drainage system (SSDS) improved with the passage of time, whereas it declined in case of skimming wells. Another advantage with SSDS was that it enabled use of higher salinity waters and for the given salinity of applied water, it improved crop yield by 10-15 % as compared to normal situation. Water reuse also reduced drainage water disposal requirement by almost 50 % in the first year and between 70-80 % in subsequent years without any salinity build up in the root zone and helped maintaining better water quality in rivers and stream during non-monsoon periods.

Monsoon climate enabled use of relatively higher salinity waters as it set in an annual cycle of soil salinization (during winter and summer) and desalinization (during monsoon season). As a result irrigation with saline waters between 6-8 dS/m even without fresh water availability proved better than no irrigation. Though there are natural differences in salt tolerance of various crops research efforts at improving salt tolerance of important crops like wheat, mustard and rice, which are grown in the region, have further improved the chances of saline/sodic water use. Conjunctive use even with very limited canal water (fresh water) availability vastly improved the crop water use efficiency and profit-
ability and bringing larger area under irrigation. Crop productivity and income generated in case of wheat, improved between 20-30 % when irrigation application with saline water of 6 dS/m increased from 100 mm to 200mm, with canal water remaining constant at 100mm. The techniques, those could be adopted for practicing salty water reuse, include blending of fresh and poor quality waters, cyclic use of fresh and poor quality waters in sequential and switching.

Reuse of sodic and high SAR (sodium adsorption ratio) proved more difficult as compared to highly saline waters in terms of impact on soil health and crop productivity. On a limited scale, waters with residual sodium carbonate (RSC) up to 8 miliequivalent per litre could be successfully used in rice-wheat after amendment with chemicals like gypsum provided half of the irrigation needs were met with fresh water. However, cropping of rice and wheat would become unsustainable in case of very limited fresh water availability and would call for crop diversification. Using UNSATCHEM model, guidelines for practicing conjunctive use sodic and fresh waters have been prepared for wheat crop and the procedure developed could be used to formulate guidelines of sodic water for other crops as well.

There are some unresolved issues like how high the limits of salty waters reuse could be raised by taking advantage of the synergy between plant salt and physical interventions like amendments and drainage for salt leaching water use. But the scope of raising the productivity and farm income on investment in drainage and chemical amendments has been very well established. In conclusion it stated that the field investigations and analytical studies provide a new insight on the role of monsoonal rain and drainage system in facilitating the use of salty waste waters in arid region on sustained basis.
Introduction/Problem Identification
For most of the first ten years of this century, southeast Australia has experienced a drought of unprecedented proportions. As river-fed water supplies fell to concerning levels in four major cities, policy makers, politicians and water utilities sought to reduce community demand and find alternative ways to supplement their city water supplies.

Since 2006, Veolia Water has been involved in major urban reuse programs in three of the four major Australian cities, and in one major rural town.

Each of these projects had to be developed and implemented at the same time as the policy and regulatory framework in each of the different States was being developed to manage them. The projects were also part of a larger policy picture on water supply and demand in each jurisdiction. These included actions to reduce water use by the community (restrictions, awareness campaigns) and installation of desalination plants to augment potable water supplies.

Analysis/Results and Implications for Policy and/or Research
The paper will use examples from five major reuse projects to illustrate the practical issues involved in making reuse water one of the major water supply platforms in major cities. The projects are:

- In Adelaide (South Australia), Veolia Water subsidiary, United Water, is part of the Glenelg–Adelaide Parklands Project, treating and delivering water to central Adelaide mainly for irrigation of the city’s parks and gardens.
- In Brisbane (Queensland), Veolia Water operates the Western Corridor Recycled Water Scheme that takes secondary treated effluent and further treats it to a very high standard to supply power stations and, when required, to supplement drinking water supplies.
- In Sydney (New South Wales), Veolia Water is part of a consortium that is privately building and operating a reuse plant and network to provide water for industrial use.
- In Ballarat (Victoria), Veolia Water is responsible for treating reuse water to a level suitable for discharge to a city-centre recreational lake.
- In Adelaide, Veolia Water subsidiary, United Water, is a partner in two large-scale research and development projects using aquifer storage and recovery to manage recycled water for use in parkland and market garden irrigation.

The paper will cover:
1. Changes to public health regulations
2. Changes to economic regulations
3. Measures to enhance public perception

1. Changes to public health regulations
Health regulations around water recycling were at a limited stage of development in most States at the time of project implementation. Historically, the focus had been on encouraging reuse to meet state
recycling targets (where these existed), with the emphasis being on using treated water for irrigation in areas that were well away from immediate contact with human beings. With the advent of new large-scale recycling schemes to substitute for potable water in a range of community applications, direct human contact was probable if not likely. This required the rapid evolution in the local and national public health and environmental requirements for reuse water quality and management.

Although the focus and approach differs from State to State, all approaches being developed by the Australian health regulators are based on the number of barriers in the treatment and supply system and the log removal of specific and proxy compounds in the water.

2. Changes to economic regulations
Water supply infrastructure and service provision in Australia has traditionally been a public sector activity. To encourage innovation in the provision of recycled water in a city environment, several States have changed their water legislation to enable “third party access”, or access of other services providers, to the networks. In New South Wales, legislation was passed to allow third parties to gain access to the sewer network and to gain licences to provide water to the community. Similar legislation is being passed in Victoria.

Veolia Water now holds the first and only (at the time of writing) privately held urban water supply licence in Australia. This result has taken several years of development as the legislation was developed, debated and passed. Critical to the success has been securing customers under mutually acceptable pricing arrangements for the recycled water.

Veolia Water is currently building the Rosehill Recycled Water Project to provide water into a recycling network that is being established through central western Sydney. The Rosehill plant will provide recycled water into the major industrial areas of the central west of the city. Customers include a power station, petrochemical plant and paper manufacturer.

3. Measures to enhance public perception
Recycled water seems to engender a love-hate relationship in much of the community. The community loves the concept that reuse water is a major part of the water supply portfolio, but the closer the water gets to public contact especially public ingestion, the larger are their concerns. Indirect potable reuse is plays only a limited part of the total range of policy options currently adopted. However, it is on the agenda of the federal and several state governments as a potential part of the longer term solution.

For the Queensland project, Veolia Water has sought and achieved accreditation of the treatment and delivery processes to the international standard for food safety, ISO 22000. This is aimed at ensuring that appropriate risk processes are in place in for the actual and potential uses of the water. It should also provide reassurance for users of the reuse water that the barriers are in place and are being appropriately maintained. Veolia Water is currently seeking ISO 22000 accreditation for its Ballarat treatment systems.
Workshop 5: Management of Groundwater Abstraction and Pollution

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Investigations of Sustainability of Arsenic Low Aquifers in Regions with High Arsenic Groundwater, SE-Bangladesh – Implications for Water Management

Restoration of Groundwater Quality in a Petroleum Contaminated Aquifer – Case Study
Health Impact and Organic Contamination of Urban Borehole Waters in Calabar, South East Nigeria

Author: Prof. Francis Emile Asuquo et al.  
University Calabar, Nigeria

Keywords: health, impact, organochlorines, borehole, Nigeria

Introduction/Problem Identification
Water abstraction from boreholes in Calabar, Nigeria is a lucrative business and many households appear to depend on borehole water which is adjudged to be clean and dependable.

Due to the erratic and irregular nature of public water system, high patronage is accorded private borehole operators, most of which the quality of water sold cannot be guaranteed. Investigations were carried from February to May 2009 to ascertain the potability of selected borehole waters in Calabar, Nigeria, which is fast becoming a centre for commerce, industry and tourism, with the intention of providing data and information for policy formulation.

Analysis/Results and Implications for Policy and/or Research
The area of study consist of three egalitarian regions namely Calabar South (bordering the Republic of Cameroon), Calabar Municipality (middle) and Calabar North (at the Tinapa area). Twenty five borehole water samples were collected with at least 7 samples from each location. Potability and acceptability depended on the quality of the borehole waters complying with the Nigeria Federal Ministry of Environment and WHO Guidelines (2009). While the levels of physicochemical factors and secondary contaminants were all within permissible limits, remarkable contamination occurred with respect to Alachlor 0.2 ± 0.01 µg/l, Atrazine 0.1 ± 0.001 µg/l, Endosulfan sulfate 0.07 ± 0.05 µg/l, g.chlordane 0.1 ± 0.02 µg/l, Heptachlor epoxide 0.08 ± 0.02 µg/l, Methoxychlor 0.2 ± 0.003 µg/l and Simazine 0.08 ± 0.032 µg/l especially in samples obtained from Calabar South. The levels of these contaminants slightly exceeded the permissible limits of WHO standards for potable waters. The data and information obtained shall form a baseline where policy could be made regarding the proliferation of boreholes, their location and potability. The health implications of organochlorines in particular suggest the need to develop and enforce Urban Clean Water and Safety Policy (UCWSP) for Nigeria and other developing countries.
Developing of an Aquifer Management Strategy for the Rapidly Expanding City of Lusaka, Zambia

Author: Dr. Roland Baeumle* et al.
* Federal Institute for Geosciences and Natural Resources, Germany

Keywords: karst, Lusaka, aquifer management, vulnerability mapping, remote sensing

Introduction/Problem Identification
Lusaka, the capital of Zambia with an estimated population of about 1.3 million in 2005, is experiencing a rapid population growth of about 3.7 percent per annum and an increase in population density of over 400% over the last 40 years [2]. According to the National Water and Sanitation Council (NWASCO), the water supply coverage by the Commercial Utility, the Lusaka Water and Sewerage Company (LWSC) is 68% [3]. Total water production in 2008/2009 reached almost 260,000 m$^3$/d while actual daily water demand (including private and commercial abstractions) is estimated at 340,000 m$^3$/d. Currently, the LWSC pumps up to 140,000 m$^3$/d from the local groundwater systems whereas the remaining water is sourced from the Kafue river situated about 40 km south of the City. The estimated water demand by the year 2030 is 640,000 m$^3$/d [1].

Analysis/Results and Implications for Policy and/or Research
The very productive, karstic aquifers are characterised by shallow water tables and a lack of a protective cover, and therefore considered very vulnerable to pollution. Industrial effluents and improper disposal of sewage and waste constitute major risks for groundwater quality. According to NWASCO, the sanitation coverage is only 17%.

The Lusaka area is covered by strongly folded overthrusted metasedimentary rocks of Katanga (Neo-proterozoic) age which have been intruded by granitic and basic bodies. The carbonate rocks cover an area of 1600 km$^2$ (see Figure 1) and are known to form a terrain undergoing recent and active karstification. On the surface, an epikarstic zone has developed with an average depth of 5 m extending to a maximum depth of 25 m below the surface. The main aquifer is hosted by the marbles of the Lusaka Dolomite Formation.

First investigations carried out during the preparatory phase of the study included the development of a groundwater information system and GIS, the establishment of a groundwater and spring and surface water monitoring network, remote sensing studies and water quality sampling campaigns. Satellite imagery was used to determine current land use distribution and to identify directions of maximum principal stress and the main trends and types of faults.

Sustainable water resources management on a regional scale requires information about long term means of the percolation rate from the soil. In addition to its significance for quantifying the amount of water available for the water supply, percolating water affects soil formation and the migration and leaching of plant nutrients and contaminants. In order to obtain reliable estimates of the groundwater recharge rate a simple, non-mechanistic simulation model of the soil water balance will be applied to calculate actual evapotranspiration and percolation in dependence on precipitation, potential evapotranspiration, soil hydrological properties and land use classes.

Water quality sampling included inorganic constituents and heavy metals as well as microbiologi-
cal indicators. The results could be used to assess the chemical water composition of areas that are affected by human pollution sources. These waters were characterised by an electrical conductivity (EC) of less than 800 mS/cm and concentrations in sodium, chloride, nitrate and sulphate below 10 mg/L. Higher levels in these parameters could consequently suggested the presence of urban pollution sources. The study proved that microbiological (including faecal) contamination and pollution is widespread throughout the City area. A next step will be to identify areas which are highly vulnerable to pollution.

A practicable and easy applicable assessment scheme has to evaluate the protective effectiveness or filtering effect of the unsaturated zone and has to take into account numerous influencing factors such as the available water capacity of the soil, the mean annual percolation rate, rock properties in dependence on lithology and degree of fracturing and the thickness of soil and rock cover above the aquifer. Although the underlying algorithms simplify the physical and chemical processes and make no distinction between pollutants different in migration, sorption and degradation behavior, the GLA approach (Hölting et al. 1995) allows assessing the protection effect of the soil and rock cover over large areas and provides valuable information related to many of the pending problems. Even though the GLA method is in principle applicable on all types of aquifers, it does not sufficiently take into account the special properties of karst. In karst areas vertical flow via swallow holes can bypass the protective cover partially or completely. Therefore, the method will be closely linked to results of the remote sensing investigations for identification of epikarst manifestations on the surface.

The vulnerability assessment will be an important step towards the development of groundwater management guidelines and the delineation of protection zones.

The successful development of the aquifer management strategy for Lusaka will depend on a thorough assessment of the groundwater potential, the current pollution status and potential risks, and the vulnerability of the Lusaka groundwater systems. Its successful implementation will largely rely on the institutional framework and capacities.
Regional Training on: Groundwater Management for Water Managers: A Role of Hydrogeological Science for Non-Hydrogeologists

Author: Ms. Anne Blenkinsopp* et al.
* DFID (on behalf of SPLASH Project), UK

Keywords: Integr. Groundwater Management, Groundwater Quality, Groundwater Pollution, Capacity Building, Science-Policy-Dialogue

Introduction/Problem Identification
In Africa groundwater is considered as the only realistic water supply option for meeting the needs of dispersed rural communities, as well as supplementing the water demand from expanding urban centers. With the emergence of the Millennium Development Goals (MDGs), a call for managing groundwater development has arisen in order to curb irrational abstractions, ensure that groundwater demand is met, and improve poor management practices. Currently however, knowledge about groundwater is rare, specialized professionals like hydrogeologists or geophysicists are lacking and consequently it is a rather neglected and often mismanaged resource on the African continent.

In July 2009 the African Groundwater Network (AGW-Net) in cooperation with SPLASH and CapNet finally hosted a training course at the University of Witwatersrand (Johannesburg) to increase awareness of groundwater problems and to acquire professional skills for developing capacity for sustainable groundwater management.

Analysis/Results and Implications for Policy and/or Research
The overall objective of this joint organized training course, entitled “Groundwater management for water managers: A role for hydrogeological science for non-hydrogeologists”, was to achieve these objectives with water managers as target group and to provide a positive contribution to the realization of the African Groundwater Commission’s (AGWC) targets. The AGWC is in interaction between AGW-Net and the African Ministers’ Council on Water (AMCOW). It will act as a sounding board for decision making by AMCOW and will provide them with strategic advice on collaborative aspects of groundwater resources management.

Beside the basics of hydrogeology the main focus of this course was on Integrated Groundwater Management, which include inter alia lectures and exercises on groundwater pollution, groundwater quality, groundwater recharge process and groundwater management strategies.

A total of 13 participants from 10 African countries attended the course, most of whom were civil engineers and hydrologists, from water ministries and water bureaus.

The course included: presentations by the lecturers; discussions; working groups as well as one-day field trip. The field excursion was a visit to the Hartbeespoort Dam area to learn the surface and groundwater interaction. The dam has a storage volume of approx. 200 million m$^3$ of which a substantial portion recharges into the underlying aquifer. Even though the water is highly polluted from acid mine drainage effluents, radioactive effluents from a nuclear research facility and insufficiently treated waste water it is used for irrigation purposes.
Through working group discussions and course evaluation, participants identified a number of management issues, including: the lack of coordination and integration and different legislation on groundwater between the various ministries that use or manage the resource. One solution commonly identified was the development of a common database of information to be used by these various groundwater users and management agencies.

Additionally the participant’s presentations showed that excessive fluoride concentrations in groundwater cause serious health problems in most East African countries. Research on fluoride removal techniques could be a useful topic for future research actions.

In summary, the groundwater management course enables:

- Exchange of knowledge among participants
- Delivery of wide experience between instructors and participants
- Introduction of applicable groundwater management strategies
- Improvement of the scientific-policy-stakeholder dialogue
- Importance of integrated work among different stakeholders for successful groundwater development
- Continent wide dissemination of groundwater knowledge
- Development of appropriate recommendations for policy makers
- Identifying of suitable research activities
- Intensified dialogue and North-South and South-South cooperation in groundwater research due to the joint organized cooperation

Based on the evaluation results and recommendations of this training course a joint subsequent training course for 2010 has been designed together with AGW-Net, SPLASH Partners and Cap-Net. The course will be hosted in Togo to disseminate the groundwater knowledge also to francophone African countries. As groundwater pollution is closely linked to surface water it is planned to improve the dialogue to the River Basin Organisations through inviting interested members of it. Furthermore the AGWC targets will be shown by members of the Commission itself. By inviting different stakeholders (including NGOs, practitioners, policy makers, researchers) the dialogue between the different actors will be fostered, which contribute to achieve a better mutual understanding and to speed up joint solutions in terms of sustainable groundwater management strategies.
Study of Transport Behavior of Arsenic and Evaluation of Remedial Options Using Groundwater Transport Model – A Case Study in West Bengal, India

Author: Mr. Biswajit Chakravorty
National Institute of Hydrology, India

Co-Author: Dr. Narayan Chandra Ghosh
National Institute of Hydrology, India

Keywords: Transport Behaviour of Arsenic, Groundwater, West Bengal, Groundwater Model, Remedial Options

Introduction/Problem Identification
Epidemiological studies conducted (1980) in groundwater samples of a few districts of West Bengal (India) established Arsenic concentration above the permissible limit of 0.05 mg/l. Latter on the groundwater samples of as many as 830 villages covering areas of 37,500 sq km in eight districts (Malda, Murshidabad, Nadia, South and North 24-Paraganas, Burdaman, Hoogli and parts of Kolkata) was reported to be under the menace of Arsenic pollution. However, there is no definite conclusion about the cause of such a larger scale occurrence of Arsenic in groundwater. The scale of the problem is increasing in geographical area coverage. In order to have an insight of such a problem an effort is made to analyze the groundwater flow and transport behaviour of Arsenic contaminated groundwater and evaluate possible remedial options in Yamuna sub-basin of Nadia and North 24-Paraganas districts of West Bengal (India).

Analysis/Results and Implications for Policy and/or Research
The study presented here analyzes groundwater flow and transport behavior of Arsenic contaminated groundwater in Nadia and North 24-Paraganas districts of West Bengal (India). The study also evaluates possible remedial options for Arsenic affected pockets. These objectives have been addressed through simulation of transient groundwater flow and transport model for the study area. The US Geological Survey three-dimensional flow model, MODFLOW and three-dimensional advective-dispersive-simple reactive modular transport code MT3D have been used as tools for flow and transport modeling.

The study area of 1500 km² (50 km X 30 km) described as Yamuna sub-basin, is bounded by river Bhagirathi in the west and the river Ichamati in the east. The river Yamuna (local name) runs from north-west to south-east direction. The presence of Arsenic was first reported in the study area in 1985. It was observed that, over the years, the concentration has increased. Monthly Arsenic concentrations monitored during 1997-98 at 58 observation wells do not depict any specific trend in space and time. However, observed Arsenic concentration data reveal maximum concentration (more than 0.2 mg/l) at six locations namely, Khusbasi, Mandalhat, Kundalia, Devipur, Maslandpur, and Ashoknagar. These locations are at a considerable distance from one another and the concentration do not depict any linkage. However, they depict activation and de-activation trend of concentration when compared with water level data. Concentration increases during rise of water table (May-July) and decreases when water table declines. Arsenic is found to be more where transmissivity is less and storativity is more. The minimum transmissivity occurs where there are clay pockets.

For modelling the area is discretized into 100 column, 100 rows, 10 layers (each 8 m thick) and 12 stress period each having a length of 30/31 days. The monthly observed water level and Arsenic
concentration data from September’97 for 58 locations are available. The water table data of September’97 is taken as the initial water table condition. The east and west side of the area has Ichamati and Bhagirathi river as the boundary. The north and south sides are treated as flux boundaries. The input parameters are from the pumping test data of 21 locations. The input time series stresses of outflow and inflow component consist of pumpage from the aquifer, evapotranspiration, inflow from/to rivers and boundaries, recharge from rainfall, irrigation return flow and from boundaries etc. The initial concentration for MT3D is also taken from September’97.

The flow model is simulated from September, 1997 to August 1998 for transient condition. The input model parameters are calibrated, the recharge and discharge pattern of the area are re-estimated till the simulated result is in coherence with the monthly observed water table condition. The transport model is then simulated considering in-situ sources of six localised pockets to study spreading, since linkages from boundaries to these locations could not be established even after 5 years of simulation. The activation process during the recharge period in subsequent years in these pockets are simulated by artificially introducing mass flux. The output of the model after 5 years of simulation shows influence of the localised sources to a maximum distance of 1.5 km from these sources.

Evaluation of remedial options indicate that the arrest of lowering of water table particularly during peak withdrawal months (November to April) to a certain level would minimize the activation processes of Arsenic in the flow domain. For this, different remedial options like (i) stepwise reducing the groundwater pumpage from the model domain; (ii) defuncting withdrawal from wells of the Arsenic spreaded areas and (iii) installing battery of recharge wells around the Arsenic affected zones to create a hydraulic barrier are attempted. Creation of artificial hydraulic barrier by recharge wells seemed to be a reliable option to arrest the spreading of contaminated groundwater.

The developed model can be used to compute the groundwater head and flow behaviour for any stress conditions with satisfactory degree of precision. Although simulation of transport process indicate spreading at a localized scale due to in-situ activation, this explanation needs validation by geo-chemical analysis However, the model is capable of simulating activation/deactivation process. Analysis of remedial options indicate that arrest of lowering of water table particularly during peak withdrawal months (November to April) would minimize the activation/deactivation processes. In general, for Yamuna sub-basin, the water table of November 1997 is found to be the safe level which needs to be maintained at these pockets. To arrest the spreading of Arsenic contaminated groundwater from localized pockets, creation of artificial hydraulic barrier through recharge wells seems to be a reliable option.
Sustainable Use of Deeper Potable Ground Water in Thickly Populated East Coastal Tract of India

Author: Dr. Prabhat Chandra Chandra
Central Ground Water Board, Government of India

Keywords: coastal aquifer, groundwater salinity, Indian coast, geophysical investigation, hydraulic conductivity

Introduction/Problem Identification
Shortage of potable water is a major social issue in thickly populated coastal tracts inherently marked by groundwater salinity, posing challenge to the development and prosperity. Besides increasing domestic dependence, anthropogenic demands and industrial use, irrigation in coastal fertile tract attracts large groundwater extraction from the fragile, sporadically distributed shallow freshwater aquifers with diminishing recharge leading to potable water crisis. East coast of India though has well developed deltas and vast plains with extensive patches of thick sea ward dipping fluvial and marine sedimentary deposits forming large repositories of groundwater, presents such a situation. Precise delineation and monitoring of fresh/saline groundwater interface dynamics in space and time help management of fresh coastal groundwater by judicious exploitation, efficient use and effective interventions to check sea water ingress, anthropogenic pollution and inundation by natural disasters.

Analysis/Results and Implications for Policy and/or Research
Coastal tracts of East Medinipur districts of West Bengal on east coast of India with thick Quaternary and Tertiary sediments represent a typical situation of thick population density, more than 1000 persons per sq. km, fertile agricultural land, growing urbanization and industrialization and out-flowing rivers under tidal influence holding unusable water most of the time leading to a large dependence on groundwater. The area holds a complex multi-layered aquifer system. The Quaternary sediment extending down to 107 to 211 m depth does not hold any promising granular zone in its top 65 to 100 m thick clay predominating Newer alluvium while the Older alluvium holds productive aquifers. The Quaternaries are separated from the underlying Tertiaries by a prominent ‘Grey Clay’ marker horizon. The Tertiaries comprising sand-silt-clay cyclic sediments form regional multiple deeper aquifers. Within the explored depth of 400m there are two prominent groundwater quality interfaces at about 120 m and 300 m below ground and the zone in between holds fresh groundwater forming the principal freshwater aquifer being tapped. Also, there exists a near-surface thin fresh groundwater column at the top in the sand dunes and palaeo-channels annually recharged through rainfall (average 1500 to 1700 mm), though the direct recharge of the top predominantly clayey Newer alluvium is not significant in the area. The freshwater aquifers are separated from the saline water zones by distinct clays. The aquifers are extensive and coast ward dipping with transmissivity ranging from 300 to 800 m²/day. Yield of the deep tube wells tapping about 40 m aquifer ranges from 2 to 37 lps for 10 to 15 m drawdown. Thick fresh water aquifers are prominent in the southwestern part. Though the groundwater salinity (Electrical Conductivity ranging from 5500 to 8200 µS/cm and maximum upto 26,000 µS/cm at places) in the Quaternary and Tertiary sediments in the area is inherent, derived from sedimentations under marine environment as evidenced by the significant presence of Bromide and Iodide, the spatial variability of salinity is large and complex.. The situation around Kanthi, the district headquarters, located about 10 km inland is still critical, having groundwater salinity throughout upto 300 m depth, while the salinity on the nearest coast line is only upto 135 m depth, where the thickness of saline water zone should have been more. The saline groundwater...
trough delineated at Kanthi is about 8 km wide and 30 km long and parallel to the NE-SW trending present day coastline. The thickening of saline water zone is attributed to the trapped sea water in palaeo-lagoon and shifting of the shore line. Here the saline / fresh groundwater interface does not show any change in quality with time, suggestive of poor flushing due to low hydraulic conductivity. The floating fresh water lenses in the highly permeable sand dunes are the only source here and are mostly exploited for the local water supply.

In contrast, in the coastal industrial area of the district there is a considerable abstraction of fresh groundwater from the deeper fresh water aquifers in the Quaternaries and Tertiaries at a rate of 100-150 m³/hr by a large number heavy duty tube wells, causing a fall in piezometric surface to the tune of 5 to 7 m during the last 3 decades. Locally the piezometric surface has gone below the mean sea level by a few metres. Fresh water aquifers being sandwiched between the saline water zones, there is the possibility of upward or downward leakage from the underlying and overlying saline water zones. However, there is no seawater intrusion so far, as the deep wells even in the nearby islands, 50 km south, in the Bay of Bengal have not shown any rise in deeper groundwater salinity.

Disposition of groundwater quality interfaces and fresh water aquifers in the 90 km long coastal tract of the district including the industrial area was assessed through 82 deep electrical resistivity soundings and geophysical logging of 16 boreholes. The resistivity of brackish/saline water saturated sand and clay is around 1 to 2 ohm.m. The brackish/saline groundwater zone extends 5 to 30 kms inland. The spatial variation in aquifer hydraulic conductivity was mapped by correlating the hydraulic conductivity values with the natural gamma radioactivity logs. Correlation of synthetic hydraulic conductivity log along the coast line helped identify permeable windows prone to sea water intrusion.

Artificial recharge is recommended to sustain the shallow fresh water aquifers in the sand dunes and reclaim the brackish water aquifers in and around Kanthi. While in the industrial area, a control is essential on incessant high discharge wells to check the upconing or vertical leakage and sea water intrusion. Aquifer salinity monitoring in the industrial area by repeat surface and borehole geophysical measurements limiting groundwater overdraft beyond sustainable yield is desired.
Issues and Challenges in Geogenic Contamination of Groundwater in India: Special Reference to Arsenic and Fluoride

Author: Dr. Arijit Dey
Ministry of Water Resources, Government of India

Co-Author: Dr. Praveen Kumar Mehrotra
Ministry of Water Resources, Government of India

Keywords: geogenic, aquifer, fluoride, arsenic, groundwater

Introduction/Problem Identification
Groundwater is one of the most important natural resources in India which provides sustainable source of water supply for meeting the agriculture, socio-economic and ecosystem need of the country. However, over the years, groundwater quality problems of natural origin have emerged as one of the major challenges in groundwater resource management threatening fresh water supplies and environmental sustainability. Out of these, Arsenic and Fluoride, the most wide spread ground water contaminants and identified health hazards have been known to occur in elevated concentrations in 258 districts out of 626 districts in the country putting 80 million populations to risk.

The paper outlines issues and challenges in addressing the groundwater quality problems in India, with special reference to the problems related to geo-genic contamination of arsenic and fluoride in groundwater. Further initiatives to address the groundwater quality problems in holistic manner have also been discussed.

Analysis/Results and Implications for Policy and/or Research
Groundwater studies aided with exploratory drilling undertaken by Central Ground Water Board have identified Arsenic infested aquifers down to the depth of 20-80m below ground level in various parts of the Ganga Basin. Studies have also revealed the occurrence of elevated concentration of Fluoride in ground water, especially in deeper crystalline/ metamorphic hard rock aquifers in various parts of peninsular India.

As a part of mitigation measures, several initiatives are being taken at National level by various organizations. Central Ground Water Board through scientific studies have undertaken delineation of uncontaminated aquifers, suitable design of tubewells, sealing of contaminated zones etc., besides regular monitoring of groundwater quality. Pilot studies were also undertaken to evaluate the efficacy of dilution effect through induced groundwater recharge in the Arsenic affected areas. National Rural Drinking Water Programme is being implemented for surveillance of groundwater quality and provision of safe drinking water to the rural habitations.

In addition to providing alternate piped water supply to the population of the affected areas, measures like implementation of treatment technologies, epidemiological studies, capacity building and awareness programmes have also been initiated.

The prevailing groundwater quality management approaches in India are largely limited to the extent of identification of infested areas on regional basis, monitoring of groundwater quality, provision of
alternate source of drinking water supply, development of few treatment technologies etc. However, keeping in view of the multi-dimensional problems associated with groundwater contamination, there is a need for a comprehensive strategy. While focusing on groundwater quality management measures at micro watershed scale, the mobilization of stakeholder’s involvement at all stages of programme implementation should also be ensured.

The case studies of Murshidabad district of West Bengal & Nalgonda district, Andhra Pradesh have been highlighted in the present paper. The study of ground water quality in shallow tubwells (upto 90m) of Murshidabad district in the area have indicated that about 50% wells out of Mur- Jiaganj block, 58% wells in Babarampur block, 50% wells in Domkal and 56% wells in Rani Nagar – I block are arsenic infested. However, deeper wells (> 100m) are found to be arsenic free.

The groundwater of Nalgonda district is well known for its very high fluoride content for the past five decades. 346 villages are affected with fluoride contamination in ground water. The maximum fluoride concentration has been recorded as 4.25 mg/l.

Based on the study, the following strategy for addressing the groundwater quality issues in holistic manner is recommended:

- Building of knowledge base and recent understanding to develop, manage, monitor and evaluate groundwater quality assessment and management programmes.
- Mapping of aquifer systems and identification of groundwater quality infested areas based on recent advances and understanding on the subject.
- Strengthening & benchmarking of water quality monitoring and surveillance infrastructures.
- Implementation of aquifer recharge for dilution in affected areas.
- Up-scaling of completed pilot studies for replication in other similarly affected areas.
- Dissemination/sharing of groundwater quality information among stakeholders.
- Launching of nationwide campaign on water quality awareness, especially for mobilization and involvement of stakeholders.
- Community involvement all level of programme implementation.
Over-Abstraction of Ground Water and Increasing Threat of Pollution: Is Farmers’ Livelihood at Stake? – A Case Study in India

Author: Prof. Rudrappan Dhamodharam  
Covenant University, Nigeria

Co-Author: Prof. Amerjothy Swaminathan  
University of Madras, India

Keywords: livelihood, environmental refugees, artificial recharge of aquifer, effluent treatment, community management of water

Introduction/Problem Identification

Introduction
India is a vast country supporting 17% of the world’s population, with barely 4% of world’s water resource. Ground water occupies a pivotal role fulfilling the water needs of more than 60% of the population. Therefore, it is important to preserve the quality and quantity of available ground water for sustainable development and for ensuring security of livelihood.

Problem
Depletion of aquifer regime due to over-abstraction and increasing threat of pollution caused by industrialization have led to surfacing of harmful fluorides, salt and ingress of sea water converting the farm land unsuitable for cultivation of any crops. Consequently, farmers have been forced to move out to eke their livelihood in the nearby urban areas as daily labourers. These environmental refugees who are displaced from their natural environment have faced a daunting future causing significant economic, socio-cultural, and political consequences in the urban areas.

Analysis/Results and Implications for Policy and/or Research

Analysis
In the context of the above problem, a survey has been carried out in the villages of Minjur Panchayat Union, North Chennai, South India to find out the extent of threat to the livelihood of the farmers and to analyse the factors that are responsible for over-appropriation that led to the degradation of ecosystem. Agriculture has provided livelihood source to more than 60% of Indians giving them food, employment and income. Negligence, encroachment and poor maintenance of surface water storage structures such as lakes and ponds have reduced the catchment area. This has led to the rainfall runoff and consequent drying up of irrigation systems. The area that was once fertile, blooming with cultivation of crops has become a barren land now, cultivating nothing.

Faster rate of ground water utilization has led to a fall in the recharge capacity of tube-wells and consequent intrusion of sea water from the Bay of Bengal which lies 8 kilometers away. Over-exploitation of ground water, most of which has become hard water due to ingress of sea water, has not only resulted in the deposit of harmful fluorides and salt on the top soil, but also affected the cultivation of crops. Besides anthropogenic activities, many industries in North Chennai which is 9 km. away have been dumping their industrial waste and discharging their untreated effluents in the waterways causing point and diffuse sources of pollution threatening the ecosystem.
The ground water sample taken in 2008 showed an increasing trend in the electrical conductivity (EC) above 3000 mic s/cm, Ph value at 13, TDS at 4000, alkalinity at 300 mg/l, sodium at 450mg/l, sulphate at 500mg/l chloride at 640 mg/l and nitrate at 180 mg/l pointing out that the ground water has become unsuitable for human consumption as per the parameters laid down by World Health Organisation.

Discussion of Results
Absence of surface irrigation has forced the farmers to use more ground water because it is a ‘democratic resource’ available to any farmer who has access to a pump set. Farmers can get as much water as they need, when and where they want it from pump sets since electricity is supplied free of cost to all farmers. In addition, ground water use is dependent on demand for water and not on supply of water. The study shows that demand – pull factors such as demographic change, economic growth and new agricultural techniques had the significant relationship with increasing abstraction of ground water. The crops have wilted on account of heavy saline nature of groundwater contaminated by sea water. More than this, the villagers have faced health complications and have to spend money not only on their health care but also on buying good quality water for their domestic needs. At the village level, the shrinking water potential has led to pollution of ground water, water lordism among rich landlords and widening inequality.

Implications for Policy and Research
To stem the tide, the Government should adopt volumetric pricing of electricity for all farmers with out exemption. In addition to monitoring, the existing laws should be strictly enforced among the pollution causing industries for the installation of effluent treatment plants. Adoption of improved irrigation such as micro irrigation, drip irrigation, and sprinkler irrigation along with fertigation techniques would allow farmers to boost their yields up using only one-third the water they would use with full irrigation. Such strategies could provide the much needed lift to the farmers’ livelihoods paving way for a direct relationship between access to water and access to food and food security.

In the existing scenario of competing demand for water, greater awareness and efforts are needed to balance it with the exploitation of ground water so as to make it compatible with environmental conservation. Adoption of sustained rainwater harvesting programme, effective community management for the use of available surface and ground water resources through formation of Water Users Associations, construction of percolation tanks, artificial recharge of water in aquifers for blocking ingress of sea water in coastal areas, conservation through watershed development programme, Integrated Water Resource Management (IWRM), periodic maintenance of water storage and other irrigation systems, and water use efficiency through proper irrigation management are some of the most effective ways in breaking the vicious circle of over appropriation of ground water, increasing pollution, poverty and other challenges to farmers livelihood.

Conclusion
Hence, the above water management strategies along with pollution abatement and prevention practices, if implemented properly will not only help farmers to reverse the water degradation trend contributing to economic growth and improving human and environmental health but also will ensure security of their livelihood in their villages.
Water Pollution, an Additional Threat to Water Scarcity in the Arab Region

Author: Dr. Abdullah Droubi
Arab Center for the Studies of Arid Zones and Dry Lands, Syria

Keywords: scarce water resources, deteriorating water quality, vulnerability of groundwater, groundwater protection, IWRM based on availability

Introduction/Problem Identification
Population growth, urbanization and expansion in irrigated agriculture have led in most of the Arab region to mounting pressure on the scarce water resources. Irrigation already accounts region-wide between 60 to 80 percent of withdrawals and water demand in rapidly expanding urban areas is difficult to satisfy.

Deteriorating water quality presents an additional threat to water availability due to combination of low river flows, inadequate wastewater treatment, intensive agricultural activities, uncontrolled industrial effluents, and over-exploitation of groundwater.

In Addition there is weak water legislation, a lack of information and lack of tools for water allocation management and planning.

Efforts will be presented how ACSAD/BGR assist the Arab Countries in using appropriate technologies to prevent groundwater pollution and improve management of resources with the help of a Decision Support System.

Analysis/Results and Implications for Policy and/or Research
Vulnerability mapping in the Damascus basin in Syria and Bekaa Valley in Lebanon was implemented to prevent groundwater pollution. These areas face a high pressure on groundwater resources. Intense urbanization, industrial development and agriculture, using high quantities of pesticides are characteristic for both areas, where small rivers collect all the sewage without treatment.

The areas where the groundwater is vulnerable to pollution or where a risk of contamination exists were outlined, following three categories high, medium and low.

The results achieved provide a good background for decision makers for future development planning and measures for groundwater protection can be defined. Installation of appropriate sewage systems and treatment plants are necessary, including an effective monitoring system to avoid any risk of pollution.

The development and implementation of a decision support system (DSS) for integrated water resources management helps decision makers to optimize management of water resources and avoid any deterioration in water quality and quantity. Two pilot areas, the Zabadani basin in Syria and the Berrechid plain in Morocco, were chosen to develop and test the technique. The Zabadani basin with the spring of the Barada river is located near Damascus, the capital of Syria. From here, groundwater is pumped in summer time to supply the city with enough drinking water. The area is also well developed in agriculture and tourism. All these sectors put high pressure on available groundwater.
in the area. The second pilot area is located near Casablanca in Morocco and is also subject to rapid development in urbanization, industry and agriculture.

The DSS deals with both ground and surface water to provide an optimal allocation strategy based on availability of water resources, groundwater recharge, soil moisture, water quality, costs of water production, and demand.

The software WEAP (Water Evaluation and Planning System), which was developed by the Stockholm Environment Institute (SEI) in Boston, USA is widely used, user friendly and free of charge for developing countries, which facilitates its dissemination. But, WEAP was previously mainly dealing with surface water systems, whereas groundwater resources were only included using a tank model. Since groundwater is the most important water resource in many countries of the Arab region, its dynamical behaviour has to be considered in detail. Therefore, it was necessary to include the aquifer characteristics and take the groundwater budget into consideration by using mathematical models to show to which extent the aquifer is capable to provide sustainable quantities of groundwater and which impact (drawdown of water level) has to be expected. To achieve this, an interactive link between the groundwater modelling software MODFLOW and WEAP was developed, providing a new and comprehensive Decision Support System (DSS). The application of the DSS in the Syrian Pilot area Zabadani basin has helped to propose a new hydrogeological concept and an improved water balance. The new concept helps for a better understanding of the hydraulic system of the region.

A direct impact of these project results was that the Syrian administration, which supplies Damascus city with water, has asked ACSAD and BGR to implement further studies in the area for a better understanding of the hydrogeological system of the whole Damascus area, mainly the location of recharge zones and groundwater flows. This should help to define the best approach for the management of the water resources in the area and minimize negative impacts.

The major output of the Berrechid pilot application was, that the Moroccan administration has decided to use the DSS as a standard tool for water management planning all over the basin agencies in the country.

Based on the successful application of the DSS in the two pilot areas ACSAD has received many requests such as from Libya, Tunisia, Morocco, Arab Gulf countries, Lebanon, Jordan, Palestine, Oman, Yemen and Saudi Arabia to assist in introducing the DSS methodology, which also was presented at a regional DSS WEAP conference in Damascus in May 2009. Contributions from countries outside the Arab region, showed their good experiences with the application of WEAP. The conference has contributed considerably to the acceptance of ACSAD as a center of excellence for WEAP-MODFLOW DSS dissemination in the region.

**Conclusion**

The groundwater vulnerability mapping method and the methodology of using the DSS developed by the project can both improve the management and optimal allocation of available water and guarantee sustainability in quality and volume. The applied methods have also made clear the necessity of accurate and reliable data about the water resources including climate and monitoring data.
Adopting a Coupled Socio-ecological Approach to Manage Groundwater in a Multiple Risk Delta Environment

Author: Mr. Joachim Ezeji et al.
WEDC, Loughborough University, UK

Keywords: groundwater, Nigeria, pollution, delta, ecosystem

Introduction/Problem Identification
The ubiquitous presence of water kiosks and vendors in major cities of Nigeria particularly those in the Niger Delta area does not only connote the commercialization of urban water supplies but also the sheer atrophy of municipal water utilities and failure of groundwater management in Nigeria. Already, public health concerns associated with impacts of industrial pollution, high population density and poorly managed on-site sanitation systems etc on drinking water supplies is still a major problem not only in the remote oil producing communities but also the major cities of the Niger Delta. Being a low lying delta area with poorly developed urban infrastructure, incidents of flooding and erosion has combined to provide a steady pathway for agricultural, industrial and domestic wastes to reach water sources. Despite these problems, random and unregulated development and exploitation of groundwater resources continues, a case of the tragedy of the commons.

Analysis/Results and Implications for Policy and/or Research
State Water Agencies (SWA), or water boards in the region, just as in other parts of Nigeria were set up to provide clean water supply. Each SWA has, in general, been established under an edict to develop and manage water supply facilities within its respective state and to meet sound financial objectives. But this is no longer the case as most of these utilities have long gone comatose. The alternative and most common way to meet growing urban needs therefore has been to exploit/overexploit groundwater resources. In parts of the Delta, tapping groundwater is the easiest solution because aside being “cheap” compared to other parts of the country, it generally relies on individual or corporate investments, and it is spatially spread with little need for major infrastructure. In tandem with the Nigerian National Water and Sanitation Policy (2000) and the National Water Resources Bill (2007), the Water Investment Mobilization and Applications Guidelines (WIMAG) and the model State Water Supply Services Regulatory Law (WSSRL) insist that each state of the federation with a State Water Agency (SWA) must establish a regulatory commission that is empowered to issue licenses for the provision of water supply services by both government and private sector entities; define minimum service requirement; set tariffs; define rights and obligations of the water service providers; and define performance standards. But these laws though enacted are currently not being enforced. The consequence therefore is the problem of sustainability. It is widely agreed that any conception of sustainability must account for the interconnections of environmental, economic, and social factors; consider both the local and global resource base; and be attentive to the long term needs of future generations. It becomes pertinent to underscore that the environment refers to the natural systems that provide the background or surrounding for human activity; and that environmental systems encompass a broad range of geophysical and ecological systems. Therefore as human pressure on limited and vulnerable groundwater resources increases in the region, efforts to manage this vital resource in a sustainable manner must be integrated into the broader and interlinked contexts of economic and social development of the environment. While the concept of Integrated Water Resources Management (IWRM) has been branded as an official tool in addressing the extant supply problems, these seems not to be truly so. IWRM which has often been defined as a process promotes the coordinated development
and management of water, land and related resources in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystem. IWRM is also based on the perception of water as an integral part of the ecosystem, a natural resource and a social and economic good; however priority has to be given to the satisfaction of basic needs and the safeguarding of the groundwater ecosystems. But in achieving this and much more there is need for adaptive management of water resources in the vulnerable delta because adaptive management deals with the unpredictable interactions between people and ecosystems as they evolve together. It takes the view that water resource management policies can be treated as ‘experiments’ from which water managers can learn. Organizations and institutions can ‘learn’ as individuals do, and hence adaptive management is based on social and institutional learning. Adaptive management is apposite for utilities in the delta because it differs from the conventional practice of resource management by emphasizing the importance of feedbacks from the environment in shaping policy, followed by further systematic (i.e. non-random experimentation to shape subsequent policy, and so on). The process is iterative; it is feedback and learning-based. It is co-evolutionary in the sense that it involves two-way feedback between management policy and the state of the resource. And for the Niger Delta, the significance of recent flood, drought, comatose utilities, pollution from agriculture and other urban wastes; does not only connote just a simplistic resort to massive abstraction of ground water resources but underscores the urgent need for a critical review of water management practices and policy under a new paradigm of coupled socio-ecological context.
Microbial Contamination of Shallow Tube Wells in Bangladesh: Evaluation of Potential Pathways and Implications for Sanitation Planning

Author: Mr. John Feighery
Columbia University, USA

Keywords: groundwater, bacteria, transport, tube well, latrine

Introduction/Problem Identification
Beginning in the 1970s, the population of Bangladesh successfully transitioned from surface water sources to groundwater, relying on over 10 million shallow tube wells for household water needs. Improved sanitation in the form of ventilated improved pit (VIP) latrines was also widely promoted and installed in many areas. Our research under the NIH/NSF Ecology of Infectious Disease grant initially aimed at exploring the relationship between contamination of the shallow aquifer and arsenic levels; however, in studying the potential sources of microbial contamination we found that a major contributing factor is the failure of latrines. This talk will explore the potential sources of widespread aquifer contamination we observed and why filtration theories developed from laboratory column experiments are not adequate in predicting the transport of pathogens from latrines and ponds into groundwater at our field sites.

Analysis/Results and Implications for Policy and/or Research
Colloid filtration theory is the widely accepted theoretical model for the processes that lead to removal of small particles such as bacteria or virus from water flowing through a porous medium. This theory was developed and validated primarily through small-scale (<20cm) column experiments in idealized laboratory conditions, yet there is a general disagreement between the results obtained from laboratory experiments and comparable field-scale experiments in real aquifers (e.g. Foppen and Schijven 2006). We began our analysis of this scaling problem by conducting a series of laboratory column experiments (12-cm length) using E. coli and latex microspheres with progressively field-like conditions to investigate the potential bias that laboratory conditions such as the use of washed and well-sorted grains might impart to column transport experiments. Transport was then measured at the field site under natural hydraulic gradients from potential sources (ponds, canals and latrines) by sampling with arrays of 3 drive-point wells installed at 50-cm intervals.

Our results, combined with an analysis of the geographical distribution of E. coli in over 100 shallow tube wells that were sampled monthly, demonstrate the difficulty in explaining the widespread groundwater contamination even at relatively shallow depths using colloid filtration theory and steady state flow assumptions. The wells follow a seasonal pattern of contamination with the peak levels occurring during the monsoon and the lowest levels at the end of the dry season, therefore it is strongly suspected that transport of some kind plays a role as opposed to back-contamination. Filtration rates in column experiments at the 10-cm scale were generally very high for all the conditions evaluated and transport distances calculated from these tests would predict undetectable E. coli levels after less than a meter of transport from even the most contaminated sources. The filtration rates from field experiments at the 1-m scale were approximately an order of magnitude lower than laboratory columns, resulting in predicted transport distances of several meters. These results are not able to explain the high levels of seasonal E. coli contamination found in nearby shallow tube wells even though geostatistical analysis indicates a correlation between contamination and distance to nearby latrines.
Another important factor that became apparent during the study is the effect of a flood control embankment built to improve agricultural productivity has on surface and groundwater flow. Surface and groundwater level monitoring show that during the rainy season groundwater flow reverses so that the heavily contaminated canals are draining groundwater water instead of discharging into the aquifer. The resulting drop in groundwater levels might enhance transport from ponds and latrines by increasing the hydraulic gradient inside the flood control area.

In a densely populated rural setting such as Bangladesh (or analogous settings, such as urban slums) where the population relies on untreated groundwater, recommended setback distances for latrines or septic systems from water sources cannot be reasonably achieved. In addition, the theoretical assumptions about transport of bacteria through porous media have been shown to under-predict the potential risk to wells from sources of fecal contamination. A statistical approach relating density of latrines to contamination risk may be more appropriate than setback distances. Risk factors such as location, hydrology, elevation, and maintenance of latrines must also be considered to minimize the probability of drinking water contamination.
Prioritising and Mainstreaming Groundwater Management in Developing Economies

Author: Prof. Stephen Foster* et al.
* World Bank-Groundwater Management Advisory Team (GW-MATE)

Advances in waterwell technology and hydrogeological knowledge have facilitated a massive expansion in groundwater use across the developing world from the mid-1970s onwards. This has produced enormous social benefits, and many countries today have large groundwater-dependent economies with major abstraction for urban water-supply and irrigated agriculture. But excessive resource exploitation has often occurred – leading to serious water-table decline, reduced access for the poor to water, damage to some wetlands, and also locally to aquifer salinisation, land subsidence and mobilisation of natural contaminants, which threatens both domestic water-supplies and livelihoods.

Improving the governance of groundwater resources and facilitating effective use control is thus now the pressing need. Not surprisingly, monitoring and administering the usage of an ‘invisible resource’ often involving thousands (or even millions) of users in a single aquifer system is an administratively and politically challenging task. Groundwater is a widely-distributed resource affected by a plethora of ‘local actors’ whose behaviour in turn is strongly influenced by national policy decisions affecting land and water use (such as agricultural crop guarantee prices, pumping energy subsidies and urban water-supply tariffs) – thus approaches to adaptive management need to span a range of different levels and scales.

This overview presentation will draw on the international experience and generic products of the World Bank-GW.MATE (Groundwater Management Advisory Team) during 2001-10. There is no simple blueprint for action due to the intrinsic variability of both hydrogeologic setting and socio-economic context, even within many individual larger countries. But experience suggests that ‘high-level reform’ may not be the only or best entry-point – and ‘pragmatic frameworks’ have been devised to define priority management action plans focusing on the local hydrogeological realities and resource use dynamics, in order to achieve an appropriate mix of actions ranging from technical supply-side and/or demand-side interventions to community participation and targeted regulation. It is necessary also to make a distinction in the institutional and technical approach adopted between urban environment and rural areas with major irrigated agriculture.
Submarine Groundwater Quality, Source of Contaminants to Reef Lagoon: Quintana Roo, Mexico

Author: Ms. Laura Hernández-Terrones et al.
Centro de Investigación Científica de Yucatán, Mexico

Keywords: groundwater, coral reef, water quality, pollutants, coastal zone

Introduction/Problem Identification
The Eastern coast of the Yucatan Peninsula has the fastest growth rate in Mexico (4.7% annual) with Playa del Carmen as the main developing city (14.7% annual rate of population increase) (Gobierno de Quintana Roo 2007). The gross domestic product of Quintana Roo is 3%, derived from tourism and related activities, which are based on the beauty and recreational opportunities offered by the Mesoamerican Coral Reef Barrier that runs all along the eastern coast of the Peninsula, the second largest in the world (see Andréfouët et al., 2002). The aquifer of the Peninsula of Yucatan has been studied over the last 30 years. Back and Hanshaw (1970), and Gaona Vizcayno et al. (1980) defined the hydrogeochemistry of the region in relation to the position of the sea/freshwater interface as well as the chemical constituents of the groundwater.

Analysis/Results and Implications for Policy and/or Research
The coral reef ecosystems in the Mexican Caribbean Sea are threatened by excessive urban and tourism activities along the shore. Groundwater in the Eastern Yucatan Peninsula coastal aquifer discharges directly into the ocean affecting the coral reef. The interaction of the hydrology of the coastal aquifer of Puerto Morelos (NE Yucatan Peninsula) was studied at different coastal environments, including mangroves, beaches, submarine springs and the reef lagoon. The concentration and distribution of pH, temperature, conductivity, NH4+, NO3-, NO2-, SRP, SRSi and fecal coliforms were analyzed. Temperature, salinity, conductivity and pH, were determined in situ using a data sonde (Hydrolab® 5S) calibrated with standard buffer solutions (Hach®). Nutrients analysis were performed using a Skalar San Plus segmented-flow auto-analyzer; using the standard methods adapted by Grasshoff et al. (1983) and the circuits suggested by Kirkwood (1994).

The results suggest that groundwater flows dominate the hydrology of this region – due in part to its karstic nature – and the loadings and rapid dispersion of polluting agents could have adverse effects, as a result of the lack of infrastructure for the collection and treatment of waste waters. Nitrogen (mainly as NO3) levels and high coliform bacteria densities indicate that groundwater in most of the wells sampled and along mangroves and beaches is polluted.

In this paper are presented the results of the distribution and variation of groundwater quality being discharged into a coastal reef lagoon in the Yucatan Peninsula, and the results of tested combining TDEM (time-domain electromagnetic survey)and VES (vertical electrical soundings) techniques, considering that TDEM is very accurate technique to map saline interface in discrete places and VES accurate finding the depth to the phreatic.

These results provide evidence for the need for wastewater treatment and the establishment of a sustainable management program of coastal aquifers to protect and preserve both water resources and coral reefs. This study suggests that a strict regional management policy on the coastal aquifer and on wastewater treatment should be established in order to prevent further impact of contaminants on the Puerto Morelos Coral Reef.
Vulnerability of Shallow Aquifers to Pollution, the Ugandan Case

Author: Ms. Lillian Idrakua F.A
Ministry of Water and Environment, Uganda

Keywords: health, impact, pollution, shallow, aquifers

Introduction/Problem Identification
The national sanitation coverage for Uganda stood at 59% and water coverage in the rural area stood at 63% in June 2007. Low cost technology options for water supply (protected springs and shallow wells) constitute 54.3% of the technologies used for groundwater abstraction. These cheap water supply technologies are preferred as they lead to quick increases in water supply coverage (MWE, 2007). Several studies however, undertaken between 1994 and 2007 have shown that protected springs and shallow wells are vulnerable to pollution (RUWASA, 1994; MWLE, 2002, 2003; MWE, 2007).

Analysis/Results and Implications for Policy and/or Research
Safe water coverage in the rural area in Uganda stood at 63% and sanitation coverage 59% in June 2007. Low cost technology options for water supply (protected springs and shallow wells) constitute 54.3% of the technologies used for groundwater abstraction. Shallow wells include hand dug wells (depth of 3 – 10m), hand augered wells (depth of 6 – 30m) and motorized augered well. Despite the increase in safe water coverage, water borne diseases remain a big health challenge. Between July 2006 and June 2007 alone, the cumulative total of cholera cases was 5,194 with 105 deaths. In November 2007, a new water related epidemic of Hepatitis E was reported with 7,136 cumulative cases and 114 deaths by August 2008. With annual outbreak of water borne diseases of such magnitude, the quality of water supplies, inadequate sanitation and poor hygiene behaviour have been cited as the main causes of these outbreaks. This paper summarizes reports on water quality from protected springs and shallow wells from various studies undertaken in Uganda between 1994 and 2007. In all studies it was observed that shallow aquifers were vulnerable to intermittent pollution especially during the wet seasons. Although only one study directly correlated water quality with outbreak of diarrhoeal diseases, in all other studies, either the area or season of outbreaks directly corresponded with location of sources with poor water quality or seasonal variation in water quality or poor sanitation. Although it may be concluded that further research is still required into the factors that render shallow aquifers (protected springs and shallow wells) vulnerable to pollution, the vulnerability of shallow aquifers to pollution poses a threat to the sustainability of achievements under the MDG target for safe water coverage and undermines the health benefits of improved water sources.
Tackling Arsenic Contamination of Ground Water in Bangladesh

Author: Mr. Tauhidul Anwar Khan
Bangladesh Water Partnership

Keywords: groundwater, arsenic contamination, treatment, management, surface water

Introduction/Problem Identification
In its frantic bid to achieve self sufficiency in food production, Bangladesh, a densely populated country has been excessively exploiting groundwater resources for irrigating its food crops. But the groundwater in the country is now found to be getting increasingly contaminated by Arsenic. About 60% of groundwater sampled countrywide, indicated presence of 0.01 mg/l arsenic while 35% of Groundwater sampled showed arsenic above 0.05 mg/l. People have reportedly died and are dying due to continuous ingestion of arsenic contaminated water in many areas, while thousands are suffering from various consequential diseases. There is a general consensus that unwise utilization and mismanagement of the ground water resources have led to such a situation. Experts believe that arsenic contamination of groundwater has been triggered by the process of ‘Oxidation’ that releases arsenic into the groundwater when sulfide compounds containing arsenic get in contact with oxygen.

Analysis/Results and Implications for Policy and/or Research
The arsenic problem in Bangladesh is getting increasingly critical. More than 50 districts of the total 64 of the country indicate presence of arsenic in groundwater in varying degrees in various layers under ground. After extensive investigations it has emerged that currently arsenic has mostly affected the groundwater in the shallow aquifers of the country. The highest concentration of arsenic occurs at depths between 20 and 70 metres below ground. Many of the aquifers deeper than 150 and 200 metres have also been found to contain some degree of arsenic. With the passage of time the problem is getting aggravated both in terms of extent and intensity. For example, tubewells lifting groundwater that were ‘safe’ a year back are no longer safe. This in itself is alarming as no one can possibly know when a tubewell water would become dangerous, as arsenic in water has neither taste nor smell. More than 50 million people are either directly or indirectly affected by arsenic contamination of groundwater which is the principal source of water for drinking and cooking to about 95% of the total population. More than 80% of groundwater utilization in the country is for irrigation during dry season when the Boro paddy, the principal supplier of food, is grown. Naturally, people are being haunted by the possibility of arsenic getting in to the food chain. Investigations have found traces of arsenic in leafy vegetables, green coconuts etc. The Government and the people are therefore, desperately trying to overcome this major crisis. Experts have suggested three major options to combat the situation. They are, wise use and management of groundwater which are still free from arsenic; treatment of arsenic contaminated groundwater; and increased use of surface water for irrigation. The groundwater aquifers which are still free from arsenic need to be used and managed carefully to supply drinking and cooking water to people as well as preserving those for the coming generations. It needs to be realized that groundwater once contaminated, might take 100 years to restore its quality again. Extreme caution therefore needs to be exercised in the governance of groundwater. Possibility of contamination of deeper aquifer by inter-layer movement of contaminated groundwater cannot be ignored. Utilization of groundwater should be so governed so as the aquifer is not left in a total vacuum for long during the dry season. In order to provide safe water to people appropriate method/ techniques like Pond Sand Filters (PSF) are being invented and evolved. For household drinking water supply different types of arsenic separator,
filters are being used. But on top of everything, Bangladesh needs to increase utilization of its surface water resources in place of groundwater. There are surface water available during dry season in the major rivers like the Ganges and the Brahmaputra, which if harnessed and distributed properly, can irrigate far more areas of Bangladesh than currently being covered by groundwater. Besides, rainwater harvesting can also be a complementary alternative. Everything shall, therefore, require a paradigm shift in the Policy of the Government. Groundwater utilization is a private sector affair in Bangladesh. In order to closely monitor its exploitation situation, all relevant information of groundwater uses throughout the country need to be routinely collected, collated and maintained by the relevant authorities. In this regard application of a system of licensing each and every dug well, hand tube well, shallow tube well and deep tube wells can be of immense help in bringing such information to the record books. The fee for such license should absolutely be nominal as the license system is meant to keep track of all the wells scattered all over the country. The Water Policy of Bangladesh amply reflects the Government’s firm commitment to ensure wise governance and management of the country’s groundwater resources. But in order to overcome the current crisis which is deteriorating every day the process of contamination must be halted and gradually reversed.
Management and Use of Uranium Contaminated Groundwater

Author: Dr. Iryna Kovalchuk* et al
* National Academy of Sciences of Ukraine,

Keywords: uranium, mining region, groundwater, surface water, permeable reactive barrier

Introduction/Problem Identification
Intensive development of the atomic and thermal energetics, extension of the uranium production, mining and treatment industry, increasing of the metallurgy of ferrous and nonferrous metals at the end of XXth century was connected with accumulation of the tremendous quantity of different toxic wastes and also with contamination of significant territories.

Analysis/Results and Implications for Policy and/or Research
Ukraine is the world’s ninth-largest producer of uranium. Very complicated state of the environment in Ukraine is now at uranium mines of largest European and one of the largest all over the world uranium ore province which is placed at the Kryvyi Rig basin.

Uranium mine are located in Dnipropetrovsk region, Zhovti Vody city. Eastern Mining and Concentration Combine Works (“VostGOK”) are mining and processing uranium ore. Zhovti Vody has a major importancy for national economy as it is the unique Ukrainian center where uranium ore milling and primary enriching is made, that provides fuel for national nuclear power plants.

There are the following ways of uranium mining: open pit mining, underground mining, in situ recovery. The situ leaching method of natural uranium mining is one of the cost-effective and hi-tech of uranium extraction. Extraction of uranium in “VostGOK” is produced by open pit mining and underground mining. Now three of twelve uranium deposits are in exploitation: Vatutinsky, Michurinsky and East zone of Central deposit.

Underground water in the depth deposits of uranium containing increased concentrations of uranium. Extraction of uranium by leaching increases the likelihood of getting uranium in surface and groundwater.

Potential pollution of the environment are also connected with activity of hydrometallurgical plant in Zhovti Vody city. At this plant processing of the uranium ores and chemical concentrates after underground and heap leaching and after stations of mine water purification take place. Huge deposits of uranium mine tailings which are a high volume, low specific activity radioactive waste from the extraction of uranium from ores are discharged as a slurry in this region.

The groundwater chemistry is stipulated by chemistry of slime waters of the tailings storage facility bowl. Mineralization of the groundwater is over 2 g/cub.dm. The water is mainly sulfate, magnesium-sodium, alkaline, total hardness is over 12 mg-equiv/cub.dm.

Thus, there are several factors for pollution and appearance of uranium in the water environment.

As seen from the above discuss the content of uranium in some water greatly exceeds the required limit. Therefore there are a great problem with the drinking water in the region on uranium mining,
because uranium gets from the places of its mining and processing in surface and underground water, which are the sources of drinking water for the population of this region. It is necessary to carry out measures to ensure the population with drinking water.

Proposed methods of removing uranium and other hazardous radionuclides from water must comply with the necessary conditions: an effective and economic methods.

At present a variety of methods has been proposed for dealing with waters, soils and silts contaminated with hazardous toxic substances. Depending on the kind of pollution, degree of contamination, and the scale of the contaminated site, in each specific case one or another method is usually proposed. Among relatively new and potentially important in situ methods of soils and wastes remediation is the use of so-called reaction-capable penetrable barriers that are mounted directly in soil on the way of underground flows. Such barriers may ensure decomposition of toxic organic compounds or oxidation or reduction of a number of metals. During the contaminated water flow through the reactor the degradation of the contaminants involving physical, chemical and biological processes take place.

Various materials have been investigated as possible materials for permeable reactive barriers and include zeolite, hydroxyapatite, elemental iron, limestones and others. It was shown that permeable reactive barriers are effective for the treatment of dissolved metals and radionuclides, acid-mine drainage and dissolved nutrients.

Biological approach in permeable reactive barriers remediation technology is also very perspective. Many environmental biotechnological applications utilise microorganisms that have key roles in the biogeochemical cycling of toxic metals and radionuclides. Microbes have the ability to facilitate the removal of uranium from water through the sorption of uranium to bacterial cell walls, through the biological reduction of uranium, and through enzymatic production or nucleation of uranium mineral precipitates.

Also, the role of inorganic support in microbiologically induced reduction is very important. Very perspective approach in permeable reactive barriers application is to combine chemical oxidation-reduction reactions and microbiologically mediated processes.

Permeable reactive barriers is recommended to be set in the aquifer of crystalline rocks and their residual soil on the area where other aquifers distributed in this district pinch out and the groundwater is discharged into the aquifer.
Strategies for Groundwater Abstraction and Pollution Management in Delhi Metropolitan, India

Author: Mr. Devendra Kumar
Indian Council of Agricultural Research

Keywords: groundwater abstraction, pollution management, Delhi metropolitan, pollution load, public participation

Introduction/Problem Identification
The Delhi city of India has a population of about 17 million, which is constantly increasing at a very fast pace. According to the World Health Organization, Delhi is the fourth most polluted city in the world in terms of Suspended Particulate Matter. The deteriorating environment is the result of population pressure and haphazard and unplanned growth. The major sources of water are groundwater through abstraction and surface water from river Yamuna. The withdrawal of water from Yamuna is constrained by extremely low flows for nine months during the year, more control of headwater states over the river as well as financial constraints. Groundwater is a major source of potable water in Delhi but as a result of very poor annual groundwater recharge due to poor precipitation, the government has put an administrative ban on further drilling for tube wells. Because of this problem, the city reels under the shortage of potable water, which becomes acute during summers.

Analysis/Results and Implications for Policy and/or Research
The exploration, exploitation, and unscientific management of groundwater resources in Delhi, India, have deteriorated quantity and quality of groundwater. The resources are experiencing over-abstraction and an increasing threat of pollution, coming from urbanisation, industrial development and agricultural activities. In some intensively developed aquifers, over-abstraction and the lowering of the water-table has led to the loss of the ecological function of groundwater needed to sustain certain types of aquatic and terrestrial ecosystems. There is extreme deterioration in groundwater quality due to point and diffuse sources. Elevated concentrations of certain trace elements, having long-term health implications for water consumers. Around 1393 million litres/day (MLD) of sewerage finds its way into river Yamuna through 19 major drains. There is progressive increase in bicarbonate, sulphate and chloride ions with increase in salinity, predominant in ground water from areas with high salinity at deeper levels. North-western and south-western part of Delhi have saline water at all levels. Fluoride concentration is more than 1.5 mg/litre which is the permissible concentration, nitrate concentration is more than 45 mg/litre and at some places it is even more than 100mg/litre. Sewage treatment capacity is about 344 million gallons/day (MGD) at present against 470 MGD waste water that is generated each day in Delhi. The industrial waste water generated in Delhi is about 70 MGD. Although some industrial units have provided facilities to treat wastewater, most small scale industries do not have such facilities. The 48 km stretch of the Yamuna River in Delhi is heavily polluted by domestic and industrial wastewater. The number of industrial units in Delhi increased from about 8000 in 1951 to more than 1,25,000 in 1991. The industrial effluent load is 320 MLD. The dissolved oxygen, biochemical oxygen demand and total coliform at Okhla in Delhi is 1.3 mg/l, 16 mg/l and 3,29,312/100 ml, respectively. Upstream of Wazirabad, the dissolved oxygen level is 7.5 mg/l and biochemical oxygen demand level is 2.3 mg/l, indicating considerable deterioration in water quality in the stretch due to discharge of sewage and industrial effluents. Even though Delhi constitutes only 2% of the catchment of the Yamuna basin, yet the area contributes about 80% of the pollution load. Approximately 1,900 MLD of waste water is discharged from the municipal sector and 320 MLD from the industrial sector.
The installed capacity for treatment is only 1,270 MLD. According to a survey by the Delhi Government, out of a total of 1,25,000 industries, there are 98,000 industries in non-conforming areas as per the Master Plan of Delhi. The Supreme Court has ordered that 15 common Effluent Treatment Plants be constructed. A study conducted by the Central Ground Water Board and Central Pollution Control Board in Delhi revealed that groundwater in most parts of Delhi are contaminated with fluoride and nitrate and is unfit for drinking without treatment. For controlling pollution in Delhi, the Ministry of Environment and Forests has now prepared an Action Plan. The plan stipulates the implementation of a time bound programme entailing a coordinated inter-departmental strategy. The Master Plan for Delhi, 2001 modified the existing plans and specified a land-use pattern for Delhi. The Plan provides a framework for controlling haphazard development and building activities. Only about 55% of the total solid waste generated in Delhi is being managed now. For controlling pollution of surface and groundwater in Delhi, further delegation of statutory powers to functionaries of the Delhi Government for carrying out enforcement functions, need to be considered for strict compliances. The problem posed by squatter colonies needs to be addressed along with development of low cost sanitation. Public participation, for controlling pollution in Delhi, will include the element of enhancing the general level of awareness about the effects of rising pollution and measures capable of being taken for abatement of pollution and inducing community spirit. Involvement of the NGOs and other community groups is essential. The NGOs can catalyse the adoption and application of new technologies, methods, and operations, particularly with respect to cleanliness drives. The private sector can be made more socially responsive, particularly those manufacturing products which generate pollution, e.g., automobiles, plastics and other pollution aiding products. The task is gigantic and requires a comprehensive approach with the involvement of all the stakeholders.
Optimal Groundwater Pumping from Skimming Wells for Safe Drinking Water Supply

Author: Dr. Sudhir Kumar* et al.
* National Institute of Hydrology, India

Keywords: India, saline aquifer, riverbank storage, skimming wells, drinking water supply

Introduction/Problem Identification
Groundwater abstraction from riverbank for drinking water supply is a common practice world over. In the northern part of India, the rainfall runoff in the rivers is confined to monsoon season (July to September). The aquifers adjacent to the large alluvial rivers get recharged by precipitation and flooding during the period. The abstraction of groundwater from these areas can be used for meeting the drinking water needs of the adjacent towns and cities.

A well field was developed in the year along the west bank of river Yamuna to meet the drinking water needs of the National Capital Territory of Delhi, India. The freshwater in the aquifer system is underlain by deposits of geologically occurring saline water. Large scale pumping from such areas resulted in deterioration of water quality, especially for drinking water purposes, due to upconing of saline water. This necessitated the need for development of optimal pumping schedule and well spacing of skimming wells in the area.

Analysis/Results and Implications for Policy and/or Research
In the present study, a conceptual model for optimal groundwater abstraction from skimming wells was developed. In this model a nonlinear, non convex problem involving discrete (location of pumping wells) and continuous (pumping rates) decision variables are solved within a simulation – optimisation (S/O) framework. This approach provides an accurate representation of the aquifer responses. To reduce the computational burden, artificial neural network (ANN) is used as a virtual simulator of a variable density numerical flow model for aquifer simulation. Simulating annealing (SA) a non-gradient based algorithm is used as an optimiser in this study.

The developed operation management model has been implemented on real life aquifer system in NCT Delhi, where 90 tubewells were installed to abstract 37 MGD (million gallons per day) water from the river bank aquifer in which fresh water is floating over saline water. The river reach is significantly recharged by floodwaters during the monsoon season. The objective of the study was to determine optimal pumping schedules while controlling the salinity (due to upconing) to desired levels.

Flood recharge to the riverbank aquifer was determined using the isotopic techniques. In general, δ18O signatures of the water of river Yamuna are depleted (-8 to -10‰) as it originates at higher altitude as compared to the local precipitation (-7 to -8‰). The groundwater levels were also monitored across the river Yamuna at weekly interval to determine the extent of recharge by flooding. It has been observed that the riverbank aquifer gets recharged by 1.0 to 3.2 meters depending on the rainfall and extent of flood.

In general, the model results suggest that the existing group of wells must be operated such that they are staggered in space and time. This is to avoid interference in upconing process between neighbouring wells. This interference enhances the advective velocities of solute (saline water) towards the grid.
cells, containing the well screens, leading to increased salinity. Therefore, care must be taken while deciding the location of future wells in the study area or similar study areas.

The existing well spacing in the northern part of the study area is very close. Further, since the locations and installed pumping capacities are already fixed, the model was implemented to decide the optimal pumping (on a daily basis) and or their switching (on / off) while constraining the salinity of water to desired level. The model was run to determine maximum pumping from a group of 80 wells (10 wells are considered to be under maintenance) restraining salinity levels to meet drinking water standards. The model predicts that 25 – 30 MGD of water can be safely pumped during a normal year with salinity levels of 720 – 780 mg/lt.

Presented model helps in understanding the aquifer flow dynamics and utilisation of bank storage for drinking water supply, which would otherwise join the river.
The Increasing Role of Groundwater Intensive Development in Global Water Policy

Author: Prof. Ramon Llamas
FMB Water Observatory, Spain

Co-Author: Dr. Elena Lopez-Gunn
FMB Water Observatory, Spain

Keywords: groundwater, intensive use, water footprint, ecosystems, agriculture

Introduction/Problem Identification
Groundwater is the largest freshwater global resource, and yet it is largely invisible to most users. In the last half century groundwater use has increased ten times- from 100.109. m³/year to more than 1000.109 m³/year, yet the governance structures are increasingly proving unable to deal with this dramatic increase in use. The paper will therefore introduce the key role that the concept of the water footprint can provide to integrate groundwater into water policy and planning, by providing a methodological tool that makes it more transparent to explain and understand the current trends in global intensive groundwater use. For example it is estimated that the water footprint of agriculture represents about 90% of the total consumptive uses for agriculture in countries like e.g. India or the North China planes, and of this 90%, groundwater is proving of significant strategic importance in highly densely populated and economically vibrant areas.

Analysis/Results and Implications for Policy and/or Research
The paper will provide some examples of win-win solutions that focus on the largest water consumptive use- agriculture- avoiding previous zero-sum approaches, and which can help to address the increased competition and conflict between sectors. The paper shows how new methodologies like e.g. the extended water footprint, can increase transparency on water use and allocation between sectors. The paper provides an example of the real possibility to move from more crops and jobs per drop, to more cash and care of nature per drop, and where groundwater can play a key role because often the economic efficiency of groundwater irrigation is much higher than surface water irrigation efficiency. This is mirrored for example in cases like India and Spain where groundwater development has overtaken surface water development e.g. in the case of agriculture. The paper will give examples from Spain, and the opportunities to e.g. re-allocate water to economically efficient users, thus freeing up groundwater resources for protected areas, looking at the example of groundwater irrigation in the region of Andalusia in Spain, and one of the largest European wetlands, the Doñana National Park. In the case of urban water supply, the use of membrane technology can offer alternative water resources to groundwater e.g. in coastal areas in the Mediterranean belt, and thus minimize pressure on coastal aquifers from urban water supply and industry. Equally virtual water trade in water scarce countries (mainly arid and semi-arid) could also aid in reducing the pressure on some intensively used aquifers, by freeing up groundwater resources for e.g. ecological flows.

All these examples will be illustrated with real cases and data that showcase examples of new ideas, concepts and technology, and where decisions makers can benefit from the inherent advantages of groundwater resources. The problem and challenge however remains with diffuse agricultural pollution from both irrigated and rainfed agriculture), which is still unsolved, and where there is a gap in terms of e.g. technology and innovative ideas.
Reducing Pollution Risks for the Water Supply of Beirut in a Karst Aquifer

Author: Dr. Armin Margane  
Federal Institute for Geosciences and Natural Resources (BGR), Germany

Co-Author: Mr. Ismail Makki  
Council for Development and Reconstruction (CDR), Lebanon

Keywords: groundwater protection, protection zones, karst, water supply, Lebanon

Introduction/Problem Identification
The water supply of Beirut depends to a large degree on springs that emerge from a limestone aquifer, which is highly karstified. Numerous pollution sources exist in the catchment of these springs. They are mainly related to: wastewater, waste disposal, quarries, small industries and gas stations. The existing land use plans presently do not integrate the need for water resources protection. Practically any kind of land use can be established anywhere in the catchment. Currently there are several decentralized wastewater treatment plants in planning to reduce the pollution risk from wastewater. However, it must be ensured that these actually achieve the objectives under the given difficult conditions, which are: lacking institutional capacity for operating wastewater treatment plants, electrical power supply for often less than 50% of the time, steep topographic gradients, active tectonic movements, highly karstic underground.

Analysis/Results and Implications for Policy and/or Research

Planned Activities to Reduce Pollution Risk
In the framework of a bilateral technical cooperation project, funded by the German Ministry of Economic Cooperation and Development (BMZ), several measures will be implemented to reduce the risk of contamination for these important drinking water resources. Groundwater protection zones will be established for all springs and wells in the project area used for drinking water supply. In order to be able to finally implement the land use restrictions, which will be proposed by the project, the water law, currently in the drafting process, needs to integrate the right of the government to declare protection zones accompanied by certain land use restrictions. Also the delineation of protection zones needs to follow an officially accepted principle. The project will propose a related guideline and try to make protection zones legally binding. The project builds on extensive experience in this field gained in Jordan, also in a karstic environment. Awareness campaigns will be conducted to increase the understanding for the land use changes which have to be implemented. The projects will also try to assist the municipalities in the catchment area in integrating water resources protection aspects into their local land use plans.

Secondly the project will assist the Council for Development and Reconstruction (CDR), which is in charge of all major investment plans in Lebanon, in finding suitable solutions for the planned decentralized wastewater treatment in the project area. Currently the need of water resources protection is not sufficiently integrated into the related planning process. Therefore CDR needs support in:
- establishing priorities for wastewater projects,
- finding suitable locations, methods and design of related facilities for collection, treatment and effluent discharge or wastewater reuse,
• preparing environmental impact assessments (EIAs) for such projects and
• preparing best practice guidelines for the design of wastewater treatment plants.
This support will be given by the project.

A third very important aspect is the installation of a suitable monitoring network. Currently water resources monitoring is virtually non-existent in Lebanon. The proposed monitoring network will a) help the Water Establishment Beirut Mount Lebanon (WEBML) to manage their resources in a more efficient way and b) help to reduce the risk of pollution in the water distribution network. The quality monitoring network will enable WEBML to switch from a pollution affected water source to a not contaminated source after receiving alert messages.

A similar approach as mentioned above was followed in the framework of German technical cooperation projects in Jordan over the past 15 years. The immense progress made during this time shows that if the government is willing to do something for water resources protection, this objective can be achieved. Important factors for the success in this respect were:
• the proposed land use restrictions must be legally binding;
• the decision makers and the local population must be made aware of the facts that there is a water resources protection zone and that they have to change their behavior;
• local land use plans must be adapted to the new land use restrictions;
• the implementation of land use restrictions must be controlled (this is facilitated in Jordan by the cooperation of water institutions with so-called Environmental Rangers, a special police task force).

The technical cooperation project will try to bring about a similar change in Lebanon.
Institutional Responses for Sustainable Groundwater Use in Puri City, India

Author: Mr. Prasanta Mohapatra
Orissa Water Supply and Sewerage Board, India

Keywords: groundwater use, Puri city, Waste water treatment, solid waste management, Apex Court

Introduction/Problem Identification
Cities and towns in India are witnessing population explosion, socio-economic growth and unplanned expansion. A typical Indian city finds it challenging to provide water and sanitation services to its population even on a day-to-day basis. The service level and quality is certainly not adequate. Urban water supply is intermittent for few hours a day to few days in a week. Freshwater sources are polluted by untreated waste water. Achieving sustainable growth in our cities and ensuring that environment is not degraded is a formidable challenge. Many a time positive change comes from Judiciary directions due to action of dedicated environmental activists. This paper analyses the institutional responses when the Puri Municipality and the State Government faced two Judiciary directions: one from the Apex Court of the country to prevent pollution and another from the Apex Court of the State to preserve and not to change the land use status to secure groundwater use.

Analysis/Results and Implications for Policy and/or Research
The city of Puri lies on the Bay of Bengal Coast and sits on a fresh groundwater aquifer. The waste water flowing in drains discharge to the sea polluting the sea and the beach frequented by tourists. Out of a public interest litigation filed by one tourist and in response to the direction of the Apex Court of the country to prevent pollution, the city is implementing a sewerage system. The existing waste water management in the city is on-site sanitation by pit latrines, toilets connected to septic tank-soak pit system and open defecation in slum pockets. These contributes to seepage of waste water underground, contamination, public health and nuisance issues in this tourist city. A large area is affected by waste water pollution. The waste water collection and treatment system being implemented in the city at present will reduce pollution to a large extent. Public awareness is being built so that all the households, hotels and commercial establishments utilize the facility instead of individual treatment effort in septic tank and soak pit system.

The water supply in the city through network of pipelines in Puri with groundwater as source started in 1934. The present frequency of supply is twice in a day for four hours. The distribution system covers part of the city and supply is uneven. Urbanization and tourism development in the city required the need of pumping more groundwater to satisfy domestic water demand. The pressure of urbanization has resulted in encroachment of recharge areas of groundwater aquifer on the outskirt of the city. The local environmental activists moved the Apex Court in the State to prevent such encroachment and illegal land use change. The present water stress indicator, which is the ratio of groundwater use to its hydrological availability, is close to high water stress condition. The groundwater withdrawal will be limited to moderate stress due to variability in rainfall recharge. Limiting groundwater withdrawal and preventing pollution is necessary for its sustainable use. Elevated concentration of nitrate in groundwater samples beyond the permissible Indian drinking water Standard was observed due to seepage from on-site sanitation. A part of solid waste collected in the city has been dumped at low lying areas to raise the ground level. These have adverse environmental consequence in the city. During rain and soon after rainy season, which typically takes place during the months of July to October,
a high volume of groundwater flow takes place towards the sea. The leachate generated during the wet season carries the pollutants and migrate with flow. This is evidenced from a nitrate plume in the GIS water quality maps.

Sustainable groundwater resource use is planned to be achieved by building infrastructures for (i) development of an alternative water source to reduce stress on groundwater consumption, (ii) collection and treatment of waste water to reduce pollution and (iii) closure and rehabilitation of solid waste dump sites in the city. The building of these infrastructures is ongoing in the city. At the same time, legal measures ensured that the land reserved for recharge of groundwater aquifer in the city surrounding is not inhabited or used for housing and city expansion. This was possible due to continued action by environmental activists.
Assessing Potential Groundwater Pollution from Flood Retention Areas

Author: Dr. Ulf Mohrlok
Karlsruhe Institute of Technology, Institute for Hydromechanics, Germany

Co-Author: Dr. Ekkehart Bethge
Arcadis Consult, Germany

Keywords: flood plains, contaminant infiltration, solute transport modelling, groundwater pollution, competing interests

Introduction/Problem Identification
Groundwater pollution is an important issue for drinking water supply. In different Countries different laws and rules exist to prevent groundwater from pollution. For instance, in Germany every kind of infiltration deteriorating groundwater quality is prohibited. For the purpose of flood prevention flood retention areas are developed increasingly along rivers what potentially increases contaminant infiltration to the groundwater. Even under German law there exists no need to proof that such retention areas do not diminish groundwater quality by potential infiltration of contaminants. Furthermore, a competing interest in these areas is very often groundwater production for drinking water supply. A modelling tool has been developed to assess contaminant infiltration to the groundwater respecting its spatial and temporal variation as well as parameter uncertainty. Such a planning tool is essential for avoiding or diminishing conflicts of interest.

Analysis/Results and Implications for Policy and/or Research
In order to assess the potential of groundwater contamination from flood retention areas a physically based quantification of the contaminant transport processes in unsaturated soils is required. The required quantification approach has to respect the spatial variability in soil properties in the flood retention area as well as within the soil profiles. The transient variability of the hydraulic boundary conditions need to accounted for as well. The one-dimensional analytical model FWinf (Bethge & Mohrlok, 2008) has been developed for the calculation of the transport of dissolved organic contaminants through the soil zone. Also contaminant specific sorption to the soil matrix and transformation, e.g. by degradation, is implemented.

This model considers two soil layers with different properties with the option of macro-pore flow in the upper one. In order to respect the spatial variability of the soil properties in the retention area this area is subdivided into sub units with unique properties so that the one-dimensional can be applied independently. The temporal variability is considered by representing the flood in three phases with different major transport processes active in the soil zone. The modelling results are given by mass fluxes to the groundwater within the simulation units and the respective phase of the flood event. Because of the very fast calculation of those mass fluxes the parameter uncertainties could be considered by Monte Carlo simulations and risk assessment of groundwater pollution is possible with spatial and temporal resolution.

This model has been applied to a study area in the Upper Rhine Valley in Germany. For this study area data were available from investigations for the planning a retention area. For the considered flood event the flood discharge and its contaminant load were assumed. The model results showed very
strong dependencies on the spatial variations of the soil hydraulic parameters and the groundwater depth in the area. Furthermore, three different interacting retention processes could be derived. Water storage can retain the mass fluxes because of limited volume infiltrated during the flood event. This storage effects determine the resident time of the contaminants which is strongly connected to the time scales related to sorption and degradation processes. Furthermore, the importance of the three different phases for mass propagation towards groundwater could be determined which is strongly related to the soil parameters and the hydraulic boundary conditions.

The studied showed the importance of respecting spatial and temporal variability of the mass flux processes in soils. The developed model FWinf provides a more detailed and more realistic picture of potential groundwater pollution by infiltration. The developed approach could be developed further to assess other kinds of infiltration conditions and the related mass fluxes to groundwater with the potential of groundwater pollution.

**Groundwater Management for Food Security: A Perspective from Pakistan**

**Author:** Mr. Khalid Mohtadullah  
IWMI

**Co-Author:** Dr. Asad Qureshi  
IWMI

**Keywords:** Pakistan, food security, groundwater management, Indus basin, livelihood

**Introduction/Problem Identification**

Groundwater exploitation in Pakistan has enabled farmers not only to increase their production and incomes, but also enhance their opportunities to diversify their income base and to reduce their vulnerability against seasonality of agricultural production and external shocks such as droughts. The benefits of groundwater in Pakistan are multi-dimensional and ranged from drinking water supplies to urban and rural population to economic development as a result of higher agricultural production. However, the current rates of exploitation are unsustainable in many regions. Falling water tables and increasing salt contents in the pumped groundwater attest that more expensive and poor quality groundwater will have to be used for irrigation in future, which will have serious consequences for Pakistan's capacity to feed its growing population.

**Analysis/Results and Implications for Policy and/or Research**

The quality of groundwater in the Indus Plains varies widely, both spatially and with depth and is related to the pattern of groundwater movement in the aquifer. The salinity of the groundwater generally increases away from the rivers and also with depth. There are large numbers of saline groundwater pockets in the canal command areas of Punjab and Sindh. In Punjab 23 percent of the area has hazardous groundwater quality, while it is 78 percent in Sindh. In the lower parts of the Indus plain, the area of fresh groundwater is confined to a narrow strip along the Indus River.

Due to overall shortage of good quality water, the use of poor-quality groundwater for irrigation has become a routine practice. The large scale exploitation of poor quality groundwater is substantial source of salt inflow in the Indus basin thereby aggravating the problems of soil and water salinization. An estimated 2.3 million tons of salts are annually brought to the surface by the extensive tubewell pumping taking place in the basin. Therefore, salt affected soils are becoming an important ecological entity of the Indus basin. According to latest estimates, about 4.5 million ha is suffering from various levels of salinity. The problem of salinity is much more severe in the Sindh province where about 56% of the total irrigated land is affected with salinity. This is mainly because of the use of poor quality groundwater for irrigation because surface water supplies in the Sindh province are far lower than the actual crop water demand. These problems have brought into question the sustainability of the system and the capacity of Pakistan to feed its growing population.

The role groundwater irrigation has attained in maintaining agricultural boom in Pakistan is very unique and vital and will further expand in future due to mounting pressure to grow more food and increasing incidences of drought in the region. More than 70% of the farmers in the Punjab province depend directly or indirectly on groundwater to meet their crop demands. This clearly indicates that without ensuring the availability of acceptable quality groundwater country would face serious food shortages as irrigated agriculture contributes more than 90% of the total grains production in the country. Therefore, it is critically important to dedicate more efforts and capital to manage this precious resource.
Determinants of Farmers’ Willingness to Protect Groundwater from Nonpoint Sources of Pollution in the Lower Bhavani River Basin, Tamilnadu, India

Author: Mr. Sacchidananda Mukherjee
National Institute of Public Finance and Policy (NIPFP), India

Keywords: groundwater quality, nonpoint source pollution, willingness to protect, subjective risk assessment, India

Introduction/Problem Identification
Pollution abatement strategies for water resources in India and other developing countries have given priority to point sources of pollution. However, it is increasingly becoming evident that improvement of quality of surface and groundwater will also require the control of pollution from nonpoint sources (NPS). Controlling NPS pollution is particularly crucial in rural areas where groundwater is an important source of drinking water. Regulatory approaches are not suitable to control NPS pollution. Economic instruments like nitrogen taxes are not feasible in the Indian context at present, although they have been used in some European countries. Voluntary approaches like collective action to protect groundwater from NPS could be a long-term solution within the existing institutional structure in India. Since the emergence of collective action institutions mostly depends on both individual and group behaviour, understanding the determinants of individual farmer’s behaviour is important.

Analysis/Results and Implications for Policy and/or Research
In several parts of India, growing access to irrigation facilities along with unbalanced and overuse of nitrogenous fertilisers, unlined and open storage of livestock wastes, and insanitary disposal of human wastes have led to high concentration of nitrate in groundwater. There is limited information on the level of pesticide contamination of water sources. However, there is substantial secondary information on the level of nitrate in groundwater as well as surface water. Farmers’ perceptions about groundwater and drinking water quality are important, which influence their willingness to adopt protection measures either individually or collectively. This study attempts to capture the factors influencing farmers’ perceptions and their willingness to protect groundwater from nonpoint sources of pollution.

Controlling pollution from NPS will be the first step towards sustainable access to safe drinking water in rural areas. In this study, we use the Lower Bhavani River (LBR) basin in Tamilnadu as a case study of NPS pollution. The Bhavani river is the second largest perennial river of Tamilnadu, and one of the most important tributaries of the Cauvery river. The LBR basin is an extensively irrigated area, and farmers apply nitrogenous fertilisers way above the doses recommended by the Tamilnadu Agricultural University. As a result, high concentration of nitrate has been reported both in shallow and deep aquifers. Secondary data on groundwater quality indicates that the level of nitrates in the groundwater is high (>100 mg/litre) in many pockets of Coimbatore and Erode districts of Tamilnadu in which the basin is located. Due to growing incidence of groundwater nitrate concentration in the basin, the environmental sustainability of safe drinking water sources is at stake. In some instances the public water supply authority has provided drinking water from alternative sources to nitrate affected rural habitations. However, a large section of the society is still dependent on decentralised drinking water systems and exposed to high nitrate contaminated drinking water. It is expected that drinking nitrate-contaminated water may have various short and long term health impacts. However, due to inadequate secondary health information it cannot be confirmed.
On the basis of long-term groundwater nitrate concentrations and sources of irrigation, six villages are identified in the basin. A pre-structured questionnaire survey (face-to-face interviews) has been administered to 395 farm-households across six villages during June-July, 2006. Apart from household questionnaire survey, other information related to land use pattern and drinking water schemes/systems of the villages were collected from the village agriculture offices and village panchayat offices respectively.

Results show that farmers’ perceptions of risks related to groundwater nitrate pollution vary across the villages, and mimic the actual groundwater nitrate situation. Estimated results of binary choice Probit models show that households depending on their socio-economic characteristics, social- and information-network and the characteristics of the resource (alternative sources/quality of drinking water) derive a subjective risk assessment of their groundwater quality. Regular monitoring of groundwater quality, assessment (objective) and communication of risks of consuming contaminated groundwater to the stakeholders could help the farmers to take measures/initiatives either individually or collectively to protect groundwater from NPS pollution. Farmers’ knowledge about impacts of agricultural practices on groundwater quality significantly influences their perceptions about groundwater quality and willingness to protect groundwater. Therefore, provision of agricultural information and education along with basic agricultural extension services could induce the farmers to protect groundwater. Farmers from comparatively high groundwater nitrate contaminated villages correctly perceive (subjective) their groundwater quality and they are willing to protect groundwater as compared to farmers from less affected villages. Therefore, it shows that any groundwater quality protection programme from NPS pollution should take into consideration the site characteristics and socio-economic characteristics of the stakeholders. Memberships in social participatory institutions significantly influence farmers’ perceptions and willingness.

This study shows that the decision to cooperate in collective action is an individual’s decision where apart from individual specific factors like economic motives, socio-economic background, factors like social connectivity (social capital) and information/consultation network play a crucial role to make decision to protect groundwater from NPS Pollution. Demand for safe drinking water varies across the villages, based on the variations of socio-economic characteristics of the sample households and groundwater quality of the villages.
Environmental Challenges in Trans-Boundary Waters, Case Study: Hamoun Hirmand Wetland (Iran & Afghanistan)

Author: Mr. Alireza Najafi
Iranian Ministry of Energy

Co-Author: Mr. Jabbar Vatanfada
Iranian Ministry of Energy

Keywords: Hamoon lakes, IWRM, Sistan basin, transboundary rivers, wetland

Introduction/Problem Identification
Hamoon lakes are transboundary wetlands between Iran and Afghanistan which get their water from Hirmand (helmand) River. The lakes sustain a rich freshwater flora, a unique aquatic fauna, including endemic fish species, and attract large numbers of migratory water-birds. The wetlands have a great ecological, economical and cultural value, and offer a livelihood to a significant proportion of the human in the Sistan basin. For decreasing Environmental challenges in Transboundary Rivers and Share wetlands, it is necessary to go toward Integrated Water Resources Management in the basin and improve cooperation between countries, prepare or strengthen water bilateral or more treaties and using international technical and other support to help wetland continue its life and keep its individual aquatics and natures for next years.

Analysis/Results and Implications for Policy and/or Research
For decreasing Environmental challenges in Transboundary Rivers and Share wetlands, it is necessary to go toward Integrated Water Resources Management in the basin and improve cooperation between countries, prepare or strengthen water bilateral or more treaties and using international technical and other support to help wetland continue its life and keep its individual aquatics and natures for next years.

In this paper recent condition of Hamoon wetlands, implemented works and suggested solution for conservation and rehabilitation of Hamoons will be presented.
Groundwater Depletion, Irreversible Damages and the Energy-Food-Water Nexus: Case studies from Gujarat and Punjab, India

Author: Dr. Kapil Kumar Narula* et al.
* Columbia Water Center India, India

Keywords: Groundwater, Depletion, Pollution, Agriculture, Management

Introduction/Problem Identification
Due to unsustainable water use patterns in agriculture, which is central to the India’s economy, there is serious concern that the several agricultural regions may soon face significant water problems with devastating consequences. Water tables are already declining at a rate of more than a meter per year, and future declines could eventually cause irreversible salinization. Excessive use of nitrogenous chemical fertilizers is already leaching to groundwater. Multiple subsidies and procurement processes for specific crops have distorted crop choices and water use. Livelihoods are also negatively affected. Crop diversification has remained an elusive goal and water and energy continue to be overused and exploited. Solving the water-use problem tries to make use of an integrated approach that links aspects of socioeconomic development with water-energy-food nexus. Agriculture extension services that incorporate environmental objectives are integrated with socioeconomic perspectives.

Analysis/Results and Implications for Policy and/or Research
Agriculture sector in India accounts for more than 85 percent of the total water use for irrigation. Within irrigation, the share of groundwater in net irrigated area is around 50 – 55 percent which is responsible for two-thirds of the total agricultural produce. Agriculture also accounts for non-point-source pollution that arises from excessive use of fertilizers and pesticides. Over and above, absence of significant public investment in surface-water-based irrigation infrastructure, free or highly subsidized electricity, unregulated groundwater pumping, and irrational pricing policies have promoted cropping choices independent of resource endowments of water and energy.

For instance, water levels in North Gujarat have declined by about 80 meters in the last 30 years. The declines in groundwater levels already average about three meters a year, and in the next decadal period of low rainfall (historic climatology in the area suggests such periods of high and low rainfall, and this is currently the high part of the cycle) this rate could more than double, especially if recommendations for greater cropping intensity are carried out. We estimate that many farmers are no longer able to generate net incomes that exceed the cost of subsidized electricity supplied to them. Similarly, for Punjab, the bread basket of India, multiple subsidies and procurement processes for specific crops have distorted crop choices and water use. Crop diversification has remained an elusive goal and water and energy continue to be overused and exploited. Inspite of huge investments in canal irrigation systems, groundwater tables in Central Punjab continue to decline at a high rate. The average rate of groundwater table fall has been close to 0.5 meters a year (in certain areas, it is more than 1 meter per year). The fall in the share of canals for irrigation is nearly matched by the increase in the share of groundwater extraction systems.

Solving the water-use problem ultimately makes use of an integrated approach, that integrates aspects of socioeconomic development, to recommend a range of solutions, including a restructuring of the supply chain, a shift in cropping patterns, defining the private sector’s role in improving regional agricultural and water outcomes through better crop selection and technology and agro-market...
development, and the creation of incentives for capital investments in devices that improve water-use efficiency. These solutions have been evaluated and tested in the study areas. A decision support system has been conceptualized that supports scientific and socio-economic understanding of issues and also helps build awareness on benefits arising from implementing range of solutions. Farmer level surveys have been undertaken. Agriculture extension services that incorporate environmental objectives are integrated with socioeconomic perspectives. Case studies highlight various steps taken on initiatives that enabled action by local stakeholders for moving towards reduction in water and energy use and higher income stability. These examine a radical shift towards crops and livelihoods that have much greater income per unit land so specialized agriculture, combined with a strong focus on off-farm agro-packaging/processing/storage/export infrastructure can occur. This approach has the potential for reduction in gross water use for irrigation in the region while ensuring greater incomes. Reduced water use can occur in the context of such shifts, since investments in micro irrigation do pay off with the drivers for adoption being higher quality, higher yields and good market access; and gross irrigated areas can actually reduce with much higher incomes from unit land; higher incomes can lead to putting a higher value on ensured future water supply. Hence, water conservation can make economic sense for the farmer.
Water Conservation and Demand Management Programme for the City of Celaya, Guanajuato

Author: Mr. Willinton R. Navarro Arismendy
Junta Municipal de Agua Potable y Alcantarillado de Celaya (JUMAPA), Mexico

Keywords: groundwater, water culture, management, conservation, water demand

Introduction/Problem Identification
Currently, groundwater is the sole source of drinking water in the city of Celaya. The Municipal Water and Sewerage Association of Celaya Gto. (JUMAPA), in order to ensure drinking water supply in the urban area, operates 76 of the 82 deep wells available, providing 1,600 lps, for a population of 399,045 (88,232 home users).

The amount of groundwater extracted from the aquifer (approximately 833 Mm$^3$/year) is greater than that infiltrated (approximately 606.28 Mm$^3$/year), generating a problem of over-exploitation, which causes a lowering of the piezometric levels, 120 m in the last 60 years, reducing the volume of water with good quality.

As a result of overexploitation, geological faults have emerged in the city of Celaya, a total of four visible faults and an unknown number of not visible faults “buried”.

Analysis/Results and Implications for Policy and/or Research
JUMAPA, concerned about all the damages that occur in the distribution infrastructure of drinking water; networks collapses, resulting from geological faults, in addition to the problems generated by operating an obsolete system, due to aging distribution networks in 60% of the infrastructure, in which the useful life of materials is between 20 and 50 years, committed to ensuring sustainable development through the knowledge of allocation of exploitation rights, and aware of the responsibility of securing an efficient management of water resources, implemented policies within the New Water Culture.

The downtown area of the city of Celaya has the oldest system with 20 and over 50 years, an obsolete system that has served its useful life with the highest loss percentage (42.5%), showing a lot of non-visible water leaks that infiltrates into the subsoil or channelled to wells or to the sewerage network.

New Water Culture
The New Water Culture is beyond the old concept of being sufficiently to indefinitely increase water supply to meet the ever increasing demand, derives from considering water as a limited resource, not increasable at will, which cannot be produced without a high cost, that water is an irregular resource with unpredictable availability as it depends ultimately on the atmospheric thermal machinery. Being fully aware of what we do to water, in any part of its cycle, will eventually have an impact on us. The new water culture has two powerful concepts for implementation: general (Water Conservation) the other more concrete and practical (Management Demand).

Conservation Water and Demand Management Programme
This programme is a set of activities that improve efficiency in water use, encouraging physical changes (network), social and cultural, and protecting aquatic ecosystems (sources).

1 Distribution infrastructure improvement: This action aims at reducing losses in distribution net-
works. The most important projects that this utility has encouraged for the development of this action are: macro improvement projects for distribution networks and water service connections, and rehabilitation of drinking water networks in various areas.

2 Public awareness to encourage water savings.

The objective of this programme is to encourage water savings in users by changing the billing policy in order for users to pay for their actual consumption (metered) and those consuming less to pay less, and not through based rate as was done traditionally due to an inefficient micro metering system. In this respect, the utility has made their best effort to expand the micro-metering coverage and to change rates to ensure the implementation of this policy.

3 Changes in water prices

In order to encourage water savings and penalise waste, the authorisation for monthly indexation rates has been achieved through policy management.

4 Introduction of saving technology in water consumption

Since 2004, a ruling for all new constructions to install water saving appliances was introduced in the technical specifications manual, by the compliance achieving a significant reduction in water demand in these new real estate developments, savings resulted in a decrease of supply from 175 l/person/day to 122.5 l/person/day, an overall savings of 30%. It is noteworthy to state that since this ruling was established to date, service 70,472 households have been benefited.

5 Water reuse

The construction project for the Water Treatment Plant (WWTP) is currently being undertaken with an initial capacity of 750 lps. This will give the possibility to offer treated water to the market, and even effectively ensures compliance with the commitments on water volume for irrigation, that are currently 7,443,784.52 m³/year (236 lps), encouraging to change drinking water use for irrigation.

6 Water Culture

A permanent water culture programme is carried out through the social communication department, which is applied directly in public or private schools of the municipality through school lectures offered at all levels of education, this year our goal is 80 lectures covering 1,840 students. Along with this programme is the commemoration of the World Water Day taking place every year, attended by 1,500 people. Other actions are advertising campaigns through different media to inform and raise awareness about the proper use of water.

7 Artificial Recharge of the Aquifer

Being aware of the need to return something to nature from what it has given to us, in the City of Celaya, through the geohydrological information of each of the deep wells (lithologic cuts), and with the help of complementary information, can specify that the construction of absorption wells as an alternative solution to flooding problems, which currently includes a total of 10 wells, reaching a total infiltration capacity of 90 lps.
Advanced Application for Water Information System based on GIS in Palestinian Water Authority

Author: Mr. Basheer Obaid
Johannes Gutenberg-Universität Mainz-Deutschland, Germany

Keywords: water management, GIS, spatial data, water quality, spatial analysis

Introduction/Problem Identification
Water Sector has a huge amount of data stored in various databases. These data need processing and analyzing to create comprehensive water information system to provide and support water sector planners, managers, and decision makers.

In Palestinian Water Authority (PWA) there is various data as rainfall, Groundwater quality and quantities, water production, wastewater quality and quantities which create necessity to develop comprehensive water information system able to provide water sector stockholders with accurate water information.

This paper displays new technique about the integration of applications of geographic information systems and Water Information System in the PWA Offices in Gaza Strip and West Bank which have been used to provide knowledge of water resource management.

Moreover, expected water applications have been illustrated under the PWA system such as Groundwater data model, Surface water data model and integrated information system.

Analysis/Results and Implications for Policy and/or Research
The current organization of the databases in the two offices of PWA, one in the West Bank and the other in Gaza Strip, basically operate in independent manner. As geographic locations are different and so are the direct responsibilities of each office, this should be no problem.

However, preparing one common dataset would allow the organization to present itself as one to the outside world, and the organization would be in a better position to support national policy objectives in the field of water resource management.

PWA has a substantial amount of water related data stored in various databases but even within the two offices itself these datasets are scattered around the organization and have practically no spatial relationship. Lacking procedures and arrangements linking the datasets prevent effective use of the data, i.e. to carry out the mandate of PWA and to serve as a planning and decision support tool for groundwater quality management. There is need for more coherent (system) approach with an enhanced geographical relationship and geographical information system (GIS) are considered the bonding tool to do that.

Expert system is created with the knowledge of a specialist subject with a view to solving problems or giving advice. Such a system may fulfill a function that normally requires human expertise, or it may play the role of an assistant to a human decision-maker in water quality management. As some functions can be performed by domain models, models are then be used together with expert knowledge to get a more secure result. This expert system with model component is the preexistence of decision support system, with high capability in numerical calculation.
Spatial decision support systems (SDSS) are designed to help decision-makers solve complex spatial problems in management of groundwater quality.

The study presented and illustrates a new technology using GIS software in order to assist in developing an information system for water management in PWA.

GIS was useful in Management of large data sets as GIS proved to be efficient in managing large amounts of data such as the PWA database.

GIS Technology is required in Decision Support System DSS to reach to the optimal Decisions and Solutions.

It would appear that there are few perceived problems with the GIS technology, the strategy and plans for implementing new technology. The obstacles to using IT effectively would appear to stem from a general lack of awareness in using the new technology within the planning profession. This manifests itself in a perception that the lack of staff and financial resources in Palestinian Institutions is the biggest obstacle to using GIS/IT effectively and Lack of an information strategy is also a significant obstacle.
Nitra-Scope, a Tool for Prevention of Diffuse Pollution by Nitrates at the Catchment Level

Author: Mrs. Julie Paille
Suez Environnement, France

Co-Author: Mr. Bastien Lemaire
Suez Environnement, France

Keywords: diffuse pollution, agriculture, groundwater, prevention, catchment management

Introduction/Problem Identification
The overall feedback from private water utilities is that a rising number of their clients are worried about the sustainable development of their resources and safety in the supply of drinking water to the public. Catchment Management (CM) is a key element in the reply to their worries. CM applies within different administrative and financial frameworks, depending on the country, but has a common technical basis. The reason for the limited implication of water utilities in developing CM activities is due, on one hand, to a reluctance of utilities to intervene in a domain involving a number of external players, on the other hand, to the low technical and financial visibility of such a subject. The response to such a situation can be resolved through the development of innovative technical approaches. The creation of a decision-making tool to help in the management of groundwater resources towards diffuse agricultural pollution appears as an adequate solution.

Analysis/Results and Implications for Policy and/or Research
The Nitra-Scope tool is based on empirical and deterministic solutions in order to offer a simplified technology but rigorous enough to be accepted by the public authorities and the scientific community. It is oriented towards diffuse pollution by nitrates. The basic needs to be covered by the tool are the followings:

- Database on agricultural practices, soil properties and hydrosystem characteristics;
- Output allowing for the determination of pollution degree for different agricultural practices and spatialization within the Catchment;
- Hydrodynamic model output allowing for the evaluation of the pollution transfer to the groundwater and to the abstraction point.

The tool allows for the determination of the most appropriate prevention policy and also the determination of the delay for the solutions to be effective on the monitored groundwater resources. The assessment of intermediary performance indicators is also facilitated by this approach and thus better guaranty the acceptability of the proposed policy by the farmers.

Two approaches can be used to define homogeneous simulation spatial units in the model: a regular grid or composite spatial units. The approach selected was oriented towards homogeneous units in order to facilitate the input of data.

This approach enables the number of these units to be limited. Discretization of the Water Catchment using this method can be limited to large crop systems and thereby reduce the number of simulation units in the model.
As a result, the parameters reflecting the characteristics of pedology, lithology, of unsaturated thickness and aquifer permeability (constant over the time) are identical for the entire unit.

For each Homogeneous Unit of Simulation (HUS), the evolution in time of land uses (crops / forest / urban area…) is defined by ratios (percentages). The rendering of land use is done through nitrate concentration applied at the under-root zone.

It will then be possible to weight different types of crops or land use and implement an evolution over the time.

Input data are applied to the baric centers of each unit, allowing for the calculation of travel times within the saturated zone.

The response obtained at the abstraction point is an average annual concentration of nitrates (historical and prospective signal).

Running the tool also allows to evaluate, per spatialized unit:
- fluxes of water and nitrogen emerging from the soil that could reach the water table
- transfer times in the unsaturated zone, from the under-root zone to the water table
- transfer times in the saturated zone, from the baric center of the HUS to the water abstraction point

Finally, it will be used by introducing scenarios of changes in land use and/or agricultural practices in the Water Catchment Area for reducing nitrate levels.

Case study, example of the Châteauroux Catchment (France):
The tool has been developed and tested from real sites (in France). The example of Châteauroux, in France is very representative since the municipality has to cope with high nitrate concentrations at the abstraction points destined to the population water supply.

As described previously, the first step of the study was to define and spatialize physical parameters (domains of soils, unsaturated and saturated zones). Then, strata have been overlaid and HSUs subjected to discretization.

Land activities of the Catchment have been roughly identified from the Corine Land Cover database (European database dating from 2000), enabling the zoning of prairies, forests, crop, urban and industrial areas.

Then, data on agricultural practices have been recovered from agencies representing the agriculture professions (Chambres d’Agriculture).

Basically, the quantity of fertilizers supplied to crops has been established from local field surveys on farming practices.

Finally, fluxes of nitrates through under-root zones have been provided by the simulation results of root zone model called SCAN, generating available database for large crop and land use units.
Under-root nitrate concentrations applicable to each soil type were defined for each type of land use.

The calculated restitution curve is close to the curve of values measured at abstraction points. Overall, trends are reproduced and the prospective study conducted from current crop data suggests that an improvement of the water quality has already started.

The use of the model has dual value:
- Assess the level of improvement that can be reached on the medium and long terms, as a result of measures engaged (action plan)
- Identify zones in the catchment with a major influence in term of:
  1. Nitrate input, by spacialization of nitrate transport weight of each homogeneous unit of simulation (transport/surface), on a year basis
  2. Spacialization of nitrate travel times from each unit to the water abstraction point (depend on unsaturated and saturated zones)
Over Extraction of Ground Water and Surface Water Pollution is Threatening Future Water Security in Dhaka City

Author: Ms. Reba Paul
Bangladesh Water Partnership

Keywords: Overpopulation, water pollution, over-extraction of ground water, environmental legislation, surface water treatment.

Introduction/Problem Identification
The over population due to rural migration, industrialization, urbanization and lack of basic services to the city people, have created tremendous pressure on natural resources like water, soil etc in Dhaka city. The existing sanitation facilities for the city people are very insufficient. Only about 30% of the city’s population is connected to the sewerage system. Some households not connected to the system use septic tanks that are desludged manually. Others dispose wastewater through surface drains, or in low-lying areas, natural drains, or water bodies that find their way to storm sewers. The laws to prevent environmental pollution are not enforced. The city is highly dependant on ground water for its water supply. Presently 87% of water supply of DWASA (Dhaka Water Supply and Sewerage Authority) comes from ground water (1669 MLD) and 13% comes from 4 surface water treatment plants (257 MLD).

Analysis/Results and Implications for Policy and/or Research
The over abstraction of ground water and severe pollution of peripheral rivers in Dhaka had made a question mark for future water security of Dhaka city. The ground water is declining at a rate of 2-3 meter/year and there is no further abstraction is viable from upper aquifer (100-200 m) and a close monitoring is required before further abstraction of water from deeper aquifer (> 200 m). In certain areas like at Mirpur and central part of Dhaka city area ground water mining is around 15% as estimated. The present water supply for 12 million city population of Dhaka is 1923 MLD against demand of 2100 MLD. The water demand of Dhaka city will be 3500 MLD by 2020 for projected 15.5 million population and if the population growth rate in Dhaka city is not decreased, there is no doubt whether the DWASA can meet city water demand. The city needs to abstract water from nearby aquifer, construction of reservoirs for storage of surface water and regeneration of DTW, augmentation of surface water supply from peripheral and large rivers and replenishing of the groundwater depletion and artificial recharge from rainwater as alternative options to meet the water demand in future. In addition, pollution control measures in Dhaka watershed must be undertaken through construction of more Sewage Treatment Plants to protect any further deterioration of surface water. The high pollution of river water put additional treatment cost for existing water treatment plants and during dry season the pollution load increased due to less water in the river.

There are approx 300 outfalls of domestic and industrial effluents, out of which 19 outfalls are the source of major pollutants in the rivers and those should be controlled immediately. Water has high electrical conductivity due to possible causes of High EC content of municipal waste, Chemical waste from tannery effluent, toxic industrial waste and infiltration of polluted Buriganga river water into nearby aquifer. The industries should have adequate treatment facilities for wastewaters. The small industries need to shifted in cluster and a central ETP should be installed for cost effective waste water treatment before its disposal to the rivers. Improvement of river water quality at hotspots to DO level of 4 mg/l or above would require different effluent discharge quality standards. This standard varies
from BOD of 10 – 50 mg/l and thus different discharge standard would require to be enforced at different locations. The only sewerage treatment plant at Pagla has capacity to treat only 10% of present sewerage generation. More sewage treatment plants are required to treat the sewage of the city. The main river of the City Buriganga needs to be made free from encroachment urgently and cleaning of the river’s bed which has a deposit of 10 feet polythene layer and solid waste, is very essential. It was found that the surface water is the only source of future water supply in Dhaka city as the shallow or upper aquifer is fully dry and water is presently being withdrawn from second aquifer and the only remaining third or bottom aquifer is a confined one and no-renewable source and further the quality of water in this aquifer is not good as it contains high amount of iron and dissolved manganese which is harmful. Rainwater and recycling of water can supplement the future demand. There is a strong need of political commitment to revive the rivers and make them pollution free in Dhaka city for its future water security. By making river water free from pollution, the treatment cost of water treatment plants could be reduced significantly. The study was disseminated in a workshop at political level. The Government of Bangladesh has taken an action recently for cleaning Buriganga river and other rivers for survival of the city and a committee has been formed headed by Hon’ble Prime Minister. Dhaka WASA has committed to come down the dependency on ground water from 87% to 50% by 2015.
Stress on Ground Water due to River Sand Mining and Its Impact on Community (Case Study in Deduru River in Western Sri Lanka)

Author: Dr. Ranjana Piyadasa
University of Colombo, Sri Lanka

Co-Author: Ms. Kusum Athukorala
Network of Women Water Professionals, Sri Lanka

Keywords: salinity, morphology, agriculture, dug wells, electrical conductivity

Introduction/Problem Identification
Sand is essential element of construction and has direct and indirect impacts to country’s development processes. In Sri Lanka after the tsunami disaster and rapid urbanization the demand for sand is increased significantly recent past years. This high demanding market of sand led to mining the sand drastically in lots of areas; not only the rain sediment sand also river bed sand and river bank sand mining are increased. Though until recently manual harvesting was the norm, increasing mechanized and often illegal, river sand harvesting has caused major loss of water security and ecosystem damage due to lowering of groundwater tables, bank erosion, land degradation and salinity intrusion; damage to infrastructure; increased health hazards, groundwater pollution and its impact on sustainable agricultural development of the country. The research study was conducted in the Deduru river (oya) basin in Western part of Sri Lanka to identify the affect of the river sand mining and its impact

Analysis/Results and Implications for Policy and/or Research
The research study reveled that in stream sand mining in the Deduru river right bank area resulted in channel bed degradation and erosion, deepening the river bed, head cutting, and stream bank erosion. All these changes adversely affect water resources balance of the area either directly by damage to organisms or through habitat degradation. Further, effects on stream geomorphology (e.g., channel incision) can result in infrastructure damage and water supply intake to the study area. As a result of the deepening of the Dedury river directly affected the water table within the valley. When the riverbed level falls, the hydraulic gradient of the groundwater is increases leading to higher velocity. As a result, immediately after the rainy periods the groundwater that flows into the rivers is drained out quickly. The water table depressed by several meters due to deepening of the channel and several water wells dried up. Immediately after the rainy periods, the water level in the rivers falls drastically leading to drought conditions. The study identified several dried up dug wells in the study area due to sand mining. Due to lack of groundwater number of non-functional wells increases and its directly affect to the irrigation and domestic activities of the area. The results revealed that total depth of the dug wells remains at 5 – 7 m depth. Wells which lie near the river basins are deep to be less than 7 m. In respect to diameter, most of the wells (71.6 %) are in the diameter range of 2 – 3 m. Dug wells which are constructed in the river basins in the alluvium sandy to sandy clay unconfined aquifer.

The Electrical conductivity values of the well water in the Deduru river basin varies within the range of 4600 to 300 μ siemens per cm (µS/cm) and its exceed the accepted World Health Organization (WHO) and Sri Lankan standards for drinking purposes (1000 and 1500µS/cm respectively). The low Electrical conductivity value in the river Deduru river emphasized groundwater quality was depends on the atmospheric precipitation. Presently Dedury river dried and no any water flow in the river,
therefore water Electrical conductivity values are low. But in the tributary of the Dedury river River electrical conductivity values are quite high and it emphasized some quantity of saline water intruded through the upper stream to the Dedyry river. However, due to salinity intrusion of the Kolamune river (main tributary of the Deduru river) Electrical conductivity values exceed the 3000 mS/cm. The study reveled the electrical conductivity of the groundwater with in the study area exceed the Sri Lankan standards for drinking purposes (1500mS/cm).

Many dug wells were constructed to supply drinking water to the urban population of the study area. The sand mining causes salinity intrusion in the river affecting drinking water and is becoming a health problem for the urban population. Women and children’s health is badly affected by lack of drinking water and women’s productive time is further diminished by the time spent on further travel in search of water. Lack of income of agriculture in turn has led to the devaluation of the river and its allied ecosystems services. With the current decline of exports due to global recession, there is exodus back to the rural sector and the need for a livelihood sustaining system is ever increasing. In such a scenario, the river sand mining related impacts drastically affecting agriculture and food security in the Deduru river basin need to be countered through an integrated action plan.
A Comparative Study of Controls on Groundwater Chemistry in Shallow and Deep Aquifer Systems in a Hard Rock Area and Its Implications

Author: Dr. Nandakumaran Pullare
Central Ground Water Board, India

Keywords: groundwater, hydrochemistry, aquifer, contamination, factor analysis

Introduction/Problem Identification
Groundwater is the principal source of drinking and domestic water supplies in many areas underlain by crystalline rock formations in India and elsewhere in the world. Groundwater occurs in the weathered residuum as well as in the fracture zones in such rock formations. These aquifers are generally characterized by very limited groundwater potential. Contamination of groundwater due to anthropogenic activities is a major constraint in ensuring safe drinking water supply from such aquifers, especially in thickly populated areas. An understanding of the vulnerability of the aquifers to contamination by anthropogenic activities is important in identifying aquifer zones suitable for such water supply schemes.

Analysis/Results and Implications for Policy and/or Research
Hydrochemical characteristics of ground water samples collected from the weathered and fractured aquifers in a typical hard rock watershed Tamil Nadu, India, have been compared. The area is underlain by Archaean crystalline rocks comprising Charnockites and gneisses. Ground water occurs under water table conditions in the phreatic zone, comprising the weathered residuum, and under semi-confined conditions in the fractures at depth. The results of chemical analysis of ground water samples collected from both the aquifers indicated higher mineralization in the phreatic aquifer when compared to the deeper aquifers with the exception of fluoride. Magnesium and Sodium are the dominant cations in the phreatic ground water whereas Calcium is the predominant cation in ground water in fractures. Comparison of correlation coefficients of the concentrations of major ions indicated considerable variation in the correlation between them in the two aquifers. Factor analysis of the data indicates that groundwater in the phreatic zone is more susceptible to anthropogenic contamination when compared to the deeper fractured aquifer. The results of the study also indicate that the shallow and deeper aquifers have only limited hydraulic connection. The results of the study have important implications for development and management initiatives of groundwater in crystalline rock formations. The study outlines a mechanism for identification of the most suitable aquifer zone to be uses as the source for drinking and domestic water supply in areas underlain by consolidated rocks. It also provides a mechanism for selection of techniques for groundwater recharge augmentation to ensure its long-term sustainability.
Discharge of Groundwater from Ukraine’s Donbass Coalfield: Institutional Overlaps & Possible Solutions – The Broader Lessons for Quality Management

Author: Mr. Shaminder Puri
International Association of Hydrogeologists, UK

Co-Author: Mr. Oleg Ulitsky
Ministry of Coal Industry, Ukraine

Keywords: dewatering coal mine, discharge of mine water, groundwater quality management, mine water for municipal needs, institutional analysis

Introduction/Problem Identification
In the Donbass Coalfields of Ukraine a considerable amount of groundwater is pumped to maintain dry working conditions for operational mines. The coalfields have been intensively exploited over the past century and of the 250 mines that operated at the peak of production over 150 have been closed or are in the process of closing. The mines are closely spaced geographically and the subsurface infrastructure has increasingly overlapped with many interconnections between neighbouring mines.

Analysis/Results and Implications for Policy and/or Research
As a result of the close geographic overlap there is a complicated network of subsurface hydraulic communications such that closed mines at times have to continue to pump for many years, to enable nearby operating mines to extract coal. While the responsibility for maintaining dry working conditions in operational mines remains with that mine’s management, the closed mines have been transferred to another agency (Agency for Restructuring) and the responsibility for pumping the closed mines with yet another agency (Agency for Mine Dewatering).

The relationship between the agencies within the coal sector and with the supervising bodies, ie the Ministry of Environment and other supervisory bodies, is assessed in the paper. Figure 1 shows the institutional map of the agencies involved. Options for alternative institutional structures are evaluated to suggest how best to maintain operational conditions, yet reduce the institutional burdens.

General aspects of mine water drainage and environmental management will be discussed drawing on examples from the Tsentralnaya Mine Pumping Station, located close to the town of Anthracite in eastern Ukraine.

The pumping of groundwater in the mining sector is often treated as an externality and insufficient attention is given to its impact on the management of the aquifers, or to the impact on the receiving waters. Since there is a ‘disconnect’ between the mining sector and the water supply sector, the potential utilisation of mine water (which after all comes from fresh water aquifers) for municipal needs is overlooked. A classic case of ‘waste’ from one sector can be conceived as a ‘resource’ for another sector – if the institutions involved can be engaged in the so called ‘joined up thinking’.

Lessons from the experience of Ukraine will be provided.
Experiences in Managing Water Supply Abstractions from the Chalk Aquifer in the UK

Author: Mr. Robert Sage
Veolia Water Central, UK

Keywords: abstraction, groundwater, aquifer, pollution, security of supply

Introduction/Problem Identification
Veolia Water abstract some 600ML/d from the Chalk aquifer in south east England. This poses some major challenges in both operational, environmental and water quality terms. Understanding source capability and the environmental impacts of abstraction are a key work area for Veolia. Water availability is also compromised by pollution, both actual and potential. Many sources are impacted by pollution and require significant treatment to render their water potable. This pollution originates from historic locations, such as old landfills and current activities, such as farming. Some sources have been abandoned, and in one case, a pump and treat system has been installed by the Veolia to protect downstream abstractions. Awareness of potential polluters in the catchments has formed a critical part of risk analysis undertaken in Drinking Water Safety Plans.

Analysis/Results and Implications for Policy and/or Research
Veolia Water abstract some 600ML/d from the Chalk aquifer in south east England. This poses some major challenges in both operational, environmental and water quality terms. The performances of the borehole sources vary with overall water levels in the Chalk, and are very dependant on winter recharge to maintain source capacity in summers. In addition to decreasing water available for supply, low recharge winters also impact on river flows, and magnify any abstraction impacts on sensitive rivers. Understanding source capability and the environmental impacts of abstraction are a key work area for Veolia. Water availability is also compromised by pollution, both actual and potential. Many sources are impacted by pollution and require significant treatment to render their water potable. This pollution originates from historic locations, such as old landfills and current activities, such as farming. Some sources have been abandoned, and in one case, a pump and treat system has been installed by the Veolia to protect downstream abstractions. Awareness of potential polluters in the catchments has formed a critical part of risk analysis undertaken in Drinking Water Safety Plans. Liaison with these polluters has been undertaken at a number of levels and in different ways. It is proposed to expand this activity over the next few years in an attempt to restrict current levels of input and prevent new pollutants from entering the Chalk. This in turn will lead to decreasing the amount of water that needs treatment, thus lowering operating costs in the future.
Alternative Arsenic-Safe Aquifers for Sustainable Drinking Supply in Gangetic Plains- A Case Study from Bihar state, Eastern India

Author: Dr. Dipankar Saha  
Ministry of Water Resources, Govt of India, India

Keywords: arsenic contamination, arsenic-safe aquifers, Gangetic Plains, Quaternary deposits, Bihar

Introduction/Problem Identification
Groundwater arsenic contamination exceeding 0.05 mg/l, affecting shallow aquifers (generally less than 120 m below ground), embedded in the Holocene deposits in Bengal Deltaic Plain, covering Bangladesh and West Bengal in India, is well documented during the last two decades. In the Gangetic Plains covering the upstream of Garo-Rajmahal Gap, contamination has initially been detected in a flood-prone newer alluvial belt of Bihar state in 2003. Later investigations revealed that the contamination is affecting large tracts of active flood plain of the Ganga in the state. The Gangetic Alluvial Plains covering nearly 90% of the geographical area of the state, are known for dependence on groundwater for its societal needs. About 9 million inhabitants in 15 districts, located on both the banks of the Ganga are residing in the risk zone. The arsenic concentration exhibits wide spatial variation, affecting nearly 10% of the hand pumps, which are the backbone of rural water supply.

Analysis/Results and Implications for Policy and/or Research
Present research covers 1450 sq km in the Sone-Ganga interfluve, delineated as one of the severest contaminated areas, both in terms of concentration level (max. 0.62 mg/l) and percentage of total population residing in the hot spots in the entire Middle and Upper Ganga Plains. Geographically the area covers northern tracts of Bhojpur and Buxar districts on the southern bank of the Ganga River. The area represents a monotonously flat terrain, having altitude ranging from 48 to 52 m above mean sea level. The area forms a part of the Middle Ganga Plain, underlain by a thick (more than 300 m) multilayered sand, clay, sandy clay sequence of post Middle-Pleistocene age having provenances both in the Himalayas in the north and the peninsular cratonic rocks in the south. The entire drinking water need of the area, with a population density of 725 person/km², and representing agriculture-based rural economy, is extracted from aquifers. The arsenic contamination (> 0.05 mg/l) is confined within the top 45 m of the sequence; jeopardizing drinking supply which is mainly catered by hand pumps (depth 25-35 m). The area is marked with shallow water level, resting within 6.5 m below ground during the month of May, before the onset of monsoon (June – September), representing deepest water level in a yearly cycle. The aquifers represent sluggish groundwater flow regime (hydraulic gradient 1:1600), where infiltration from monsoon recharge is the major contributor to the net annual recharge (0.301 million cubic meter/km²/year).

The research aims to delineate aquifers which are low in arsenic concentration (less than 0.01 mg/l) and are hydraulically separated from the contaminated zones. Such low-arsenic aquifers should be potential enough to yield sustainably for community-scale water supply. The geometry of the aquifers systems have been studied on the basis of sub-meter scale lithologs of sixteen bore wells (depth 220 to 290 m below ground), prepared by visual analyses of drill-cut samples. Groundwater arsenic concentration from each aquifer system has been determined. The configuration of the aquifers with low-arsenic load and separated from the contaminated ones by clay/sandy clay aquitards, have been delineated. Aquifer hydraulic parameters have been ascertained by conducting six long-duration
Groundwater ages from different aquifers have been estimated by carbon-14 analyses of eleven samples representing different aquifer systems.

Within 300 m below ground, a two-tier aquifer system exists, separated by an extensive 16 to 24 m thick aquitard, made up of clay and sandy clay. The upper aquifer system extends up to 70-90 m below ground. The top 12-16 m sequence of the upper aquifer system is often marked by sand mixed with clay and silt, rich in organic matter, referred as dirty sand. The lower part (beyond 45 m depth) of the upper aquifer system is contamination free (max. 0.01 mg/l). The lower aquifer system which extends up to 260 m below ground and beyond, is relatively coarse-grained and exhibits low-arsenic load (max. 0.008 mg/l). Storage coefficient values (less than 2.5x10^-3), determined by analyses of time-drawdown data of pumping tests, using Walton (1962) method, reveals confined to semi-confined mode of groundwater occurrence in the lower aquifer system. Groundwater in the upper aquifer system occurs under unconfined condition. The hydraulic head of the lower unit rests at 0.8 – 1.12 m above the water table representing the upper aquifer system. The groundwater flow directions of both the aquifer systems are towards north pointing the Ganga as a gaining river. The carbon-14 concentrations of the groundwater from the lower aquifer system vary from 29.97 to 77.61 pMC, while it remains at a significantly higher level (132 to 164 pMC) in shallow arsenic contaminated zones. Synthesis of aquifer-aquitard geometry and carbon-14 values of groundwater indicates that the recharge area of the lower aquifer system remains at a far off place, in the Pleistocene sediments exposed in areas further south. The recharge in upper aquifer is modern, mainly from infiltration of monsoon rainfall. The lower aquifer is hydraulically separated from the contaminated upper aquifer and the downward leakage through the aquitard is hindered as the hydraulic head of the lower aquifer system remains at higher elevation than the head of the upper one. The lower aquifer is arsenic-safe and can be used for potable groundwater extraction. The transmissivity value of the deeper aquifer, determined by Walton (1962) method, (considering semiconfined mode of groundwater occurrence), varies between 3700 and 6900 m²/day, indicating that it can be put into community-scale use by heavy duty deep tube wells wells for drinking supply.
Combining Sound Science, Legal Action and Stakeholder Involvement to Protect a Vulnerable Coastal Aquifer on the Island of St. Kitts

Author: Dr. Halla Sahely* et al.
* St. Kitts Water Services Department, Saint Kitts and Nevis

Keywords: coastal aquifer, geophysical mapping, small islands, protection, IWRM

Introduction/Problem Identification
The unconfined coastal aquifer underlying the Basseterre Valley is a significant economic and social asset for the people of St. Kitts-Nevis. The potable water extracted from this aquifer represents over 40% of the total water supply for St. Kitts. The area is subject to urban encroachment, inappropriate land use and threats from pollution. A project was devised and implemented using an integrated approach to help government and communities take practical actions to protect this vulnerable aquifer by demonstrating proper management and protection on three fronts: mitigation of threats from contaminants, protection of the aquifer and improved water resources management. The project is supported by the Global Environment Facility (GEF) as part of the Integrating Watershed and Coastal Areas Management (IWCAM) project for Caribbean Small Island States. The two major outcomes of the project are a water resources management plan and establishment of a National Park in the well-field area.

Analysis/Results and Implications for Policy and/or Research
A comprehensive hydrogeologic evaluation of the aquifer was undertaken in order to aid in the development of a water resources management strategy for the Basseterre Valley Aquifer. Traditional methods and novel techniques were utilized to better understand and characterize the aquifer. The paper will highlight the main findings of the study including hydrogeologic interpretations, water quality analysis and modelling of contaminant transport and pumping regimes under various scenarios.

Multi-electrode electrical resistivity (MER), a novel surface geophysical technique, was used to delineate the thickness and distribution of sediments throughout the aquifer, zones of increased porosity, zones of possible contamination and the fresh/salt water interface. Traditionally, these aquifer parameters are estimated by direct observation from drilling of multiple boreholes and installation of monitoring wells. However, drilling is a time consuming, labour intensive and costly activity. In contrast, each hour of MER mapping is equivalent to drilling 56 boreholes. The results of the hydrogeologic study uncovered three distinct geologic units across the site and focused on the accurate delineation of the fresh/salt water interface and its response to long-term pumping. Together with slowly declining static water levels and elevated dissolved solids levels, the early stages of salt water intrusion have been documented. Groundwater modelling suggests that adjusting the pumping regime, redeveloping some of the existing wells and relocating other wells is a viable option for increasing efficiency and preventing dewatering over the long-term. Overall, the study has provided a wealth of new information about the aquifer for a reasonable cost. This knowledge is an integral part of the integrated water resources management plan for the Basseterre Valley aquifer as we move forward in our efforts to protect this valuable resource.

Hand in hand with increased data collection and analysis on the water resource itself, various other surveys were undertaken including a survey of land use and sources of pollution. Concurrently, a review of current policy and legislative framework with recommendations for reform was performed.
At present, the majority of the Basseterre Valley watershed is vegetated land with over 30% representing disused government-owned sugar cane fields. As a result, there is a lot of pressure to develop these lands. Currently, the trend is towards medium to high density subdivisions with increased residential development in the upper watershed areas and growing commercial and industrial development in the Basseterre area. The transformation of the landscape has brought with it associated pollution threats such as indiscriminate dumping of solid waste in vacant lots and waterways, nutrient loading from informal livestock farming and unregulated commercial and industrial waste effluent discharges to the environment in the lower watershed area. In addition, a review of environmental laws and policies revealed a fragmented approach to water issues exacerbated by weak enforcement.

An action plan with various time horizons was devised to cope with these issues and will be discussed in this paper. The main actions realized during the project’s lifetime were the drafting of a new Water Resources Act and public education and outreach to major stakeholders. The major elements of the new water legislation include separation of functions between water utility regulator and provider, development of a national water master plan as a statutory requirement and permitting system for the abstraction and use of water. In addition, a public education and outreach campaign saw targeted interventions with key stakeholders such as livestock farmers, power utility officers and community members.

Finally, the cornerstone of the project was the establishment of a National Park around the sensitive well-field area. A park management plan was also devised to actualize the following goals: protect the aquifer, restore and maintain a native forest, provide green space in an urban setting, create a high-valued tourist attraction, contribute to socio-economic welfare and development and serve as an outdoor classroom. This final component serves to unify the scientific data uncovered as part of the water resources assessment, the legal actions taken to update water legislation and to declare the protected area and the involvement of key stakeholders, all of which are key ingredients for success. This project is novel and multi-faceted in its approach to protect a vulnerable coastal aquifer.
Ground Water over Abstraction and Declining Water Quality in Urban Areas – A Comparative Analysis of Four South Indian Cities

Author: Dr. Manasi Seshaih  
Institute for Social and Economic Change, India

Keywords: ground water quality, ground water depletion, drinking water, ground water markets, urban water demands

Introduction/Problem Identification
Rapid Urbanization and its effects on the environment have made its impact felt in many facets of urban areas. One of the critical concerns is with respect to scarcity of water in meeting the extensive demands of the population and their diverse needs. Urban water supply sector in developing countries are suffering from inadequate levels of service, increasing demand-supply gap and deteriorating financial and technical performance. When water resources are utilized at a rate faster than they can be replenished their use becomes unsustainable. A World Bank Report emphasized that the world “is facing a serious water crisis” 1.1 billion people have no access and by 2025, 4.4 billion people could face severe water stress stressing on improvement in access and service delivery as urgent in the developing world. At the global level it is estimated that consumption of water for all non-irrigation uses will rise dramatically by 62 percent and more than 90 % will be in developing countries.

Analysis/Results and Implications for Policy and/or Research
In India, water, being the subject of Concurrent List of Constitution of India, its supply and management is the responsibility of states and providing quality and required quantity of drinking water has been a challenge with ever expanding towns and cities. A severe water crisis is emerging and unless the changes are adopted forcefully, the challenges would lead to irreversible complexities. Hence, critical measures in addressing them are needed. While India is making good progress in increasing infrastructure for Water Supply and Sanitation, it is lagging behind in expanding services that are reliable, sustainable and affordable.

In this backdrop, the current paper captures the extent of ground water dependency and quality status in four cities of Karnataka in Southern India – Hubli, Dharwad, Belgaum and Kolar. Similar to any other city, urban population resultant of growing urbanization, is not new to these cities. However, the problem has existed for more than three decades and has become more acute in recent years. Water supply to Hubli, Dharwad and Belgaum cities is sourced both from surface and groundwater unlike Kolar where it is completely dependent on groundwater. Quality is an issue that needs to be addressed. Across four cities 6430 households and 756 ground water samples for 16 physico-chemical parameters were covered. Analysis indicated 45, 42 and 22 percent samples were non-potable in Dharwad, Hubli and Belgaum respectively, while Kolar showed striking realities of 97 per cent as non-potable and was affected with severe fluoride and nitrate contamination. In Kolar, more than 80 per cent of the children in the age group of 6-14 suffer from skeletal and severe dental fluorosis due to excess fluoride. Epidemiological survey has revealed that over 26,000 people suffer from dental and skeletal fluorosis and more than 39,000 people are prone to it. People congregated at hospitals due to joint pain, tooth corrosion and fatigue. While the rich had the capacity to purchase mineral water, the poor were left with no choice. No proper treatment had been adopted for supplied water except the application of bleaching powder. However, recently,
the government has initiated rainwater-harvesting structures. Only one De-fluoridation plant was installed but had no trained personnel.

The major contaminants were turbidity, hardness, total dissolved solids, sulphates, nitrate, calcium and Coliforms in Hubli and Dharwad, whereas in Belgaum and Kolar, water was heavily contaminated with fluoride. The fluoride concentration in groundwater of Kolar ranges from 2.8 to 4.3 mg/L, which is far above the permissible levels. The physico-chemical analysis of water has shown the presence of certain parameters in excess of permissible limits. This was mainly due to the larger depths in the groundwater table and wastewater intrusion from households and industries. Efforts have been made towards improving existing strategies and Kolar has defluoridation plants. None of the cities had provision for treatment of neither effluents nor any policy on charging the polluter, which certainly had aggravated the problem. In Hubli, Dharwad and Belgaum, unlike Kolar no prominent impacts on health have been noticed. One of the reasons is that the groundwater is used only for usage and not drinking and no quality testing is done to see the impacts of water on health by government or any agency, hence, no studies links the health ailments to water. Although laws prevail to address water quality, implementation is poor in all cities.

Widespread surface water shortage problems and weak performance of water supply agencies have resulted in increased dependency on ground water – 51 per cent in Hubli, 30 per cent in Dharwad, 37 per cent in Belgaum and Kolar entirely depends on groundwater. Kolar fall under Dark zone where utilisation quantity was more than 85 per cent and water levels have reached up to 1000 ft. There are intensive irrigation activities around the periphery of Kolar town and change in land use/land cover patterns. The paper also captures key constraints encountered and its implications. Reforms undertaken of the respective agencies are positive, however, the progress in terms of the magnanimity of the problem indicates huge gap in achieving standards in accessing adequate and safe drinking water, leave alone sustainability. Emerging water markets determine the seriousness with booming bore wells business alone capturing huge business turn over of more than Rs. 50 crores invested in Hubli, Dharwad and Belgaum. Kolar, the city tops with annual turnover of Rs.120 million investments on bore wells. Given the seriousness of the situation, it is imperative to seek options – awareness creation, rain water harvesting, water conservation need more focus. Current policies are existent but are rudimentary and calls for integrated approach towards water management involving all stakeholders.
Local Initiatives for Conserve Traditional Water Sources through Rainwater Harvesting & Ground Water Recharge

Author: Dr. Roshan Raj Shrestha et al.
UN-HABITAT

Keywords: rainwater harvesting, ground water recharge, water conservation, local water management, water shortage

Introduction/Problem Identification
The historical cities in the Kathmandu Valley were built over 2000 years ago. Former ruler constructed rain-fed ponds and springs then linked the ponds to stone spouts and dug wells to provide water to the cities. Those structures were expanded and elaborated networks of canals, ponds, and water conduits were constructed. This water supply and management system was efficient, and was able to adequately supply good quality water to the urban population throughout the year. These systems were neglected with the introduction of piped water system in the Valley about a century ago. They are further affected by the recent uncontrolled exploitation of groundwater and the destruction of the former rainwater collection ponds and recharge areas. Today, the valley is suffering from chronic shortage of water. To meet the supply-demand gap, ground water from shallow and deep aquifer is heavily extracted. The groundwater abstraction rate exceeded the natural recharge capacity by 6 times.

Analysis/Results and Implications for Policy and/or Research
Rainwater harvesting and artificial recharge into shallow aquifers offers a promising approach for reversing the trend of water resource exploitation, groundwater depletion and for meeting water demand at the local level. The average rainfall in the Kathmandu Valley is around 1900 mm which is more than twice the world average. If rainwater harvesting practice together with recharge is promoted in the Valley, such traditional water sources could be revived and support in minimising current water crisis.

An intensive study of traditional stone spouts in the city of Patan in the Lalitpur Sub-metropolitan City of Kathmandu Valley conducted in 2008 with support from UN-HABITAT recommended to further enhance activities to improve and rehabilitate recharge functions of ponds and to seek possibilities of harvesting rain to feed the aquifer. Research has also shown that the geological formation of Patan is highly favourable for groundwater recharge with gravel layer over clay layer, thereby holding the water recharged within itself. Traditional ponds were created on these water bound layers to feed the stone spouts, dug wells and for recharging the shallow aquifer.

This recommendation became convincing to many when most of the stone spouts dried out in the dry season of 2009. One positive situation has been created by the scarcity: search for alternatives. Many individuals and organisations are starting to show their interest in rainwater harvesting. There is a need of examples to show the methods and techniques of water harvesting, support centres to facilitate and create awareness among the broader masses.

Under urban rainwater harvesting initiative, strategy need to be taken to collect water to the extent possible at household/community level based on their affordability. What cannot be stored should be diverted for groundwater recharge. Sporadic recharge of ground water does not show tangible result. Therefore, wider initiatives are required to recharge the ground at mass level.
Initial research in a small community of Patan has proved that artificial groundwater recharge supports in augmenting the water discharge in the nearby stone spouts and dugwells. Rainwater from roofs as well as surface runoff from houses, courtyards, and surrounding areas was collected and channelled to a recharge pit as an experimental case. Motivated by this, local communities in Patan are taking initiation for establishing groundwater recharge systems as a major step towards sustainable management of their traditional water sources- stone spouts. In response to this community initiative, UN-HABITAT is providing support through its partnership with private sector like Coca Cola, academic institution like Bentley University, USA, local authority of the Lalitpur Sub-metropolitan City, local NGO and local community groups to establish groundwater recharge systems in different communities of the city of Patan. Through this intervention, it is expected that the groundwater recharge rate is increased and that local communities manage and utilise rainwater and the stone spouts and dugwells. In addition, it is also expected that the local authority will acknowledge the benefits of this initiative and institutionalise these efforts for long term sustenance of the local water resources.
Groundwater Development and Management in India: Critical Issues

Author: Dr. Kulwant Singh
AMDA, India

Co-Author: Mr. Andre Dzikus
UN-HABITAT

Keywords: deplition of the water table, water logging and salinity, ground water quality problems, groundwater development & management, state & peoples participation

Introduction/Problem Identification
Economic growth, increase in irrigated agriculture and rise in population have led to increase in demand for water in India. Groundwater meets 85% of drinking water needs of rural India, 50% of urban and industrial sectors and 55% of irrigation requirements. The rise in usage of groundwater has resulted in depletion of the water table in many parts of the country. As regards usage of groundwater, the agriculture sector accounts for 92%, industry 5% and domestic sector 3%. India’s water resource potential in major river basins is 1,869 Billion Cubic Metres. However, only 690 BCM is usable because of constraints of topography and uneven distribution. In addition, 433 BCM of groundwater (annually replenishable) is available. India’s commitment under the UN’s Millennium Development Goals is to halve the proportion of the population that does not have access to safe drinking water by 2015. Groundwater is a key resource to meet this goal. The challenge is to use it in a sustainable manner.

Analysis/Results and Implications for Policy and/or Research
This paper focuses on the critical issues of ground water development and management in India with special reference to the water quality. The main issues pertain to (1) highly uneven availability due to diversified geological formulations (2) the issue of sustainability which is assuming importance as in most regions, drawl is higher than the recharge and the dark zones are increasing (3) Deterioration of water quality has become one of the serious issues in India. There are also issues of equity and efficiency. The major problems in management of ground water relate to its over exploitation leading to environmental and health related issues, rising cost of irrigation, negative externalities, failure of wells and unviable agriculture.

The paper also examines difficulties in separating land rights and water rights and also looks at questions relating to (a) water as a common good (b) water as a state subject; and (c) high transactions cost of effective regulations and management. Management problems have compounded due to policy failures particularly relating to inconsistencies between water policy on one hand and power policy, credit policy and price policy on the other.

India invested in large-scale development of water infrastructure leading to much higher crop yield on irrigated land. However, since the 1960s certain critical changes took place. First, electricity supply expanded in rural areas. Second, in areas where water logging and salinity was a growing problem, it was realized that this could be addressed by pumping groundwater. Third, less expensive modular well and pump technologies became widely available, as did subsidized credit. Fourth, farmers realized that groundwater was abundant, especially in the large alluvial basins and could be used when needed. Groundwater irrigation developed at an explosive rate while tank irrigation almost disappeared and
surface water irrigation grew very slowly. Over the last two decades, 84% of the total addition to net irrigated area came from groundwater, and only 16% from canals. Depletion of groundwater occurred in urban areas too. Estimates suggest that 11% of Delhi’s water needs and 40% that of Bangalore are met by groundwater. Between 1977-1983, water level declined by 4 meters in most parts of Delhi.

**Water Quantity and Quality**

The unscientific and inefficient use of groundwater has contributed to overexploitation. Growth in the country’s population has also added to the pressure on this resource. Today, India’s population has grown to over a billion from 400 million in 1947 and per capita water availability has fallen from 5,000 to 2,000 cubic metres per year and the actual usable quantity is around 1,122 cubic metres per year.

Excessive groundwater withdrawals have not only affected the availability of water, it has also resulted in deterioration in the quality of the groundwater. Also, the unsystematic use of synthetic fertilizers coupled with improper water management has affected the groundwater quality in many parts of the country. Zinc has been found in shallow aquifers of Delhi at places located near areas of intensive agricultural practices and extensive use of chemical fertilizers. West Bengal faces the problem of excess Arsenic in groundwater. High fluoride concentration in groundwater has affected around 25 million people in rural areas spread over 17 states in the country.

Other water quality problems in India include: (a) varying iron levels in groundwater, which restricts water utility owing to colour, turbidity and taste, especially in north-eastern India; (b) presence of heavy metals such as Chromium, Lead, Nickel, Zinc, Copper, Manganese and nitrates especially around industrial towns; and (c) bacteriological contamination (widespread owing to reasons including poorly maintained or non-existent hand pump platforms, inadequate or no drainage, poor hygiene around drinking water sources, and poor sanitation).

The paper also looks at the role of State in development of ground water resources taking a holistic view in development and management of water resources, emphasizing demand management, treating water as an economic good beyond certain level of use and looking at the possibilities of investments in recharging and also improving its quality. The role of State in regulation and management of ground water resources is examined for (i) introducing zoning, and regulation on drilling in dark zones; (ii) putting a ban on digging of wells for some time in dark zones; (iii) emphasizing re-charging in the scarcity zones; (iv) exploring possibility of taxing and also on metering water use along with power use. To ensure peoples participation, the paper also looks at mechanisms for the involvement of local governments in the development and management of ground water resources; develop community owned water sources for drinking water; and sensitize people and their representatives on dangers of over-exploitation.
Technique to Limit Abstraction of Ground Water for Sustainable Use in Sri Lanka

Author: Dr. W.D.L Stanley
Agricultural Research Centre, Sri Lanka

Keywords: technique, sustainable, abstraction, drawdown, recharge

Introduction/Problem Identification
Ground water can improve productivity by giving farmers access to water at the right time and in the right quantities. In large part of south Asia and North China where ground water tables are dropping as much as 2 – 3 meters per year. For poor farmers it becomes more and more expensive to extract water as water table drops. Highly fractured lateritic formation is seen in the Gampaha district of Sri Lanka where the study was undertaken. However in the District under investigation, large number of regions of agricultural lands are brought under rain fed agriculture but with supplementary irrigation using ground water. When seasonal rainfall fails, ground water abstraction is carried out in excess of farmer requirement resulting in the development of inland salinity and therefore there is a tendency for the agricultural lands to become saline and also dropping of ground water table in the region. But the challenge of ground water is how to develop and manage the resource sustain ably.

Analysis/Results and Implications for Policy and/or Research
The study area was located at a Latitude of 790 05’ and Altitude of 70 06’ and was the Gampaha district of Sri Lanka. The study area covered an area of two hundred and ten square kilometer (210km²). The study initiated pumping tests of wells selected randomly to represent the study area. A grid with known dimension was developed to cover the study area and to locate the wells selected for pumping tests. Pumping tests provided drawdown and recharge data. Drawdown and recharge data were plotted against time. The point of intersection of these two curves showed the depth to water level at which drawdown is equal to recharge. This level was better indicator to stop further abstraction of ground water to maintain sustainable use. Similar levels are estimated for various wells selected for study, and using these values, a contour map was developed to show the maximum level to which water from well could be safely abstracted for supplementary irrigation by farmers in the study area. The contour level varied from 0.5m to 12.5m. In India community recharge initiatives have successfully reversed falling water table (Shah2000). In Sri Lanka most part of the country is dry and receive less rainfall amounting to about 500 to 570 mm and there fore recharge technique adopted in India cannot be adopted in the dry part of Sri Lanka but in the study area could be practiced. The developed technique together with the recharge technique may improve the availability of ground water for farmer cultivation even during the drought in the study area. In Mexico aquifer management councils are providing farmers with education on sustainable ground water use and is a forum for dialogue on how to manage the resource sustain ably (Shah 2004). In canal based irrigation schemes conjunctive management of ground water and surface water can improve sustainability and help farmers with poor access to irrigation water (Hussain et al 2004). The department of agriculture in Sri Lanka mainly responsible for introducing new technique for farmers to carry out their cultivation to obtain higher productivity, can initiate awareness program to popularize this technique as is being done in Mexico by aquifer management councils to promote sustainable ground water use by creating a forum for dialogue on how to manage the resource sustain ably. The resistivity tomography technique used in South Africa is a rapid resistivity acquisition system that provides a pseudo section of the subsurface in terms of changes in resistivity and Resistivity is a non invasive geophysical method that can be used.
to provide additional information on the subsurface. These changes in resistivity are then related to expected changes in the properties of the subsurface. The bulk resistivity of different subsurface units varies mostly because of either changes in salinity of ground water, changes in porosity or changes in water saturation. In sub Saharan Africa ground water remains largely untapped, in part because of costs of getting it out of the ground. But potentially could provide much needed source of water especially for supplemental irrigation. Already farmers in Kenya, Malawi, Zimbabwe use treadle pump for groundwater. Wetlands also can be impacted by dropping water tables. Improving water productivity can help but reducing ground water depletion in some areas will likely mean less agriculture less wealth and less job. No country has completely solved the problem of sustainable ground water management but there are some examples of limited success. Agricultural and domestic wells are located in the region of unconfined aquifers and are the sources for supplementary irrigation for cultivation in the study area of Sri Lanka. The new technique developed can also be tested when the farmers use their wells to obtain supplementary irrigation for their cultivation and their by reducing labour to be used if they are to test the technique separately and therefore they can have an idea of the benefit of the new technique. Ground water resources are increasingly threatened by pollution in South Africa. The Aquifer vulnerability assessment protocols was developed to specify improved methods and to control the problem. Although the exercise is about various techniques to deal with the problem of ground water, they are tools under different situation and the new technique is easy and directly applied to find the solution to control the over abstraction of ground water. It was concluded that this technique could be extended to other regions of the country to maintain sustainable use of ground water thereby avoiding the development of inland salinity in the region and also to conserve water for supplementary irrigation at the time of drought. Awareness program to educate the farmers to select appropriate water level using the developed map, beyond which they should not pump, was considered a must for farmers using ground water for their cultivation.
Water Resources Protection in Jordan

Introduction/Problem Identification
Water resources of Jordan are heavily overexploited. Groundwater deficit stands at around 200 MCM/a and water levels have been at a steady decline of between 1 and 2 m/a in most areas since more than 20 years. Jordan is resorting to an increased exploitation of fossil groundwater resources and large-scale desalination projects.

Agricultural development started in the mid 1960s, industrial development in the early 1990s. Only since the turn of the century that regulations for land use change were introduced. Before that practically any kind of land use could be established anywhere. Numerous pollution sources exist in the contribution zones of springs and wells and pollution has become widespread. The main pollution sources are related to: wastewater, waste disposal, quarries and mines, small industries, animal farms and gas stations. Until now the existing land use plans do not integrate the need for water resources protection.

Analysis/Results and Implications for Policy and/or Research

Activities Implemented to Reduce Pollution Risk
In the framework of bilateral technical cooperation projects, funded by the German Ministry of Economic Cooperation and Development (BMZ), several measures have been implemented to reduce the risk of contamination for important drinking water resources in Jordan.

A stepwise approach was followed to convince the government that water resources protection is necessary. In the beginning groundwater vulnerability maps were prepared for rapidly growing areas in order to convince decision makers in the water sector that priority areas for water exploitation needed to be declared and on the other hand to help land use planning authorities to select sites for activities hazardous to groundwater in such a way that water resources would not be polluted. Between 1995 and 2009 the project prepared six groundwater vulnerability maps. These maps give an indication for land use planners where activities which are potentially hazardous to groundwater resources may be allowed and where not.

But when pollution became more widespread in the late 1990s Jordan had to take more drastic action. It was finally accepted that only by declaring protection zones and following up on their implementation the risk of pollution for drinking water resources could be reduced. During the course of several cooperation projects groundwater protection zones have since 1999 been established for more than 30% of the water used for drinking water supply: for 7 springs, for around 100 wells in 7 well fields and for 2 dams. In order to be able to finally implement the land use restrictions, which were proposed by the project, the water law, currently in the drafting process, needed to integrate the right of the government to declare protection zones accompanied by certain land use restrictions. Also the...
delineation of protection zones needed to follow an officially accepted principle. The project prepared two proposals of related guidelines for the delineation of groundwater and surface water protection zones. These proposals were then discussed in a Higher Committee which brought together members of all ministries and other important stakeholder groups. It took four years until an agreement was reached. The main problems were:

- to agree on the maximum size of protection zone 2,
- to accept that pesticides should not be used in protection zone 2,
- to find a solution for the existing contamination sources within protection zone 2.

Because of the steep topographic gradients, the zoning system of the guideline for surface water protection zones was based mainly on the parameter slope angle, which determines the flow time to the reservoir.

Awareness campaigns were conducted to increase the understanding for the land use changes which had to be implemented, both among decision makers and the local population. In the current project the municipalities in the catchment area will be assisted in integrating water resources protection aspects into their local land use plans and regular controls will be conducted by the Water Authority of Jordan (WAJ) and the Environmental Rangers, a police task force, which closely coordinates with the Ministry of Environment.

From 2005 on the project supported the land use licensing committees, which had to decide on requests for land use change, by providing a GIS platform which shows all graphical information required to make a well founded decision. In the current project this will be taken a step further, by trying to integrate all relevant information into the land use planning process so that potentially polluting activities will only be planned in areas where the pollution risk is low.

The immense progress made in Jordan over the past 15 years shows that if the government is willing to actively protect the water resources, this objective can be achieved. Important factors for the success in this respect were:

- the proposed land use restrictions must be legally binding (water law and guideline for delineation);
- the decision makers and the local population must be made aware of the facts that there is a water resources protection zone and that they have to change their behavior;
- local land use plans must be adapted to the new land use restrictions;
- the implementation of land use restrictions must be controlled.
Degradation of Subsurface Environment Depending on Development Stage of the City in Asia

Author: Dr. Makoto Taniguchi* et al.
* Research Institute for Humanity and Nature, Japan

Keywords: groundwater pollution, land subsidence, tracers, urbanization, vulnerability risk

Introduction/Problem Identification
This project study assesses the effects of human activities on the urban subsurface environment, an important aspect of human life in the present and future but not yet evaluated. This is especially true in Asian coastal cities where population numbers and densities have expanded rapidly and uses of the subsurface environment have increased. The primary goal of this study is to evaluate the relationships between the developmental stage of cities and various subsurface environmental problems, including extreme subsidence, groundwater contamination, and subsurface thermal anomalies. We address the sustainable use of groundwater and subsurface environments to provide for better future development and human well-being.

Analysis/Results and Implications for Policy and/or Research
The research methods being used by this study are as follows:
(1) Relationships between the developmental stages of cities and subsurface environmental problems are being assessed by socio-economical analyses and reconstructions of urban areas by use of historical records;
(2) Serious problems in subsurface environments and changes in reliable water resources are being studied after evaluations of groundwater flow systems and changes in groundwater storage by use of hydrogeochemical data and in-situ/satellite gravity data;
(3) We also evaluated accumulation of materials (contaminants) in the subsurface and their transport from land to ocean including groundwater pathways by use of chemical analyses of subsurface waters, sediments and tracers; and
Target study areas are basins including the cities of Tokyo, Osaka, Bangkok, Jakarta, Manila, Taipei and Seoul. In addition to the methods mentioned above, numerical modeling of the subsurface environment and data compilation has been made for social economic, land use/cover change, and observed subsurface environment based on Geographical Information System. Integrated indices on changing society/environment and natural capacity have been developed.

The 15 integrated indices, such as population and income (Driving force), groundwater pumping and dependency (Pressure), groundwater level (State), land subsidence (Impact), and regulation of pumping (Response), have been made on a yearly basis for seven cities over 100 years (1900-2000). Five development stages of the city are recognized in Tokyo based on the DPSIR, and six other cities are compared with Tokyo for land subsidence and groundwater contamination. Groundwater storage and groundwater recharge rate in seven cities have been compiled as integrated indices for natural capacities of changing climate and society. A five-stage model and a DPSIR model revealed that Bangkok had the following benefit (relatively small damage with same driving force/pressure), Taipei had a higher natural capacity (higher groundwater recharge rate), and Jakarta had excessive development compared to Tokyo for land subsidence issue.

Numerical modeling of the subsurface environment was established for Tokyo, Osaka, Bangkok, and...
Jakarta to evaluate the groundwater recharge rate/area, residence time, exchange of fresh/salt water. GIS data base of land cover/use changes in seven cities have been made for three different periods (1930’s, 1970’s, and 2000’s) for Tokyo, Osaka, Seoul, Taipei, Bangkok, Jakarta, and Manila with 0.5 km grid using 9 different land cover/use types.

The results of this project study are summarized as follows;
1. We have developed groundwater aging methods using CFCs and 85Kr. The groundwater flow system in the urban aquifer has highly disturbed by human pumping. A dominant vertical downward flux was revealed in the urban area using CFCs and C-14, which originated from anthropogenic activity in the urban area.
2. 3D groundwater simulation (MODFLOW) showed spatial change of the groundwater recharge area, the major recharge area of the pumped aquifer. This spatial change of the groundwater potential was strongly affected by regional groundwater pumping regulations, and the success or failure of those regulations are mostly affected by the availability of alternative water resources for the city area and the legal aspect of the groundwater resources.
3. Accumulations of trace metals and dissolved nitrogen in groundwater were found especially in Jakarta and Manila. Various N sources and areas of denitrification were found by using N isotope distributions in groundwater.
4. Groundwater salinization was found in Osaka, Bangkok and Jakarta. The difference of marine alluvium volume (same as topographic gradient), natural recharge and intensive pumping period controlled the degree of salinization.
5. Minor amounts of terrestrial submarine groundwater discharge (SGD) were measured but huge material fluxes were seen by total SGD in some Asian coastal cities. The spatial variation of SGD was estimated around each city, using a topographic model and radon measurements.
6. Based on the accumulation and transport of pollutants, we evaluated the “vulnerability risk” for all cities. For example, a relatively higher risk of nitrate contamination was found in Jakarta and Manila, and arsenic pollution was found in other cities, depending upon the redox conditions. The pollution accumulation and transport were controlled by natural factors such as topography, climate and geology as well as human impacts including pumping rate and pollution load.
7. Core sampling in the coastal zone and groundwater sampling have been made to reconstruct the history of contamination in each study areas.
8. Interpretations of chemical components and stable isotopes from the groundwater in Bangkok, Jakarta and Manila revealed the origin of the groundwater and degree of nitrogen/ammonium contaminations.
Groundwater Management Challenges And Initiatives: 
A Case Study Of Pakistan’s Punjab

Author: Mr. Asrar Ul Haq
Punjab Irrigation and Power Department, Pakistan

Co-Author: Dr. Muhammad Aslam
Punjab Irrigation and Power Department, Lahore, Pakistan

Keywords: aquifer mining, quality deterioration, saline water intrusion, secondary salinization, policy and strategy

Introduction/Problem Identification
Pakistan’s Punjab has a huge underground water reservoir with storage capacity of about 100 MAF in fresh groundwater (GW) areas. Punjab farmers, through about one million tube wells are meeting 40-50% of their crop water requirement from GW. As a result of conjunctive use of surface and GW, cropping intensities and crop yields have significantly improved. The annual benefit as a result of increased agricultural production is estimated to be Rs 150 billion. Groundwater is also meeting domestic water needs of 90% population of Punjab.

The major GW management challenges include: unregulated and uncontrolled abstraction, nonexistence of GW ownership and rights, aquifer mining, quality deterioration due to salt water intrusion, secondary salinization due to use of poor quality GW, excessive abstraction of GW in and around urban centres to meet domestic water needs and water-borne diseases due to use of poor quality drinking water.

Analysis/Results and Implications for Policy and/or Research
Presently, more than a dozen agencies have been involved in groundwater development and monitoring in Punjab, but there is no coordination, proper staff availability and adequate logistics. None of these agencies has complete knowledge of issues and none has operational responsibilities in groundwater management. In addition several impractical and even impossible solutions are being tabled, such as defining groundwater entitlements or enforcing regulatory measures on one million private tube wells owners.

If the current scenario continues, it will likely to turn into a crisis situation. The agricultural productivity being heavily dependent on groundwater would be hampered severely due to secondary salinization thereby would contribute towards food insecurity, poverty and environmental problems in Punjab. Health of Punjab population will also be affected adversely.

Directly regulating one million tube wells of Punjab is not an option due to excessive costs and enforcement problems. Controlling abstractions or closing tube wells will negatively impact on provincial agrarian economy as crop yields would decline. Balance can be achieved in water stress areas by supply and demand side management.

In order to address GWM challenges through policy and strategic actions to preserve and improve GW quality and to ensure its availability on equitable and sustainable basis, Irrigation and Power Department (IPD) has developed a GWM plan as part of its overall water sector reform programme.
The plan covers policy guidelines and strategic action plan, which includes: GW monitoring, public awareness campaign on GWM and regulation, institutional set up, development of GWM strategy, identification of critical areas, phased implementation of management regime, development of legal framework and gradual shift from management to GW regulation. The implementation of the plan follows a parallel track approach which includes: undertake prior institutional actions, prepare and implement GWM pilot projects, improve the knowledge base and improve the legal/institutional framework.

The IPD has initiated a GW monitoring program to monitor depth to water table and GW quality through 2745 piezometers and 3287 water quality points across the entire Punjab. GIS groundwater database is being developed and managed. Stakeholders are involved in groundwater monitoring and management activities. The IPD is implementing the Punjab groundwater management plan using pilot approach. In this context, various pilot areas for GW management in Punjab have been selected where GW management interventions will be implemented and their impact will be evaluated under the International donors funded projects: Punjab Irrigation System Improvement Project being funded by JICA and Lower Bari Doab Canal Improvement Project being funded by ADB. The interactive GWM orientation dialogues have been held by IPD with stakeholders of pilot areas to provide a comprehensive introduction and orientation to stakeholders about GWM projects being launched in the pilot areas by Punjab Irrigation Department. The GWM interventions to be implemented in the pilot areas include: awareness raising, involvement of stakeholders in groundwater monitoring and management, capacity building of all the stakeholders, create awareness among the farmers to improve water use efficiency through improved agricultural and irrigation technology, appropriate conjunctive use of surface and groundwater, soil and groundwater quality improvement, gradual implementation of proper laws and regulations with participation of stakeholders and coordination with other public and private agencies for judicious use of surface and groundwater.

As a way forward, various hardware and software management interventions for optimal use, regulation of GW abstraction and quality protection would be implemented in pilot areas in collaboration with relevant research centres and institutions. Later, using the refined and improved participatory groundwater management (GWM) approach that emerges from pilot areas experience; implementation of groundwater management plan would be extended to the entire province to enhance sustainability of groundwater resource.
Groundwater Protection and Sustainable Sanitation

Author: **Ms. Vanessa Vaessen**  
Federal Institute for Geosciences and Natural Resources (BGR), Germany

Co-Author: **Dr. Thomas Himmelsbach**  
Federal Institute for Geosciences and Natural Resources (BGR), Germany

Keywords: groundwater protection, sustainable sanitation, water quality, land use planning, health

**Introduction/Problem Identification**

Presently, 1.1 billion people lack access to improved water supply and 2.6 billion to improved sanitation. Inadequate water supply and sanitation are responsible for the vicious circle of poverty and ill-health. The UN declared 2008 as the International Year of Sanitation (IYS) to raise awareness for the global sanitation crisis which presents one of the major obstacles to human development in many developing countries. BGR addresses sanitation issues in many projects from the perspective of groundwater protection. Lacking or insufficient sanitation facilities threaten the quality of groundwater resources which provide drinking water to many people. As groundwater is worldwide the major source of drinking water supply, especially in arid regions, the protection of groundwater resources from pollution is a key element of sustainable human development.

**Analysis/Results and Implications for Policy and/or Research**

BGR aimed to highlight the immense problems of groundwater pollution due to absent or inadequate sanitation facilities in developing countries by organising an international symposium on “Coupling Sustainable Sanitation and Groundwater Protection” from 14-17 October, 2008 in Hannover, Germany which was held in cooperation with international co-convenors (BMZ, UNEP and WHO).

**Conclusions**

- **Prevention is better than cure.** If drinking water wells are located in direct neighbourhood to a pollution source such as malfunctioning pit latrines, microbiological pollution of the well triggers a vicious faecal oral infection cycle causing severe sickness and 2 million deaths per year. Appropriate sanitation solutions reduce microbiological pollution, unwanted dissolved organic and inorganic substances in the groundwater body. Unaffected groundwater is an inexpensive and safe drinking water source, which makes distance water supply or expensive surface water treatment unnecessary. Thus, every precaution in form of sustainable sanitation and appropriate groundwater protection is much more cost-effective than any costly treatment of spoiled water resources or distance water supply.

- **Groundwater protection needs reliable information about spatial extend, quantity and quality of groundwater bodies.** Existing data have to be evaluated and made transparent to all stakeholders. Geo-scientific investigations are necessary in order to achieve a better understanding of complex groundwater systems and their dynamics. Information drawn from these studies are an essential input to land-use planning.

- **Town planning is dominated by top-down technocratic approaches which often derived from colonial urban planning principles.** Supply driven planning usually benefits high and middle income families without covering operational and maintenance costs. Innovative planning requires stakeholder participation which inspires planners to understand power relations, ensure effective participation and build in the user perspective. Planning concepts require the poor to be served.

- **There is a demand in the sanitation sector, especially within the planning community, for more**
Information and cooperation on groundwater vulnerability. The link between sustainable sanitation and groundwater protection is considered as a substantial factor in achieving the Millennium Development Goals (MDGs).

**Recommendations**

- Both, groundwater protection and sustainable sanitation represent basic tasks for every development planning. Every new settlement should take groundwater resources into account and the protection of the aquifer should have high priority. Innovative sanitation planning including participatory and demand driven approaches must be adopted now. Land-use planning, based on a holistic approach and therefore economically, socially and ecologically sound, is required to protect precious resources like groundwater.

- Participation of all stakeholders at all levels of planning, implementation and operation is considered the key issue for success of any water and sanitation project. Approaches like IWRM and IWM exist, which cater for the need for participation and holistic concepts.

- Technical standards for all components of sanitation systems are necessary and serve as a tool for a reliable and sustainable planning, contracting and construction of sanitation systems.

- Waste water is considered a valuable resource; however, its uncontrolled and unregulated utilisation must be prohibited. Guidelines for the safe reuse of excreta and wastewater have been published by WHO. These guidelines need to be translated into practice and become implemented. The reuse of wastewater, human excreta and greywater in agriculture requires further studies and implementation policies in developing and developed countries.

- There is a huge need to increase capacity in developing countries to monitor and manage groundwater. Vitally required data such as groundwater quality and quantity as well as recharge and backflow need to be collected and analysed on a regular basis in order to protect the groundwater resource. Capacity development as a multi-faceted approach is needed, covering groundwater protection, planning, and sustainable sanitation systems.

- Awareness creation and education concerning health, hygiene and sanitation, serve as a basis for the successful participation and involvement of all stakeholders which are key-factors to develop ownership. Appropriate incentives and the clear formulation of benefits are necessary in order to change attitudes and introduce new concepts.

- Efficient political structures, policies and legal set-ups are essential. Neglecting the improvement of general sanitation conditions and thereby contaminating groundwater endangers the overall national gross product due to increasing costs in the health, labour and production sector. Thus sanitation and groundwater issues have to be addressed on the highest political level.
Investigations of Sustainability of Arsenic Low Aquifers in Regions with High Arsenic Groundwater, SE-Bangladesh – Implications for Water Management

Author: Mr. Mattias von Brömssen* et al.
* Ramböll Sweden

Keywords: groundwater, arsenic, irrigation, management, Bangladesh

Introduction/Problem Identification
Groundwater has been the main element for two recent achievements of Bangladesh. Due to extensive use of groundwater most of the population came under safe water supply and self-sufficiency in rice production; today about 70% of irrigation water is abstracted from aquifers. However, due to high geogenic As groundwater, tens of millions of people in Bangladesh are affected by As exceeding WHO:s provisional guide line value for drinking water. Different types of alternative safe water options have been tested. Several studies have shown that they have not been well accepted by the stakeholders. The concept of drinking tubewell water is deeply rooted in the minds of the Bangladeshi. Instead, drillers target presumed safe groundwater on the basis of the local colour of the sediments or from known deeper As-low aquifers. The objective of this study was to investigate the sustainability of targeted low arsenic aquifers in regions with high arsenic groundwater.

Analysis/Results and Implications for Policy and/or Research
Field investigations in Matlab 50 km SE of Dhaka, adjacent to Meghna R., included piezometer installations at different depth, monitoring and dating of groundwater by analysis of 14C. The results from field investigations were combined with groundwater modelling on local- and regional scale to enhance the understandings of the alluvial aquifer systems of eastern Bangladesh. Both a groundwater system disturbed and undisturbed by groundwater abstraction was modelled.

The investigations resulted in the determination of hydraulic properties of the aquifers and delineation on how abstraction of groundwater and the aquifer system itself affect the sustainability of identified safe and low As-aquifers. Through the modelling two separate flow-systems could be identified, a regional horizontal flow system with recharge areas at the eastern Tripura Hills or below and local flow systems driven by local topography. The local flow systems reach a depth of approximately 30 m.b.g.l. in the study area.

The age of the groundwater was linearly correlating to the depth of the tube wells and the groundwater samples were old, 1250 – 11 960 yr which indicates restricted groundwater flow across the interface of the aquifers per today. Measured groundwater levels in the installed piezometer nests indicated a vertical downward gradient of approximately 2 % over the top 200 m of the aquifer which was consistent with the result from the groundwater modelling.

It is concluded that the vertical flow is low enough to ensure that cross-contamination has not occurred during the last thousands of years. The natural gradient and modelled hydraulic conductivity results in a groundwater flow that correlates with the 14C-ages of the analyzed groundwater samples.

Today, the risk for cross-contamination between high- and low As-aquifers are small in the study area but if irrigation- and/or production wells are lowered to deeper depth an increased vertical flow will be
induced. The vertical flow and risk for cross-contamination will be correlated to the abstraction rate. In Matlab the present groundwater abstraction is less than in other parts of the country, as much as 0.2 m/yr has been assumed for Bangladesh. If irrigation water would be tapped from deeper depth the risk for cross-contamination within decades would possibly occur.
Restoration of Groundwater Quality in a Petroleum Contaminated Aquifer – Case Study

Author: Prof. Kun Zhu
Lanzhou Jiaotong University, China

Keywords: groundwater, contamination, remediation, techniques, oxidants

Introduction/Problem Identification
Being a groundwater supply base, the study area is situated in an intermediate zone between a hilly region and a wide plain in Dawu County of China where land surface is covered by Quaternary sediments below which, an unconfined karst groundwater aquifer is buried. Groundwater was found to be polluted by a refinery that was wrongly built at the up-reaches of groundwater flow direction, then some 60 petroleum contaminants beyond drinking water standards were detected in the study area due to the leakage of oil tanks and wastewater drainage pipelines and ditches nearby the refinery. The feather-shaped pollution plume was continuously expanded along flow direction towards down-reaches with a velocity of 300m/year, by which the groundwater supply base would be abandoned within a decade. How to restrain the pollution plume movement and remediate contaminated aquifer became a big challenge for protecting groundwater supply base while many countermeasures should be implemented.

Analysis/Results and Implications for Policy and/or Research
In the study area, both the topography and geological structure of karst bedrock are basin shaped to form a shallow unconfined aquifer that was exploited as the water supply base for the county and provided the abundant high-quality water to domestic consumption and industries. Combined effects of rainfall recharge and artificial extraction produce the groundwater level fluctuation from 28 to 46 meters below the land surface. Generally, groundwater recharge occurs in the hilly area of up-reaches where rainfall and surface flow can be collected. However, a refinery that caused the serious pollution, right stands at the recharge area, as a result, contamination plume was formed, then expended and moved towards the down-reaches, and threatened the water supply base. On basis of concentration contour of groundwater aquifer, the plume containing more than 60 organic pollutants had a high total oil concentration of 6.82mg/L at the central point. It was monitored that the water supply base would be ruined by plume extension within 12 years if the countermeasures for prevention and remediation were not carried out on time.

As techniques for groundwater pollution control and in situ remediation should always be based on experience and the characteristics of contaminated aquifer. As soon as groundwater was found to be contaminated, clean up of pollution sources and removal of top polluted soils might be completed immediately. Regarding to that no single approach is universally applicable because of variations in technical limitation or cost factors, the pilot study used the integrated techniques mainly including capture zone abstraction, biodegradation, air stripping and chemical oxidation. Firstly, the plume movement was incepted by vertically setting 7 pumping well to form a capture zone. The drawn contaminated groundwater was injected back to the aquifer through a vertical line of 5 injection wells that were located towards the up-reaches direction in front of the pumping wells. It looked that a water wall like a fence was built by injection wells, which was followed by a water valley that created with the pumping wells. The hydraulic measures trapped the main part of plume and successfully changed groundwater flow direction. However, the great amount of groundwater body beyond capture zone at...
low reaches was already contaminated to different extent, thus three purifying technologies with the
consequent steps as chemical oxidation, biodegradation and air sparging were utilized through the
different wells following the original groundwater flow direction. The air-pump pushed the fresh air
into the aquifer while the floated water with saturated dissolved oxygen was injected into the aquifer
too. Some evaporated organic compounds could be blown out as dissolved oxygen could partially
decompose some unstable organic matters. The seeding of specifically domesticated microorganisms
mixed with nutrition was added into the contaminated aquifer periodically for promoting biodeg-
radation of hydrocarbons. For the remedial project, the oxidants were firstly selected by a series of
experiments in lab. A comparison was made of the remedial effect on organic contaminants using
ozone, chlorine dioxide, potassium permanganate and hydrogen peroxide in laboratory tests. Chlorine
dioxide was chosen for use in situ remediation of a petroleum contaminated aquifer because it could not
produce cancerogenic THMs as liquid chlorine did. Laterally, potassium ferrate was used as oxidant
in case study with a concentration ratio of 1:3 for potassium ferrate to oil after substituting chlorine
dioxide. As potassium ferrate has properties such as high stability, oxidizing power, selectivity, and a
non-toxic by-product Fe(III), that make potassium ferrate(VI) an environmentally friendly oxidant
for natural water treatment.

The remediation of the aquifer contaminated with organic hydrocarbon involves very complex reaction
mechanisms and is a formidable challenge. The pilot study shows that the integrated techniques can
obviously control expansion of contamination plume when both the capture zone and injection wells
played a promising role. After operation of integrated remedial methods for 2 months, the water sample
analysis proved the oil concentrations in remedial profile of groundwater body reduced by 23-27%.
Some unsaturated hydrocarbons were easily decomposed or removed excluding that some of saturated
alkane and alkene and polycyclic aromatic hydrocarbons and heterocyclic compounds were appeared
to be stable. It was evident that desorption of organic contaminants from aquifer media significantly
affected the groundwater quality during remediation process. Therefore, groundwater remediation
must take early responsible measures for the cleanup of top soils and aquifer media. However, it can
be affirmed that complete restoration of contaminated groundwater has generally not been possible.
Workshop 6: Minimising Land Use Based Water Pollution

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Use of Space Techniques and GIS for Mapping Transported Sediments: The Case of Jeddah Flood 2009, Saudi Arabia

Author: Dr. Mashael Al Saud
King Abdulaziz City for Science and Technology, Saudi Arabia

Keywords: sediments, polluted water, drainage system, satellite images, Saudi Arabia

Introduction/Problem Identification
Recently, aspects of water pollution have been raised in different regions of Saudi Arabia. However, sediments-prone contaminates result from erosion processes are the most common aspect. These processes are generated by rainfall events, which are rarely witnessed in this arid region, but they are anticipated in next decades as a matter of climate change. In this region, huge amounts of sediments are accumulated in valleys and might be removed during any torrential rainfall event.

A typical example, is the flood which was occurred in Jeddah, a western coastal Saudi region, in winter 2009. Hence, many areas were totally covered by turbid water that filled by large amounts of transported sediment. The magnitude of impact was severely damaging in areas where human settlements are located, notably along the pathways of water flow.

Analysis/Results and Implications for Policy and/or Research
Identifying the hydrologic mechanism of water flow along different drainage networks is essential to determine the sources of sediments-prone polluted water. This requires a comprehensive vision of assessment, and it needs certainly considering the whole drainage system. However, monitoring water flow among this system can be done effectively by using space techniques.

This study was carried out, in a broad sense, to: 1) identify the extent of denudated region, 2) delineate the flow mechanism of sediments-bearing water among different drainage systems, 3) determine sources of polluted water and 4) to propose implications for flood control system in the region.

For this purpose, IKONOS satellite images were used, since they are characterized by high spatial resolution and enable identifying objects on terrain surface up to 1m² area from space and with a comprehensive vision. The used images were for the flooded region before and after the flooding event. This helps comparing the changes and reaching a detailed impact assessment.

Satellite images were processed using ERDAS Imagine software, which is dedicated for this purpose. In addition, the extracted data from these images were manipulated and analyzed in the Geographic Information System (GIS); hence, digital mapping approaches were followed.

A map showing flooded areas was produced to cover the entire region. It was characterized by five categories showing different levels of impact, starting from very high to very low impact. The higher levels were found to be located almost in regions where thick sediments exist among valleys’ courses.

The technical part of this work was accompanied with field verification to assure the reliability of data obtained by remote sensing techniques and applying volumetric measures. Therefore, 63 sites were
selected for this verification. Consequently, the reliability of data reaches more than 92%, which in turn motivates applying these techniques in estimating water pollution from sediments transport.

Resulted maps show that approximately, 118 km² were almost covered by turbid water, which includes huge amounts of sediments and rock debris. Use the advanced techniques also enabled calculating the volume of eroded sediments, which was estimated at 105m³. The percentage of sediments and rock debris among the polluted water was five-times exceeding the amount of flooded water.

Also, it was found that the two major established dams in the area played a positive role in retarding water velocity and storing huge amounts of turbid (approximately 25 million m³ each) instead of flowing by the running water towards urban areas. This catalyses constructing further dams along drainage tributaries to mitigate the flood impact. Therefore, the production of spatial data in the GIS system with feasible and understandable figures helps decision makers taking proper implementation for flood risk control.
A Successful Story on a Model Project to Address the Pollution Issues in Badulla River Watershed in Sri Lanka through Participatory Planning

Author: Mr. Kaushal Jeevaka Attanayake
UNDP

Co-Author: Mr. Chaminda Janaka Gamage
UNDP

Keywords: land use management, watersheds management, flood, participation, community

Introduction/Problem Identification
The “Badulla” District is situated in the hilly part of Sri Lanka covering a land extent of around 2861 sq.km and located as an isolated geographical area which is called as “Uva basin”. The “Badulla River is the main water source in the district which is being used for many water related activities including drinking. It is a known fact that this watershed has been largely damaged by the floods and landslides occurred in the past few decades. Nowadays, even during a small precipitation, Badulla River is fed instantly with tremendous amount of muddy water due to the poor land use management practices within the water shed. As a result, the water intake for the Badulla town located in the river bank get frequently affected causing many issues in water and sanitation activities in the urban area of Badulla district. In addition, illegal encroachments which had been taken place in reservation areas also has led the river to be at a high hazards zones of inundation and landslides

Analysis/Results and Implications for Policy and/or Research
The watersheds are the home for our key natural recourses and have been one of the basic elements in land use management systems throughout the hydraulic civilization of our country. “Badulla River” is one of the main watersheds in Badulla District which runs across six Divisional Secretariat areas of the district. Total catchments area of the Badulla river is about 1400sq.km within the district consisting of five main sub catchments. Ella sub catchments which represent 190sq.km could be identified as the most important feeding area of the Badulla River. This area mainly represents the tea estates and agricultural lands with a weak land use management due to poor maintenance of tea estates and forest coverage including drastic new settlements. This has caused the reduction of rain water infiltration while increasing runoff water drainage. The water supply to Badulla City is increasingly degrading from pollution due to bad practices in the watershed area. The floods and landslides occurred in recent years have been increasingly affecting the community who live in lower areas of river basin. This situation has resulted frequent floods in lower catchments areas of Badulla River even in a small precipitation. This situation is causing water pollution and drying off of the watershed even in a moderate drought while threatening the community settlements. As a result, the socio-economic patterns of the river basin communities have fallen into trouble while increasing the health related issues often due to the impact of poor water quality. Hence, an initial project was started to promote proper land use management to manage the surface water pollution, soil conservation and flood management towards a better water management. Consequently, a model for water source protection plan was to be developed highlighting the urgent actions for an optimal land use management efforts.

Improved surface water drainage and soil conservation are the main options that might lead to control the water pollution and flood in lower catchments area. The direct benefits of the model project were
delivered to the community who are settled in the lower catchments area of Badulla River. The model project was performed with the sense of economic development through land use development and water source protection. The above objectives of the model project were strategically setup to motivate the community in upper catchments area. These strategic objectives were needed to provide direct benefits of the project implementation to the community who are living in upper catchments area for their motivation even though the main implementers of the project was the community who are living in lower catchments area.

Efforts were sharpened by integrating the best land use practices in the catchment as well as the use GIS for such initiation to enhance the effectiveness of the design. The land use authorities joined together in the program to develop the land use maps for the entire area and introduce the optimal land use options to apply within the area to sustain the efforts. The Disaster Management Authorities in Badulla District who lead program focused on different types of actions in river basing management with joint planning with relevant stakeholders and other planning authorities in the process of preparation, implementation and monitoring. Generation, computation of basic data, strategy development on catchments scales were carried out by the land use planning authorities to introduce an effective land use management with the community perceptions.

The watershed and catchments area management must be carried out with the blessing of local community and a framework developed through a participatory decision making. The willingness of the local community is very important from the inception of the programme in order to achieve the project objectives in a sustainable manner. There were many lessons learnt during this project in addressing water management issues while considering socio-economics and environment related activities in the area. Results achieved could address many issues in relation to flood protection, habitat management, water protection and water quality management. Food risk or water pollution generally are related to the specific characters in a particular catchment and this model project proved that such issues can effectively be addressed through a joint programme properly designed and coordinated through. Solving these problems sometimes requires changes or restriction of land use management. Therefore water management needs first a planning instrument to define spaces with a context and second set of instruments to influence the communities involved. Land property and maintenance of public areas also require new strategies for a sustainable and optimized use of this environment.
Managing Watershed to Address Land-based Pollution: The Experience of the Philippine Watershed Management Coalition

Author: Ms. Yolanda Benitez-Gomez
Streams of Knowledge Foundation, The Philippines

Keywords: watershed, land use, people-centered, watershed plan, protection

Introduction/Problem Identification

This is about the experience of the Philippine Watershed Management Coalition (PWMC) in promoting people-centered watershed to ensure the protection of watershed, production of quality water and address land-based pollution issues. It deals on the paradigm of watershed management changes that leads to the creation of watershed management programs at the local levels involving upland dwellers, lowland communities and more importantly local government units. 70% of Philippine land area falls within watershed. Literally, everybody lives within the watershed. As an integrated ecological system, the management of watersheds must be viewed from a holistic approach, consistent with integrated water resources management principles, the framework adopted by PWMC in its quest towards a people centered watershed management approach.

Analysis/Results and Implications for Policy and/or Research

Conscious of the need to sustainably manage watersheds and cognizant of the fact that government alone cannot effectively carry out the task, the Philippine Watershed Management Coalition (PWMC) came into being. The watershed convenors felt that there was a need to create a network in order to know more about a relatively new frontier—the watershed as the unifying and planning unit for natural resources management. Thus, the birth of the Philippine Watershed Management Coalition (PWMC), initially composed of 23 watersheds with members coming from government agencies, local government units, academe, NGOs and peoples organizations.

The vision of the Coalition is to build and strengthen a responsive body of individuals and groups working together for the protection and rehabilitation of watersheds across the country. It aims to develop a well informed constituency at the same time promote local environmental governance. The Coalition is regarded as: avenue for continuing education in the area of watershed management and related efforts; a platform for discussing and responding to broad-based issues related to the management and development of watershed; a support and lobby group for on-ground implementation of watershed activities and a resource for participatory action researches for the effective management of watersheds.

As an agent of change, the Coalition is governed by IWRM principles relevant to the advancement of watershed management in the Philippines. It strongly advocates: that people should always be given preferential option and that people participation in all watershed management activities be pursued; encourage the co-management of watershed by stakeholders by building their capabilities and transforming them into partners; and support to local government units by strengthening local environmental governance.

For the last 10 years since its formation, the Coalition has gained grounds in the area of watershed management. Basically, its accomplishment and experiences are focused on: advocacy and awareness
building through intensive information, communication and education campaign; creating and harnessing partnerships; and building of capacities of watershed stakeholders. These are important in ensuring that watershed management is understood and internalize by the different stakeholders, especially in ensuring the integrity of watershed areas in general, and quality of water in particular. PWMC assume the role of a facilitator among various stakeholders often with competing and conflicting priorities for the use of watersheds. This was done through the various programs and activities being spearheaded by PWMC and its members. Its IEC initiatives ranged from conduct of information caravan, photo exhibits in strategic areas, as well as Eco Tours – all of which were intended to make people understand the role of watershed in lives of those who live within it.

A Watershed Magazine is also being published by the Coalition to facilitate exchange of information and experiences among members in the promotion of watershed management initiatives. In keeping with information technology and in order to reach a broader area of constituency, the Coalition is maintaining a virtual office and a website (www.philwatershed.org.).

The other area of concern that the Coalition is actively pursuing is institutional and individual capability building in the area of watershed management within the framework of IWRM. Cognizant of the needs of local watershed stakeholders, in particulars, local government units, non-government organizations, civil society and even government workers, the Coalition has embarked on capability building initiatives such as conduct of watershed management training programs, workshops, conferences as well as series of round table discussion.

Through the efforts PWMC, local watershed planning has been institutionalized at the local levels and plans have been prepared and implemented. Perhaps this is the most important effort of the Coalition as this clearly addressed proper land use planning and pollution management aspects within watersheds. Perennially watersheds are faced with issues such as: deforestation, changing land use, siltation and erratic streamflow and pollution from use of fertilizers and pesticides due to intensive cultivation. These issues are being addressed through the development of a rational watershed management and development plan wherein proper land use and zoning within watersheds are made possible. In the case of the province of Bukidnon, a provincial watershed protection and development council was created to oversee the implementation of a localized watershed management plan. A similar approach was done in the province of Davao del Sur wherein the Mainit-Balasiao Rivers Integrated Watershed Management Plan has been developed and implemented in an effort to protect the watershed, Moreover, there is also the development and implementation of the Mt. Matutum Protected Landscape in Cotabato—all these were made possible under the guidance of the PWMC. These efforts were directed towards ensuring that the watershed areas were protected and managed in such a way that supply of quality water is assured for the local population for their domestic and industrial uses, making sure that the local economy prosper. The watershed development plans developed clearly addressed current and potential pollution issues as it prescribes land use practices that must be observed within the watershed area.

Today, PWMC membership has more than doubled made up mostly of local government units, the academe, quasi public organizations, peoples organizations, NGOs and government agencies—all linked with a common mission of creating awareness and sensitivity to the importance of watershed management as a way to address pollution issues especially those that are land-based in nature.
European Scale Water Quality Modelling and Pollution Scenarios

Author: Dr. Ilona Bärlund* et al.
* University of Kassel, Germany

Keywords: continental-scale modelling, BOD, salts, nutrients, scenarios

Introduction/Problem Identification
Although catchment scale modelling of water and solute transport and transformations is a widely used technique to study pollution pathways and effects of policies and mitigation measures there are only a few examples of global water quality modelling. Yet over the past decades the idea that water research and policy have not only local and regional aspects but also important continental and global scale dimensions has gained importance. Against this background a new continental-scale model of water quality (WorldQual) has been developed with the aim to analyse the effect of changed climate and anthropogenic conditions on diffuse and point loading and consequently on surface water quality. Estimates of future water quality are needed for two major reasons: to assess the future state of aquatic ecosystems and to determine the suitability of surface water supply for different water users such as industries and the domestic sector.

Analysis/Results and Implications for Policy and/or Research
For this purpose the focus in this study has been laid on three different types of water quality variables: TDS as a measure of the suitability of water for household, industrial and agricultural use, biological oxygen demand (BOD) as an indicator of the level of organic pollution and its oxygen-depleting potential, and for the overall health of aquatic ecosystems and finally total nutrient concentrations as an indicator of eutrophication in surface waters and a link to European policies such as the Water Framework Directive. The model is being developed as part of the EU-funded SCENES project which has the principal goal of developing new scenarios of the future of freshwater resources in pan-Europe up to 2050s. The starting point was to construct the model for baseline conditions, the 2005s.

As an example, the current distribution of BOD loading shows the relatively even distribution of domestic loading highlighting areas of dense urban population whereas manufacturing BOD is much more localized. For diffuse loading large parts of Europe show very small diffuse BOD loadings of 0.1 to 10t/3months, especially Scandinavia, parts of Eastern Europe and the Iberian Peninsula. Values over 500t/3months can be found in hot spots like the British Isles and in parts of Western, Southern and Eastern Europe. The main driving variables for diffuse BOD loading are the animal numbers and runoff which are the main components in the export coefficient equation describing diffuse loading in WorldQual.

The effect of climate change on transport and transformations of substances is threefold: 1) changes in precipitation and air temperature affect the hydrological cycle, 2) the changed runoff conditions affect transport processes like diffuse pollution from agriculture and loading from sealed areas and finally 3) several transformation processes like degradation are temperature dependent. For SCENES three Global Circulation Model – scenario combinations were selected to highlight the variability of future climate projections for Europe: IPSL-CM4+A2 for high temperature increase with low precipitation increase or decrease, MICRO3.2+A2 for high temperature increase but high precipitation increase or low decrease and ECHAM5/MPI-OM+B1 for small temperature increase and average precipitation change.
The main drivers for the scenario analysis of point loads are connectivity to sewage networks and the level of treatment. Also changes in population, GDP and emission factors (currently only for P) play a role. A key role in derivation of the changes in the driving forces is played by the SCENES pan-European panel, a group of stakeholders working on scenario development on that scale. During the panel meeting information on these key drivers was asked for per region (pan-Europe is divided into seven regions) and per scenario (four storylines): trend (% per year) change in connection to public sewerage system, level of treatment, level of connection (% in absolute terms) and an additional question whether all new connections to sewers get treated.

The results show that climate change has a clear impact on water availability and river discharge. Thereby the summers will mainly have a decrease in water availability and river discharge and the winters an increase in big parts of pan-Europe. Sensible areas with bigger changes are in particular Scandinavia, Western Asia and the Iberian Peninsula. The distribution of the percentage change for diffuse BOD loadings mostly equates to the distribution of changes in water availability, but the change in the absolute amounts of diffuse BOD loadings is very small. The reason for this effect is the dominance of livestock in calculating the diffuse BOD loadings. The baseline calculations suggest however that there is a clear difference between selected basins (Danube, Ebro, Kokemäenjoki, Thames and Vistula) concerning the share of diffuse loading of total loading. This ranges between 3% (Thames) and 37% (Ebro).

For point load scenarios in these basins smallest changes are expected for Northern Europe (Kokemäenjoki, Thames) for all scenarios. For Southern Europe (Ebro) the loadings would be increasing for two of the SCENES scenarios (Policy Rules and Economy First) by 20% and 40% respectively by 2050s. For Eastern Europe central (Vistula) only Policy Rules shows a small increase in point source loading whereas the Danube integrates loading changes from Western and Eastern Europe regions which are mainly decreasing. The final aim of this study is to compare the effect of climate and socio-economic changes on loading of BOD (and other above mentioned substances) and eventually in-stream water quality addressing questions such as will the small increase in domestic loading in Northern Europe be more clearly seen in the Thames (share of total loading 93%) basin but be overridden in Kokemäenjoki by climate change effects when the share of domestic loading of total loading today is only 35%.
Towards a New Dynamic for Reversing the Trend of Diffuse Water Pollution in France?

Author: Mr. Boris David  
Veolia Water, France

Co-Author: Mr. Marc Alary  
Veolia Water, France

Keywords: diffuse pollution, agriculture, pesticides, water quality, water resources management

Introduction/Problem Identification
The extensive use of pesticides and fertilisers in agriculture has led to the deterioration of many water bodies in France, including those used for drinking water supply. In order to reverse this trend and meet the objectives of the European Water Framework Directive, a new regulatory instrument has been introduced by the French government in 2006. This instrument, referred to as the ZSCE scheme, enables to define action plans to protect source catchment areas (AAC) from pollution sources and is expected to create a new dynamic for diffuse pollution control in the country. The main aspects of the scheme are initially described and its implementation in practice illustrated through a number of examples. Factors that contribute to success or failure of pollution control measures in practice are then discussed in order to draw some implications for policy-making and research in the field of diffuse pollution control.

Analysis/Results and Implications for Policy and/or Research
The ZSCE scheme requires local authorities that rely on sources contaminated with nitrates and pesticides for drinking water supply to improve source water quality by defining and implementing action plans aimed at reducing pressure from diffuse pollution on the source catchment areas. From a technical point of view, a key aspect of this new scheme is the requirement to carry out detailed catchment studies in order to identify zones within the source catchment area where pollution control measures are likely to be the most efficient and where action plans should be targeted in priority. The scope and content of those catchment studies has to follow a well structured methodological approach comprising of two phases that are described in some details and illustrated through case studies. The first phase of studies is concerned with the delineation of source catchment areas and the identification of the most intrinsically vulnerable zones from a water quality point of view. The second phase of the study is concerned with assessing diffuse pollution pressures on water resources from agricultural and other activities within the catchment areas. This relies primarily on data obtained from national and regional farming databases, but may also involve, if necessary, detailed survey of agricultural practices at the farm and field scale. Results of both study phases are presented on maps that are subsequently overlaid in order to identify zones of high vulnerability and high pressure where action plans comprising of various pesticides and fertilisers reduction measures should be defined and implemented in priority. This aspect is arguably a major innovation compared to past schemes implemented in France since the 1990s, as it enables to focus action and investment on areas where pollution control measures are likely to be most efficient to improve water quality in practice.

Like previous diffuse pollution schemes that have been implemented mostly on a voluntary basis in France, pollution control action plans continue to be at the heart of the ZSCE scheme. These plans are defined on the basis of above-mentioned studies and may comprise various pollution control meas-
ures. This includes measures eligible for state subsidies within the frame the Common Agricultural Policy (CAP), such as agri-environmental measures to limit fertiliser and pesticide inputs, soil cover management measures, culture rotation and crop diversification measures, etc. This may also include measures falling outside the scope of the CAP, such as land acquisition for conversion to biological agriculture and tree planting. Another key aspect of the new ZSCE scheme however, is the fact that pollution control action plans now have a legal status and that the state has the possibility to make them compulsory if insufficient water quality improvements are achieved in practice. 507 drinking water sources have already been designated as “priority sources” by virtue of their strategic importance and existing water quality. For those sources, preliminary studies have to be under way so that action plans will be in place by 2012.

Experience with diffuse pollution control action plans presented in the paper enable to identify factors that are critical for the success of these plans in practice. These include for instance stakeholder involvement and in particular involvement of local authorities and farmers, which is a prerequisite for successful implementation of action plans. These also include the need to reach a right balance between subsidies and farming advice and to ensure that pollution control measures are adapted to the local context, enforceable, and sufficiently long-lasting for results to be obtained from a water quality perspective. On the other hand several factors contributing to failure have also been identified such as the unwillingness of some farmers to participate in diffuse pollution control schemes and to change their current agricultural practices. The existence of stakeholder conflicts locally and the limited period of CAP-based agri-environmental measures have also been identified as factors contributing to action plan failure. In most cases, source catchment hydraulic characteristics play a significant role in the success or failure of diffuse pollution control action plans. Low inertia catchments where a rapid response to pollution control measures can be observed from a water quality perspective notably help keeping the various actors motivated in the pollution control effort.

Although still in infancy, the new ZSCE scheme introduced by the French government and presented here seems promising as it proposes a well structured and integrated methodological approach and relies on a whole range of environmental policy instruments. The key aspects discussed in this paper should in particular contribute to greatly improve the effectiveness of pollution control measure in France and thereby lead to significant water quality improvements.
Integrating Sanitation, Bio-waste Management and Agriculture through Terra Preta Sanitation

Author: Mr. Horacio Factura et al.
Hamburg University of Technology, Germany

Keywords: terra preta sanitation, soil degradation, nutrient recovery, food security, urban agriculture

Introduction/Problem Identification
About 2 million hectares of agricultural lands are lost every year due to severe land degradation caused by agricultural activities posing a great threat to global food security. Terra Preta (TP) is the anthropogenic dark soil discovered in the Amazon. These soils are 500–7000 years old but still remain very fertile without fertilizer application. Productivity of crops is twice higher in TP than crops grown in other soils. A hectare of metre-deep TP contains 250 tonnes of carbon compared to only 100 tonnes in unimproved soils. When charcoal is mixed with soil and organic waste TP is created. From these concepts Terra Preta Sanitation (TPS) has been adopted. TPS is a new dry sanitation technology that uses charcoal in handling faeces, allows urine separation and makes use of storage (lacto-fermentation/silage condition) and vermicomposting in transforming excreta into a sustainable fertile soil that can be used in urban agriculture. No water, ventilation or external energy is required.

Analysis/Results and Implications for Policy and/or Research
Researches which conducted investigations on TP showed that carbonized materials from incomplete combustion of organic material (i.e. charcoal) are responsible for maintaining high levels of soil organic matter and available nutrients in TP soils of the Brazilian Amazon basin. The accumulation of ashes from burned biomass and its effect on soil pH is a well-documented mechanism for improving soil fertility. Organic matter helps the soil store water and nutrients and releasing them to plant roots in a gradual way.

When soil pH is below 5.5 the availability of Al and Mn is increased to the point that they could become toxic to plants and the availability of plant macronutrients such as P, K, Ca and Mg decreases. This is the situation in very acid soils which account for 200 million hectares worldwide. The majority of food crops prefer a neutral or slightly acidic soil (pH 6.3-7.0). TP can play a vital role in alleviating this condition.

According to literature application of charcoal which inevitably contains ash add free liming materials such as K, Ca and Mg to the soil solution raises the pH of the soil and improving the availability of nutrients for plant growth.

Nutrient retention can also be improved with charcoal additions to soil. This is especially important in highly weathered soils in the tropics where ion-retention capacities are low and leaching of nutrients is high. Mixing relatively large amounts of charcoal with soil increases the cation exchange capacity (CEC) by about 50% in comparison to unamended soil. The CEC of the soil is determined by the amount of clay and/or humus that is present. CEC indicates soil’s capacity to hold cation nutrients. The cations needed by plants in largest amounts are Ca, K, and Mg.
Charcoal may not only change soil chemical properties but also affect soil physical properties such as soil water retention and aggregation that may enhance the water availability to crops and decrease erosion. A higher nutrient retention can also be achieved merely by retention of soil water. Low soil
organic matter contents may be responsible for the low available water capacity and the weak structure of many agricultural soils. If water percolation in soil can be reduced nutrient leaching will also decrease. By this mechanism nutrients can be retained which are normally not adsorbed to soil particles and are very mobile and susceptible to leaching such as nitrate. It is well known that charcoal has a high surface area due to its porous structure. Estimates say that it can have inner surface areas of 200–400 square meter per gram of charcoal. Literature says that water retention can be increased by up to 18% upon addition of 45% (by volume) charcoal to a poor sandy soil.

Research is currently on-going at the Technical University of Hamburg (TUHH), focusing on optimizing the design and operation of the TPS technology. TPS makes use of a simple bucket system for the collection and treatment of faeces. Preliminary results show the feasibility of the technology with regards to odour elimination and a shorter treatment time. The results suggest that it is possible to convert faecal matter in combination with kitchen biowaste into a nutrient rich organic matter after storage and vermicomposting. TPS promises to address the triple-pronged problem of soil degradation, food security and inadequate sanitation.
An African Approach to Prevent Water Contamination by Obsolete Pesticides

Author: Mr. Joop Harmsen* et al.
* Alterra, Wageningen UR, The Netherlands

Keywords: pesticides, Africa, stock pile, risk reduction, land and water management

Introduction/Problem Identification
In Africa several old stockpiles exist, containing obsolete pesticides. Most of the pesticides have been shipped to Africa for locust control but did not arrive on the proper place or proper moment thereby becoming obsolete.

Analysis/Results and Implications for Policy and/or Research
High concentrations of pesticides can be generally measures in soils on the stockpiles. Basically it was found that in the centre of the contamination, pesticides were penetrated to a larger depth. It is not to be expected that the soil will be removed and remediated elsewhere due to the high costs. If soil will not be removed, isolation or in-situ remediation are possibilities to reduce the risks.

Removal of these concentrations using northern technologies (e.g. incineration, bioreactor) or removal and transport of high amounts of contaminated soils was not found to be feasible. Remediation however is necessary to prevent that the pesticide will contaminate ground- and surface water and also to prevent contact of the local population with the pesticides. From a risk-based point of view, contaminations are only a risk if they are or may become available for transport to water bodies or become available for local people. This widens the range of options and therefore can facilitate more tailor-made solutions for individual sites. The following steps are necessary:
1. First investigation of the site.
2. Defining of the site specific risks.
4. Possibilities for site specific and sustainable remediation by risk reduction.
5. Implementation.

Sites in Mali and Mauritania have been investigated in 2007 according steps 1-3. Most important risks identified were a) inhalation, b) transport to groundwater, c) physical contact by human and cattle d) run-off by rain (Mali) and e) wind erosion (Mauritania). Based on the results obtained, risk reduction proposals have been made and discussed locally (step 4). All proposals are based on the use of local conditions to stimulate biodegradation and/or to prevent rain water to transport the pesticides both vertical as horizontal.
Agriculture, Water Quality and Water Security in Sri Lanka

Author: Mr. Upali Imbulana
Ministry of Agriculture Development & Agrarian Services, Sri Lanka

Keywords: water pollution, agriculture, irrigation, fertilizer, policy

Introduction/Problem Identification
Annual Water Resources of Sri Lanka is about 45,000 Million m³, resulting in a per capita water availability of about 2,250 m³ per annum. Though not considered as a water scarce country, poor quality of water is a major concern for the population. Only about 35% of the population has access to pipe-borne water supply and the access by the rural population to such facilities is much lower. Therefore, the pollution of water bodies is having considerable impacts on water security of rural population. Agriculture is the main livelihood of rural Sri Lanka, and has heavily contributed to improve the living standards. But poor agricultural practices adversely affect the water quality. Industry, urban and domestic waste and agricultural waste contribute the water pollution. This paper focuses on the agriculture sector’s contribution to water pollution, and analyzes major driving forces that cause pollution and the societal responses.

Analysis/Results and Implications for Policy and/or Research
Driving forces and pressures: Current agricultural policy promotes intensification of agriculture and increasing the production. Accordingly, fertilizer for paddy farming is heavily subsidized and farmers were paying only about 10-15% of the market price. This has increased the production, but over-use of fertilizer has been reported. Heavy use of chemical pesticides is a concern as well. It is found that the degradation rate of some popular pesticides is slow in Sri Lankan agricultural soils and hence the risk of contaminating groundwater due to leaching is very high. The irrigation system is designed according to a “cascade” principle from the ancient times. It allows upstream drainage and excess water to flow to a downstream irrigation system, via natural streams and rivers, to be re-used. Although this method increases the water use efficiency, it has resulted in the accumulation of pollutants.

Studies in Walawe river basin in the southern Sri Lanka indicate that the quality of irrigation canal water is below the bathing water standards. The drainage of irrigation water to downstream wetlands is affecting the bio-diversity in those ecosystems. Eutrophication and blooming in the Kotmale reservoir in the upstream of Mahaweli basin is blamed on excessive use of fertilizer in the upper catchments. Similarly, in the irrigation reservoirs and canals of north central province, which benefit from Mahaweli river diversions, high phosphate and agrochemical levels has been reported. One of the causes for heavy incidence of kidney patients in this province is suspected to be groundwater getting contaminated with fertilizer and agrochemicals.

The concentration of pollutants can be expected to increase towards downstream, due to accumulation of more pollutants as well as discharges from domestic and industrial waste. Heavy concentration of industries in the coastal districts adds to the pressures on the water resources through waste discharge. The location of several large cities in the coastal areas where good quality drinking water is high in demand, further complicates the situation.

There are several constraints and challenges to address the problem. A proper water quality monitoring system for either surface water or ground water does not exist in the country. The indication of water
pollution is obtained from occasional studies, which are sometimes externally funded. But, studies of limited time duration are not sufficient to assess or control water pollution, due to dynamic nature of water quality. It has been observed that the pollution levels increase in surface water in base-flow periods in streams, and at the onset of rains due to washing off the pollutants on ground surface.

Though there are several legislations and policy initiatives to address water pollution, most of them are conceived and implemented by institutions concerned with conservation, rather than the institutions concerned with development. The commitment of development agencies is essential for the control of water quality.

Responses: The Government has responded by framing necessary policy and legislation such as National Environmental Policy, Watershed Management Policy and National Environmental Act. The Ministry of Agriculture recently initiated a program to promote organic fertilizer. It is planned to increase the percentage of organic fertilizer among paddy farmers to 25% of total fertilizer application. This is to be achieved through increased production of organic fertilizer, training of farmers and creating awareness among them. In the field of irrigation water management, action has been taken to improve irrigation scheduling, repair infrastructure and build “night storage” ponds to reduce drainage in selected irrigation systems. Under an ongoing project to modernize the hydro-meteorological information system, it has been proposed to incorporate a water quality monitoring programme. Several community organizations and NGO’s have taken active interest in controlling water pollution, as well.

Policy Implications: Therefore, it is evident that a proper water quality monitoring system is a prerequisite for framing a strategy and addressing the problem. Existing farmer organizations, community based disaster management committees and school children are the opportunities to ensure and improve community participation. However, such interventions have to be supported by development policies and legislation. Isolated experiments in irrigation water management have to be incorporated to policies. Active participation of development agencies in framing and implementing strategies to address water pollution is essential as well. Despite having a substantially high level of per capita water availability, it can be seen that the water security of the people is threatened unless action is taken on the water pollution.
Mitigation of Deterioration of Water Quality Due to Land Use Practices

Author: Mr. Primal Jinadasa  
National Water Supply & Drainage Board, Sri Lanka

Co-Author: Mr. Rasika Kodagoda  
National Water Supply & Drainage Board, Sri Lanka

Keywords: water quality, catchment, deforestation, land use practices, awareness programs

Introduction/Problem Identification
Since the lack of advanced water treatment facilities in the rural areas of Sri Lanka, it is important to mitigate the contamination of raw water. This case study was carried out to control the deterioration of water quality due to human activities in the catchment area. The Gealoan area which is the catchment area of the water source of Monaragala water supply scheme has undergone many changes during the last decade. Illegal settlements, cattle farming and cultivations have resulted in deforestation in the catchment at an average rate of 15 hectares per year. This has affected both quantity and quality of the water source. Hence resettlement of people, provision of hygienic facilities, prevention measures for soil erosion and awareness programs were adopted as counter measures in year 2007 with the assistance of local authorities, politicians, and community-based organizations. Turbidity and E-coli count was analyzed and considerable improvement in the water quality has been reported.

Analysis/Results and Implications for Policy and/or Research
In the Monaragala water supply scheme, slow sand filtration and chlorination are the treatment done before distribution of drinking water. At the commissioning of this scheme, the Gealoan area which is the catchment area of the water source has mainly consisted of forest area. Total catchment area is about 25 km². Due to human activities, Gealoan area has undergone many changes during the last decade. Illegal settlements, cattle farming and cultivations have resulted in deforestation in the catchment at an average rate of 15 hectares per year. This has affected both quantity and quality of water where treatment plant operators experienced difficulties in filtering the raw water using slow sand filters.

Raw water quality data of the Monaragala water source was analyzed since 2004. Turbidity and E-coli were used as the basic parameters to investigate the deterioration of water quality due to human activities. Monthly highest values of each parameter were used in this analysis. Table 1 shows the monthly highest turbidity up to December 2009 and Table 2 gives the monthly highest E-coli count.

Table 1: Monthly highest turbidity. (NTU)

<table>
<thead>
<tr>
<th>Month</th>
<th>Year</th>
<th>2004</th>
<th>2005</th>
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<td>18</td>
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<td>9</td>
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</tbody>
</table>
Aug  12  11  18  12  17  11
Sep  23  30  35  28  30  19
Oct  55  67  72  60  42  30
Nov  67  72  67  60  42  24
Dec  64  65  51  48  30  20

Table 2: Monthly highst E-Coli count (/100ml)

<table>
<thead>
<tr>
<th>Month</th>
<th>Year</th>
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<tr>
<td>Jan</td>
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<td>Mar</td>
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<td>378</td>
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<tr>
<td>Oct</td>
<td>&gt;1100</td>
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<tr>
<td>Nov</td>
<td>&gt;1100</td>
</tr>
<tr>
<td>Dec</td>
<td>884</td>
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It can be seen that during rainy period of October to December the turbidity and E-Coli count are higher in the years 2004-2007. Main reasons for this are the illegal settlements, cultivations, cattle farming, deforestation, poor sanitary facilities etc.

In order to mitigate the degradation of water quality due to the above activities, a committee was appointed. The committee consists of officers from water supply sector, local authorities, politicians, and the representatives from community based organizations. The committee has prepared a master plan to mitigate the degradation of the catchment due to human activities. Following proposals have been included in their proposal.

- Prevention of new illegal settlements
- Relocation of illegal settlers to the downstream area.
- Provision of sanitary facilities to the ancient settlers.
- Conduct awareness programs.
- Prevention measures for soil erosion.
- Plantation of local plants

All the above proposals were implemented except the relocation of illegal settlers in year 2007. Because of the difficulty in finding lands in downstream areas and unwillingness of the people, relocation off all the illegal settlers has been miscarried. The main objective of the illegal settlers is to find lands for their cultivations. Hence, they are not willing to shift to the downstream areas even if they are given a land free of charge to construct their dwellings. Even though the shifting of illegal settlers was not successful, they were provided with sanitary facilities to minimize the pollution of water. In addition awareness programs were carried out & pit latrines were introduced to the residents to minimize their unhygienic practices.
Low cost prevention measures such as rubble mound breakwaters, ditches were introduced to the cultivations to minimize the soil erosion.

Awareness programs for cattle farmers were carried out on composting so that the water pollution due to cattle farming can be minimized. This might have reduced the amount of synthetic fertilizer used by the farmers and consequently lower the pollution due to fertilizer.

Since the implementation of the above proposals in year 2007, considerable improvement in the water quality has been reported. Maximum turbidity has been normally reported in the months of October to December which is the main rainy season. Before the year 2007 maximum monthly turbidity value in the rainy season is greater than 60 NTU. However the maximum turbidity is in the range of 30-42 and 20-30 in the year 2008 and 2009 respectively. Before the implementation of the countermeasures, E-Coli count was greater than 1000 and in 2009 it has been reduced to less than 500. These improvements of the water quality imply that the measures taken to mitigate the degradation of water quality have been effective. If the legal actions can be imposed to resettle the illegal settlers it can be expected that the water quality will be suitable to treat with slow sand filters. However in future, proper quality test to be carried out to check the pollution due to pesticides.
Management of Human-induced Salinization in the Berg River Catchment (South Africa)

Author: Dr. Nebo Jovanovic* et al.
*CSIR, South Africa

Keywords: Berg river, dryland salinity, hydrological modelling, land use, semi-arid climate

Introduction/Problem Identification
The Berg river is a major source of water to the City of Cape Town and West Coast District Municipality, irrigated agriculture and the industries of Saldanha (South Africa). The South African Department of Waters Affairs and Forestry has found increasing trends in salinity in the Berg river since the mid 1970’s. Natural dryland salinity (predominantly NaCl salts trapped in Proterozoic Malmesbury shale sediments) has been identified as the source of some of the salts affecting its water quality. The hypothesis was that enhanced mobilization and discharge of these salts occurred by clearing natural vegetation and pasture land to make space for agricultural production.

Analysis/Results and Implications for Policy and/or Research
A cycle of research is currently under way to mitigate dryland salinization of the Berg river. The approach included three intensive monitoring sites: i) Langgewens experimental station where the water and salt balances of different crop rotations were investigated; ii) Goedertrou small scale catchment where hydrosalinity fluxes were quantified; and iii) Voelvlei Nature Reserve where evapotranspiration of endemic renosterveld vegetation was compared to an adjacent wheat monoculture field. The results obtained from the intensive monitoring sites served to inform hydrological modelling of salinity in the Sandspruit river, a seasonal tributary of the Berg river, which was identified to be particularly saline (maximum electrical conductivity EC ~ 2,000 mS/m at the end of the rainy season). Mineralogical analyses brought evidence that oceanic salts were deposited via rainfall in geological ages when climatic and vegetation conditions were different from the present conditions. Concentration of these meteoric salts through evapotranspiration resulted in a gradient of groundwater salinity as an inverse function of annual rainfall (groundwater quality becomes increasingly saline from the recharge area at the top of the Berg river basin towards the bottom, semi-arid area of the basin). Salts accumulated in bulges in the regolith above groundwater, flushed downwards by infiltration and recharge, and transported upwards from the groundwater table by capillary rise. Seasonal perched water tables are likely to occur at the interface between the soil mantle and the Malmesbury shale having low hydraulic conductivity. Different land uses (e.g. indigenous vegetation, crop rotations etc.) are likely to affect greatly the water and salt balance of the system. In particular, endemic, well-established renosterveld with a deep rooting system was shown to transpire more than a wheat monoculture throughout the year. This has implications to the control of salt release, as groundwater tables in annual cropping systems are likely to rise, mobilize salts trapped in the regolith and enhance salt discharge. The first flush of salts commonly observed in irrigated systems at the beginning of the rainy season did not occur. This is due to the relatively low accumulation of salts on the soil surface following drought, and the location of salts being deep in the regolith material. Peaks of salt loads were generally measured in the middle of the rainy winter season, when the wettest conditions occurred. Annual salt load from overland flow measured at runoff plots was between 0.016 and 0.236 t/ha, depending mainly on annual rainfall, land use and management, and soil type. Salts mobilized through interflow at the interface between soil cover and Malmesbury shale were in the same order of magnitude as those mobilized through overland flow. Groundwater quality ranged from fresh water in the upper parts of the Sandspruit...
catchment to very saline in the lowest reaches, where groundwater EC was measured to be ~ 2,000 mS/m, similar to the maximum EC in the Sandspruit river at the end of the rainy season. The lowest reaches of the Sandspruit catchment were therefore identified to be a salinity hotspot and the adoption of salt tolerant forage crops was recommended for this area. Data collected at intensive monitoring sites were used to develop algorithms and input data sets for hydrological models, namely the Object Modular Systems (OMS, United States Geological Survey) and the Jena Adaptive Modular System (JAMS, Friedrich Schiller University of Jena). Twenty-year historic data indicated that bulk atmospheric deposition accounted only for a third of the mass of salts discharged by the Sandspruit river. The remaining salt output was delivered by groundwater and interflow from the weathered shale and the soils within the catchment. This human-induced salinization of the Berg river can be mitigated by manipulating the water and salt balances. Scenario hydrological modelling is currently being used to develop land use and management systems that would reduce salt loads in the Berg river (e.g. introduction of new cropping systems, planting renosterveld strips or high water-consuming trees, shallow tillage etc.). Predictive modelling is used to assess how long it will take for salts to be leached out of the system and at what rate.
Minimising Land Based Pollution in Pangani River, Tanzania

Author: Mr. Sylvand Kamugisha* et al.
* IUCN, Tanzania

Keywords: policy, assessment, nutrients, degraded, services

Introduction/Problem Identification
The Pangani River Basin, which is 43,650 km², flows from Mount Kilimanjaro and Mount Meru in northern Tanzania to the Indian Ocean in the town of Pangani in Tanga Region. The river and its basin are very important to Tanzania in terms of irrigation, domestic, fisheries, livestock, industries, mining and hydro-power. However, the growing demand for water resources in the basin coupled with limited baseline information about the status of river health pose serious challenges in managing the water resources. The inadequacy of baseline information on the status of the river health limits the work of the Pangani Basin Water Board face to operationalize the provisions of the National Water Policy (2002) and the Environmental Management Act (2004) for allocating water to environmental resources and social economic development.

Analysis/Results and Implications for Policy and/or Research
One of the objectives of the Pangani River Basin Management Project was to assess land use practices and their impacts on the Pangani River health. The assessment was conducted using methods developed in the River Heath Programme of the National Aquatic Ecosystem Health Biomonitoring Programme of South Africa. This involves the collection of information necessary to characterize a site, to provide an indication of catchment condition and land-use, together with relevant abiotic (water quantity and quality) and biotic (invertebrates, fish, riparian vegetation) information.

The assessment, showed that the quality of water in the river is deteriorating due to poor land use practices. Effluent and solid waste pollution have decreased dissolved oxygen and increased nutrient levels in the river. This has reduced services provided by the river system thus affecting social-well being of the people who depend on it. The results also indicate that Pangani estuary is in poor conditions compared with similar tropical estuaries around the world. Fewer fish, birds and other animal species have been recorded. Sea water is intruding further upstream as river flows decrease due to high upstream abstractions; Pollutants, such as decomposing plants and fine silt from agricultural land, are reducing the oxygen levels so low that most fish and other animals cannot survive there. A once-abundant fishery is now seriously depleted.
A Model for Sustainable Watershed Management: The Case of the Drivers River Watershed Management Unit, Portland, Jamaica

Author: Ms. Lisa Kirkland
National Environment and Planning Agency, Jamaica

Keywords: watershed model, community engagement, integrated, sustainability, advanced participatory

Introduction/Problem Identification
A Watershed Area Management Model was developed under the Global Environment Facility funded Project, Integrating Watershed and Coastal Areas Management (GEF – IWCAM). The Project is implemented locally by National Environment and Planning Agency, using lessons learnt from previous projects and practical applications that were implemented in the Drivers River Watershed Management Unit of Portland, Jamaica. Two major challenges to sustainably manage watersheds over the years have been firstly the lack of a framework within which public bodies could collaborate with each other to achieve an integrated approach and secondly the need to focus on attitudinal and behaviour changes of community members, individually and collectively. The Model therefore address these challenges by providing watershed practitioners, government agencies, NGOs, funding agencies and the ordinary citizens a simple, practical and flexible method of working together to achieve sustainable watershed management.

Analysis/Results and Implications for Policy and/or Research
An integrated approach was taken to combat these challenges, which brought all Stakeholders together. The strength of the model therefore lies in its approach, whereby state agencies and communities collaborate in “pooling” together their limited resources to bring about the much needed rehabilitation of the watersheds. These are practical measures that were implemented in the Drivers River Watershed of Portland, Jamaica.

The Watershed Area Management Model (WAMM) essentially consists of ten components of Engaging the Community from the onset to ensure maximum participation and “buy-in”, while simultaneously using the advanced participatory method The Governance Approach of a “Bottom Up” methodology was used; where communities are fed with relevant information and allowed to make decisions based on the consensus of the group; Reconnaissance of Resources to gain baseline data on available or potential natural resources; again community members are equally involved. Establishing Indicators for Assessment and Evaluation which are then used to evaluate the progress towards achieving long term goals, such as the sustainability of the watersheds themselves; Capacity Building through Training where community members are trained in aspects of watershed management and given the opportunity to implement same as a combined Team; Environmental Monitoring, Mitigation and Evaluation in order to assess the status and trends of social and natural resources within the Watershed and to develop and implement solutions; Capacity Building to Access External Funds for Community Project to enable community groups to prepare project proposals and to seek funding from various donor agencies, hence assisting in the sustainability of the process; Developing Sustainable Livelihoods which comprises the capabilities, resources, and activities required for a means of living which does not undermine the natural resources; innovation ways have been used to ensure a paradigm shift in the way of life of community members while at the same time, providing a means of income; Cap-
turing Lessons Learnt which involves the collection, validation, consolidation and documentation of experiences, developments, and risks found during project implementation; and finally Broadcasting the Experience by sharing success stories and lessons learnt with others, as the lessons will be useless, unless disseminated to other to make meaningful changes.

Therefore as a result of the implementation of the Model, the Watershed was visually cleaner. For the first time in the Watershed, garbage collection was regularized and some schools now have upgraded sanitation systems; incorporating a “flush system”. The Communities were more aware, empowered and were united in the improvement of their Watershed. They have identified the solutions that were necessary and they are now a part of the Implementation Team. For the most part, best management practices were carried out by communities in conjunction with the Project and the many state partners and Non Governmental Organizations in the Watershed. Community members were actively involved in all aspects of monitoring in the Watershed e.g. stream flow levels and rainfall data. Currently, these inputs have been work in progress. More importantly, community members that have sat for years and have done nothing to improve their environment have been empowered and have implemented best management practices in farming, sanitation and solid waste management; they have learnt that they are capable of initiating the change in their Watershed. As a result of a number of seedlings that were planted and the soil conservation techniques that were employed, the visible levels of soil erosion have decreased.

The Model can only be successful if all agencies are willing to work together and as such each agency was asked to make a commitment by the signing of a memorandum of understanding (MOU) which states that in keeping with the agencies’ mandate watershed management will be initiated using the Model. Ninety eight percent (98%) of participating agencies in the Drivers River Project expressed a willingness in principle to continue working in a similar manner to how they collaborated during the project. Further this Model will also be used to inform the Watershed Policy of Jamaica which in turn will be promulgated into a White Paper.
An Effects-based Abatement Strategy for Non-point Source Pollution: Otago, New Zealand Case

Author: Mr. Graeme Martin et al.
Otago Regional Council, New Zealand

Keywords: effects-based, non-point source pollution, intensive agriculture, contaminant measurement tools, water quality standards

Introduction/Problem Identification
New Zealand State of Environment report (2007) identified the impacts of non-point source pollution as the most serious freshwater management challenge in New Zealand freshwater environments. Although water quality in New Zealand is of high standard as compared to OECD average, agricultural land use creates a significant pressure on water quality. The management of non-point discharges to water bodies is socio-economically a challenging issue as the agricultural sector makes up the largest component of the national and regional economies.

Otago region in south of South Island of New Zealand faces the diffuse pollution challenge under intensifying agricultural land use. Previous local government responses (mainly input controls) were found to be ineffective achieving the desired improvement in water quality. To meet this challenge, regional government (Otago Regional Council-ORC) considered implementing an effects-based strategy to manage the negative impacts of diffuse pollution.

Analysis/Results and Implications for Policy and/or Research
This study examines the non-point source pollution issues in Otago and the regional government response. Proposed paper analyses the adoption of a new (effects-based) strategy to manage the impacts of non-point discharges to avoid deterioration of in-stream water quality and share the local government practice in New Zealand. Since the agricultural diffuse pollution literature is mainly model-driven and needs a perspective of empirical studies (Dowd et al: 2008), proposed paper intends to share the Otago case in the context of strategy implementation.

In the making of this strategy, a set of different approaches and their suitability for Otago have been considered, including voluntary, command & control approaches and economic instruments. A thorough investigation of these approaches showed that Otago’s distinct geographical, environmental, socio-political characteristics require a tailored approach that deviates from commonly implemented command and control approaches. It is also found that input control was not sufficient to influence farmer behaviour and would not achieve improvement in in-stream water quality. The main characteristics that urged Otago Regional Council to consider an effects-based strategy are:

Voluntary approaches: Sectoral partnership (Clean Streams Accord) between governmental and sectoral authorities resulted in agreeing a voluntary agreement towards managing farm effluents and showed willingness of cooperation in tackling non point source pollution but did not have regulatory teeth.

Command and control approaches: They were practiced to a great extent within a very supportive educational framework however did not necessarily help improving water quality and occasionally worked against balancing agricultural production and farmer realities.

Economic instruments: Resource governance in New Zealand does not allow regional government...
authorities to consider economic incentives/disincentives in diffuse strategies. Resource management is highly decentralized and national government involvement is at guidance level. Regional councils are responsible managing water quality under the Resource Management Act (1991).

Scale of the pollution: Diffuse pollution is unseen at the individual/farm level.

Scale of economic production and intensification: Agricultural sector is nationally and regionally significant, making up 17% of exports

Previous policies and farmer behaviour

These factors urged local government to consider a different non point source management system contrary to common practices used in other parts of New Zealand and the world. The new approach is:

- Output-focused: looking at regulating what comes out of the farm
  - Regulatory: setting threshold values for contaminant parameters (turbidity, soluble nitrogen, soluble phosphorus and microbes) rather than in-stream water quality standards and using these threshold values to manage discharge contaminants
  - Compliance-driven: Uses monitoring at farm-level and modelling to set standards for discharge contaminants through a stakeholder process driven by communities and farmers
  - Local government guided: based on mutual learning, greater sectoral-community involvement and education
  - Self-policing: flexible in what type of inputs and outputs can be managed, does not impose methods for management, understands farmers' autonomy and has the capability of not limiting reasonable land use

A preliminary strategy drafted for implementation included a complete re-focus on the activities regulated previously and involved using some novel ways in the deployment of monitoring and contaminant measurement tools for controlling non-point source pollution. The strategy implementation can be summarized in six important steps:
* Step 1: Development of new monitoring tools and contaminant measurement devices
* Step 2: Mutual learning, outcome modelling for setting discharge standards. Wide usage of devices by farmers, extensive awareness on catchment dynamics and how diffuse pollution moves under given circumstances which ultimately aims to create an improved catchment understanding
* Step 3: Setting discharge standards based on accumulated knowledge of catchment outcome modelling
* Step 4: Farming is permitted as long as the standards are met.
* Step 5: Compliance action will be taken against offenders

The execution of these steps will mean that regulatory changes occur in the medium term. This would catalyze the farmer behavioural change in the long term and provide a framework for farmers being responsible in making decisions for the management of diffuse pollution on their farm. This will ultimately prevent the deterioration of good in-stream water quality. Strategy implementation is not linear and management challenges are analyzed in the context of risk management.
Managing Water Quality in Agriculture: A Review of OECD Policy Experiences

Author:  Mr. Kevin Parris
Trade and Agriculture Directorate, OECD

Keywords:  agriculture; water; pollution; policies, OECD

A major challenge for policy makers across many countries is how to increase agricultural production and reduce the pressures (pollution) on water quality, while balancing the economic, social and environmental costs and benefits of policy actions to achieve these goals. This presentation reviews OECD country policy experiences in addressing diffuse and point source water pollution from agriculture, such as the use of taxes, regulatory instruments, payments, market based and voluntary approaches.
Towards Better Understanding of Relationship of Urban Land Use and Water Quality—evidence from Pune City, India

Author: Mr. Pratap Raval (CESID), College of Engineering, India

Keywords: land use, informal settlements, natural systems, urban infrastructure, town planning

Introduction/Problem Identification
Urban land use and water quality has close relationship. Rapid urban population growth over the past 50 years has introduced important implications for the water environment. Large area of land is converted for habitation. Agriculture land and hillsides were converted to urban and residential land use, the concrete infrastructure sized for the original urban footprint was soon overwhelmed, increasing the potential for flooding in residential and commercial neighborhoods.

As urban local authorities begin to address the wastewater and urban runoff problem, it has become clear that a watershed-based planning effort is necessary to identify and prioritize opportunities for stormwater mitigation and water quality improvement. By applying fundamental Low Impact Development planning concepts throughout the urban watershed, hydrologic function may be restored by reversing the hydromodification effects of urban infrastructure.

Analysis/Results and Implications for Policy and/or Research
This paper discusses the circumstances which help to understand the relationship of uncontrolled land use and its impact of water qualities on river. Rapid urban population growth over the past 50 years has introduced important implications for the water environment. Cities in India like Pune face the challenge of managing their impact on the natural environment and the stress on aging urban wastewater infrastructure. The fast growing cities of India can best be described as a fragmented setting. There is widespread failure to recognize and support economic agglomeration processes and to plan for urbanisation. Land use changes as decided under town planning framework failed to control water pollution in cities. The urban environment in most cases is synonymous with unhealthy living conditions, especially for the poor. Inadequate sanitation and water supply systems in formal and informal settlements along tributaries of river have turned rivers into sewers and have contaminated ground water supplies. The present paper discusses the impact of land use and activities on the water quality of the rivers Mula and Mutha flowing through Pune City. Pune city spread over 143 sq.km of geographical area and settlement has increased 2-4 times in last 40 years. Pune urban agglomeration is located in Upper Bhima River basin. The urban local authorities are trying to treat large amount of wastewater generated in urban areas but efforts are not effective in controlling water quality of rivers. Unaccounted flows of wastewater through streams are major challenges for deteriorating water environment in city. The study is an attempt to assess the impact of land use on water qualities of streams and state of art decentralized measures in the form of natural systems to treat flowing wastewater and urban runoff to improve water qualities. Such measures were helpful in controlling urban runoff qualities and creating better environment for living. The stream gardens called in local language as Nala Garden implemented on large scale with the help of community.
Pay for Environmental Service to Recover Quantity and Quality of Water in the Basin La Marina-Opio in Coatepec, Mexico

Author: Dr. Rabindranarth Romero-López
Universidad Veracruzana, Mexico

Co-Author: Mr. Alfredo Galán
Universidad Veracruzana, Mexico

Keywords: willingness to pay, contingent valuation method, bassin, coffee, environmental service

Introduction/Problem Identification
Coatepec is the main producer of coffee in the center of Veracruz, but at the present time this region as several problems relate to water like insufficient offer of water demands, low efficiency in the use of water in the agricultural sector, low efficiency in the public urban use of the water, degradation of the quality of water, damage to environmental sustainability. This research tries to evaluate the environmental service of the forest and its relationship with the water to preserve the forest into the basin Huehueyapan.

Analysis/Results and Implications for Policy and/or Research
It is necessary evaluate the environmental service in the basin La Marina-Opio. For improving instruments in the decision-making, it is necessary to do an analysis of the impact of costs and benefits of the environmental service. This can be done by taking as economical indicator of profitability the current net value, supporting the development of a new politics of the water in the basin and using better techniques for preserving the hydraulic resources of the basin. Even if there are various methodologies to economically value environmental quality; it was decided to use the Contingent Valuation Method (CVM). This method is based on surveys randomly given to a group of people, with the purpose of getting the Willingness to Pay (WTP) to recover an environmental asset, in this case the forest in the basin La Marina-Opio related to water. This hypothetical and direct method allows obtaining estimations of the effect that certain actions have in the wellbeing of the individuals. It is based on the construction of a hypothetic market in which the individuals normally have to express their maximum WTP for a change in the quality or quantity of the environmental actives. The study zone for the research is La Marina-Opio Basin, because of its natural delimitation and its hydrological characteristics. It was determined a sample size of approximately 400 homes of study to obtain WTP. The surveys were depurated according to the inconsistencies and protest answers defined in the VCM. A clean data base was obtained. One of the most important variables is the agricultural production due to the great volumes of water that are used for irrigation, the agricultural production was estimated in 0.5 DLS$/m^3$. To calculate the agricultural productivity three fundamental aspects were taken into account: the agriculture productivity, the quantity of rain and the basin area. In order to know people’s opinión about the environmental problematic in La Marina-Opio Basin a questionnaire was designed. According to the questionnaires there is a strong concern from people to rescue the forest and the basin. The VCM is different from other methods since in Mexico there are no sufficient statistical data. It has the advantage of giving an economical value to an environmental asset and also allows the direct extraction of the social perception taking into account people's opinion on an environmental problem. Therefore, this can be used to apply a public policy. This research can be improved and used for future studies. The use of controversial or innovative methodologies offers the possibility to keep on researching the social perception and the economical value of an environmental
wellbeing. Finally, it is important to emphasize that all the information generated over the last years is very reliable that is why an invitation to the authorities is made in order to create Politics of Distribution and Management of Water in the Basin. Besides the law it is important to go beyond because when some users do not obey the agreement there is no penalty for them. This situation would not happen if there were a law. The foundation of results is very useful to make a proposal, therefore it is the authorities’ responsibility to change the paradigms and use new tools in the decision-taking.
Peak Phosphorus and Eutrophication of Surface Waters: A Symptom of Disconnected Policies to Govern Agricultural and Sanitation Practices

Author: Dr. Arno Rosemarin
Stockholm Environment Institute, Sweden

Keywords: phosphorus, eutrophication, agriculture, sanitation, policy

Introduction/Problem Identification
Phosphorus is a non-renewable but recyclable resource fundamental to our food systems. That it is quickly being depleted from available fossil deposits and is ending up at the bottom of lakes and oceans unavailable for reuse continues to be of little or no concern to most governments around the world. The concerns centred around water quality and eutrophication are not connected to finite resource depletion. The P reserves that can be economically exploited within the bounds of today’s technology can be depleted within 75 years and already within 25 years in the US. This inconvenient truth still has yet come to the surface and remains one of the most important neglected sustainable development issues of our time.

Analysis/Results and Implications for Policy and/or Research
Eutrophication of surface waters continues to be one of the most common water quality problems around the world. Major water quality improvements have taken place in the OECD countries and unit fertiliser consumption has been dropping since the 1990s in the EU but agricultural practices using excessive amounts of fertiliser leading to runoff losses to both freshwater and coastal zones remains a problem in many other parts of the world. The EU subsidizes agriculture to the tune of one billion Euros each week as part of the CAP (Common Agricultural Policy). The result is over-production and overconsumption of food with ensuing environmental and health impacts. Similar trends can be seen in the US.

Phosphate fertiliser prices soared in 2008 (600% increases in one year) when oil prices were over 100 USD per barrel and the US and other countries increased the use of food crops to produce ethanol as a liquid fuel. The UN held three food security summits following this rapid increase in fertiliser and food prices (the highest over the last 100 years) only recommending short-term remedies like increased food aid to poor countries unable to afford the high costs of chemical fertiliser. No systems or integrated view was taken questioning excessive use of chemical fertilisers, the need for eco-friendly and climate-smart agricultural practices or examining the world’s limited fertiliser resources.

Phosphate prices are set essentially by only 3 countries (US, China and Morocco) and potassium essentially by only 4 countries (Canada, Russia, Germany and Belarus). Globally, food prices rose 40% in 2007 and even in the poorest countries the food index rose 25%. For rural smallholder farmers in developing countries, chemical fertilisers are still no longer affordable even following the global economic collapse of 2008/2009.

In order to cope, more sustainable conservation agriculture practices are necessary such as strategic cropping and low- or no-tillage practices, water harvesting and recycling of nutrients from various organic sources including manure and humanure. The agriculture challenge is truly mammoth: 800 million people living in 46 countries are malnourished; 40,000 die every day of hunger and hunger-related diseases.
And the human sanitation challenge remains: 5000 children die every day in the world due to water-borne diseases linked to lack of basic sanitation; 700 million people in 50 countries eat food from crops irrigated with untreated sewage; 3.5 billion people are infected with helminth worm parasites; and half the world lacks basic sanitation systems. Meeting this the largest MDG target will have a cross-sectoral social impact improving livelihoods and general productivity. Productive sanitation linked to agriculture can provide new growth opportunities for poor countries.

A closer look is necessary to understand how sanitation and agriculture can be linked. The average human produces 500 L of urine and 50 L of faeces per year. This is equivalent to about 5.5 kg of NPK (4 kg of nitrogen, 1 kg of potassium and 0.5 kg of phosphorus) per capita per year varying from region to region depending on food intake. The rule of thumb is that one day of urine from an adult is sufficient to fertilise a square meter of cropped area for each cropping period. This means one year of urine from a person can support agriculture over an area of about 300-400 m². If used mainly as a phosphorus fertiliser, one person’s urine over a year can support even higher areas of 500-600 m². Sub-Saharan Africa could become self-sufficient in fertiliser supply if it were to adopt productive or ecological sanitation practices. This would provide the necessary supply of nutrients to smallholder farmers and provide food security and new opportunities for income.

As fertiliser prices continue to increase, the economic value of urine and composted organic wastes and faeces from both livestock and humans will make these products more and more attractive alternatives. And there will be more pressure to develop these options. There are major stumbling blocks preventing widespread development in these directions due to general ignorance and cultural taboos and attitudes about human excreta. There is a serious lack of capacity in the world today to carry out large-scale productive sanitation with agriculture applications. Policies and regulations are also lacking to help promote and main-stream these practices. So much work through extension services and training is required before we can make the leap to close the loop on nutrients to benefit mankind.
Sedimentation as Land Use Based Water Pollutant in Mara River Basin, East Africa; Past and Possible Future Trends

Author: Mr. Joseph Sang
Jomo Kenyatta University of Agriculture and Technology (JKUAT), Kenya

Co-Author: Dr. Gathenya Mwangi
Jomo Kenyatta University of Agriculture and Technology (JKUAT), Kenya

Keywords: sedimentation, land use change, Mara river basin, hydrological modeling, Lake Victoria

Introduction/Problem Identification
Lake Victoria, in East Africa, has in recent decades undergone profound ecological changes. These changes can be associated with the excess sediment and nutrient loading that result from deforestation and greatly increased agricultural activities throughout the Lake’s catchment. Furthermore the region supports one of the densest and poor rural populations. In Mara river basin, part of the Lake Victoria catchment, this has been the case with only about 10% remaining under forest cover. Land use changes in the basin are primarily due to agricultural extensification. This has cause an increase in sediment loading in the river and Lake Victoria. However, this land use based pollution cannot be quantified currently due to lack of past and current records. Furthermore, most conservation efforts focus on forestlands, which only cover less area and generate less pollution than agricultural lands.

Analysis/Results and Implications for Policy and/or Research

Analysis approach
Due to lack of sedimentation of historical sedimentation data, this study utilized remote sensing, available historical hydrological and climatic data, geographical information (GIS) and hydrological modeling to reconstruct the past sedimentation rates. Remote sensing for the last five decades were compare to identify areas and spatial extent of land use. This informed hydrological modeling on future trends. The climatic data was used to calibrate the model and the hydrological information was used to calibrate the model. The calibrated model was then use to study possible future trends under Best Management Practices (BMPs) as intervention measures were also evaluate. Local knowledge from selected agricultural official was also sort and used to support the conclusion of this study.

Results
Currently less 10% of Mara river basin is under forest cover. Increased land use change to agriculture has exacerbated sedimentation problems in the basin. Modeling results estimated that sedimentation in the basin has increased by about three folds and this is likely to continue due to the increasing population pressure and poor farming practices. This erosion is mainly from agricultural lands. If adopted BMPS could have the potential to reduce the estimated sedimentation rates considerably. For example Conservation Agriculture (CA) if widely adopted in the basin could reduce the estimate current sedimentation rate by about 50%. However, there are farmers related, institutional and market bottles to such BMPs adoption.

Implication for Policy and Research
There is need to re-focus conservation efforts, both at local and policy level to include adoption of BMPs in the basin. However it is anticipated that a shift to agricultural intensification with adoption of BMP
approaches could yield different land use based pollution due to agrochemicals to be used. This will raise a new front of pollution for the river and the Lake. Further research and monitoring to improve on knowledge of such possible outcomes will be essential for regulations and policy formulations.
Minimising Agricultural Land Use Induced Pollution in the Northeast India: Farming Systems Approach through Integrated Watershed Management

Author: Dr. Uttam Chand Sharma
Centre For Natural Resources Management, India

Co-Author: Dr. Mrimoy Datta
Indian Council of Agricultural Research (Icar)

Keywords: Agricultural land use, Minimising, Pollution, Farming systems, Northeast India

Introduction/Problem Identification
The northeastern region of India, having 255 090 km² area, is predominantly hilly. The region receives an average of 2450 mm of rainfall, annually, but its mismanagement has rendered the region in a polluted and fragile state. More than 75% of population is engaged in agriculture and shifting cultivation is the main form of land use, involving 14660 km² area. The sediment yield per ha through runoff has been reported to be 130.3 to 170 t ha-1 in shifting cultivation, on a 70% slope watershed. The existing land use has caused settlement of sediment-borne contaminants from erosion, siltation, fertilisers, and pesticides in different sinks, polluting the water bodies. Silting of river beds has resulted in high magnitude floods in the region. The fast growing population has pressurized the food production base and to satisfy needs, the people have mismanaged and polluted water resources. The land tenure system, free range grazing and deforestation has aggravated the problem of pollution.

Analysis/Results and Implications for Policy and/or Research
To evolve eco-friendly and sustainable farming systems to replace shifting cultivation, a multi-disciplinary, long-term study was undertaken with seven land use systems on micro-watersheds viz.; livestock based (grasses and fodders), forestry, agro-forestry, agriculture, agri-horti-silvi-pastoral, horticulture and shifting cultivation, to monitor their comparative efficacy with regard to in-situ retention of rain water, water and sediment yields, effect on soil constituents and influence of livestock on soil properties. The livestock included cows, pigs, rabbits and goats, which were kept in the watershed itself as per farmer’s practice. Sediment and water yield was monitored through representative gauges installed at the exit point of each watershed. The watersheds slope varied from 32% to 41% and, soil and water conservation measures followed were contour bunds, trenches, bench terraces, half-moon terraces and grassed water-ways in all land uses except forestry and shifting cultivation. The average results 10 years showed that, on an average, 0.16 to 0.82 tonnes of sediment yield ha-1 and more than 90% of rainwater was retained in-situ in new land use systems as against 36.2 tonnes ha-1 of sediment and 66.3% rainwater retention in shifting cultivation. Due to more infiltration of rainwater in the soil, the runoff has considerably reduced in new land uses, resulting in low flows to river channel. Precipitation has caused soil, nutrient and heavy metal ions loss through leaching, resulting in contamination of groundwater in the region. The NO₃-N, sulphates and chlorides in the groundwater varied from 17 to 51 mg l⁻¹, 102 to 175 mg l⁻¹ and 105 to 245 mg l⁻¹, respectively, while pH was from 4.9 to 6.2. To reduce the leaching of nitrogen beyond the saturated zone and reach the groundwater level for contamination, proper land use with sufficient vegetation cover is necessary so that maximum N is absorbed by the plant roots. The sediment load in flood water was found to be; 1.5 to 30.0 g l⁻¹ of soil and, 6.4 to 25.8, 2.3 to 8.5, 15.4 to 33.8, 7.5 to 22.7, 5.0 to 8.5 mg l⁻¹ of NO₃-N, P-PO₄³⁻, K₂O, micronutrients and SO₄, respectively. Maximum increase of available P was found in horticulture.
land use, where it increased from 2.7 (initial status) to 24.9 mg P kg\(^{-1}\) of soil, followed closely by agri-horti-silvi-pastoral, agriculture and livestock based land uses (21.4, 17.6 and 16.2 mg kg\(^{-1}\) of soil, respectively). It was observed that the soil pH, in the land use where grasses and fodder crops were grown, increased from 4.9 (highly acidic) to 6.2 (moderately acidic) conditions over the years. The organic carbon increased from 0.9% to 1.2%, humus from 0.2 to 0.5%, while exchangeable Al decreased from 117 to 30 mg kg\(^{-1}\) of soil. The development of humus after 10 years was maximum in the agro-forestry system followed by horticulture, grasses/fodders and horti-agriculture land uses. However, up to 6th year, the humus content was higher in land use with grasses and fodder crops due to more addition of organic material in this land use compared to agro-forestry land use where the trees were in growing stage initially and leaf litter added was in small amounts. The study has amply demonstrated that by adopting suitable crop land uses with watershed approach, the soil erosion and sediment load can be brought much below the permissible limit as against shifting cultivation where it is many-fold higher. The leakage from pesticides can be plugged and residual effect minimised with proper crop management practices. The new land uses would solve the food problem of this food-deficit region as their productivity is 2.5 to 3.5 times higher than shifting cultivation. It was observed that keeping of livestock in-situ in the watershed and incorporating their dung and urine in the soil continuously for 5 to 6 years resulted in sufficient fertility build-up to avoid the use of inorganic fertilisers without compromising the crop yields. This has significantly reduced the sediment load in the runoff from these land use systems and considerably reduced the pollution.

With increase in demographic pressure and consequently food and water needs, the pressure on natural resources would grow with risk of irreversible damages to water bodies. All efforts by the government to wean away the shifting cultivators from the practice have met with little success because the people are socio-culturally attached with it and the absence of suitable alternatives. The success of the long-term study has given an alternative to the farmers to adopt a land use as per their requirement and agro-climatic situation. The central as well as state governments of the region have replicated these experiments as demonstrations at different locations to make the users aware of new eco-friendly land uses. New schemes/projects have been started by investing huge amounts of money to stop shifting cultivation and go for new land use systems with watershed approach.
Catchment Management Strategies for Control of Land Use Based Water Pollution

Author: Mr. Laurence Smith* et al.
* Centre for Development, Environment and Policy, School of Oriental and African Studies, University of London, UK

Keywords: wicked problems, catchment management, diffuse pollution, adaptive management, governance

Introduction/Problem Identification
Land use based water pollution is a difficult policy issue. Diverse non-market benefits and costs from polluting activities justify intervention by government or community. Diffuse pollution arises from dispersed activities and sources. It comprises true non-point sources such as sheet run off or nutrient seepage into ground water and many minor point sources such as field drains. Individually each may have negligible impact, but at catchment scale are significant in aggregate. Unlike point sources diffuse pollution cannot be cost-effectively controlled by regulation alone. Solutions require behavioural change and a broad societal response, and must be adaptive to stochastic conditions and trends. Measures include: regulation; incentives and voluntary agreements with land users; self-regulation; advisory work; and land acquisition or easement. The challenge is how to determine and implement the best combination of measures given local conditions and preferences and national priorities.

Analysis/Results and Implications for Policy and/or Research
This paper presents findings from investigation of the scientific, social and governance accomplishments of innovative catchment management programmes in the USA, Australia, and north-west Europe. The characterisation of a ‘wicked’ problem has been used to examine the policy challenges posed by diffuse pollution and to identify and test solutions. Cases such as the New York City watershed, South East Queensland and UK implementation of the EU Water Framework Directive illustrate both successes, and unresolved tensions between top-down regulation and efforts by stakeholders to work as partners in collaborative catchment management. A ‘template’ approach for catchment management has been derived which assimilates scientific understanding and governance procedures as tested in actual decision making and management practice in case study catchments. This framework integrates interdisciplinary appraisal and implementation of measures to protect water resources. It integrates scientific investigation with policy, governance and legal provisions, and provides a means to share best practice. The framework is informed by comparative analysis of catchment processes, organisational structures and institutional arrangements, and the testing of international experience in two UK catchments. Key lessons include the following.

Catchments and all sources of pollution should subject to a holistic analysis, and environmental criteria considered with the economic, social and cultural goals of all affected, led by a vision of viable communities set in a landscape in good ecological status. Land use based pollution cannot be considered in isolation, and the diversity of stakeholder interests must be acknowledged from the earliest stages; targeting farming whilst ignoring other interests may reduce credibility with farmers and achieve only partial success. A catchment-wide and cross-sectoral approach is needed, but this statement belies the complexity of technical issues and conflicts that underlie it. Where there is uncertainty about technical issues and society’s preferences a twin-track (analytic-deliberative) approach of well validated research and inclusive stakeholder deliberation is required. This might be self-evident but it is rarely
made explicit, and insufficient attention is often given to the institutions, techniques, processes and intermediaries that can make this duality function effectively.

Improvement in water quality requires a target-based approach, an adequate research base and an adaptive management strategy. Agreed goals can establish interdependence in recognition of a shared problem, and specific measurable objectives. Capability is needed for determinations of: quantification of sources, ranking by significance, prioritisation and targeting, selection and implementation of measures, monitoring and evaluation of outcomes, and refinement of implementation. Without such capacity conflicts between economic activity and water quality may remain unresolved. However, even in poor economies the ‘best need not be the enemy of the good’. A start can be made with limited data and robust tools for risk mapping to identify ‘win-wins’ and most achievable incremental gains.

Land management has a local basis and protection of water requires local measures and participation supported by enabling higher level governance. The legislation and policies that support a programme are critical to the balance of regulation, voluntary initiatives and incentives needed to change behaviour. Local leadership and authorities, with legitimacy from local accountability, higher level endorsement and sound technical support, are needed for integrated management of spatial planning, roads, storm water, dispersed sanitation, farming practice, extension advice and agri-environmental incentives, stream corridors, and monitoring and research.

Recognition of local responsibilities and authority is most likely to manage diffuse pollution sustainably, but creates two needs: reforms if the local functions needed cannot be readily assimilated within higher legal and administrative structures, and investment in local capacity. Innovative interim initiatives such as community-led catchment groups and river charities may be effective in founding action given goodwill and trust amongst the parties concerned, but will usually need statutory status as priorities shift, new challenges arise and finance grows. The principle of adaptive management applies as much to governance arrangements, as to the knowledge base and implementation of measures. Even with the right structures and degree of decentralisation, catchment management necessarily involves multiple agencies and civil society organisations. It requires partnership working and functional cooperation and coordination. In the cases studied in Europe, USA and Australia there has been a discernible shift from top-down, hierarchical modes of governance towards more networked forms of this nature.
Minimising Land Use Based Water Pollution through Sustainable Wastewater Sludge Management Practices – South African Case Study

Author: Dr. Heidi Snyman
Water Research Commission, South Africa

Keywords: sewage sludge, sludge guidelines, pollution prevention, wastewater sludge, South Africa

Introduction/Problem Identification
The responsible management of wastewater sludge emanating from wastewater treatment plants is often considered in hindsight. Unsustainable disposal practices such as stock-piling and sacrificial land disposal have lead to land degradation as well as surface and groundwater pollution. This presentation addresses the benefits of adopting sustainable sludge management practices in a developing country such as South Africa. The paper addresses the evolution of the South African Wastewater Sludge Guideline series as a case study of how the South African water sector participated and bought into the new concepts.

Analysis/Results and Implications for Policy and/or Research
The responsible management of wastewater sludge emanating from wastewater treatment plants is often considered in hindsight. Unsustainable disposal practices such as stock-piling and sacrificial land disposal have lead to land degradation as well as surface and groundwater pollution. This presentation addresses the benefits of adopting sustainable sludge management practices in a developing country such as South Africa. The paper addresses the evolution of the South African Wastewater Sludge Guideline series as a case study of how the South African water sector participated and bought into the new concepts.

The first part of the presentation deals with the challenges experienced in the past when trying to implement the sludge legislation published in 1997. The legislated guidelines had several limitations and were difficult to interpret and implement (Snyman, 2001; Snyman et al., 2000). As a result the use of indiscriminate dumping, sacrificial land disposal and stock-piling was observed which proved to be polluting soil and groundwater (Snyman et al., 2004, Herselman et al., 2005). As an interim measure, an addendum to the guidelines (WRC, 2002) was prepared to broaden the treatment and disposal possibilities for wastewater sludge. This addendum was intended as an interim document to assist in the responsible handling of wastewater sludge. In parallel to the development of the Addendum, the South African Water Research Commission (WRC) initiated a research programme in the 2002 to further develop the knowledge base for the management of sewage sludge in the South African context. Although the results of these research projects do not address all the unknown factors, it provided enough information to develop an updated version of South African Sludge Guidelines with limits for metals, nutrients and organic pollutants based on scientific criteria to ensure credibility and user acceptance.

The underlying principle for the new guidelines was sustainability, i.e. only management option that do not harm the environment or cause a build-up of a substance in the environment could be considered. With current knowledge, there are three ways in which sludge management can contribute to sustainable development: (1) Utilising the calorific energy value (example: generating heat); or (2) Utilising useful constituents such as carbon and nutrients (example: agricultural use); or (3) Extracting useful constituents (example: extraction of phosphorus).
South Africa adopted the second option i.e., utilising the useful constituents such as carbon and nutrients in the sludge, particularly in agricultural practices as the basic tenet of sludge management. The reason for this was primarily driven by the fact that South African soils have very low organic carbon contents and the use of sludge in agriculture can benefit the soil both chemically and physically. The costs of inorganic fertilizers also keep rising and the use of sludge as an alternative can reduce costs. This was agreed through an extensive stakeholder engagement process using the reports from scientists and practitioners illustrating the benefits associated with the agricultural use of wastewater sludge who found it to be a viable and sustainable option in South Africa.

However, one also needs to be realistic and recognise that not all sludge generated in South Africa is suitable for agricultural use. It was therefore necessary to develop guidelines for other management options such as disposal and incineration and also provide opportunity for innovation. Each sludge management option was developed as a separate guideline volume. This simplified the Guidelines for users, as each guideline focuses on the management, technical and legislative aspects associated with a particular option. Each of the management options has different regulatory requirements and the sludge classification requirements for each option vary.

The last part of the paper focuses on lesson learned as well as the measured and potential impact of the guidelines as they are applied in practice. South Africa, as a developing country, has progressive and comprehensive environmental legislation and guiding documents. Sadly, the implementation and regulation fail in some cases. Although the sludge guideline series were well received by the authorities and the water industry, it is important to establish whether the intended objectives will be achieved in the medium to long term. An assessment was done on the current and potential future impacts of the wastewater sludge guidelines on the social, economic and environmental aspects (Van der Waal, 2008). The aim of this work was to quantify the potential impact of the Sludge Guidelines on South African society by analysing current examples of wastewater sludge best practice that are aligned with the new Sludge Guidelines. The study showed positive economic impact of the use of sludge in land application, brick manufacturing, composting and fertiliser manufacturing. An example of the City of Cape Town will be presented. The city reported an R 18 million (+/- € 1.6 million) saving by selecting alternative management options. In addition, the city reported add-on benefits such as the extension of the landfill life span as well as an increase in crop yield from historic poor soils.

Economic benefits were either in the form of profitable private enterprises or local authorities reporting significant savings when applying sludge beneficially as well as job creation (Van de Waal, 2008).

The paper contributes to the theme of the workshop on Minimising Land Use Based Pollution through a case study of an intervention that will reduce land based pollution while benefitting society in terms of environmental, financial and social benefits through research, partnership and demonstration. Some of the principles and lessons could be applied to other pollutants such as chemical fertilizers and pesticides.
Introduction/Problem Identification
Driven by concern over unsustainable rates of freshwater consumption and recharge and the growth
and severity of nitrogen-fueled dead zones across the globe, economists, policy makers, and envi-
ronmental leaders have been experimenting with innovative solutions to managing water resources
by working to capture a willingness to pay for watershed improvements, hoping to help maintain
high-impact ecosystem services with a diverse set of payment mechanisms. For the past decade, Forest
Trends, more recently through its Ecosystem Marketplace, has been reporting on the emerging water
markets and market-like payment schemes around the world. Tracking the project-level activity of
these nascent, often fragmented, and hard-to-find payments schemes led to a report focused on the
current State of Watershed Payments designed explicitly to establish a baseline to inform a diverse
group of stakeholders about where these schemes are being developed, in what context, and with
what level of investment.

Analysis/Results and Implications for Policy and/or Research
Using 2008 as the baseline year, research unveiled 286 Payments for Watershed Services (PWS) and
nutrient trading schemes in varying stages of activity. Far fewer programs recorded actual transactions
in 2008, numbering just under 100. The transaction value in 2008 is estimated at US$8.6 billion,
which may be conservative considering the number of programs where transaction activity could not
be determined. Sophistication of program design, regulatory drivers, defined property rights, market
structure, and monitoring and verification methodologies vary by program with each program unique
to the local watershed conditions.

Trading schemes are found in the United States, Australia, New Zealand and Canada, spawn a total
of 73 programs, with 14 identified as active in 2008, generating US$10.8 million in transactions. The
U.S. accounts for more than 85% of the total programs and while this may make the U.S. appear
as an early trend setter, many programs are currently stuck in neutral, awaiting implementation of
regulatory-based water quality standards that set much needed limits on nutrient loads. Absent this key
driver of demand for water quality credits, transaction activity has tapered off since a peak in 2006.

From the global investigation of all other PWS schemes, Latin America has emerged as a leader with a
total of 103 payment schemes, 36 of which actively recorded transactions in 2008, contributing some
US$31 million to watershed-conservation measures. Anchored by the development of Water Funds,
the use of this tool to fund upstream conservation by downstream users is poised to serve as a model
for replication in other regions, and as an example for other ecosystem markets around the world.

The number and variety of PWS schemes in China have escalated in recent years, from around
eight in 1999 to more than 47 in 2008, with an estimated transacted value of US$5.5 billion. Current
watershed payment schemes in China are almost exclusively government-mediated, and many
programs have been created in response to the central government’s call to promote the development of and innovation in “eco-compensation mechanisms”. Another potentially significant boost to eco-compensation mechanisms could come from a new water pollution emissions trading system, currently under design. The story in the rest of Asia is much less clear, although research identified a total of 33 programs, anchored by projects created and supported by RUPES (Rewarding Upland Poor for Ecosystem Services).

PWS schemes totaled 20 in Africa. In most cases, watershed management activities in Africa are part of national ecosystem conservation programs that include investments in watershed service enhancement and rehabilitation, and in improvements of the capacity of local communities to design integrated ecosystem management activities. Transaction data is scarce, but may improve with new initiatives such as those funded by WWF through the Table Mountain Fund in South Africa.

Aside from the well-known Vittel PWS scheme in France, research in Europe yielded only four programs none of which reported transactions in 2008. The developments regarding water quality in Europe have for the past decade been guided by the EU Water Framework Directive (WFD), which sets an explicit timeline to achieve ‘good’ water quality benchmarks across the continent’s freshwater resources by 2015. Implementation is delegated to each member country and requires the development of watershed management plans. While not active as of 2008, the World Wildlife Fund’s Danube Carpathian Project is one to watch for future activity in Europe.

The U.S., beyond trading schemes, sports significant government-driven investment in water quality initiatives through four key federally funded conservation programs totaling $3.1 billion in support of water-related ecosystem service enhancements in 2008. Activities to develop new tools and test market-based schemes are sure to increase with the creation of the Office of Ecosystem Services and Markets within the U.S. Department of Agriculture.

The global trends point to continued expansion of the use of market-based tools to aid in the improvement of water quality and ecosystem health. Practitioners are grappling with issues of quality, transparency, and the need for performance-based metrics to demonstrate real improvements in ecosystem health. These key features are sure to influence program design and thus how these tools will evolve in the coming decade. A growing constituency is arguing for valuing water-related ecosystem services as part of overall ecosystem health. That expanded lens would incorporate watershed services with other ecosystem services such as biodiversity, carbon sequestration and those associated with coastal and marine environments, further increasing the opportunities for these tools to work for water quality improvements, conservation, communities, and people.
River Water Salinisation in Central Asia: Causes, Prediction, Management

Author: Prof. Volodymyr Starodubtsev
National University of Life and Environmental Sciences of Ukraine

Co-Author: Mr. Bogdan Urban
National University of Life and Environmental Sciences of Ukraine

Keywords: water salinity, runoff regulation, irrigation, reservoirs, deltas

Introduction/Problem Identification
River flow regulation and extensive irrigation development in arid regions (like Central Asia) causes fast and strong water salinisation and its quality decrease. Such water becomes unsatisfactory for communal and industrial supply, for plants watering, for a river biota. Landscape salinisation in river valleys and deltas is the especially danger consequence. The strongest water salinisation processes manifested themselves in “Soviet” Central Asia in 70-90s of last century. In that period runoff in lower reaches of some rivers decreased to zero and salt content in water became very high. That is why we consider that period as a natural model of extreme river changes that is suitable for water salinisation prediction in similar basins. And an experience of salt content decrease in “post-soviet” time can be used (in a certain sense) for a salinisation processes management in arid regions.

Analysis/Results and Implications for Policy and/or Research
Water salinisation we analyze in two different rivers – the Syrdarya River that runs into the Aral Sea, and the Chu River with a continental delta.

In the Syrdarya basin irrigation area (in 4 states) reached about 2.5 million ha in 80s, water consumption for irrigation reached 33-37 km$^3$/year and became comparable with water resources of the river. Water inflow into Aral Sea after 1970 decreased to 2-4 km$^3$/year, some time all river water in the lower reaches was used. Salt content in river water increased in lower reaches from 0.3-0.5 g/l in 40-50s till 1.7-1.8 g/l (with maximum value more than 3.0 g/l). In ions composition sodium and sulphate became predominant.

In the Chu River basin irrigation area in 80s reached in Kyrgyzstan and Kazakhstan 480 thousand ha, water use exceeded water resources and realized owing to multiple reuse of return water from irrigated fields. Salt content in the Chu river water in lower reaches increased since 0.53-0.58 g/l in 50s till 0.8101.11 g/l (with maximal value 1.75 g/l) in 80s. In the delta (v.Ulanbel) annual average salt content reached 1.05-1.35 g/l with maximal value 3-4 g/l and more. In the most western part of the delta (v.Tasty) this characteristic reached 10 g/l and even more. Strong landscapes desertification and salinisation in this part of the river valley manifested themselves at that period.

The main reasons of such salt content increase in river water are: 1) strong water filtration at irrigated sub-mountain fans (cones) and this polluted water return into a riverbed in foothills (“saz” zone), 2) return (drainage) water inflow into river from irrigated fields at plain, 3) salt content increase in reservoirs, 4) water evaporation in river valleys and deltas, etc.

In 90s and in the beginning of XXI century (after Soviet Union disintegration) salt content in a river
water strongly decreased owing to irrigation area reduction, anti-filtration measures implementation, irrigation rate decrease, shortening of rice and cotton area, etc.
Contamination Risk Assessment of Water Quality in Vietnam

Author: Prof. Harro Stolpe
Environmental Engineering and Ecology, Ruhr-University of Bochum, Germany

Keywords: Vietnam, risk assessment tool, contamination potential, sensitivity, contamination risk

Introduction/Problem Identification
Water quality issues play a critical role in Vietnam. Dynamic population and economic growth, expansion and intensification of agricultural land use and deforestation with all their negative side effects is intensified by an insufficient water supply and sanitation infrastructure.

The German-Vietnamese joint research project „Integrated Water Resources Management Vietnam“ funded by the Federal Ministry of Education and Research (BMBF) is developing GIS based Planning and Decision Support Tools for IWRM on a regional scale. The aim of the project is to create tools for evaluation of Water Balance and Contamination Risk Assessment. After the evaluation, areas with priority need for action are identified. The project is located in the provinces of Nam Dinh, Lam Dong and Can Tho.

The Contamination Risk Assessment Tool as one part of the Planning and Decision Support Tools comprises the three main immission pathways considering data availability and quality in the project area.

Analysis/Results and Implications for Policy and/or Research
The Risk Assessment Tool is based on the consideration of Contamination Risks. The Contamination Risk for the water resources (groundwater and surface water) is the result of a combined assessment of their Sensitivity and the Contamination Potential of pollutants:

\[ \text{Contamination Risk} = \text{Sensitivity of water resources} + \text{Contamination Potential of pollutants} \]

Parameters for the determination of the groundwater Sensitivity (infiltration) are thickness and retention potential of covering layers, yield of aquifers and the relevance for water supply.

Parameters for the determination of surface water Sensitivity (erosion, direct discharge) are river network density, soil erosion and the relevance of water intake facilities for water supply.

To identify the Contamination Potential, pollutants from point and non-point sources will be considered. The point sources include industrial zones, craft villages and settlements. Non-point sources refer to diffuse discharge of pesticides and fertilizers. The intensity of their application depends on different land use categories (e.g. cultivation of perennial crops such as coffee, fruit trees, tea, cultivation of rice and other annual crops such as vegetable, maize, sugar cane, etc.).

Pollutants can reach water resources via three different immission pathways. The pathways are:
1) Infiltration of solute pollutants into the ground water,
2) Particle-bound pollutants transported into the surface water (effected by erosion),
3) Direct discharge of pollutants into the surface water.
The aggregation of the Sensitivity and the Contamination Potential for each of the three immission pathways results in the Contamination Risk and thus in areas with priority need for action. A significant part of the project area reveals high Contamination Risks, i.e. increased conflict intensities due to the intense agricultural use and a water infrastructure in need of improvement regarding its ability to guarantee a sufficient sanitation and supply of clean drinking water for the population.

The identification of such conflicts on regional level is the starting point for the derivation of measures. The identification process enables decision makers to effectively attend to the issues with high priority ratings first.

Examples for possible measures are:
- Soil protection measures
- Establishment of an industrial emitter register
- Implementation of good agricultural practice
- Establishment of water protection zone concepts
- Development of cooperation concepts (e.g. water services and farmers)
- Designation of water supply sensitive areas for future planning and development
- Monitoring
Water Quality Degradation due to Anthropogenic Activities: A Case Study on Eutrophication in Natural Wetland (Barabila Beel)

Author: Mr. Md. Waji Ullah  
Center for Environmental and Geographic Information Services, Bangladesh

Co-Author: Mr. Shahriar Rahman  
Center for Environmental and Geographic Information Services, Bangladesh

Keywords: aquatic environment, aquatic imbalance, dissolved oxygen, eutrophication, water quality

Introduction/Problem Identification
In Bangladesh, surface water is constantly polluted due to the anthropogenic activities (agriculture, municipal, industrial, etc) which are responsible for limiting the fresh water availability for drinking and household purposes. As the livelihood of rural Bangladesh is based on agriculture, use of fertilizers (nitrogen and phosphorus) has been increased many times with the growing population. Agricultural spillages induce toxicity in the surface water has its adverse impacts on water quality, aquatic environment and habitats. This study has been carried out to demarcate the aquatic imbalance of a perennial waterbody (Barabila beel, a water body located in Pirganj Upazila of Rangpur District) and temporal changes in concentration of selected physical, chemical and biological parameters. Two different approaches; (a) analytical and (b) modeling approach (widely used water quality model, QUAL 2E) were used in this study.

Analysis/Results and Implications for Policy and/or Research
Water quality and hydrological monitoring of the natural wetland, Barabila Beel, were conducted at the seven sampling sites, four within the water body (C1, C2, C3 and C4) and three at the boundaries (B1, B2 and B3). The annual application of urea in the study area was about 372 kg per hectare, and that of Triple-Super Phosphate (TSP) was about 224 kg these indicated the nitrogen emission of about 5.35 percent reflecting high risk of eutrophication problem. The water balance was done analytically for the period of May-October and the rain generated runoff caused the movement of nitrogen and phosphorus to water body and major agro-chemicals. The analytical approach to calculate the inflow and outflow balance computation was found within a range of 1 to 4 % seems to be reasonable for this study. Sophisticated water quality measurement equipment, DataSonde 4a, was used in-situ conditions to measure the water quality parameters for the analytical approach. Water temperature of the Barabila Beel was found lower up to the month of March than that from April and onwards and the measured pH value revealed that the water was found alkaline. A quite low range of chloride content(highest 160 mg/l) was deliberated and average dissolved oxygen (DO) content was found 8.7, 4.7, 4.4 and 6.6 mg/L for the months of February, April, August and November respectively. The low DO content in August can easily be interpreted by the abrupt reduction of plankton numbers from July to August. The BOD content of collected water samples inside the beel and at inlets reflected the water was polluted throughout the year. Nitrate concentration was found at about 8.5 mg/l in the month of November which indicated pollution due to fertilizer run-off from agricultural fields adjacent to the Barabila Beel. Phosphate content ranges between 0.12 mg/l in March and 3.6 mg/l in July are within the allowable limit for drinking (6.0 mg/l) and for irrigation (10.0 mg/l) set by the Department of Environment of Bangladesh. Considering the fecal contamination, the beel water is not suitable for drinking and for fisheries but was found usable for irrigation all the year round. During
the period of May to July, the growth of a particular species Chlorophycea was found high compared
to the other species, which indicated the water is eutrophic in nature at that time period. Considering
environmental condition, widely used QUAL 2E water modeling software was used for water quality
modeling. Three channels reaches, two upstream and one downstream boundary considering flow
and concentrations of different water quality parameters; hydraulic and water quality data were used
within the model domain of QUAL 2E for channel systems schematization. By increasing the number
of iterations, non-convergence of the model result was confiscated. The visual observation shows same
trend for observed and calibrated temperature. But calibrated results showed less than observed values,
which was an indication of more tuning in the temperature correction factor. Relatively higher values
of calibrated DO were found in C1 and C2 sites (in Choto beel) and on the other hand smaller values
of calibrated DO found in C3 and C4 sites (in Boro beel). The calibrated BOD at C3 and C4 show
reasonable matching with the observed BOD. But there was a considerable variation of observed and
calibrated BOD found at C1 and C2 (both are in the Choto beel). Comparing with the observed
values, the calibrated nitrate values showed good similarity for C1 and C4 sites but relatively high
for C2 and low at C3 site. The observed phosphate values show no variation along reach 1 (C1 and
C2) and reach 2 (C3 and C4) whereas the calibrated values at C1 and C2 show significant variation
due to excessive phosphate coming through the boundary at reach 1. The QUAL 2E model could not
predict the phosphate value close to the observed value due to influence of high boundary phosphate
value within a short distance, while the calibrated result bestowed good matching for the C3 and C4
sites. The calibrated result of the water quality model used in this study indicated good matching for
some of the physico-chemical parameters at some sampling sites and did not show good results in
some other sampling sites.

This study would be helpful to develop a planning tool to assess the water quality problems, pollution
from non-point sources and its management for wetlands in Bangladesh. This study will help to
envisage the current water quality state of the waterbodies and also can be included in formulating
water quality related policy guidelines. This study will be helpful to determine water quality and in
assessing social and environmental impacts due to degraded water quality and also in planning and
decision making for drinking water supply and sanitation projects.
A Key Necessity for Stakeholder’s Participation in Control of NPS Pollution from Agricultural Watershed in Krishnagiri Catchment Area, India

Author: Ms. Sudha Velu et al.
Centre for Water Resources, Anna University, India

Keywords: agricultural watershed, non point source pollution, sediment nutrients, eutrophication, stakeholder’s participation

Introduction/Problem Identification
Non Point Source (NPS) pollution is a serious environmental threat and is the result of land-use activities. It is an important social and economical problem and an essential factor in assessing ecosystem health and function. Dissolved and suspended loads of nutrients carried by the runoff inflows into reservoirs and tanks constitute NPS pollution in agricultural watersheds. Krishnagiri reservoir is a hyper eutrophicated reservoir located in Dharmapuri district one of the drought prone districts in Tamilnadu, India. The reservoir water is being used for various uses such as irrigation, drinking, fish rearing and recreation. catchment consists of agriculture watersheds and severely affected by erosion and NPS pollution. Sedimentation reduced the storage capacity of the reservoir from 66.10 Mm$^3$ to 39.26 m$^3$ in the last five decades. It is essential to implement policies on control of NPS pollution with the participation of the stakeholders to save the water quality in the Krishnagiri Reservoir.

Analysis/Results and Implications for Policy and/or Research
As soil erosion and sediment transport accounts for a major part of the NPS pollution load to water bodies, it is essential to control the process of soil erosion and sediment transport from the upstream catchments. Landuse changes are one of the important factors of NPS pollution in urban as well as rural areas. Krishnagiri reservoir catchment in one of the severely eroded catchments in India and it consists of eight watersheds. The total catchment area of Krishnagiri is 5430 sq kms, which lies in other two neighbouring states. The rate of soil erosion varied between 4 to 23t/ha/y. The research conducted on sediment nutrients shows that the high concentration of inorganic phosphorus and total phosphorus in the sediments at the inflow point of the reservoir which implies that there was a significant input of nutrients due to erosion and runoff from the catchments. The experimental study conducted on sediment nutrients revealed that there is an internal loading of phosphorus from the sediments in Krishnagiri Reservoir which is an important factor for hyper eutrophicated condition of the reservoir. Because of the poor reservoir water quality the fish yield has also come down and it has major impact on livelihood of fishermen who are solely depending on.

Remedial measures such as soil conservation measures such as contour bunding in the dry land, gully control and construction of check dams across small streams can be done to prevent soil erosion. Percolation tanks may be constructed in the streams to prevent soil erosion and to increase the water table of the wells in the downstream side so as to increase the additional food production. Terracing and contour trenching can be done to the sloppy dry lands. Vegetative protection can be given for both the banks of rivers to prevent erosion. All the tanks in the subwatersheds are to be desilted to hold more water for cultivation. Walls with boulders can be introduced across the valley at various contours to check the velocity of water.

Policy and implications for Stakeholder’s Participation
NPS pollution problem could be tackled to an extent by suitable policies that internalize soil erosion.
to producer decision making wherever possible. Rather wrong policy choices in the Indian context have aggravated the problems to mention a few, zero or subsidized pricing of electricity for tubewell irrigation, heavily subsidized surface water for irrigation and subsidized chemical inputs. Like overuse of poor quality tubewell water has led to soil salinity. Economic instruments in the form of incentives will be a cost effective measure to encourage farmers to adopt soil conservation practices. For problems regarding over application of inorganic fertilizer, in the long run, conjunctive use of chemical inputs with bio inputs along with farm residues is the only answer. The information base on which farmers make decisions is incomplete with respect to internalizing rapid changes in soil and water quality variables by moving to more sustainable practices such as integrated pest management, more land conservative crop rotations. Integrated approach to the problem of degradation linking agriculture and environment is yet to be attempted even though at the policy level, it has been stressed. The existing land use policy failed to bring right results due to lack of integrated approach to different components of agriculture such as land, soil and water. So far the programs did not meet with success due to the absence of participatory approach. While more attention has been paid to issues such as forest land conversion to agriculture, which is related to extensive cultivation, not much focus has been given to degradation. Thus from a policy perspective, there is a need for public and private initiative on several fronts increased investment in resource management, research and extension. It was identified from this research that the underlying causes of improper land use activities have been very often the basic socio-economic structure and institutional structures of developing economies. Among them are land shortages, small and fragmented land holding type, poverty, and population growth. However, the diverse factors that contribute to the problem make it necessary that an integrated approach has to be taken by the authorities responsible for policy in different areas such as food security, forests, soil conservation, and water resources. Since the catchment lie in two other neighbouring states of Tamilnadu, the Government of Tamilnadu can frame a policy not only for the payment for environmental services and also the policy for the payment for polluter can be framed. The abstract implicates that the prevention of soil erosion and NPS pollution can only possible with participation of stake holders and implementation of strict policies on soil and water conservation among the states in case of river basins.
impacts of irrigated agriculture on water and soil sustainability: the case of harran plain, turkey

Author: **Ms. Gül Özerol**  
University of Twente, The Netherlands

Co-Author: **Prof. Hans Th.A. Bressers**  
University of Twente, The Netherlands

Keywords: water pollution, land degradation, irrigated agriculture, policy implementation, harran Plain

Introduction/Problem Identification

Having arid regions and relying on agricultural production in rural areas, Turkey is among the countries that allocate most of its water resources to agricultural sector. Accordingly, huge investments are made in order to extend irrigated agriculture and increase agricultural income. Harran Plain is one of such regions. Within the scope of GAP (South-Eastern Anatolia Project), a multisectoral regional development programme, many irrigation projects are carried out in the plain since 1980s. However, the impacts on water and soil are inevitable as negative externalities of irrigated agriculture and degradation of water and soil quality is observed. The major water quality problem is the pollution that arises from chemicals and fertilisers used for agricultural production, whereas the soil problems are salinisation, degradation and waterlogging due to chemicals and fertilisers, excessive water use, high degree of evaporation, lack of drainage systems and the clay characteristics of soil.

Analysis/Results and Implications for Policy and/or Research

The analysis made in this paper is based on the interactions of agricultural, water and environmental policies, and the actions of stakeholders that have major role about these policies.

The major stakeholders of water and soil sustainability can be named as Ministry of Agriculture and Rural Affairs (MARA), Ministry of Environment and Forestry (MEF), DSI (national water body under MEF), irrigation associations and farmers.

Increasing the income from agricultural production is among the objectives of agricultural policy. MARA provides subsidies to farmers for certain crops as well as artificial fertilisers. However, there is no monitoring about the quantity and quality of chemicals and fertilisers used by the farmers, neither for their impacts on soil and water resources. Furthermore, the income support for certain crops encourages intensive agriculture resulting in excessive water and fertiliser use.

DSI aims at allocating adequate supply of irrigation water to agriculture as part of the water policy. Combined with the energy policy that emphasises hydropower, large scale water development projects are undertaken by DSI. The operation and maintenance of irrigation canals are transferred to the irrigation associations (IAs) that are formed by local administrators and elected farmers. IAs have close relationship with DSI, which has substantial effect on their activities. They collect irrigation fees from the farmers in order to cover administrative and operation and maintenance costs; however irrigation water is free. Furthermore, current legislative setting gives the IAs neither the authority nor responsibility to take actions in terms of water and soil sustainability.
Protection of water and land against pollution are objectives of the environmental policy. Related legislation enacts that MEF and MARA are jointly responsible for preventing water and soil resources from pollution due to agricultural activities and that they have the authority to take preventive measures. However the presupposed coordination between these two ministries is not effective in the region given the impacts of agriculture on water and soil. The pollution of water and soil from chemicals and fertilisers is usually monitored and reported as part of research projects or studies, which do not result in policy actions.

Being almost the only target group of all three polices, farmers have a crucial role in water and soil sustainability. However, lack of awareness about environmental issues in general, and the environmental impacts of irrigated agriculture in particular, is a common characteristic of the farmers. Irrigated agriculture became the major income source after 1995 and created a substantial change in the economic and social status of the farmers. The preparedness of farmers was insufficient since they did not receive training, e.g., about sustainable irrigation, water use and land conservation, etc., before starting to practice irrigated agriculture.

Consequently, water and soil quality problems experienced in Harran Plain can be considered as the negative externalities of multiple policies, which interact with each other and have interrelated objectives. However, due to the existing sectoral approach, the instruments of different policies bring about unaligned and divergent outcomes.

Experiences from different countries show that alleviation of the negative outcomes and prevention of further degradation of water and soil is possible through the harmonisation of related policies in terms of their objectives, instruments and expected outcomes. For the case of Harran Plain, analysing the interaction of multiple policies reveals improvement opportunities. Following recommendations are made for policy harmonisation towards the prevention of water and soil pollution:

- Collaboration and cooperation among the implementing agencies of agricultural, water and environment policies is indispensible. Impact assessment and monitoring and evaluation mechanisms can be developed and implemented jointly in order to enable integrated assessment of water and soil resources and to inform policy makers.

- Multi-level stakeholder involvement is needed to effectively implement the prevention measures. Particularly, the role of IAs is critical since they act as the key actor of irrigation water use. Actions can be taken towards empowering the IAs in multiple dimensions.

- The quantity of irrigation water used by the farmers should be monitored and economic measures should be taken in order to prevent excessive use. In that respect, water pricing is inevitable as foreseen in the mid-term. However, the cultural and political obstacles are vital for effective implementation.

- Stakeholders should become more knowledgeable about the impacts of irrigated agriculture. Active dissemination of scientific and technical information to all stakeholders, and especially to the farmers, can raise awareness about the problems, causes and improvement opportunities.
Workshop 7: Resilience, Uncertainty and Tipping Points

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Introduction/Problem Identification
Accelerating pressures on the global environment are increasing the risk of abrupt environmental changes that can have dramatic impacts on human economies and societies. For example, large, persistent algal blooms associated with lake eutrophication pose health risks, impact recreational activities and lakeside property values, and increase water treatment costs. Such large, abrupt, persistent environmental changes are known as regime shifts in the scientific literature, and have been documented in a variety of systems, including lakes, coastal zones, coral reefs, agricultural systems and the climate system. Understanding regime shifts is important for ecosystem management due to their impacts, and because they are difficult to predict and costly to reverse.

This paper provides a brief introduction to the theory behind regime shifts, explaining how and why they occur, and how regime shifts relate to concepts of tipping points and resilience. Several illustrative examples of water-quality related shifts will be presented. Drawing on a developing database of regime shifts in environmental systems, I present a synthetic overview of the main drivers of regime shifts, and the impacts of regime shifts on the environment and human well-being. The paper concludes with a discussion of options for avoiding or reversing regime shifts, and current scientific work on early warning indicators of regime shifts.
Introduction/Problem Identification

In 2007, a 20-county area encompassing the Dallas-Fort Worth Metroplex was designated by the State as a Priority Groundwater Management Area (PGMA) in need of implementing strategies for groundwater conservation. The newly created PGMA's population is expected to increase from 5.5 million in 2000 to 9.5 million by 2030 with projected water needs rising from 1,677 million m$^3$ in 2000 to 3,034 million m$^3$ by 2030 according to a study by Texas Commission on Environmental Quality (TCEQ). The Trinity Aquifer supplied 73% of the area's groundwater in 2000, with the aquifer outcrop zone being highly susceptible to anthropogenic sources of contamination. Parker County is within the Upper Trinity Groundwater Conservation District (UTGCD) and is largely a rural area with many residents dependent upon private shallow, groundwater wells. Groundwater resources are under escalating pressure from urbanization, natural gas drilling, and predicted intensifying of droughts due to global climate change.

Analysis/Results and Implications for Policy and/or Research

During periods of extreme disturbance, such as drought, aquatic biota depend upon the availability of refugia for their survival. Perennial spring pools have been shown to serve as important refugia for many invertebrate taxa, and surviving taxa likely play a vital role in recolonizing regional intermittent streams. Two first order spring-fed streams in Parker County were selected for this 18 month study beginning the summer of 2006, during the county’s worst drought in its 123-year record. Surrounding land uses are a mix of livestock-grazed ranchland, gas exploration related to the Barnett Shale play, and rural residences. Today, the vast majority of the springs of Parker County have failed due to declining water tables. Both streams had groundwater-fed pools that persisted through the drought and Ash Creek maintained flow for 2.0 km in contrast to regional streams with negligible surface water and no flow. Pools were classified based on flow permanence (perennial or disconnected) and riparian cover (70% or greater riparian cover, or pools in full sun). During the drought, groundwater pools supported sensitive aquatic invertebrates such as mayflies, (Stenonema femoratum and Leptophlebia sp.) and caddisflies, (Marilia flexuosa and Helicopsyche sp.). Taxonomic richness by macrohabitat type was significantly different (ANOVA, F3, 44=27.34, p<0.0001). Student-Newman-Keuls test for taxonomic richness revealed preferential use of drought refugia and grouped the habitats as: Riffles> Perennial pools = Shaded disconnected pools> Full sun disconnected pools. Rare, relict taxa with low resilience, such as the travertine beetle, Lutrochus sp., and caddisflies, Mayatrichia sp. and Neotrichia sp. would likely be extirpated without perennial stream refugia. Aquatic invertebrates play a key role in ecosystem dynamics through their role in transferring energy to higher trophic levels within aquatic and terrestrial ecosystems. This research provides a baseline for researchers and agencies interested in groundwater conservation and the protection of regional biodiversity of groundwater-dependent ecosystems.

Texas has a unique political landscape and the right to withdraw ground water is reflected in the laws governing groundwater. Generally in Texas, groundwater is governed by the rule of capture, which...
grants landowners the right to capture the water beneath their property, regardless of the effects on neighboring wells. That was not a problem in the 1920s when a family on 100 hectares pumped water by hand. Over the past few years, developers have created mini-ranches where a family with two horses on 1 hectare can pump thousands of gallons with electric pumps to water non-native landscaping. The increase in new water wells combined with the unprecedented extraction of water for gas wells in the area, which use 10-20% of the total water consumption to fracture the shale layer to extract the gas below, creates an unsustainable demand on the aquifer. These economic interests and urban sprawl makes groundwater conservation a sensitive issue even if neglecting to address it would risk a severe crisis within 10-20 years that could be devastating to the community.

Over abstraction of groundwater has reduced the quantity and quality of groundwater, causing many private wells to fail and springs to cease flowing. Depletion of the aquifer will require that these remotely dispersed developments will have to be connected to a public water supply supplied by surface reservoirs. This would dramatically increase the burden for Parker County as large parts of these areas are unincorporated. The need for public water supply will be a heavy financial burden upon the county that would likely be funded through increased property taxes.

The locally controlled four county UTGCD was the first district in the state given the ability to charge the oil and gas industry a fee for the groundwater they use as well as forcing them to abide by well spacing rules, and other rules of the district. Once formed, GCDs must generate operating funds through property taxes or through well production fees. Sustained support from experts and scientists is crucial to educating residents of the necessity for conserving groundwater as GCDs struggle with designing and implementing conservation measures.

Research during extreme drought, such as our study, builds our understanding of how aquatic organisms respond to variable environmental conditions. Groundwater conservation is critical to preserving a spatial and temporal patchwork of groundwater-dependent refugia for aquatic biota that increases these variable ecosystems resilience to disturbances and is thought to maintain regional species diversity. With a better understanding of the aquatic biota, water planners will be better equipped to balance the escalating demands placed upon finite water resources in a manner that supports the long-term sustainability of groundwater-dependent ecosystems.
Developing Scenarios for the Water Sector Institutional Landscape to Develop Effective Responses to Water Quality Challenges in a Semi-arid Region

Author: Dr. Marius Claassen
CSIR, South Africa

Keywords: scenarios, institutional landscape, water quality, uncertainty, global change

Introduction/Problem Identification
The South African legislation and policy introduced significant changes to the institutional landscape. This strong drive towards democratization of governance redefined the roles of government towards decentralization of power and the increased opportunities for participation. However, these changes have not brought about the desired results. In describing the “Water for Growth and Development” programme, the Department of Water Affairs acknowledges the critical role of water in poverty alleviation and reliable access to safe drinking water, but says that they are “deeply concerned about the persistent backlogs in certain parts of the country”. The paper will present key drivers and uncertainties related to the future of the institutional landscape of the South African water sector and their implications for social and economic development. The paper will discuss the role of scenarios in identifying and evaluating options and pursuing an effective course of action.

Analysis/Results and Implications for Policy and/or Research
While scenarios describe the future (or plausible futures), the utility of both the process and the products are also vested in the present. Knowledge about key drivers and uncertainties of the future can provide information towards better decisions in the present. A better understanding of key drivers and trajectories of changes will not only clarify the impact of decisions, but will allow active countering of undesirable trajectories of change. The identification and characterisation of key uncertainties will also facilitate a more structured approach to risk management. Strategies and decisions can be played out in different futures to secure the most beneficial outcome through the most robust approaches while incurring the least risk. Scenarios which describe plausible futures will benefit resource managers and decision makers and empower all the role players in the water sector to engage in participative governance. This extends from politicians and policy makers through to government officials, the private sector and civil society, and from the urban middle class to poor rural communities.

The structured research supported by the Water Research Commission targeted existing and new institutional structures, to ensure that a far-reaching participative process is followed and a broad range of stakeholders was involved. The research team deployed a range of methods, such as interactive workshops and consensus conferencing, to include rural- and urban-based stakeholders from different cultures and with different educational backgrounds. Importantly, therefore, the beneficiaries of the research acquired knowledge both by participating in the research process and through appropriate and relevant products that will be made accessible after completion of the project. Due to the nature of uncertainty, which is inherent in the scenario development process, it is possible that new information may change the understanding or expectations. The research process is therefore iterative and allow for continuous assessment, learning and adaptation.

Driving forces of the Water Sector Institutional Landscape by 2025 have been identified through literature, personal interviews and the Human Sciences Research Council’s social attitude surveys.
of 2008 and 2009. Each driver will be presented with a brief description and an assessment of its uncertainty and importance. The driving forces are: Privatisation, Global change, Political stability, Decentralisation, Rights to water, Equitable participation, Biophysical constraints, Civil society, Social and economic growth, Skills, Staff turnover, Technology development, Funding for operations, Intersectoral dependencies, Regulation, Water use licensing, Economics of water, Balance development and protection, Strategic planning, Local government, Ownership, Regional development, Land restitution, Disease, Water quality, Prioritisation and Globalisation.

The effective and sustainable deployment of water resources (including water quality) depends on a sound understanding of the resource base, the assessment of the levels of sustainable use, the evaluation of the different socio-economic activities that can be supported by the resources, effective decisions about resource allocation, and monitoring and evaluation to ensure that objectives are achieved. The paper will discuss the implications of the key drivers and uncertainties in relation to these aspects and present a way forward towards incorporating uncertainties in planning for the future to ensuring that we achieve the legislative principles of equity, efficiency, sustainability in water resource management in South Africa.
Uncertainty, Risk, and Possible Futures of the World Water System

Author: Mr. William Cosgrove* et al.
* Water Watch Assessment Program, Canada

Keywords: uncertainty, change, drivers, scenarios, tools

Introduction/Problem Identification
The principal decisions that determine the future of the world’s water uses and their relation to water resources are not made by those who traditionally are considered water managers. They are made by actors in government, the private sector and civil society who make decisions in response to and related to demographics, politics, social change, the economic outlook, the use and abuse of technology, energy demand and supply, and even the change of our climate. For the developing world, the water challenge is crucial, especially when facing increasing risk and uncertainties in addition in many cases to their already severe water problems. Thus decision makers are faced with a complex task, but at the same time, many are looking for answers on how to move more quickly while taking account of uncertainty and managing risks. The World Water Scenarios in preparation can both inform them and provide a tool with which to approach decision-making.

Analysis/Results and Implications for Policy and/or Research
The objectives of the World Water Scenarios project are: 1) To develop a second generation of global water scenarios to support anticipatory decision-making on the global water system, including the identification of major risks and opportunities and alternative futures, and to provide a perspective for individual national and sub-national scenario building; 2) To provide an interdisciplinary articulation of the current scientific understanding of the global water system, including major uncertainties and principal areas of agreement, using qualitative and quantitative inputs, expert opinion and analysis of available information; and 3) To support scenario building at the national and sub-national scales, by stimulating the interchange of experiences, mutual learning and reciprocal capacity-building among the interested groups working at these scales, and by developing a scenario tool-box and training material.

The first phase of the project has been completed. It involved an in-depth literature review of ten principal drivers of change by a team of ten graduate level researchers to identify the future developments being considered in the domain of each driver that may have impacts and water resource use or the resource itself, their likely timing, and whether there are linkages to other drivers. These were reviewed by small teams of experts in the most important areas identified to gain a perspective on their relative importance and likelihood of their happening at the dates forecast in the literature. Based on this, the drivers and critical events to be taken into account in the preparation of scenarios covering the next 25 years were selected. A paper describing the process and results of this work was released earlier World Water Week.

The second phase began with the establishment of a Scenario Development Panel (SDP). Membership in the panel includes data and water sector experts, modellers, scenario experts, and representative decision-making stakeholders. The SDP has access to expertise in specific areas to the team preparing the United Nations World Water Development Report 4. Members of the SDP were provided with the detailed findings of the research into the individual drivers, the comments of the experts who
reviewed these and summary descriptions of scenario work related to water use and resources that have been conducted since 2000 or are ongoing.

The process continued with a Real Time Delphi (RTD) discussion by SDP members who reviewed and revised the selection drivers and critical events to take into account in the preparation of four scenarios covering the next 25 years. The next step will be to write summary qualitative “storylines” to be discussed in a meeting of the SDP. The storylines developed will provide an understandable and transparent basis for understanding scenario assumptions, provide a more attractive method for communicating the substance of the scenarios to non-technical people than numerical data, and distil the combined views of the stakeholders and experts.

In parallel, modellers will produce scenarios of the quantifiable aspects, providing numerical data, and making possible a consistency check of the storylines. This part of the work will be based on models already existing, engaging their builders in providing simulations specifically geared to the questions of interest for the scenarios. IFPRI, IWMI, GWSP and SEI are among those already involved in this process. While the exercise will not finance new research efforts, it might be necessary to commission the tailoring of existing models and some recalculations of data to fulfill the needs of the scenario construction.

At the national and sub-national scales, the same general approach will apply, with the difference that the scenario construction process, and the scenario findings, can be more directly connected to concrete actors and decision-makers, gaining in realism and usability. At these scales, the global scenarios can be suggestive of a general direction and provide a perspective and a set of functional constraints for the national and sub-national scenarios. The latter provide flesh and specificity to the whole exercise, and demonstrate the diversity of situations involved in the water issue. The downscaling to local scenario building will be financed independently, contingent on the existence of local interest and the availability of sources of funding.

The main products of the project will be the set of qualitative and quantitative scenarios and their documentation; a document discussing the main strategic implications of the global scenarios, the identified critical nodes for action, and the insights obtained from the scenario exercise; a set of local water scenarios; a tool-box for local scenario-building; and improved scenario-building capacity among decision makers at local levels.
A Framework for a Collaborative Information Exchange Network in the Context of Water Resources Management Regions

Author: Ms. Fernanda Dalcanale* et al.
* Colorado State University, USA

Keywords: water quality, collaborative network, knowledge exchange, water resources regions, IWRM

Introduction/Problem Identification
Water quality management involves dealing with a number of environmental factors that interact and impact a water body. Water quality management also involves the manipulation of the supplementary tools designed to collect and analyze data as well as methods to transform data sets into useful information and convey this information to managers, decision makers, and the public in general. Management of water quality also includes the implementation, evaluation, and compliance to the set of regulations, practices, and programs designed to keep, or bring, the quality of water to desired levels. The complexity of the process demands information and knowledge exchange, at all levels and from all players. The trend of integrated approaches, and participatory processes only adds to that demand.

Analysis/Results and Implications for Policy and/or Research
From the command-and-control and structural measures approach to a more comprehensive and integrated water resources management, the players of the water management process have changed in type, numbers and knowledge levels. Integrated water resources management involves multidisciplinary and participatory processes where different degrees of information being conveyed. From raw data to indicators and indexes, everything may be relevant to one or more stakeholders. The focus on the watershed as a management unit also brings the need of coordination with a range of agencies and organizations, and this connection leads to an increasing need of communication between them, especially when dealing with water quality issues.

The goal of this project was to develop a framework for a collaborative information exchange network that will fit the needs of different water management regions, evaluate how the stakeholders interact within the context of a river basin region and how water information exchange can help to better understand and evaluate the main challenges, as well as to improve the final decisions. The framework was constructed after the evaluation of suitable means and tools needed for a dynamic and multidirectional network. The recommendations include the type of system, how it operates and how to address information reliability and communication tools. The recommendations were developed based on community responses and pilot testing in a basin committee in Brazil.

The pilot testing demonstrates that this new approach can be a useful tool to deal with water conflicts and alternative courses of action in the context of a river basin region. The prospect of exchanging information and different perceptions, may lead to a better understanding of the complexity of water management in general and water quality in particular. As a result, it also suggests that public participation and harmonization of multiple interests are enhanced and, therefore, the integrated and adaptive management approaches are facilitated.
Interplay of Ecological Trends, Socio-economic Patterns and Environmental Policy: A Case Study of Colombo Flood Detention Area Wetlands – Sri Lanka

Author: Mr. Missaka Hettiarachchi
University of Moratuwa, Sri Lanka

Co-Author: Prof. Ajith de Alwis
University of Moratuwa, Sri Lanka

Keywords: ecological regime shifts, environmental degradation, ecosystem services, socio-economic trends, environmental policy

Introduction/Problem Identification
Colombo Flood Detention Area wetland is a vast system of freshwater marshes located along the eastern boundary of Colombo City (Sri Lanka). These wetlands support a rich biological diversity and offer a range of ecosystem services. Due to the rapid urbanization trend in Colombo for the past 15-25 years the wetlands are threatened by rapid degradation and visible changes in the ecological regime, imposing a serious danger on water related services derived from the wetland system. Urban flood incidents have increased during the past 15 years creating a vicious cycle of harmful causes and effects. The policy and governance improvements needed to control this situation are governed by the interplay among the ecological quality of the wetland with socio-economic trends and land-use patterns. This paper presents a study on the recent changes in the ecological regime of this wetland system, the possible causal factors and the current environmental policy/institutional framework.

Analysis/Results and Implications for Policy and/or Research
The selected study area (Kolonnawa Marsh) is the largest segment of the Colombo Flood Detention Area (CFDA). The study included investigation of different aspects of the wetland environment such as the change in land-use, vegetation patterns, faunal diversity, water & soil chemistry and socio-economic trends in the basin area.

It was identified that 12.85% of the original wetland extent has been converted into non-wetland use between the 1981-2008 period in the protected wetland area. The conversion rate was 62.50% in the unprotected area during the same period. The native vegetation of the study area comprised of sedges and grasses. A systematic succession of shrub habitats over the native grasses and sedges is observed during the 1981–2008 period. 48% of the extent is now covered with invasive shrubs and small trees (Annona grabra, Lantana camara, Cerbera manghas). A trend of these shrub species being eventually succeeded by upland species (trees such as Leucaena glauca) was observed in certain points of the marsh. The surface water quality of Kolonnawa Marsh significantly deviates from accepted ambient water quality standards. The water is also unsuitable for any form of human contact. Seasonally decomposed trend analysis (seasonal Kendal method) and correlation analysis of historical water quality data indicate that the BOD5, Ammonia and PO4-P are the most significant pollutants. BOD5 and Ammonia concentration in surface water showed a steady rising trend along with the increasing hydro-periods in the 2000-2005 period. While nitrates demonstrated a strong decreasing trend, all climatic parameters did not to show to any systematic trend during the same period. It was also identified using discriminant function analysis that the water quality of the wetland was distinctly different between the interior water ways and peripheral canals. All evidence point towards severe
and steadily increasing water quality degradation in the wetland dominated by dispersed domestic sources. A notable difference between fish and bird diversity was also observed between 1994 and 2008. 33 fish species and 93 bird species were recorded from the study area in the Wetland Site Report prepared by Central Environmental Authority of Sri Lanka in 1994, whereas only 14 fish species and 59 bird species were identified in the field investigations carried out in this research. Fish species such as Kissing Gourami (Helostoma temminckii), Knife fish (Notopterus Chilata) and Thilapia (Thilapia mozambique) which thrive in polluted and oxygen stressed waters were found in abundance, indicating a systematic succession of robust invasive fish over more sensitive native varieties of barbs, murrel and catfish. Investigation of soils revealed a high accumulation of nutrients (Ext. N range: 120 – 280 mg/kg; Ext. P range: 18– 65 mg/kg), thus indicating a serious condition of nutrient enrichment in the wetland. All facts point toward water-quality degradation, nutrient enrichment and systematic succession of invasive species in the wetland. This may lead to a complete shift of the ecological regime from a marshland with emergent herbaceous vegetation and two-dimensional water flow into a wetland with woody shrubs and more defined waterways. The regime shift will result in a permanent reduction of flood control and drainage services provided by the marsh. Investigation of socio-economic trends revealed the main causal factors of this degradation. 87% of the population living with 100m from the wetland didn’t have safe sanitary latrines and 44% of them directly discharged their gray water into the wetland. 63% of these households were affected by floods and 35% recorded water related diseases in the past 5 years.

CFDA is the only drainage infrastructure in suburban Colombo. Therefore an ecological regime change, which may take place beyond a certain level of degradation (tipping point) will be irreversible and call for large investments to replace the ecosystem services derived from the wetland with engineering measures. However CFDA has nearly a century old tradition of regulation based management approach that would not highlight this economic importance of the wetland and also neglect the incentives for degradation created by the urban process. However the study revealed that the existing stakeholder agencies have adequate statutory powers as well as technical capacity to handle their mandates. Therefore it is recommended to provide a common platform for stakeholder institutions and community participation. The institutional reforms suggested by the National Wetlands Policy of Sri Lanka (2006) can be adopted effectively to achieve this objective. Implementation of the above institutional and procedural changes will incur considerable transaction costs; therefore it is essential to have an indication of the economic value of wetland services to justify these costs.
Incorporating Uncertainty to Climate Change into Governance Assessments: Lessons Learnt From 2 Case Studies in the Alps and Andes

Author:  
Ms. Margot Hill  
University of Geneva, Switzerland

Keywords: uncertainty, governance assessment, adaptive capacity, extreme events, climate change

Introduction/Problem Identification
Climate impacts on glacial retreat, precipitation patterns and associated changes in run off regimes are already observed from the Alps to the Andes, posing novel risks to the governance of water and societies. Even though many have long demonstrated adaptive practices, accelerating rates of change are pushing systems past environmental thresholds and outside the range of experience, thus leaving communities increasingly unable to apply prior experience to current problems. Building adaptive capacity is seen as crucial to the sustainable management of water resources under the uncertainty of future conditions. Since governance is an issue at the heart of the water discourse, strengthening adaptive capacity in governance frameworks is essential for responding effectively to future climatic uncertainty and stress. Understanding how governance systems have adapted to past stresses from extreme events may allow us to draw lessons for how they could build resilience to future uncertainty.

Analysis/Results and Implications for Policy and/or Research
It is vital to increase capacity to cope with future uncertainty and change through robust and flexible management/policy approaches, while legislation, policy and institutional frameworks should collaboratively contribute to adaptive capacity (UNEC, 2009, p36). In order to achieve this end, scientists and policy makers can look to the past to learn about how to manage the future. Managers can learn from what has already been done, successfully or unsuccessfully, to inform their decisions about what should be done. Adaptation to past events, such as extremes in the form of heat waves and floods, can inform our understanding about how a system can be responsive to change (IISD, 2006). Therefore, this paper will present the challenges and lessons learnt in the further development of the governance assessment methodology that was produced in the STRIVER/BRAHMATWINN projects (www.striver.no; http://www.brahmatwinn.uni-jena.de), to take better account of the dynamic interplay between the human (governance), hydrological and climate components of the system. It will discuss the methodology development of an adaptive capacity component for the governance system and detail its empirical application in the Canton Valais, Rhone Basin in Switzerland.

The initial Swiss governance assessment tested 3 indicators of good governance, accountability, transparency and participation, as well as questions relating to the implementation of principles of Integrated Water Resource Management (IWRM). This assessment raised serious questions as to whether the Swiss governance arrangement could be ‘able to anticipate problems and to manage risk and challenges in a way that balances social, economic and natural interests’ (Hurlbert et al, 2008, p7). The paper will discuss the role each of these indicators has to play in an adaptive capacity assessment (IWRM is broken down into component parts), as well as how further indicators are identified from the literature and operationalised. Therefore, a more comprehensive set of adaptive capacity indicators are integrated into the assessment (Decentralisation & Subsidiarity; Predictability; Resources; Networks, Experience, Flexibility, Leadership), in order to more accurately measure the ability of the system to cope with increased uncertainty from climate change.
Previous studies assessing the adaptive capacity of water law to climate change have utilised case studies of water stress events to provide insights into ‘important modifications in the institution of water law which will increase adaptive capacity’ (Hurlbert, 2009, p1). This study will be looking beyond just water law, to the holistic water governance framework. Additionally, not only will drought scenarios be explored, but case studies of past extreme events will be used to serve as reference points of climate variability and as useful indications of impacts in a future, warmer climate. These case studies of extreme events can allow deeper investigation into the potential performance of the governance system under climate change impacts, by serving as reference points of climate variability and as useful indications of impacts of extremes in a future, warmer climate. Return period analysis is applied to understand the current development of such events and to project the likelihood of such extremes happening under climate change scenarios. Interviews then explore particular problems experienced under climatic extremes, and assess the extent to which the principles of adaptive capacity have been translated into specific rules, procedures and institutions and the consequent relationship to adaptation within the different extreme events. Utilising empirical knowledge from past experience in dealing with climate related events will allow the study to better understand coping strategies, adaptive capacity and explore adaptation to variability and extremes under uncertainty.

Further work will take place in summer 2010 in the Aconcagua Basin in Chile. The development of the governance assessment aims to more comprehensively understand the extent to which the governance framework fostered or threatened resilience within these case events. It is proposed that the research, and challenges discussed in developing its methodology, would expand on other studies concerning climate change impacts on water governance through deeper integration of quantitative data on climatic extremes for a more comprehensive understanding of how to deal with uncertainty in water governance regimes. A critical approach to concepts such as adaptive governance will also be taken, in order to thoroughly question the extent to which they can provide answers for dealing with future uncertainty.
Developing a ‘Sustainability Framework for the Protection of Aquifers’; A Paradigm Shift in Policy Design, Recognizing the Need for Resiliency

Author: Ms. Deborah Jarvie
University of Lethbridge/Monash University, Canada

Keywords: sustainability, policy design, resilience, aquifers, environmental tax & incentives

Introduction/Problem Identification
This paper introduces a ‘Sustainability Framework for the Protection of Aquifers’, and discusses the effects on aquifers from the coalbed methane industry. Studies and concerned citizens have both addressed issues such as 1) the drawing down of aquifer levels, 2) the detrimental effect that ejected water from operations has on surrounding agricultural land and on water bodies, 3) the increased methane levels in well water, and 4) the occurrence of sinkholes.

As the demand for the world’s water supply increases at an alarming rate, the protection of all sources of potable water must be at the forefront of global policy decision-making. Thus, this paper introduces and discusses several policy instruments within the framework – some currently utilized and some proposed, for the protection of groundwater. The framework also builds resiliency into policy making, as the interactions between man and nature can no longer be viewed as operating in a closed system.

Analysis/Results and Implications for Policy and/or Research
The specific environmental issue addressed in this paper is that of the coalbed methane industry and its effects on aquifers, as cited by numerous examples. This study is addressing the effects in three distinct regions of the world; the Horseshoe Canyon in Alberta (Canada), the Powder River Basin in Montana (U.S.A.), and the Sydney Basin in New South Wales (Australia). One or more of the concerns previously mentioned – aquifer drawdown, ejection of contaminated water, contaminated well water, and sinkholes – have been cited at each of these locations, and as such, provide the study with a source of secondary data. While there are currently thirty-one members in the international ‘Methane-to-Markets’ partnership, these three cases have been selected for a number of reasons, including the fact that they are amongst the largest producers of coalbed methane in the world, and all three locations have drawn significant attention over the past decade.

In order to address and mitigate environmental damages from industrial practices, this paper proposes a ‘Sustainability Framework for the Protection of Aquifers’, which is the topic of my PhD thesis. The complete framework encompasses the science of aquifers and coalbed methane, policy instruments (which include regulations, market incentives, and stakeholder governance), and theories of legitimization, resilience, and complex, dynamic systems. This particular paper will focus specifically on 1) the environmental issues of coalbed methane extraction and its effects on aquifers, 2) the development of environmental tax policy (by way of direct taxes and incentives) and its role in protecting aquifers, and 3) the need for resiliency in policy setting within a complex system, such as this issue presents.

The paper will address the traditional debates concerning the choice of policy instruments, stemming back to Tinbergen (1978). The paper will then discuss the theoretical framework of environmental taxes, from the early writings of Pigou (1952) to today’s growing body of literature. The link between
traditional policy and the more recently embraced concepts of resiliency and complexity will be then be discussed from a paradigm shifting perspective.

The paradigm shift proposed in the paper is that the development of policy can no longer proceed in a ‘static, linear’ manner, but that resiliency and theories of complex systems are essential components in the design, and must be incorporated from an ‘organic, nonlinear’ perspective. The interaction between man (industry) and nature (aquifers) is recognized as that within an organic, emerging framework. Although the issue still demands that traditional models of policy be established in order to ensure sustainability, the framework proposed in this framework must be capable of quick adaptation to challenges and opportunities as they present themselves.

Resiliency is now recognized by a growing number (Folke et al., 2005; Walker et al., 2004; Hamel & Valikangas, 2003; and Chapin et al., 2009, to name a few) as a necessary component for environmental protection, and thus, this paper will present the theoretical framework of this body of knowledge. The theory of emergence in complex systems (Kauffman, 1995), the relation between order and chaos (Prigogine & Stengers, 1984), and systems theory from the likes of Scott, 1987; Powell & DiMaggio, 1991; will be also discussed in the paper in order to develop the theory of the need for a paradigm shift in policy setting.

(As a note, primary research will be conducted this spring, whereby stakeholders will be interviewed in an open-ended method in order to enrich the components of the framework. Interviews will be coded and this primary data will be triangulated with the secondary findings, from which theories are expected to emerge using a grounded theory methodology. While these results will not likely be available in time for the final writing of this paper, they will be available for subsequent discussion at the conference, should my paper be accepted.)
Climate Change Adaptation & Resilience Building through Sustainable Water Management Systems

Author: Mr. Amit Kumar
Earthwatch Institute, India

Keywords: water management, climate change, adaptation, resilience, mitigation

Introduction/Problem Identification
Ladakh, a high altitude cold desert region in Western Indian Himalayas is facing an unprecedented environmental crisis as glaciers in the region are shrinking at an alarmingly rapid rate. ICIMOD predicts that 35 per cent of Ladakh’s glaciers would have disappeared in two decades. And a region that depends on glacier water for its sustenance is already facing unpredictable weather, floods which can have severe impact on water supply, agriculture-based livelihood and infrastructure. Less snow is falling, so there is less moisture for growing crops. In village after village, we are witnessing the end of farming where snow melt on the fields was the only source of moisture. The residents are feeling the impact and have also seen freak weather in recent years, including flash floods in Leh and Nubra Valley. So adaptation & capacity building through sustainable water management systems is critical for survival of Ladakh Himalayas.

Analysis/Results and Implications for Policy and/or Research
A participatory Research cum Survey has been conducted in 42 villages of Ladakh located in Leh, Nubra & Zanskar Valley to study the impact of climate change on water resources & its further affects on agriculture & livelihood & how he communities are adapting to these erratic changes.

Ladakh has already seen the effects of less glacial melt, which is only expected to get worse with coming years. Here all life depends on snow as high altitude desert is having only 50mm of rainfall. Ladakh’s Water comes from the snow melt – both the snow that falls on the land and provides the moisture for farming and pastures, as well as the snow of the glaciers that gently melts and feeds the streams that are the lifeline of the tiny settlements.

Statistics compiled by the Indian Air Force shows that temperature of Ladakh has risen by one degree Celsius over the last 35 years which is alarming for the region. The water level of the river Indus has fallen alarmingly over the years thus affecting irrigation schemes. Not only depletion of glaciers will affect agriculture, but also it will destroy numerous industries in the Indus river valley such as food processing, mining, paper production, and chemical and steel plants, which all require a reliable source of water. There is water scarcity as the only sources of water are melting glaciers and minimal snowfall. In Leh, the capital of Ladakh, only 10 percent of the population has access to ground water through taps & rest survives on government tankers & borewells. Climate change is also impacting the high altitude wetlands like Tsomoriri & Pangong in a big way & is threatening the endangered migratory birds like Black-necked Crane and Barheaded Goose. The past eight years have been especially short of snow, leading to abandonment of fields, inability to grow crops like wheat which requires more water, and less income from local agriculture. A high percentage of drying of springs can be linked with erratic weather conditions besides increasing frequency of tourism outflow, roads construction & other development activities in Leh, Nubra and Zanskar valley. The region that normally sees minimal rainfall is experiencing excessive rains and flash floods over the last three four years. Beside destruction of water springs & irrigation channels, compounding the problem is the fact that construction
material used in over 90 per cent of houses in this region is mud. It is a tradition to built mud houses here but the rains are destroying them. A total of 15-20 % of water resources beside irrigation channels were destroyed by flash floods in Nubra Valley, Ladakh over the years.

Conservation of water in Ladakh is part of daily life, and scarcity of water resources does not hold as much of a threatening message as it does in other parts of the world. The effects have only started to show their marks, and it’s only predicted to get worse. The most commonly practiced method of conserving water is the turn system, perhaps the simplest method possible. Because there isn’t enough water to supply every household, they take water based on a turn system. Each house can use the water for their fields on only a certain day or week. This promises an equal amount for all houses. Along with the turn system, the pond and canal system is used in almost every Ladakhi village. The river is diverted into ponds, which each household has, and during the day opened up into canals which irrigate the fields.

A decentralised approach to water harvesting through artificial glaciers is an example of how grassroot communities are adapting to climate change. The only water source is glacier water coming down the mountains. When glaciers melt in summer, they release a little water that is used by the people of Ladakh to irrigate their crops. The artificial glacier comes as a bonus for farmers. Tsewang Norfel is a Ladakhi engineer who builds artificial glaciers to maintain a consistent and constant water supply to thirsty villages in all regions of Ladakh. Norphel’s innovation involves channelizing water to the shadow area of a mountain close to a village. After going through metal pipes, the water freezes, creating a glacier close to the village. It enables them to get water a whole month before the snow starts melting on the mountain tops. This is particularly useful to start sowing, as the sowing season ends before water from natural glaciers begins to flow down the mountain.

Ladakhi communities are trying to build resilience through traditional water & agriculture systems beside working on flood preparedness like deepening of channels to meet future threats. Issues like Promotion of Horticulture & Climate resilient crops and special initiatives like crop insurance should be given more priority. Public participatory process for major developmental changes & an efficient ecotourism policy is much needed for a high altitude terrain like Ladakh.
The Upper Guadiana Basin: is it Possible to Align Changes in Ecological Systems with Changes in Social Systems?

Introduction/Problem Identification
The Upper Guadiana basin is a dramatic example of a deep (reversible?) change in a socio-ecological system. Intensive groundwater use has meant that over a period of approximately 40 years, more than 3000 Mm$^3$ have been abstracted from a 5,500 squared km aquifer, to fuel the spectacular socio-economic development of what used to be a relatively poor and backward region in central Spain (La Mancha). This however has been at the expense of a MAB reserve, the Mancha Humeda, a series of wetlands, the most iconic being the Tablas de Daimiel National park, where it is estimated only 20% of the original area remains and very few of the wetlands function naturally.

Analysis/Results and Implications for Policy and/or Research
The analysis offers two perspectives; first a retrospective analysis of the regime shift over the last 40 years. This is through a series of snapshots of changes in the Upper Guadiana basin using a range of techniques, namely Bayesian belief networks, the extended water footprint and regulatory impact analysis of collective action. These provide new lenses to understand and explain the drivers that have led to current ecological problems of the Tablas de Daimiel National Park, and conflict with irrigated farming which competes for the same water resources. The paper then offers a prospective analysis, zooming into the current situation, by presenting an analysis of the Special Upper Guadiana Plan. The plan with a budget of 5,000 million euros started in 2008 and will be operational until 2027. It is currently considered the main measure contemplated within the Water Framework Directive for the already identified water bodies in compliance with the Water Framework directive, in order to achieve good quantitative status and good qualitative status for 2015 (2027 under special conditions). The Special Upper Guadiana plan has now been operational for almost 2 years, and some preliminary analysis can be undertaken on the implementation of the plan, from the perspective of e.g. the participation of stakeholders and the re-allocation of water rights. It can offer some insights into the potential and limitations for regime shifts, and also the implementation difficulties and high costs of reversing situations once a certain threshold is crossed. The Plan in many ways can be analysed as a large scale effort not only in ecological restoration but which also aims to incorporate its social aspects i.e. aiming to restore a complete socio-ecological system. A series of techniques (like e.g. Bayesian belief networks, regulatory impact analysis, etc) are used in order to analyse past (1970 to 2010) and possible (2010-2030) regime shifts in the Upper Guadiana basin, to draw some conclusions on policy measures on large scale socio-ecological regime shifts.
Water and Sanitation towards Disaster Risk Reduction

Author: Mr. Zahidul Mamun
Concern Universal, Bangladesh

Keywords: ensuring WatSan facilities, resilient WatSan facilities, disaster risk reduction, improved health & environment, reduced morbidity & mortality

Introduction/Problem Identification
Bangladesh is a country that has been intrinsically associated with natural disaster, frequently suffering devastating floods, cyclones, storm surges, tornadoes, riverbank erosion, and drought and constituting a very high-risk location for devastating seismic activity. Every year thousands of water and sanitation facilities are built in Bangladesh without taking into consideration the effects of natural disasters and a large part of it is destroyed during disasters, the affected populations deprived and vulnerable to health risks. The destruction of water and sanitation facilities also represents unavoidable losses of energy, finance, and time, not only for affected populations, but also for Bangladesh’s development efforts, and the international and national community supporting water and sanitation projects. There were again multiple examples of damaged water and sanitation facilities during the floods and cyclone in year 2007 (June-July-August, September and October) in Bangladesh.

Analysis/Results and Implications for Policy and/or Research
Though a significant development has been occurred on water supply and sanitation in Bangladesh in response to Millennium Development Goals (MDGs) and Bangladesh Poverty Reduction Strategic Plan (BPRSP), still there is remarkable gap in between water-sanitation and natural disaster in Bangladesh, which is very emerging in a high disaster prone country. As a result, huge numbers of water & sanitation facilities are being regularly damaged due to natural disaster every year, which is imposing negative impacts in terms of diminishing national WatSan coverage, severe safe water crisis and safe excreta disposal on regular basis and during disaster/emergencies, which jointly impose massive health hazards as an epidemic causes huge death toll as a very common phenomenon. Considering the situation in regards to Water supply & Sanitation and natural disaster, Concern Universal very strategically generated the concept naming ‘disaster friendly WatSan’ with the vision to exclusive implementation as well as continue strong advocacy to national and local levels for ensuring exclusive implementation of disaster friendly WatSan facilities by all actors in Bangladesh. Concern Universal believes that Disaster is such a thing in Bangladesh, which needs to be properly considered in every development issue. And also there is clearly written in Bangladesh WatSan legislation to consider disaster on implementing WatSan programs, but in practical most of the actors including Government, UN, national and local NGOs have been implementing WatSan facilities without taking consideration and respecting the legislation statement and repeating the negative multiple impacts of damaging WatSan facilities, safe water crisis, safe excreta disposal crisis, prevelance of water borne diseases as well as massive health risks on regular basis and during disaster/emergencies and finally result huge numbers of deaths every year. Disaster Friendly Water and Sanitation concept and technologies intend to provide water and sanitation facilities which can resist to natural disasters allowing the population to have continuous access to the facilities during and after disasters. It also contributes, all the time and in times of disasters and post-disasters, to limit the spread of diseases due to contaminated water and lack of sanitation facilities. This concept is new in Bangladesh where it is particularly welcome and appropriate in Bangladesh as it is a major prone disaster country. Concern Universal – Bangladesh in partnership with Dhaka Ahsania Mission, YPSA & SPACE started implementation of ‘disaster friendly WatSan projects supported by ECHO, IrishAid and Cordaid.
The CUB programme on WatSan towards disaster risk reduction includes community mobilization for building awareness on use of safe water, sanitary latrines during/after disaster/emergencies and on regular basis, disaster preparedness, emergency water supply, capacity building of stakeholders and beneficiaries on WatSan & disaster preparedness, providing upgraded & improved disaster resilient WatSan technologies for ensuring safe water and sanitary latrines, continued advocacy at the local & national level for the concept’s wider adoption, fund raising and knowledge & experience sharing to the national and international audience. Till date CU installed about 800 safe water options and more than 550 sanitary latrines in various institutions (schools, shelters and public places), which are used as shelters during emergencies. They are fully functioning very well and imposing very positive impacts during disaster/emergencies and also for the school children on regular basis. CU has been continuing the program gradually to the extended areas but in small scale due to fund limitation. Strategically CU choose institution and publics places to install WatSan facilities because (i) crisis of safe water and sanitary latrines in shelters/schools is emerging tends to massive health hazards (ii) CU is still dealing with small granted project, which cannot address WatSan for the whole community or House Holds based approach. Therefore, the initial mandate of CU is to ensure safe water and sanitary latrines for the disaster victims and school children as well as build mass awareness & knowledge, skill, capacity of the stakeholders and continue advocacy for exclusive implementation of disaster friendly WatSan by all actors in Bangladesh. By this time, Concern Universal has got an international exposure to present this concept in “the 3rd International Dry Toilet Conference in Finland” where it has been regarded as a global crisis as ‘WatSan for disaster preparedness’. CUB has been working extensively to both implement and promote ‘disaster friendly’ water and sanitation facilities. Often, existing facilities can be upgraded to allow them to be disaster resistant. The upgrades are simple and relatively inexpensive and, therefore, can be done also by households.
Global to Local Green and Blue Water Demand for Maize Production under Future Scenarios, Including Global Climate Change and Competing Urban Demands

Author: Dr. Marty Matlock  
University of Arkansas, USA

Co-Author: Dr. Cully Hession  
Virginia Technical Institute, USA

Keywords: maize, CERES, global, yield, drought

Introduction/Problem Identification
Global agricultural production depends largely on green water, with supplementary blue water irrigation. The volume of blue water required within a region to produce a given crop depends on the water budget during discrete growing stages of each crop. Precipitation duration and intensity, daytime temperatures, relative humidity, and wind affect evapotranspiration. These processes are predicted to change over the coming century as a result of global climate change processes. The impact these changes will have on production of maize globally were investigated using the CERES 4.0 Maize model (DSSAT, distributed by ICASA). Maize production (measured as yield, MT/ha) was calibrated using five degree resolution crop production data benchmarked to 2000, developed by Foley et al. (2005) at the Center for Sustainability and the Global Environment. Model validation was performed using 2005 yield data from five high-data-density locations.

Analysis/Results and Implications for Policy and/or Research
The inputs for the DSSAT CERES-Maize corn growth model included daily climate data (min temperature, max temperature, precipitation, and solar radiation), soil profile data, cultivar type, and management information (planting date, harvest date, crop density and planting depth). Daily precipitation values (in mm) for the years 1999 and 2000 were provided by the Tropical Rainfall Measuring Mission. Temperature (°C) and radiation (mJ/m²), were derived from monthly averages from data collected between the years 1961 and 1990 and were provided by the Climatic Research Unit (CRU). Soil profile data were based on the database created for DSSAT based on the ISRIC WISE soil database (FAO). We tested four different generic varieties of corn built into the model. Planting depth was set to 4 cm and three values of crop density were tested: 10, 20 and 30 plants/m². For planting and harvest dates, the global dataset was divided into two groups: areas that do early year planting and areas that do late year planting (based on data from SAGE). Crop calendar data from SAGE was then used to develop representative planting ranges for each group, and DSSAT was set to automate exact planting and harvest dates based on the climate data.

The geographic scope for the analyses included river basin, country, and sub-continent. Scenarios were developed for analysis based on IPCC AR4 predictions for 2015, 2025 and 2050 for green water availability. Model predictions were informed by UN population predictions for global urban growth, with per capita demand integrated into the water budget at each scale. Blue and green water were analyzed to determine the impact of global climate change at each scale under each scenario. Soil moisture during each growth stage for maize was simulated to determine the critical period for water supplementation and yield. Areas with marginal water availability and with predicted rainfall deficits under IPCC scenarios showed increase water stress and deficit demands for blue water. The
impacts of reductions in water use demand from drought-tolerant maize developed in concert with the Gates Foundation and Monsanto Company were analyzed at five degree resolution globally. The impact of increasing urban demand for blue water within the geographic regions was analyzed to determine where and when, and under which scenarios, water resources would become limited for agricultural production.
Evaluation of Socio-Economic Consequences from Regime Shifts; Strategies to Minimize the Vulnerability from Asian Monsoon

Author: Mr. Sirisena Meegasmullage
Ministry of Irrigation and Water Management, Sri Lanka

Keywords: Asian monsoon, consequences, strategies, tipping point, vulnerability

Introduction/Problem Identification
This paper is the reflection of the author after being involved in the research study done by the University of Colombo and the Human Development Center in 2007, demonstrating the impact of the drought, which completely disrupted the social-ecological systems of Kirindi River Basin. Secondly, it discusses dangers of sudden swings in the Sri Lankan climate and how these regime shifts can be anticipated within the Indian Monsoon tipping point. Further it illustrate the tools that can be useful to deal with uncertainty and how these risks can be reduced through adaptive management and scenario planning, to improve land and water management interventions securing the future of the river systems in the Indian Monsoon Region.

Analysis/Results and Implications for Policy and/or Research
Introduction: The climate changes will make Indian Monsoon rains more erratic, causing frequent flash floods in some areas and severe droughts in other parts of the Indian Sub continent, in future years as happened in past decades. It contributing to shifts in droughts and floods patterns, increasing environmental pressures. There is a clear evidence in Sri Lanka, where sudden and surprisingly large changes in the functions took place in the Kirindi River System (KRS) switching from huge water regime shift to dried-empty water system, after an undesirable tipping point—the catastrophic drought in 2002. It was reported that entire irrigated crop area of 13,300 ha, completely destroyed hindering to the 25,750 farmer families, drinking water and sanitation facilities collapsed and resulted in extensive and irreversible damage in all parts of the basin. These types of regime shifts happen everywhere, but not in every time, because, this type of catastrophic drought event was reported after five years time in 2007 across much of the Sri Lanka.

Problem Analysis: The KRS, with Lunugamwehera Project is rapidly developing system, covering area of about 416,00 km², sharing three Districts, over 70 % of the population dependent on irrigation agriculture. KRS watershed became heavily populated and river pollution from sewage, low quality effluent from non-point sources dramatically increased. After the drought the natural flora and fauna were displaced by species tolerant of low or no flow, river lost its natural services and become a health hazard and aesthetic nuisance. These were influenced regional planning among three municipalities, resulting inferior land uses along the river.

Discussion: Mitigating this the government of Sri Lanka, followed an effective tool, the IWRM approach to mitigate drought through, not in charge of the whole watershed, but operate on a basis of issues, encouraging participation of its stakeholders in planning and policy making under the Irrigation Ministry. Immediately they supplied drinking water, food and sanitation facilities to the settlers. In long term for ecological restoration including the reconstruction of eroding river banks, the removal of invasive species, and reconstruction of riffles, within the river for mosquito larva eradication carried out in 20 km of riparian habitat with the people participation, paying compensation (PES) and
again the tool could manage resilience of social-ecological systems. Later it helped to promote the river and the lagoon as a recreational resource by developing green spaces. It is often difficult, costly, and sometimes impossible to reverse these situations but with the IWRM, a properly managed watershed, provides such a resilient interface. Drought and flood control planning requires accurate mapping and they used GIS model developed by the IWMI, on a sub watershed basis for protection of flood plains. Research study reveals that the ecosystem protection and integration of water with land and forest management are the key strategies to reduce the drought risk. And it will secure the future of the river system and the economy, through enforcing new environmental regulations and policies implemented in conjunction with both the Rio Declaration. They promoted ecosystem reforestation in upper watersheds, while 65% reduce exploitation by enforcing Law with the Forest Department. These people were rewarded by the Ministry, for their massive initiative in applying reforestation or at least avoiding deforestation which could qualify for carbon sequestration funds of clean development mechanism (CDM)-Kyoto Protocol. The project management adopted new agronomic techniques to deal with the uncertainty. Renovated the ancient cascade system as supplementary water storage. Developed a mechanism to get maximum use of effective rainfall. They shifted to “wet and dry” irrigation, no – constantly flooded. The study showed that the water duty in the 2003 after the drought was 8.5 ac/ft, and it reduced to 5.5 ac/ft in 2008. Although some improvements have been observed as a result of these efforts, attempts to introduce a fee for irrigation water ended in failure, due to social and political hindrance. However most of the Farmer Organization collects fees from their members for operation and maintenance fund.

Conclusion: Adaptation measures should need proper integration with in broader development goals. Authorities must take measures to protect the hydro-ecosystems from unsustainable exploitation by enforcing new regulations and policies. Managing the resource effectively, through well conceived IWRM approaches and a properly managed watershed provides such a resilient interface. The basic and most important requirements is a sound knowledge and information system with analytical tools. Other countries also, should therefore give priority to land use planning and watershed management with peoples active participation.
Distinguishing Human and Climate-Induced Contributions to the Columbia River Hydrology

Author: Dr. Pradeep Naik
Ministry of Water Resources, India

Co-Author: Prof. David Jay
Portland State University, USA

Keywords: climate change, human impact, flow regulation, sediment transport, salmon (fish)

Introduction/Problem Identification

The Columbia River (USA) had until recently the world’s largest Chinook salmon runs. Restoration of the system’s severely decimated runs requires understanding changes in the hydrologic variables (e.g., flow and sediment transport) important to salmonids. A problem fundamental to all analyses is to distinguish human and climate effects in the flow record. Also, there is an apparent disparity between the modest changes in river flow that have occurred and the large response of juvenile salmonid survival to changes in river flow. It is, therefore, necessary to seek processes where climate or human-induced changes are amplified by non-linear ecosystem processes. We describe here methods to distinguish the human and climate-induced contributions to Columbia River hydrologic processes relevant to the crucial seaward spring migration of juveniles through the tidal river and estuary.

Analysis/Results and Implications for Policy and/or Research

Analyses of flow and sediment transport data allow an approximate separation of climate and human impacts on the Columbia River (CR) hydrology over the last 120 years. Annual average flows have decreased >15% due to climate change and irrigation depletion. The size of the spring freshet has been strongly affected by flow regulation, with smaller contributions from climate change and irrigation. Spring freshet timing has been altered by all three factors, but the dominant climate effect occurred before 1920, whereas human impacts increased after 1970.

The above changes in hydrologic processes should also be placed in context of catastrophic events that temporarily disrupt salmon populations. Bottom et al. (2005) have argued that the great life history diversity of salmonids is the primary factor that allowed salmon to survive and (in the long run) prosper along a tectonically active coast. We need, however, to better understand hydrologic changes and salmonid reactions to them. In this way, we can facilitate recovery of salmon stocks through their inherent genetic diversity.

Restoration of CR salmon runs requires difficult decisions regarding allocation of scarce water resources. A better understanding of historical changes in hydrologic processes may not reduce the social dislocations associated with these choices. This knowledge, however, tells us how management and climate have changed the system, and defines 19th Century conditions (at the end of the little ice age), before the onset of rapid, human-induced hydrologic changes and decreasing salmon runs.

Global sediment discharge is being decreased more by trapping in reservoirs than it is being increased by human impacts like agriculture, mining and deforestation. Limited evidence not presented here suggests that the contribution to Columbia River sediment supply caused by human disturbance was never very large and may have decreased in recent decades.
The Aral Sea Regional Problems under Changing Climatic Conditions

Author: Prof. Yuriy Popov* et al.
* Ecotera Ltd., Kazakhstan

Keywords: climate cyclic rhythm, bared sea bottom, water management, winter flow, territorial-natural complexes

Introduction/Problem Identification
Leading factor in the development of Kazakhstan arid zone landscapes is the climate which has expressed cyclic rhythm of 1800 years.

Since 1960 the level of the Big Aral Sea decreased by 22 m. On the bared sea bottom there are ruins of ancient settlements of X-XII century. Extensive nature management has sharply accelerated natural processes of drying off and desertification of ecosystems. Since 1993 the power hydrological regime with winter floods in the Syrdarya lower reaches has been accompanied by extreme consequences, it mismatches ecosystem biorhythms. Supply of population with potable water must be done in line with construction of the centralized water supply and sewage system. Introduction of water management and saving technologies, mandatory payments for use of natural resources. Establishment of agro industrial enterprises within the minimum territorial-natural-economic complexes with preservation of interrelations with the adjacent territories is also perspective.

Analysis/Results and Implications for Policy and/or Research
One of leading factors in the development of Kazakhstan arid zone landscapes is the climate which has expressed cyclic rhythm of 1800 years. Now we are in the intermediate climatic phase, in the second half of the third millennium a dry phase could be expected, and only in the first half of the fourth millennium a wet phase will begin.

Currently the level of the Big Aral Sea has decreased by 22 m in comparison with the year 1960 of the last century. On the bared sea bottom ruins of ancient settlement and mausoleum appeared, which are preliminary dated X-XII centuries.

Slow natural decrease of the Aral Sea level in the 70-es of the last century was influenced by powerful anthropogenic pressure caused by extensive use of water and land resources of the rivers Amudarya and Syrdarya. The share of natural factors in the sea level decreasing makes 10-5 %, but these factors are long-acting.

General drying process of the basin is confirmed by condition of water reservoirs and glaciers feeding the Aral Sea. At the present stage water resources of the Aral Sea basin have been almost completely used. The years of water abundance are followed by dry years. In 2008 the water volume in the Toktogul reservoir on the river Naryn decreased to the critical level. As at June 1, 2008 the full volume of water was 7 million m3 against design volume of 19500 million m3. Such picture was observed practically on all rivers and reservoirs. Currently reduction of mountain glaciers in the upper river basins of Kyrgyzstan has been observed.

At present there are problems related to changes in hydrological regime of the Syrdarya river. Along
with the changes in runoff regulation the hydrological regime of Syrdarya was changing as follows:

Natural changes in 1912-1961;
Anthropogenic changes caused by irrigation in 1961-1987;

The period of anthropogenic hydrological regime of the river caused by irrigation differs from the natural one. Along the whole current of the river water intake for economic use has started to decrease. During this period winter floods had not been observed.

The period of anthropogenic hydrological regime of the river water usage for hydropower stations began in 1993 with transition of Toktogul reservoir to a power mode of operation. This caused ice jams along the river current during winter resulting in floods with extreme consequences for social and economic life of the region. Insufficient discharge capacity of the Syrdarya river in its lower reaches in winter causes flooding of farmlands and settlements. Winter discharge capacity of the river bed is 2-3 times lower than the summer one. This hydrological regime mismatches biorhythms of the developed ecosystems of lower reaches and river delta. Koksaraisk counterregulator with the capacity of 3 km$^3$ which is currently under construction will accept a part of superfluous winter flows from the Shardara reservoir, and support admissible water runoff in the Syrdarya lower reaches.

The problems of improvement of the regional populations living conditions and maintenance of the open water in the Aral Sea are different in their scientific and technological nature. Environment management in the Syrdarya lower reaches has to solve two problems. The first of them includes improvement of living conditions of local population, supply of population with potable water meeting sanitary standards and construction of the centralized water drain and treatment facilities. The second problem includes reduction of the irrigated land area, introduction of water management and saving technologies and mandatory payments for use of water and other natural resources along with the penalties and criminal prosecution for environment pollution and damage.

Establishment of land plots according to the minimal territorial-natural-economic complexes. Parceling out of land for these recognized complexes will enable use to find solutions for many land reclamation problems with minimal negative impact on water resources and adjacent areas. Understanding of interrelations between technical, organizational, legal and social measures is required for sustainable economic development and social protection of local population, taking into consideration the interaction among neighboring territories and higher level regional relationships.

In order to eliminate negative consequences of winter power flow augmentations the Koksaraisk counterregulator is being constructed. Also an international project is being implemented: Regulation of the Syrdarya river bed and preservation of the Northern Aral Sea.

During planning of the water economic activities for a long-term prospective in the conditions of intermediate or dry climatic phases it is necessary to take into account the ecological risks connected both with anthropogenic and natural factors.
Study the Pattern of Flooding and Zones Affected/Flood Vulnerability Mapping of Cooum River-Chennai

Author:  
Ms. Arivarasi Renganathan  
Anna University, India

Keywords:  flood vulnerability, flood hazard, flood risk, flood damage, damage cost

Introduction/Problem Identification
The geographical position and topographic composition have made Chennai vulnerable to natural disasters. Chennai city has a flat terrain, which is on an average of 1.50 m above mean sea level (MSL). The city has considerable areas of low lying lands which are prone to get inundated during heavy flooding. Mostly all floods affect Chennai in large scale and cause maximum damages to the lives and properties in comparison to other areas. The risk of people life directly related to the population density and because the Chennai is having high population density, it is more vulnerable for risk of people life.

Analysis/Results and Implications for Policy and/or Research
Flood risk assessment is the first and the most important step for flood damage reduction. Flood hazard and vulnerability mapping are essential for flood risk assessment. Vulnerability is the degree to which a society is threatened by the impacts of natural hazards. The flood vulnerability analysis will be carried out based on physical, social and economic factors. Physical vulnerabilities will be determined by conditions of housing, infrastructure, environment and other factors. Social and economic vulnerabilities will be analyzed by demographic, health, education, employment and standard of living. Maps will give a more direct and stronger impression of the spatial distribution of the flood damage than other forms of presentation (verbal description and graphs etc.). Thus maps are valuable for presenting and assessing the local flood situation. In addition they provide information for flood protection, flood disaster management and mitigation works.

In this study, an attempt is made to prepare the flood vulnerability map for the Cooum river. The vulnerability map of the study area is prepared and the approximate damage-cost curve for various flood return periods is developed. Vulnerability map is prepared by overlaying various vulnerability factors on the hazard map by using remote sensing data and GIS analysis. Hence, the vulnerability map will show the area, road, infrastructure and population which are more vulnerable to flood, in and around the study area for various return periods and the damage cost curve will show the approximate cost of flood damage for various return periods. I will present the exact result in the workshop.
Impact of Degrading Cloud Affected Forest (CAF) Ecosystems upon HEP Generation and Water Quality in Hydrologically Sensitive Tropical Dam Watersheds

Author: Mr. Leonardo Saenz
King’s College London, Colombia

Keywords: watershed services, dams, fresh water ecosystems, dry season flows, HEP generation

Introduction/Problem Identification
Sustainable management of global watershed services is key to assure both, continued improved human welfare and maintenance of the fresh water ecosystems upon which they depend. However, the fact that watershed services have been often undervalued means that the natural ecosystems that provide them have been habitually mismanaged. The department of Geography at King’s College London is currently working to better quantify the impact of land use and climate change upon tropical fresh water ecosystems and the economic consequences upon human activities therein. This paper presents results from research that explores the impact of land use change upon water quantity and quality to tropical dams. This is being achieved through detailed hydrological research, by assembling a new Geo-referenced Tropical Dams Database (GTDD), and by developing and using innovative modelling tools to quantify the relationships between ecosystem structure, function and potential value of watershed services.

Analysis/Results and Implications for Policy and/or Research
The value of goods and services, which is directly related to freshwater ecosystems is estimated to be around US$8.25 trillion per year (around 25% of goods and services provided by ecosystems) (Bergkamp et al. 2000). In the tropics, however, the pressures posed by humans upon a large number of their watersheds are already significantly large (Shiklomanov 1998; Revenga 1998). Using the recently developed Geo-referenced Tropical Dams Database (GTDD) (Saenz and Mulligan 2009) preliminary results show that there are around 19000 tropical dams, which benefit from water flows accumulated from close to 32% of tropical land masses, and whose catchments capture a significant proportion of both, regional rainfall (almost 25%) and surface water resources (around 6%).

Moreover, a prioritization of areas that contribute the most water to these dams revealed the hydrological importance of the actual global cover of CAFs ecosystems (Cloud Affected Forests, as modelled by Mulligan and Burke (2005). While CAFs cover only a very small fraction of these tropical dam watersheds (below 5%), they account for just below 50% of the surface water resources that supply tropical dams. In entire regions such as the Andean system of basins, for instance, water that flows downstream from these mountainous environments supply large HEP demands of around 60,000 GWh/yr, underpinning a strong regional economic sector of around 5 billion USD on annual energy sales, and that has attracted big players such as Endesa Spanish Energy group, which accounts for around 5 million customers in the whole region (Saenz et al. 2009).

And yet, the tropical watersheds under CAFs cover and the freshwater ecosystems therein that sustain the supply of these services are still under high levels of risk. This study indicates that the current average CAFs loss in tropical dam watersheds (CAF outside tropical boundaries only) is of potentially around 50% of its original cover, with current increasing urbanization expansion, land degradation, climate change and the still large number of rural poor, threatening both, the unprotected CAFs and,
in particular socio economic settings, the protected remnants as well. Further loss of these ecosystems
could exacerbate shortages in the supply of clean high quality and well regulated water to humans and
to the environments downstream, while in some particular settings (e.g. sub-humid to dry upland
regions originally under CAFs cover, for instance to the south pacific coast of Mexico), the current
ecosystem loss may well have already led some watershed services, such as the regulation of dry season
flows and sediment yield control to reach the tipping points.

In order to improve our understanding of these impacts, this research has first explored the potential
consequences of degrading CAFs upon dry season flows that feed tropical dams, and second, the
combined effect of affecting water quality (increased sediment loads) and dry season flow regulation
functions upon HEP generation outputs in several detailed case studies.

By selecting seven large tropical dams in the countries of Mexico, Colombia, Brazil, Kenya and India,
in river basins that already face large water withdrawals, and also water stress, where the presence
of CAF ecosystems is likely to affect positively both, sediment yield control and dry season flow
regulation functions (the latter due to extra water inputs from fog intercepted by the vegetation);
preliminary results from the implementation of the model FIESTA Delivery indicate that average
dry season flows could potentially drop significantly (up to 10%) at the dam points following the
conversion to pasture of the remaining CAFs upstream the dams. These drops potentially depend
upon the levels of dry season rainfall, prevailing winds and the extents of CAFs, among others though.
Moreover, they also indicate that despite that such drops are likely to be less significant upon current
HEP generation levels for some of the annual reservoirs (where a tipping point in the provision of
dry season flow regulation services may have already been reached), further forest loss together with
the greater sediment yields following forest conversion to pasture could impact negatively the current
performance of dams and have strong negative consequences upon the maintenance of both, water
quality standards for humans and ecological flow requirements, particularly during the dry season in
the sensitive dam watersheds under study.
Reliability, Resilience and Vulnerability of the Two Purposes Canal Systems in Vojvodina Province (Serbia) under Existing Water Management Scenarios

Author: Prof. Bojan Srdjevic* et al.
* University of Novi Sad, Serbia

Keywords: reliability, resilience, vulnerability, twofold canal use, drainage and irrigation

Introduction/Problem Identification
A majority of farmers along canal network of the Danube-Tisza-Danube hydro system in Vojvodina Province (Serbia) has clear understanding about importance of exploiting parts of canal network for the two purposes, drainage and irrigation, on switch on-off basis. Encountered shortages in scheduled supplies and degraded quality of drained water due to extensive use of fertilizers in agriculture initiated re-assessment of existing management policies implemented jointly by Public Water Management Company Waters of Vojvodina and local communities acting as farmers’ supporters. Research has been focused on performance of small and medium drainage/irrigation systems during irrigation seasons by introducing specific dynamic performance measures such as reliability, resilience and vulnerability. Recent studies shown that two purpose systems performance, not only technical but also social-ecological, might efficiently be improved if proper structural and non structural measures are applied.

Analysis/Results and Implications for Policy and/or Research
In evaluating existing procedures for controlling water regime and mid-term (seasonal) management plans which include pumping schedules, prescribed or on demand, several key performance measures are identified and elaborated, namely reliability, resilience and vulnerability. Because formal descriptions of performance indices are mostly problem dependent, each representing an attempt to capture certain part of complex information on system performance in a long time period, herein we adopted definitions applicable to both quantitative and qualitative (water related) contexts. Reliability is defined as a probability of not failing to achieve some target at specific locations where farmers need water for irrigation, or require quality of drained water to be above threshold (standard) values. For example, it is probability that canal will not fail to deliver targeted water to specified farmer. If one define reliability of water supply as probability that system performance at given demand point is satisfactory if supply is within tolerant shortage (e.g. 10%), then the higher value of probability, more reliable is the system. Various levels of aggregation are possible to obtain overall system’s reliability. On the other side, resilience is a performance index which describes how quickly a system is likely to recover from failure, once failure has occurred. The higher value of this index, more resilient is the system. In cases there are not failures system is, by definition, considered fully resilient. Vulnerability is commonly measured as how much deep is the system in unacceptable status once it went into that status; it may be defined in statistical way but also, and more common, in a heavy hazard contexts.

In this work we describe a logical framework for straightforward evaluation and ranking of a set of management scenarios for small scale two-purpose hydro-systems (drainage and irrigation) and derive mechanism for follow-up of their implementation consequences from the performance measurement perspective in aforementioned sense. We developed computerized mathematical tools that deal with uncertainty and risks by measuring especially resilience in order to see how to protect farmers from long lasting deficits in water supply for irrigation (especially during peak demands periods), or occur-
rence of risky decreases of water quality in canals. The ultimate goal is to establish an adaptive global water management, mainly by improving operation of lockers and pumping equipment along canals. Time frames spanned are multiyear periods with only irrigation season months (April-September), and both quantity/quality requirements setup at multiple points throughout hydro-systems.
Companion Modelling for Resilient Water Management: Gaming and Simulation to Integrate Stakeholders’ Perceptions for Collective Learning and Action

Author: Dr. Guy Trébuil
GREEN, CIRAD, France

Keywords: companion modelling, resilience, water management, multi-agent systems, role-playing game

Introduction/Problem Identification
Problems of collective water management are complex & have to be solved in rapidly changing, increasingly uncertain conditions. They involve stakeholders’ with differing knowledge base, interest & perceptions of the conflict. Building a common point of view on ecological & social dynamics through improved communication can stimulate collective learning & help to initiate mediation.

The Companion Modelling approach focuses on co-designing models used with stakeholders to integrate perceptions of such dynamics, share knowledge & simulate possible future scenarios. This constructivist approach facilitates inclusive negotiation leading to new coordination mechanisms, action plans & improved capacity for adaptive management in an uncertain world.

9 ComMod processes were implemented at catchment scale in diverse eco regions of the Mekong basin & Himalayan highlands to examine various water quality, irrigation, soil & water conservation issues. More at http://www.cpwf25.sc.chula.ac.th

Analysis/Results and Implications for Policy and/or Research
Multi-agent systems was used to build conceptual models, role-playing games (RPG) and associated computer agent-based models (ABM) in iterative and evolving collaborative modelling processes. The 12 steps of a full ComMod sequence are presented. The synergistic effects between the RPG and ABM tools were used to enrich and validate the co-designed models with the stakeholders and to run time efficient simulations of possible future scenarios of their choice. When relevant, tipping points were identified and used to build agreed upon indicators for the joint assessment of simulation results by the concerned participants.

The ComMod simulators are understood by the stakeholders, even those who did not receive formal education, and they were eager to use them to explore possible future scenarios of change. The two key tools, RPG and ABM, were used either separately or integrated in creative and flexible ways to tailor them to specific needs in different cases. The length of a full process varied depending on group dynamics and the more or less supportive institutional (community-based NRM in Bhutan) and policy (decentralization in Thailand) contexts. While the RPG is taken seriously by the participants and is very useful to enrich and validate conceptual models, the computer ABM (implemented with very similar features than the RPG) is more adapted to explore future scenarios and to communicate simulation results to larger groups of participants (out-scaling) or to decision-makers (up-scaling).

The nine cases studies showed that the companion modeling approach could be useful to examine collectively diverse conflicting problems in water management under different bio-physical, socio-economic, political and cultural conditions.
The role of the ComMod process designer is crucial and demanding as he needs to maintain a gaming and simulation atmosphere while managing social inequity and power relations that express themselves in the proceedings. ComMod processes facilitates resilient water management by helping people to learn to live with change and uncertainty, by nurturing diversity of opinions and practices, combining different types of knowledge for learning (researchers being considered as one kind of stakeholder among others), and creating opportunity for self-organization towards social-ecological sustainability (Folke et al. 2002).

ComMod processes facilitate resilient water management by creating and stimulating negotiation and action arenas where rules are discussed and agreed upon by their local users. Through such process the crafting of these rules is embedded in the local social and ecological context.

Diverse and more or less cumulative effects were generated along these ComMod processes. They range from individual learning about the current situation, increased awareness of a collective problem, improved communication among stakeholders, understanding each other’s perceptions, reaching a common agreement on the problem, exploration of new water management rules, implementation of new practices, and ultimately institutional innovation. ComMod participants have increased their adaptive capacity at both collective and individual levels. At the collective level they generated rules to manage the common resource and cope with external shocks such as the arrival of migrants or a dry period. At the individual level, for example, they formalized new behavioural patterns for cropping to be less dependent on the variability generated by other users and use of the resource.
Transformative Management for More Resilient Food-Producing Social and Ecological Systems

Author: Mr. Alain Vidal* et al.
* CGIAR Challenge Program on Water and Food, Sri Lanka

Keywords: livestock, sediment, nutrient flow, payment for ecosystem services, brackish water

Introduction/Problem Identification
The global food crisis can be summarised in terms of real lives on a global scale: there are 3 billion people below the poverty line of US$2.5 per day, 2 billion suffering from malnutrition, and 1 billion suffering from hunger. For the 75% rural poor that make up the majority of the 1 billion, alleviating hunger means reducing rural poverty, which in itself should be achieved by increasing farmers income and resilience of food-producing social-ecological systems.

Improved water management, both on quantitative and qualitative aspects is key to increasing resilience of such systems. Often neglected is the water quality that support food-producing communities. This keynote presentation shows, from three examples in developing countries, how the concept of resilience and regime shifts can be used to inform management about the potential of transformation of social and ecological systems to more resilient and productive states.

Analysis/Results and Implications for Policy and/or Research
The first case describes how research conducted in the Uganda cattle corridor, which covers the western third of Uganda, helped re-green the land and restore the water quality of reservoirs and gullies. Pastures were heavily degraded due to overgrazing; even though rainfall was potentially sufficient it all ran off. Termites had again and again destroyed efforts to reestablish pastures – they are all the emerging seedlings. The situation examplify a typical situation where the ecosystem had passed a seemingly irreversible threshold, and was unable to recover. Ugandan Animal Science researchers brought an idea from Ethiopia and convinced cattle holders in their community to corral their animals together at night so as to concentrate manure. Doing this for two weeks allowed the pasture seedlings to get established for the first time in many years of trying to replant. It turned out that the termites prefer to eat the manure, not the seedlings. Once pasture was established, rainfall infiltration was greatly improved, soil erosion is reduced and crops as well as pasture could be established.

Restoration of vegetative pasture grass cover, having controlled the termites resulted into more feed availability to animals for production; reduced surface water runoff and evaporation; prevented silting and sedimentation of the valley tank water reservoirs; thus preventing water degradation and improving water quality. The research team also found that plants of Nymphaea and Lemna species allow aeration which increases the efficiency of nitrification increasing nitrogen levels in the soil. Further more use of Lemna is particularly suitable because it reduces evaporative water loss up to 20% compared to open water sources and absorbs sediments. In response to the development of these technologies, local communities have passed by-laws to protect the riparian vegetation and water quality. Local livestock keepers are now investing their own resources in the development and maintenance of common property pasture and water resources. In terms of resilience analysis, this “re-greening of the Uganda cattle corridor” is a good example of how transformative management of can reverse a non-linear and seemingly unrecoverable evolution.
The second case describes how research on payment for ecosystem services in the Andes helped improve water quality for downstream users and resilience of upstream social and ecological systems. The Rio Ambato is a tributary of the Rio Paute, about 150 km south of Quito in central Ecuador. Communities managing a range of high altitude Andean production systems including multiple cropping and livestock (from about 3000 to 4500 masl) affect the water quality for municipal water supply and electricity generation in the city of Ambato, with an estimated population of 212,000. Agriculture and cattle raising have degraded the ecosystem specially the paramo (the high Andean alpine-like ecological zone, composed of high altitude wetlands) because of the expansion of the agricultural frontier. Changing from traditional agriculture methods to conservation agriculture, especially for potato production, was selected as a mechanism to decrease the sediment and nutrient flows. Relocating cattle to medium altitude improved the fertilization of cropland and allowed restoration of paramos which returned to their original role of buffering and filtering water in the upstream part of the basin.

A new local trust fund, financed so far by donations from the water and electricity utility companies and from the city council, has invested in conservation agriculture by upland farmers. It has also encouraged those upland communities to withdraw from use of vulnerable areas needed to maintain flow of quality water to urban areas. Further investment by utility companies in a reservoir will further reduce sediment flow to the city and also supply irrigation water to small farmers. Such mechanisms of payment for ecosystem services, by enabling “downstream users can pay upstream farmers for sending them better quality water”, and presently spreading in the Andean region, help reverse the non-linear degradation of those fragile land and water ecosystems, shifting them back to a “safe operating space” where they continue to provide their services to local communities.

The third case describes how improving the operation of sluice gates in the Mekong Delta has enabled brackish water to be used as a resource for farmers, and has helped restore the sustainability of the deltaic agro-ecosystem. In Vietnam, starting in 1990, investments had been made in the Mekong delta to increase rice production by the progressive introduction of sluice gates, intended to prevent saline water intrusion so that a dry-season rice crop could be grown after the main rainy season crop. This strategy backfired, however, in the western part of Bac Lieu province, where there is a predominance of acid sulphate soils unsuitable for rice production, and where saline water is needed for a highly profitable emerging brackish shrimp industry. In 2004, shrimp diseases had severely increased, and the area suffered from unbalance between fresh water river flows and salt water intrusion from the sea. Through availability of more sophisticated decision models, local government water management offices had the capacity to monitor water quality in their zones and modify sluice operations to ensure suitable (salty or fresh) water quality for areas under their control. A new zoning delineated land use zones with different patterns of fresh and brackish water supply. Some zones were designed to have fresh water all year round for rice and vegetable production. Other zones were designed to have fresh water in the wet season and brackish water in the dry season for rice-shrimp rotations. Still others have brackish water all year round for shrimp production.

Using a whole range of innovative components selected by researchers with farmers, individual farm households, in their turn, adopted and adapted new production systems with crops and aquatic organisms (shrimp, fish and crabs) to reduce production risks and increase income for the farmers of each zone to adapt to their needs. Examples included growing reeds in the shrimp fields to regulate pond temperature and reduce shrimp disease; multi-culture with shrimp and crab instead of shrimp monoculture; planting upland crops after two rice crops instead of three in fresh water zones; and using new short-season rice varieties. The Bac Lieu government changed its land-use policy from
encouraging monoculture rice to encouraging a diversified farming system of agriculture and aquaculture. It also adopted the recommended sluice operation procedures. More than 8,700 farmers had adopted the intensive production practices by 2006, contributing to the 15.7% growth rate of the province from 2003-6.

Those three examples are discussed in terms of their non-linear past degradation trajectories, identifying where tipping points occurred, and of how transformative management introduced by innovative approaches helped reverse the degradation trend and recover a more resilient state of the socio-ecosystem.
A Case Study – Benefit Optimization Modelling in Resolving Competing Interests among Cultural, Environmental, Social and Economic Well Beings

Author: Ms. Mangala Wickramanayake
Coast Conservation Department, Sri Lanka

Co-Author: Ms. Kusum Authukorale
Netwater, Sri Lanka

Keywords: cultural practices, environmental issues, community participation, decision making, benefit optimization

Introduction/Problem Identification
Lakes Rotorua & Rotoiti in Bay of Plenty Region, New Zealand are two major reservoirs in series at the head waters of Kaituna River Catchment. In the past the lakes provided beneficial storage for floodwaters and released them gradually. Though the lake storage eased flood problems in lower Kaituna River it caused high lake levels, flooding and poor drainage around the shores of Lakes in wet seasons. In 1962 & 1971 there was local flooding in both lakes. Due to public pressure the Catchment Commission had proposed to control lakes by a weir structure between Lakes (Ohau weir) and replace the rock ledge at the outlet of Lake Rotoiti with a automated gate control structure ( Okere gates). In 1982 the lakes became one of the most controlled lake systems in New Zealand; Lake Rotorua (200 mm) & Lake Rotoiti (150 mm). Though the change was very favourable for economic activities in Rotorua, cultural practices & environmental issues in Lake Rotoiti were adversely affected.

Analysis/Results and Implications for Policy and/or Research
The catchments of Lake Rotorua are the most heavily populated areas with extensive urban (Rotorua City) and recreational development along the lake shoreline within the past few decades. The catchments of Rotoiti are natural with pine forests. Hence Lake Rotoiti was an unpolluted lake and a source a fish supply to indigenous communities (Maori) and is considered as a sacred lake for their cultural practices.

Prior to installation of the structures the lakes fluctuated naturally, each over an average range of about 500mm. There was no lake level control on either Lake apart from the natural rock ledge at the Lake Rotoiti outlet. Although the gates construction is economically favourable for lake related activities pollution levels in Lake Rotoiti have risen due to the controlled water systems.

Lake Rotorua is circular in shape where as Lake Rotoiti has an elongated shape. Due to both inflow and outflow to Lake Rotoiti is at one corner, the residence time of the inflow waters to Lake Rotoiti from Lake Rotorua was very less as it released through the rock ledges. After the construction of the gates, water releases to Kaituna River much faster in rainy seasons as gates wide open to maintain controlled levels. Therefore although the water mass is large, pollution isn’t a big issue as the water get flushed out fast in wet seasons. However in dry seasons the residence time of the polluted water coming from Lake Rotorua becomes much higher, because water is stored to maintain the controlled levels in Lake Rotoiti and only the biota requirement is released to Kaituna River. As a result the pollution levels of Lake Rotoiti have increased in dry seasons and habitats are lost for ever. Also lake beaches are lost due to the limited fluctuation of levels.
The Resource Consents for operation of the two control structures are due to expire in June 2010. Under the Resource Management Act New Zealand, renewals of consent applications have to be lodged 6 months prior to expiry of the current consents.

Environment Bay of Plenty has initiated the Resource Consent process and carried out background technical investigations to review current structure operations, investigate alternative operating scenarios, and identify benefits and the disadvantages of the current and alternative operating regimes.

Investigations have included speaking with a number of interested groups, the community affected, and consultation with key stakeholders. While some stakeholders favour the complete removal of the gates and have natural climatic variations, it has been shown that the original pre-gate levels and flows could be achieved operationally with the gates in place. Most stakeholders support keeping the Okere Gates in place and developing an operational strategy that provides the most benefit to the wider community.

A model has been developed to equally consider cultural, environmental, social and economic well-beings. Performance indicators, measures and options for further discussion and refinement have been identified under each well being to balance benefits. All issues (indicators) related to lake control have been categorized under the four well beings.

The indicators identified under Cultural well being are; Maori funeral practices, cultural practices on lake beaches, food abundance & fishing practices. Indicators identified under Environmental well being are Lake Biodiversity, Lake Water quality, Lakeshore erosion, Wetland biodiversity, Fisheries, River ecosystem viability & Aquatic weeds. The Social indicators are Odour, Jetty access, Algal blooms, Swimming, Navigational issues, Septic tank issues, Road culverts & drainage issues. The economic indicators are Rafting, Aesthetics, Tourism, Hot pools, Road maintenance and Property values.

Extensive awareness programs were carried out through public meetings and news letters. All interested individuals and groups have been included to take the survey in identifying critical issues as per their interests. As a result of this survey a relative weighting percentage has been calculated for each indicator within the respective well being.

Thereafter a benefit optimization model was used with the relative weightings obtained as input data. The benefit optimization model was an iterative process which gives a rule curve to operate the gates which can satisfy most of the performance measures, thereby provide benefits for a wider community. Further, the optimization model gives a comparison of present, past and proposed scenarios for each indicator.

The overall cultural performance indicators will be improved from 0% – 70% under the proposed regime. Environmental indicators will be improved from 30% – 80%. Social indicators will be reduced from 90% – 60% & economic indicators will be initially reduced to 50% but later on improve up to 70% through the management practices proposed.
Workshop 8: Origins, Pathways and Accumulation of Pollutants – An Urban Perspective

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Urban Runoff as a Pathway for Transmission of Pollutants into Receiving Waters (Minsk, Belarus)

Author: Ms. Alena Aucharova
National Academy of Sciences of Belarus

Co-Author: Prof. Valery Khomich
National Academy of Sciences of Belarus

Keywords: urban area, main pollutants, snowmelt runoff, rainfall runoff, carryover of pollutants

Introduction/Problem Identification
Urban runoff quality and its impacts on receiving waters are a major problem for the sustainable development of Belorusian cities. Urbanization even at a low level of development (10% of the watershed area) exerts effect on receiving waters. Urban runoff is an important pathway for transmission of pollutants into receiving waters. Pollution of runoff is one of the integral indicators of the ecological condition on the urban area. It is clear that runoff quality depends on several factors, such as the climate, the land use, the population density and the type of sewer system (combined or separate). Furthermore runoff quality data collected in the same experimental catchment vary from one storm event to another, because of the characteristics of the event, such as the rain depth, rain intensity, rain duration and previous dry days.

Analysis/Results and Implications for Policy and/or Research
On the one hand, urban runoff is a source of receiving water pollution and degradation of surface water quality; on the other hand, urban runoff is subjected to pollution because of deicing agents application, pollutant emissions from mobile and stationary sources, polluted urban soils, household rubbish, etc. Such types of loads result in urban runoff pollution by heavy metals, suspended solids, oil products, polycyclic aromatic hydrocarbons, etc., as well contribute to transformation of chemical composition.

In 2008, according to our estimation the carryover of pollutant by urban runoff from Minsk area (213 square kilometers of drainage area) amounted to 1,492.5 tons of hydrocarbonates, 12,732.1 tons of chlorides, 311.9 tons of sulphates, 98.1 tons of nitrates, 4.9 tons of nitrites, 50.9 tons of ammonium, 562.9 tons of calcium, 92.2 tons of magnesium, 10,579.4 tons of natrium, 179.7 tons of potassium. In 2008 from Minsk area in whole was carried over 25,943.5 tons of solute substances and 11,420.7 tons of suspended solids.

It should be noted that the main part of chlorides and natrium (about 98 percent) was carried over by a snowmelt runoff. Contrariwise, about 93 percent of phosphorus transmission was related to a rainfall runoff. The discharge of hydrocarbonates was distributed in equal parts between a snowmelt and rainfall runoff. The contribution of a snowmelt runoff to the carryover of such main ions as sulphates, nitrates, calcium, magnesium, potassium was about 65 percent. In whole 95 percent of solute substances and 60 percent of suspended solids were carried over from Minsk area by a snowmelt runoff.
Assessment of Main Urban Pollution Sources by Means of Microbial Contamination Indicators and Toxicology

Author: Dr. Claudia Campos
Javeriana University, Colombia

Keywords: microorganisms, toxic substances, indicators, industries, domestic waste

Introduction/Problem Identification
Several pollution sources are found in towns and big cities of developing countries, where there is poor sanitation infrastructure. The contamination origin is from domestic and industrial discharges, including erroneous sewage distribution networks, slaughterhouse waste, agricultural activities and pluvial waters. In all cases the main pollution sources are associated with microorganisms of faecal origin and toxic substances which affect the environment and public health. A comprehensive assessment of water quality is untenable due to time and analysis costs, reason why the use of pollution indicators turns out to be a useful tool for assessing water quality. Predicting environmental and public health effects will certainly facilitate to proposal for alternative solutions.

Analysis/Results and Implications for Policy and/or Research
The Bogotá river is the main river basin of the city of Bogota, capital of Colombia. The basin receives water from households, industries, slaughterhouses, urban farms and pluvial waters, causing serious pollution problems to the river; affecting also its tributary rivers, wetlands and soils used for agricultural purposes. The city holds a wastewater treatment plant with a chemical assisted primary system that treats only the wastewater produced by two million inhabitants of a total of eight million. The systems have been monitored for 5 years by the use of faecal contamination indicators such as bacteria (fecal coliforms), viruses (somatic phages), parasites (helminth eggs) and toxicity with animal models (Hydra attenuata) and vegetables (Lactuca sativa) in order to evaluate contamination levels, its origins, and the effect over the environmental and public health. Based on these data alternative solutions to such problems may be proposed. The indicators levels of the water in rivers, wetlands and at the treatment plant are typical of residual waters, showing negative effects and the need to ensure measures to reduce radically water pollution.
Intelligent Sewers: A Stepping Stone to Sustainable Pollution Control from Sewer Spills

Author: Mr. David Evans
Arup, UK

Keywords: sewer flooding, intelligent design, control strategy, pollution control, wastewater infrastructure

Introduction/Problem Identification
Complying with the Water Framework Directive means that the UK will need to address the growing problem of our ageing sewer network and the issue of combined sewer overflow spills into the environment. Compounding this problem is the increase in the volatility of weather patterns that we have seen over recent years. A country that, historically, was more used to gentle rain is experiencing more frequent heavy rain without necessarily an increase in the annual levels of rainfall. Today, we find that we need to adapt our wastewater infrastructure to deal with changing precipitation patterns and the consequent increase in sewer flooding and associated pollution. In Wales this has been achieved through an innovative control strategy to maximise the usability and lifespan of existing sewers by re-directing flows within the network to reduce flooding and pollution.

Analysis/Results and Implications for Policy and/or Research
The amount of surface water in combined sewers is at least an order of magnitude greater than those for foul flows. Increases in rainfall intensity is thus having a significant impact on available hydraulic capacity in existing sewers. It is the dominant cause of hydraulic overload leading to surface flooding and pollution. In order to comply with stricter environmental regulations, the number of spills from sewers need to be reduced.

One water company in the UK has assessed the sewage unit flows, expecting flows to increase by at least 30% over the next 25 years. This increase is driven primarily by three factors:

1. New development;
2. The so called “urban creep” (the increase of additional paving and roofs adding to impermeable land which contributes to flows to the sewer networks); and
3. The increasing intensity in storms that is predicted to occur with climate change.

The sewers in Cardiff used to drain directly into the adjacent sea/estuary – a legacy from Victorian times. In the last 10 years, to meet stricter regulations, the flows to the sea were intercepted and passed to new wastewater treatment works. However, flooding to low lying locations in the city remained a problem. In some locations, flooding (and associated pollution) occurred every one to two years. This was particularly problematic for the local water company, Dŵr Cymru Welsh Water, who are required to ensure that properties or areas external to properties are protected from flooding for a 30-year event and are under pressure from the Environment Agency to reduce sewer flooding because of its detrimental impact on the environment.

Our goal was to create a solution to sewer flooding that would make the network more robust and deter frequent flooding and pollution. The control strategy we designed maximises the usability and lifespan of the existing sewer network, resulting in a significantly reduced flood risk and reduced operating costs. By contrast, traditional solution systems as implemented during the early years of the
environmental clean-up following the privatisation of the water industry, create additional capacity to store flood waters; a capital intensive and unsustainable infrastructure solution.

The design breakthrough came when we considered splitting the main catchment into a number of smaller sub-catchments. A solution emerged centering around developing local solutions and stitching them back together to form a whole managed catchment.

The key was the modus operandi; a control strategy was thus born – with the following underlying principles:

The sub-catchment solutions are based on gathering information on the behaviour of the sewerage system at strategic locations. We use this information to activate penstocks (gates) within the sewerage network to divert flows, optimising the use of the overall storage within the catchment.

Each sub-catchment has a primary control point. Robustness is increased by adding a secondary control in the event that the primary control was overloaded or failed. In addition, the control point in a neighbouring sub-catchment could be used in as a standby. This approach was defined by what we have termed the control algorithm.

The control algorithm is a fully automated system. Actual water levels in the sewers (or, in some cases, the rate of rise of these levels) will feed the algorithm to determine the openings of individual penstocks. This ensures that the levels throughout the catchment are controlled to prevent flooding from the main trunk sewers during storms, with return periods up to 1 in 30 years.

The control strategy is designed to automatically prevent flooding from the trunk sewers in the event of a 1 in 5 year return period storm. It will also prevent or manage the risk of flooding up to the 1 in 30 year return period event.

The benefits to society are clear; the scheme helps to reduce pollution spills from overloaded sewers and alleviates the misery associated with sewage flooding to houses and back gardens. It works by distributing flows around the sewer network and thus optimising storage use. When this full, there is over-spill to local watercourses. However, the amount of over-spill is far less than that prior to the implementation of the scheme.

If the UK is to meet the requirements of the Water Framework Directive in the most sustainable and cost effective fashion, innovative solutions such as the Cardiff East control strategy will need to be replicated across the United Kingdom and perhaps the world.
Substance Flow Analysis for Selected Priority Pollutants in Stockholm, Sweden

Author: Dr. Arne Jamtrot et al.
City of Stockholm Environment and Health Administration, Sweden

Keywords: substance flow analysis, priority pollutants, source identification, environmental distribution, water framework directive

Introduction/Problem Identification
The ScorePP project (Source Control Options for Reducing Emissions of Priority Pollutants) was a European Specific Targeted Research Project aiming to develop comprehensive and appropriate source control strategies that stakeholders can employ to reduce emissions of the priority pollutants (PPs) for which Environmental Quality Standards have been adopted.

One topic within the ScorePP project has been to analyse the flows of selected PPs in case cities. The objective of this paper is to describe and analyse substance flows in one case city (Stockholm, Sweden) for selected PPs: di(2-ethylhexyl)phthalate (DEHP), cadmium, mercury, benzo(a)pyrene (B(a)P) and pentabromodiphenyl ether (PentaBDE). This was done by using information on sources, environmental distribution and fate at wastewater treatment plants collected in the project. The results were compared to monitoring data from WWTPs, thus evaluating if the collected data can be used as a basis for calculating flows of PPs in cities.

Analysis/Results and Implications for Policy and/or Research
The major sources to water and wastewater systems identified and quantified in the Stockholm SFA were:
DEHP: Abrasion particles (“waste in the environment”), floor and wall coverings, coated textiles and lacquers and paint.
Cadmium: Long range transport, car wash, artist paint and food.
Mercury: Dental clinics and human excrements (due to amalgam fillings)
B(a)P: Domestic greywater.
Penta(BDE): Abrasion particles from polyurethane articles.

The identified sources include use of articles and materials rather than industrial production activities. This means that releases can not easily be dealt with by traditional mitigation options like legislation, since the pollutants will remain in the accumulated products in the technosphere several years after they have been phased out from production, and will continue to be emitted from them.

The results from the SFAs are generally in reasonable agreement with the findings of the monitoring at the WWTPs in the city. The major discrepancies are explained by

Limitations in data availability: For some of the sources identified in the emission string database it was not possible to find release factors. If so they could not be included in the SFA, and the calculated values were underestimated. Likewise, for some sources a release factor was reported in the database, but the local information to which the factor was to be related when calculating the release could not be obtained.
Simplifications in calculating the redistribution: Releases to air may to some extent be deposited within the city, and thus act as releases to soil and stormwater. This has not been taken into consideration by the SFA. The fate at WWTPs is sometimes based on model calculations which in turn are based on physico-chemical properties, and may not in detail reflect the real situation in the treatment process.

The emission string database developed in the ScorePP project may serve as a valuable source of information when performing a substance flow analysis for a European city. However, for calculation of loads in a specific city, there is need for local information and adjustments of the data, which may limit the possibilities to get a full quantitative description. There is also a need to handle the results with care and judgement, since some release factors are based on old or only a few data. Still the approach gives a good overview of potential sources of priority pollutants. Such information will serve as guides in the development of source control strategies for the reduction of priority pollutants in urban catchments, in order to meet the Water Framework Directive.
Fate of Emerging Pollutants in Soils from Thetula Valley Irrigated with the Untreated Wastewater from Mexico City

Author: Dr. Blanca Jimenez* et al.
* Universidad Nacional Autónoma de México

Keywords: emerging pollutants, irrigation, aquifers, soil, wastewater

Introduction/Problem Identification
This report contains the results of emerging pollutant transportation and fate in the Tula Valley. In an area which has been under irrigation with wastewater for 110 years several research studies have been performed to assess emerging pollutant concentrations in wastewater, soil and water sources. The fate of pollutant depends on the nature of the compound involved, the pathway of introduction to the valley and the type of soil pollutants will be differently distributed. Most are removed and retained on soil and secondly in water through a complex interaction of natural attenuation mechanisms involving dilution, sorption, biodegradation, photolysis and precipitation. Comparing with their content and variety in the wastewater, the remaining concentration of emerging pollutants is could be considered as non significant. Nevertheless, due to the constant introduction of these compounds to the environment could overpass the natural depollution capability of the Tula Valley.

Analysis/Results and Implications for Policy and/or Research
Increasing urbanization worldwide is augmenting the volume of untreated and treated wastewater. These effluents need to be disposed of into the environment and contain a new generation of micro-pollutants commonly known as emerging pollutants. Wastewaters are the most common source of these compounds and this has created several concerns among scientists and policy makers dealing with water use, for example:

a. the reuse of water for human consumption intentionally or not
b. the reuse of wastewater for irrigation and when aquifers are recharged indirectly through this activity
c. in soil-aquifer treatment systems
d. when aquifers are intentional recharged in order to increase water sources
e. The need to change the concept of wastewater disposal to that of reintegrating used wastewater into the environment (Jimenez, in press).

This panorama poses a new challenge to environmental scientists as previous situations have considered the removal, fate and transport of what can be termed conventional pollutants not this disparate mixture of many classes of compound with widely varying properties that have been labelled as emerging compounds. To contribute to set research needs it is important to review what we know and what we do not know concerning emerging pollutants especially with respect to their fate and transport, which ultimately will define risks. The major limitation for this is the lack of laboratory data concerning the presence of emerging pollutants in the environment, and more specifically their transport and fate (determined by similar analytical procedures) in a specific region and over period of time.

The Tula Valley is an area located to the north of Mexico City (a megacity of 21 millions people) -and receives 90% of the untreated wastewater from the city where it is used for agricultural irrigation. The wastewater follows a complex pattern of flow and is applied directly to crops after having
been conveyed in open channels and rivers or stored in dams. After soil application water infiltrates through the soil, subsoil, and the bedrock, and is recovered in wells, dug wells and springs for human consumption. The circumstances in the valley are the opposite of a small, highly controlled laboratory experiment and allows a large scale study on the fate of emerging pollutants over an entire region. In fact, this site has been the subject of research by different groups and this report summarizes information from these studies. Data contained in this report is of interest to both developed and developing countries because it sets out a first approach on the fate and transport of emerging pollutants contained in treated and untreated water. In both cases results may assist in putting in perspective the fate of emerging pollutants, notably when:

a  Wastewater is reused for human consumption through indirect methods;
b  MARs (managed aquifer recharge systems) are used as a method to increasing drinking water supplies;
c  Untreated or treated wastewater is disposed of / reintegrated to the environment though soil instead of water sources.

Additionally, the strength and reliability shown by soil and aquifers to control pollution should be a trigger to increase that knowledge and to promote policies to better use under controlled conditions as well as a new tool to install additional barriers to a multibarrier approach – that has proven to be effective and reliable for conventional pollutants and emerging contaminants.

Organic contaminants can be introduced into soils in various ways, for example from atmospheric deposition, from soil amendment with sewage sludge and of course from reuse of wastewater for irrigation of agricultural land. Nevertheless, it is important to understand well the fate of these contaminants because, in addition to their presence possibly affecting the health of the soil directly persistence as well as adsorption properties will determine which are likely to pose a risk to groundwater. This is important not only for developed countries where the reuse of treated wastewater for agriculture is increasing but also for developing countries where untreated wastewater is used on nearly 10% of the total area irrigated worldwide.

The present study will show that through the use of wastewater to irrigate and during its transport and application in soil, emerging pollutants are removed but as well will show that they tend to accumulate slowly in the environment.
Evaluation of Nutrients Loads from Urban Areas: Case Study from the Neman Drainage Basin

Author: Dr. Alena Kalmakova
Belarusian State University

Keywords: rivers, nutrients loads, water quality, urban areas, Neman drainage basin

Introduction/Problem Identification
This paper is devoted to the identification of human pressures from urban areas into surface waters at belarusian part of the Neman drainage basin. The aim of our investigation is to evaluate nutrient loads including surface overflow from urban districts and pollution emissions from wastewater treatment plants. The pollution load is determined as a difference between pollution input (upstream of urban areas) and pollution output (downstream of urban areas). Using of the proposed method allowed us to evaluate significant human impacts on watercourses at the basin before the deadline set by the EU-WFD.

Analysis/Results and Implications for Policy and/or Research
In the investigation the data from 24 hydrochemistry stations were used. Data on mean months run-off, volume of wastewater discharge and months concentrations were needed to the estimation of months and annual polluted run-off. Ammonium, nitrites, nitrates, phosphates, total phosphorus were used as the researched contaminants. Calculations of removing contaminants were made for the period from 1981 till 2008. The analysis of such long research period gave us the opportunity to indicate the trends of the changes of human pressures and surface water quality in urban areas.

The input of nutrients into watercourses from urban areas for the period of hydrochemistry observations was evaluated (table).

<table>
<thead>
<tr>
<th>Periods</th>
<th>NH₄⁺</th>
<th>NO₂⁻</th>
<th>NO₃⁻</th>
<th>PO₄³⁻</th>
<th>Total P</th>
</tr>
</thead>
<tbody>
<tr>
<td>1981-1985</td>
<td>635</td>
<td>157</td>
<td>1735</td>
<td>226</td>
<td></td>
</tr>
<tr>
<td>1986-1990</td>
<td>1098</td>
<td>107</td>
<td>2299</td>
<td>317</td>
<td>1188</td>
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<tr>
<td>1991-1995</td>
<td>1168</td>
<td>60</td>
<td>1979</td>
<td>104</td>
<td>1343</td>
</tr>
<tr>
<td>1996-2001</td>
<td>672</td>
<td>87</td>
<td>1620</td>
<td>47</td>
<td>123</td>
</tr>
</tbody>
</table>

The study indicates that rapid growth of urban areas and population, intensive industrial production are the main culprits of surface water contamination. The tendencies to water quality deterioration in 1980-s and improvement in 1990-s due to the changes of demographic load and industrial pressure were determined. The correlations between the population density, the drainage area and pollution loads were found. Attention was focused on the priority of contaminants in accordance with the technological specifics of industrial activity in the urban areas.

Pollutants are generated from a wide range of sources, including industry sector, traffic, buildings and other infrastructure. It came to a point that ¾ of phosphates and more than ¼ of nitrogen load get into the rivers from point sources in urban areas. The cities Grodno and Mosty in Neman basin...
presents the greatest environmental risk. The problem of pollutants transmission is especially important because of the near state border with Lithuania. At the middle water content years the output of nitrogen from belarusian part of the Neman river basin to Lithuania is about 7857 t/year, total phosphorus – 528 t/year.
Evaluating the Impacts of Sanitation Options on Urban Water Quality by Using the Material Flow Analysis Method: Case of Fada N’Gourma, Burkina Faso

Author: Dr. Halidou Koanda* et al.
* CREPA, Burkina Faso

Keywords: groundwater, sanitation, impacts, pollution, MFA

Introduction/Problem Identification
Fada N’Gourma is a small commune of 40,000 inhabitants located in the eastern part of Burkina Faso in West Africa. The current sanitation status is characterised by 78% of simple pits, 5% of septic tanks, 10% of open defecation and 20% of soak pits. According to the strategic sanitation plan, households will be equipped by 78% of VIP, 8% of septic tanks, 9% of pour-flush with infiltrating pits, 2% of open defecation and 30% of soak pits. The solid waste are collected door-to-door by local women NGOs and discharged in the environment without treatment. The rainwater is drained by few open channels and discharged in the water dam located in the city centre. The water supply service covers 59% of the population.

In this article we describe how the material flow analysis (MFA) can be used as a tool to evaluate the environmental “friendship” of sanitation options. MFA studies the flows of resources used or transported by several processes within a system border.

Analysis/Results and Implications for Policy and/or Research
The laboratory analysis show that the nitrate content is 8.93 mg/liter in greywater, 6.35 mg/liter in sludge of septic tanks and 7 mg/liter in faecal sludge. The wastewater is contaminated by E.coli as well as the water in the simple wells constructed and used by families.

The model shows that the options of the strategic sanitation plan will increase the water consumption by flushing, and will not impact the rate of reuse of nitrogen on city scale. Each year, an inhabitant of Fada rejects approximately 3 kg of nitrogen in the groundwater. In fact, there is no treatment of wastewater and no reuse of nutrients. Consequently, the groundwater is contaminated by pollutants (chemical and bacteriological) as revealed by laboratory analysis of wastewater and groundwater samples.

The results show that the options can be improved by introducing new technologies which favor nutrient recycling/recovering such as co-composting solid waste with dried faecal sludge, soak pits and tight latrines, and urine diverted toilets. Introducing urine diverted toilets in rural and peri-urban areas of the commune, urine and feces are collected separately and hygienized for reusing in agriculture, the water consumption for flushing will decrease and the groundwater pollution will decrease if latrines are constructed out-ground. This can contribute to solve groundwater pollution problem. Our study confirms the feasibility and relevance of Material Flow Analysis method in the context of developing countries. It is on using in combination with economical models for developing sanitation options for other small cities of the country. With this combined method, we can ensure that households can afford for the proposed sanitation options and with reduction of the environmental impacts. It is also important in the context of water scarcity (Sahelian country) to save water resource by reducing the water consumption for flushing the toilets.
Media campaigns, quality control of drinking water (from wells) and infrastructures are necessary to minimize health risk and groundwater pollution by the on-site sanitation facilities. This can be achieved if the capacities of the local actors specifically the municipal authority are reinforced in planning and monitoring processes.
Distribution and Sources of Polycyclic Aromatic Hydrocarbons in the Mediterranean Lebanese Seawater

Author: Ms. Abir Kouzayha* et al.
* LAEC-CNRS, Lebanon

Keywords: PAH, Mediterranean, Lebanese surface seawater, solid phase extraction SPE, GC MS

Introduction/Problem Identification
Polycyclic aromatic hydrocarbons (PAHs) are globally distributed environmental contaminants which attract considerable concern because of their known toxic and bio accumulative effects in aquatic organisms and their serious health risks for humans including cancer and DNA damage. Several sources affecting the presence and distribution of PAHs in the marine environment, such as petroleum contamination due to large oil spills accidents and oil discharges from ships, fallout from air pollution and terrestrial runoff. The Lebanese coastal zone presents 13 pollution hot spots according to the European Environment Agency EEA. Domestic and industrial wastes are discharged directly into the sea in the major coastal cities. Maritime transport is also a main source of petroleum pollution. The aims of this work is to study for the first time the distribution of PAHs in the surface seawater along the Lebanese coast in the eastern part of the Mediterranean basin, and to recognize their sources.

Analysis/Results and Implications for Policy and/or Research
An analytical procedure based on extraction by solid-phase extraction (SPE) on C18 cartridges followed by gas chromatography–mass spectrometry (GC–MS) analysis has been developed and applied to the determination in seawater samples of 15 PAHs classified as priority pollutants by the United States Environmental Protection Agency US EPA (10). Recoveries and standard deviation of PAHs in spiked tests were above 70% and less than 20% respectively. This study was carried out between January 2009 and April 2009. The sum of the 15 PAHs measured in the surface seawater were found in the range of 35-50 ng.L-1 at the most polluted sites located in south Lebanon and ports, and in the range of 3-12 ng.L-1 at the other sites. Although comparative data on the occurrence of PAHs in the dissolved phase in seawater are few in the literature and intercomparison studies of PAH analysis are relatively poorly developed, the values measured can be considered as relatively moderate levels in water in comparison with those reported for marine systems around the Mediterranean. PAHs composition was dominated by two-, three- and four-rings compounds. The absence of heavy PAHs is indicative of the strong binding of these PAHs to the dissolved or solid matters and their low seawater solubility. Diagnostic interpretation of the distribution of certain PAHs in seawater such as phenanthrene PHE / anthracene ANT and fluoranthene FLT / pyrene PYR ratios has been used to distinguish the possible pyrogenic or pyrolytic sources of pollution in the sea. The ratio of FLT/PYR <1 was usually attributed to petrogenic source, while FLT/PYR >1 was suggested to indicate pyrolytic sources. The ratio of PHE/ANT <10 was usually regarded as an indication of pyrolytic sources, while PHE/ANT >10 was mainly from petrogenic source. Based on these ratios, it could be seen that seawater was mainly contaminated by petrogenic PAHs in some sites and by pyrolytic PAHs in other sites. In addition, it also could be observed that the occurrence of PAHs may originate from both pyrolytic and petrogenic sources in some sites.
The Occurrence and Reduction of Priority Substances and Heavy Metals in Storm Water

Author: Dr. Thomas Larm et al.
Sweco Environment, Sweden

Keywords: storm water, priority substances, environmental quality standard, dissolved heavy metals, treatment facilities

Introduction/Problem Identification
The concentration of human activities in urban areas has lead to an extensive use of materials containing heavy metals and organic chemicals. This has resulted in spreading of these substances to the aquatic environment using storm water as one of the pathway. As a measure to remove these pollutants from European water bodies, 33 chemical groups have been listed as Priority Substances for elimination by the European Water Framework Directive (WFD).

Many storm water treating facilities have been evaluated regarding concentrations and reduction efficiency of the total fractions of nutrients, heavy metals, suspended solids, oil and PAHs. There is still a lack of knowledge considering the occurrence, concentration and reduction efficiency of WFD priority substances, dissolved fractions of metals and PCB. There is a need of better understanding of these substances in storm water and in receiving waters.

Analysis/Results and Implications for Policy and/or Research
The aim of this seminar is to present unique results from storm water sampling. The aim of this study was to increase the knowledge of the occurrence of priority substances, PCB and dissolved fractions of heavy metals in storm water. The objective was also to evaluate the reduction efficiency of these substances in wet ponds. Another purpose was to compare analyzed concentrations to the WFD Environmental Quality Standards (EQS) for surface water. These standards were used because of the lack of reference data on these substances that are specific for storm water. Furthermore, the total concentrations of heavy metals were compared with the Swedish Proposed Quality Standards for storm water.

Method
This study has been given unique sampling possibilities for evaluating the occurrence of priority substances, PCB and dissolved fractions of heavy metals by flow proportional storm water sampling at the inlets and outlets of two wet ponds. The two wet ponds that were investigated, Ladbrodammen and Tibbledammen, are situated in two communities north of Stockholm, Sweden. Ladbrodammen has a catchment area of 201 hectares and a runoff coefficient equals 0.31. 70% of this area consists of urban areas. The catchment area of Tibbledammen is 649 hectares and the mean runoff coefficient equals 0.17. 40% of this area consists of urban areas.

Samples were taken automatically and analyzed every two or four weeks during a whole year in the inlet and outlet of the wet ponds. Concentrations of detected priority substances and dissolved fractions of heavy metals were then flow weighted to arrive at annual mean concentrations and compared to the EQS for Annual Average (AA) and Maximal Allowable Concentration (MAC). The total concentrations of heavy metals were compared to the Proposed Quality Standards for storm water outlets. Then the inlet and outlet concentrations of all substances, that were detected more than five times, were compared to each other to calculate the mass reduction efficiency.
Results

Priority substances and PCB were detected in both studied ponds.

There were 34 detected of 84 analyzed substances in pond Ladbrodammen. 24 of them were detected five or more times. Monobutyltin, nonylphenol, PCB 28, PCB 52, PCB 101, PCB 118, PCB 153 were the most frequent occurring substances, detected in ten or more samples. Diuron, DEHP, nonylphenol, PAH, monobutyltin (MBT), dibutyltin (DBT), tributyltin (TBT) and tetrabutyltin occurred in concentrations above AA-EQS and/or MAC-EQS in both the inlet and outlet of Ladbrodammen. The reduction efficiency for DEHP and nonylphenol was negative while PAH, tinorganic compounds and PCB were reduced with 70-90%.

There were 29 detected of 84 analyzed substances in pond Tibbledammen. Nine of them were detected five or more times. DEHP, nonylphenol, MBT, DBT, TBT and two PAHs occurred in concentrations above AA and MAC-EQS in the inlet and/or outlet of Tibbledammen. As in Ladbrodammen the reduction of DEHP and nonylphenol was negative. A reduction of the other substances occurred even if some concentrations still were above the quality standards.

The concentrations and amount of total and dissolved fraction of heavy metals varied between the two ponds. Cu, Pb and Zn are metals that occurred in total concentrations above the Proposed Quality Standards for storm water in the incoming water to the wet ponds. This shows that there is a need of treating the storm water. All outlet concentrations were lower than the proposed standards.

The analyzed dissolved fractions of heavy metals in the outlets of the two ponds were also compared to the WFD EQS. There are standards available for Cd, Hg, Ni and Pb and the concentrations were below the standards by a comfortable margin for all parameters.

The treatment effect of the total amount of Al, As, Ba, Cd, Co, Cu, Cr, Hg, Ni, Pb, Zn, Sb and W were overall between 30-80% in both Ladbrodammen and Tibbledammen. The reduction of the dissolved fractions of these substances was lower, but there were still an overall measurable separation.

Conclusions

This study gives a great contribution in gathering data on the occurrence of priority substances and dissolved fraction of heavy metals, as well as the functioning of wet ponds as treatment facilities for urban storm water. It was shown that storm water definitely functions as a pathway for priority substances from urban areas to receiving waters. It has been shown that wet ponds may be used for prevention and effective measures against the spreading of priority pollutants to downstream areas. These functional and naturally adapted solutions for storm water treatment are good examples that may be implemented by communities while adapting to urbanization. This study and its results may be of great importance in accomplishing a non-toxic environment in streams, lakes, coastal areas and seas in all developing countries.
Applying Pervious Concrete to Reduce Pollutants in Urban Storm Water Runoff

Author: Mr. Gregory Majersky
Liquid Asset Development, LLC, USA

Keywords: sustainable, pavement, storm water, runoff, pollutants

Introduction/Problem Identification
Urban water pollution, typically in the form of surface runoff accumulating solid and liquid pollutants, has come under greater scrutiny as the world seeks to address the alarming deterioration of global water quality. Rain water is typically slightly acidic (more so in urban environments) but otherwise clean. When it comes into contact with urban surfaces, it can dissolve, transport accumulate a wide variety of metallic, organic, solid, liquid and micro-organism pollutants. The sources are diverse in the urban environments: automobile solids and liquids, concrete, asphalt, dust, food waste and resulting products of decay in dumpsters, human and animal waste, legal and illegal refuse, etc. Mitigation is difficult due to the complexities of enforcing refuse laws and the constant emission of various pollutants and treatment is difficult due to the many, small point sources of discharge, such as storm drains and leakage from pavement near surface waters.

Analysis/Results and Implications for Policy and/or Research
The following is a summary of laboratory and field results to date.
EPA People, Places, Prosperity (P3) grant:
- Well over 99.99% removal/neutralization of Micrococcus luteus bacteria. Influent concentrations were high enough to require measurement as TSS.
- 65%, 70% and 99% removal of copper, sodium and iron nitrates, respectively. Iron in the effluent was visible as an orange precipitate.
- % removal of copper declined as concentrations increase from 0.13 mg/L to 130 mg/L, there is suspicion that the lab reported the samples in reverse.
- % iron removal stayed fairly constant at or near 100% as the concentration increased from 5 mg/L to 500 mg/L.
- % sodium removed decreased with each trial, while the influent concentration stayed the same at 35000 mg/L
- Reaction rates for all three metals decreased as concentrations increased. Average increase of DO of 1.8 mg/L, average temperature reduction of 1 C.

Colorado State University Bangladesh flood simulation competition:
- U. of Colorado Denver, Colorado State U., New Mexico Tech, Texas Tech and U. of New Mexico all involved.
- Simulated flood waters containing motor oil, rice, kaolin clay, anchovies, cotton and Miracle Grow fertilizer
- Motor oil may have interfered with the removal of nitrogen, TKN was slightly higher than the other systems.
- Oil did cling to the filter slightly, the oil in the effluent was frothy and very light in appearance. Considerable precipitate was at the bottom of the collection vessel.
- Total phosphorous removed was 66% to 73% greater than competing systems. This is key in light of potential “peak phosphorous” problems.
• DO increase was less than other systems most likely due to oil and clay.
• pH of effluent was 11 vs 7 for other systems.
• All other systems required 4-6 people to assemble and were large. I was able to carry the filter unit by myself and sit it on a 2”x4” piece of wood while in operation.
• This filter was 75% smaller by volume than the P3 filter.

• The filter used in this experiment was the same size as that used in the Colorado State U. competition.
• 60%, 74% and 85% removal of sodium, zinc and iron, respectively.
• Over 60% of sulfate removed or reduced.
• It was noticed that some of the metal sulfates clung to the plastic 10 gallon (38 L) container walls even after being washed with soap and distilled water.
• pH in the distilled water was correctly prepared to be a pH of 5, in keeping with the pH at the actual mine site. The addition of metal sulfates lowered the pH to 2.7.
• The reaction rate differences between dissolved and total metals did not differ significantly, by 0.001/sec for zinc and sodium, 0.045/sec for iron.
• Hydraulic breakthrough appears to have occurred in the 5th hour. It is expected that the effluent concentrations would remain stable until the portland cement is sufficiently eroded or armored. Most likely these two processes would occur in unison.

Honduras field experiment:
• It is suspected that the bottled water is only treated for organisms.
• Due to geologic activity, arsenic is ubiquitous in the environment. Arsenic and barium would also be ingested through vegetables and meat, as untreated water is used for irrigation and animals.
• Conducted in the cities of Villenueva and La Lima.
• Arsenic at Villenueva and La Lima at concentrations near US and EU maximum contaminant levels.
• No coliforms were present in some tests, in others, extremely large colony counts were observed.
• 25% removal of arsenic in the initial tests.
• Sodium, magnesium, manganese, iron, copper, zinc and arsenic were reduced by 4.76%, 2.74%, 66.25%, 50.00%, 56.25%, 66.67, and 24.75% respectively. The differences in performance versus the larger EPA P3 and AMD filter units are as follows (substance, % less than EPA P3, % less than AMD): Sodium, 58.46%, 72.79%, Iron, 45.83%, 49.86%, Copper, 3.29%, Zinc, 9.93%.
• Salts, most likely metal sulfates in a geologically active region binding to plastic effluent containers despite being washed with soap and bottled water. This behavior was also noted in the acid mine drainage laboratory experiments.
• The office manager informed us that the samples would be tested as a batch and may sit for 1-2 weeks. This is evidenced by the lower pH of older samples as the water moved back towards equilibrium and the relatively high pH of more recent samples as well as the extremely high coliform counts when some organisms did get through the filter. The organisms would have had sufficient heat and nutrients in the sample containers to reproduce while waiting to be analyzed.
• Recent research in the US by the concrete industry has shown that pervious concrete can collect car based pollutants in parking lot structures. The introduced research reinforces filtration applications.
Identifying Origins of Pollutants in Urban Stormwater: A Prerequisite for Developing Pollution Source Controls

Author: Dr. Jiri Marsalek
National Water Research Institute, Environment Canada

Keywords: urban stormwater, pollutant sources, heavy metals, pollution prevention, source controls

During the past 45 years, researchers identified more than 600 chemicals in runoff from urban areas, but only a small fraction (~10%) of these could be described as pollutants occurring at the levels that could potentially cause human health or aquatic life effects. The list of pollutants transported by urban runoff is not limited just to the chemicals, but also includes solids, micro-organisms, and waste heat. Origins of these pollutants are of great interest, because past research indicates that pollution control measures applied at or near the source are highly practical and cost-effective, when compared to other measures, such as the containment and removal of pollutants after their dispersal in the environment.

In urban areas, the three main sources of pollutants are (a) Atmospheric deposition, (b) Catchment surface, and (c) Urban land use activities. Dry atmospheric deposition represents the materials landing on urban surfaces; wet deposition includes particulates and dissolved chemicals resulting from scavenging of the air by rainwater drops. The main source of deposition is air pollution transport, from both local and remote sources. An example of atmospheric deposition of polycyclic aromatic hydrocarbons (PAHs) from a local industrial source will be discussed.

The catchment surfaces release pollutants during wet weather, when dry deposits are eroded by rainfall drops as well as the overland and gutter flows. The strength of this source of pollution depends not only on the pollutant availability, but also on the transport capacity of runoff, which in turn is controlled by rainfall characteristics. Generally, high rates of erosion may occur on unprotected bare soil surfaces, particularly during construction activities. To mitigate such erosion, sediment and soil erosion controls are applied. In the current modelling practice, removal of sediment and chemicals from surfaces is described for soils by the Universal Soil Loss Equation adapted to urban conditions and by various wash-off equations for materials accumulated on impervious surfaces. In the latter case, pollutant availability is considered and two situations may occur: (a) Mass-limited wash-off and (b) Transport-limited washoff. It has been recognized that sediment or total suspended solids production in urbanizing catchments greatly exceeds that in natural undisturbed catchments (by two orders of magnitude), but as the urban catchments mature and their surfaces become better protected, the annual sediment yield drops down and can be even lower than in the predevelopment catchment.

In the last category, land use activities represent such sources as those related to residential properties (garden chemicals, grass clippings, litter, pets), open spaces/parks (pesticides), traffic (heavy metals, oil & grease, PAHs, spills), winter road maintenance in cold climate (sand and salts), attrition/wear/corrosion/elution of chemicals from urban structures and construction materials, and sediment/soil deposits. Concerning various pollutants, much attention focused on heavy metals, chloride, micro-organisms, and lately on waste heat. Extensive studies indicate that heavy metals originate primarily from traffic and structure/building materials (e.g., metal roofs, galvanized surfaces of bridges, safety barriers, and sign posts). With respect to traffic, the sources of individual metals were identified: Cd – tires and brakes; Cr – car frames and tires; Cu – brakes and tires; Fe – frames and litter; Pb – brakes, tires, wheel balancing weights, and fuel; Ni – brakes and tires; and, Zn – frames, brakes and tires. In cold climates, high use of road salts in winter road maintenance (millions of tones annually) causes
environmental concerns about toxic levels of chloride in road snowmelt and winter runoff. The main sources of pathogenic micro-organisms impacting on urban recreational waters are pets and wildlife (birds). Finally, waste heat is conveyed in summer months by runoff from hot impervious surfaces and causes thermal impacts on receiving waters, with eventual succession from cold water species to less desirable warm water species.

A good understanding of sources of pollutants in stormwater runoff contributed to the development of source controls. Examples of successful source controls include: (a) Phasing lead out of gasoline (reducing lead concentrations in highway runoff by 1-2 orders of magnitude), (b) Substitution of materials in brake pads (brake pads used to be a major source of Cu in road runoff; not anymore following material substitutions), (c) Banning lead weights for car wheel balancing (lost weights were pulverized by traffic and Pb entered runoff); (d) Reducing road salt use in winter road maintenance (promoting smart salting leading to lower application rates and using substitute de-icers in salt-sensitive areas); (e) Public awareness / education / participation programs emphasizing the need for source controls (e.g., taking care of pet faeces, responsible use of home and garden chemicals, banning cosmetic pesticides, recycling); (f) Protective coating of metal surfaces to avoid elution of heavy metals (e.g., protective coating by plastics eliminates zinc export from zinc roofing materials); (g) Development of self-cleaning concrete with TiO2 nanoparticles (promotes photocatalysis contributing to oxidation of some organic contaminants and inorganics); and, (h) Near-source controls – street sweeping.

In summary, studies of sources of pollutants in urban stormwater continue to attract attention, because their findings contribute to pollution prevention and the development of new source control methods greatly improving stormwater quality.
Urban Runoff On-site Treatment by the Innovative Treatment Technology Contributing to Non-point Pollution Control, Peak Cut of Flooding, and Reuse

Author: Prof. Saburo Matsui* et al.
* Kyoto University, Japan

Keywords: urban runoff, up-flow filtration, porous polypropylene (PPL) media, heavy metals, PAHs

Introduction/Problem Identification
Urban road-runoff brings many pollutants into water courses, which originated from variety of human activities including air pollution, dust discharge from housing, traffic exhaust gas and oils, and wear of tires and asphalts, etc. Pollutants are either dissolved or particulate-bound. The first flush of road runoff can harm the ecology of receiving environment, and then more extensive rainfall would have less impact due to the large dilution of pollutants in the road run-off. A possible abatement of pollutants from road-runoff is installation of an on-site treatment facility at each sink of road, by which each event of run-off can be treated and stored for peak cut. It is introduced in this paper an innovative on-site treatment technology which eliminates effectively and economically small size SS that adsorbs many types of pollutants including COD, BOD, T-N, T-P, oil, heavy metals, polycyclic aromatic hydrocarbons (PAHs), etc.

Analysis/Results and Implications for Policy and/or Research
Whole road-runoff was collected to the device and the amount of runoff equivalent to 10 mm/hr was treated. The runoff amount above the equivalent was passed in the way of overflow in the device. The treatment method consists of a sedimentation process, an up-flow filtration process and a post-sedimentation process. Treated water was discharged into the existing storm drain pipe. In the treatment device, the cylindrical filter column had dimensions of 30 cm diameter and 50 cm high, and polyethylene mesh (opening: 500 um) was set at each end of cylinder to hold the treatment media. Polypropylene (PPL) particles of 1~3 mm diameter were filled as filter media. The head loss by the PPL media was almost negligible, since the apparent density and the bulk specific gravity were 0.65 g/cm³ and 0.2, respectively. At eight rainfall events between October 2000 and January 2001, the samples were collected at the inflow and outflow collection sections of the treatment device. The total amount of rainfall and maximum intensity for the eight rain events ranged from 7 to 51 mm and from 2 to 10 mm/hr, respectively. The filter media of polypropylene is excellent for adsorbing smaller size particulates of SS, because smaller size of particulates originate basically from diesel and gasoline exhaust, while the filter holds larger size particulates originated from the wearing process between automobile tires and asphalt roads, and other sources of clay and sand, etc. accumulated on roads. Maintenance of the device needs replacement of the media once or twice a year depending local traffic conditions and others, which is not so expensive because we may use waste polypropylene to make the media.

Traditionally in Japan, a draining system includes draining grid sink installed at generally about 20 m intervals on both sides of road for the drainage of road-runoff (Japan Society of Road, 1987). The maximum lane width is 3.5 m, except in certain cases, and the number of lanes depends on traffic conditions. In this research, runoff from a road consisted of four lanes (two lanes on each side) was considered as the runoff amount. Therefore, the designed catchment area (A) of road runoff is 140 m². The designed maximum runoff flow rate (Qmax), based on the road engineering and drainage
guideline is 0.389 L/sec. The experimental site where the treatment device was installed was located along the roadway of Route 161 (in Otsu, Shiga, Japan), which consists of four lanes that have two lanes on each side. The average traffic density between 7 am and 7 pm at this experiment site was 38,086 vehicles/12 hrs during the study period. The average particle size distributions (PSD, expressed as volume%) of road runoff inflows for eight rain events are obtained for the initial (at the beginning of rainfall) and post runoffs (after about 300 min from the beginning of rainfall). The particulate size in the initial runoff was relatively smaller (over 90 vol% of particulates had a diameter smaller than approximately 100 um) than that in the post runoff. The average d10, d50 and d90 of PSD were 4.3, 14.9 and 38 um, respectively. These indicate that the smaller particulates dominate in initial runoff. In the post runoff, over 90 vol% of particulates had a diameter smaller than approximately 350 um. In addition, 71.3 vol% of the particulates were the diameters less than approximately 100 um. The values for d10, d50 and d90 of PSD were 25.6, 70.2 and 168.8 um, respectively.

These results indicate that the smaller particles flow faster with runoff than the large particles. Particulate-bound pollutants such as heavy metals and PAHs tend to be adsorbed on the smaller particulates due to higher specific surface area and higher organic carbon content. This is also verified for road-runoffs. Therefore, for the further removal of these micro pollutants, the smaller particulates must be efficiently removed. This is especially true for the initial road runoffs.

The removal efficiency of various pollutants in initial runoff, in which pollutant concentration was relatively high, is shown for each rainfall event. The SS removal efficiency ranged from 86.7% to 97.8% with 92.3% average removal efficiency. The COD and T-P removal efficiencies ranged from 36.7% to 87.1% and 11.9% to 96.9% with 71.9% and 43.6% average removal efficiencies, respectively. The average removal efficiencies were approximately more than 70% for heavy metals: 88.7% for Pb, 87.1% for Cd, 76.2% for Zn, 75.2% for Cu, 71.3% for Mn and 69.9% for Cr. The higher removal efficiencies of Pb and Cd suggested that this behavior correlated closely to that of SS. This result for Pb was confirmed by the stronger correlation between Pb and SS. The average removal efficiency of PAHs was above 60%, ranged from 59.6% to 76.5%.
Impact of Urban Development of the Mingoa River Watershed on the Municipal Lake of Yaoundé (Cameroon) Chemical Pollution

Author: Ms. Marielle Naah et al.
Laboratory Water Environment and Urban Systems (LEESU ex -CEREVE), France

Keywords: urbanization, water, Africa, xenobiotics, sediments

Introduction/Problem Identification
Urbanization is characterized by the production and the discharge of exogenous chemical substances in the aquatic environment. They can come from traffic (PAHs, heavy metals), from industries (PCBs, alkylphenols), and from households (personal and home care products containing parabens). Some of these contaminants are persistent, can accumulate in sediments and in biota, and have negative impacts on ecosystems and human health. In Africa, there are no efficient wastewater treatment systems and urbanization rates are high. It is important to take into account xenobiotics in the management of urbanized watersheds.

This presentation aims to analyze the historical link between the urban development of the Mingoa River Watershed, and the chemical pollution of the Municipal Lake of Yaoundé, an artificial lake built in 1951. Selected tracers (PAHs, PCBs, heavy metals, alkylphenols, parabens) have been measured in sediment cores, wherein is reflected the evolution of urbanization.

Analysis/Results and Implications for Policy and/or Research
The studied watershed is a densely populated area, where are mixed planed neighborhoods and informal settlements, characteristics of urbanization in developing countries. In organized districts wastewater is managed via septic tanks, but no assessment is made for runoff. In slums, no management is made for urban waters and all effluents are discharged directly to water bodies.

We have found that the concentrations of the studied contaminants vary along analyzed sediment cores. Although the concentrations found are less important than in developed countries, water managers should particularly pay attention to domestic wastewater, containing new type of pollutants like parabens that are classified among endocrine disruptors. Indeed, the Municipal Lake of Yaoundé is used for fishing, which turns water pollution into a socio-economic and a public health problem. The discharge of endocrine disrupters diminishes the fish population, reduces fishermen income, and exposes consumers to health risk on long term.

Levels of PAHs and PCBs are under critical developed countries levels. However, in developing countries where little or no regulation exists, research must be used to build programs like Reach, that have been developed to sustain new European regulations like the Water directive. Use of research must be more general in the process of urbanization in order to build models to test potential future scenarios and analyze their environmental impacts. More research is also needed for household products, and for population practices. Nowadays new technologies of analysis allow to measure new pollutants molecules and determine their environmental impact. The studied watershed is a densely populated area, where are mixed planed neighborhoods and informal settlements. In organized districts wastewater is managed via septic tanks, but no assessment is made for runoff. In slums, no management is made for urban waters and all effluents are discharged directly to water bodies.
Minimizing the Water Pollution and Improving Sanitation at “Dacha’s” Territories in Ukraine

Author: Dr. Valentina Pidlisnyuk* et al.

* Kremenchug State University, Ukraine

Keywords: “dacha’s” territory, non-point sources, water pollution, educational campaign, self-financial support

Introduction/Problem Identification

One of the most dangerous non-point sources for water contamination in Ukraine are so-called “dacha” territories. “Dacha” itself is out-of-city house located in a small piece of land, approximately 0.06-0.1 hectares. Such housing estate territories can be observed around each middle-size and big cities in Ukraine and are wildly spread.

“Dacha” territories were mainly created during Soviet time as some sort of “summer” houses for rural citizens and that time used seasonally. After collapse of the Soviet system “dacha” territories were consistently transformed in suburb territories where people began to live all seasons. Taking into account that dacha territory are small land area with intensive agricultural practice and high concentration of people, particular in warmer seasons, discharge of pollutants from houses without any treatments as well as from yards are tremendous and exceeded in many times the permit able levels.

Analysis/Results and Implications for Policy and/or Research

Currently around 40% of Ukrainians own “dacha” for living, in addition many of them still are served as a place for week-end outings and vacation places for millions of people with low income. Retired and low-income people use “dacha” for growing fruits and vegetables for their own needs and for market.

Having this specific background “dacha” territories don’t have any centralized water supply and/or waste water collected systems. Water quality there are not a subject of control either for regional or local sanitation service or state water authorities, and contamination problems are exacerbated.

In addition lack of knowledge regarding appropriate environmental and agricultural practice, proper water management contributes to the deterioration of water quality, loss of fresh water and marine ecosystems and poses threats to public health.

To resolve the situation educational campaign was jointly done by Kremenchug State University and Sustainable Development and Ecological Education Center in order to educate “dacha” communities regarding proper water management, use and sanitation. Previously created Extension Program, focused on water management and sanitation was used. Program includes such topics as: (a) proper water management for small territory, (b) prevention measures for safety water use, (c) deterioration of water quality and impact to health, (d) proper sanitation (e) proper water use in agriculture (f) interconnection between water resources and climate change.

Beside the lectures participants of the campaign were resented case-studies regarding good practice at “dacha’s” territories in terms of water management and sanitation, were familiarized with measures for decreasing water use including irrigation, told about direct interconnection between water qual-
ity and health state. Citizens received brochures about effective simple approaches of drinking water purification and improving sanitation.

Campaign was accomplished in summer and fall 2009 for dacha’s citizens in Kyiv (dacha settlement “Osokorku”) and Kremenchug (dacha settlement “Pizane”). Using sociological surveys an obvious and direct connection was established between state of health of interviewed citizens, quality of drinking water they used as well as with level of their ecological awareness and environmental education.

The provided actions helped to minimize and to some extend to stop water pollution from “dacha’ territory”. Citizens of “dachas” territory also decided to explore the option for self-financial support for environmental services at their territories.
Monitoring Surface Water Quality Using Remote Sensing Techniques

Author: **Dr. Amin Shaban**
National Council for Scientific Research, Lebanon

Co-Author: **Dr. Nadine Nassif**
Lebanese University

Keywords: water contamination, river, turbidity, satellite image, Lebanon

**Introduction/Problem Identification**
The rapid population growth in Lebanon led to intensive exploitation of water resources, which is also influenced by the abrupt decrease in the average precipitation rate in the last few decades. This has been reflected on the per capita, which is reduced to 50%. The anthropogenic interference exacerbated the problem; notably the contamination of surface water sources. For this reason, a comprehensive water quality assessment is needed. As an advance techniques, remote sensing can fulfill assessing the quality of water and tracing sources of pollution. These techniques follow systematic approaches of analysis and quality monitoring.

**Analysis/Results and Implications for Policy and/or Research**
Deterioration of surface water has been exacerbated in the absence of quality control management. This has been also increased in the lack of appropriate methods of analysis to monitor water quality; especially for large-scale areas. The current study aims to utilize advanced techniques in water quality monitoring; and more certainly to identify the flow regime of contaminated water, changes in water quality behavior and levels as well as to determine the sources of pollution.

The used approach of analysis depends mainly on satellite images processing, which can provide complimentary maps with different classes for surface water quality from selected rivers in Lebanon. This has been followed by filed verification to confirm the reliability of the applied approach.

For this purpose, two types of satellite images were processed. These are ASTER and Landsat 7 ETM+ images, which are characterized by high-resolution in distinguishing objects from space. The processing of these images was undertaken by using EVNI-4.3 software, since is specialized in treating satellite images, and capable to recognize and classify water bodies at different quality levels.

The concept behind analyzing these images depends on a number of optical and digital advantages in the used software. The most commonly used advantages are: edge detection, color slicing, filtering, enhancement and combination of different spectral bands. In addition to these advantages, thermal differentiation can be also applied to distinguish the difference in temperature of water bodies. The latter can be applied by using Thermal Infrared (TIR) bands, which proved it is creditability in many previous studies (Shaban et al., 2005; Shaban and Nassif, 2007). In combination with satellite images, the extracted data from these images was analyzed and manipulated in the Geographic Information System (GIS) in order to represent this data in map forms.

The majority of quality assessment in this study implies identifying the turbidity, bacteria, nutrients and temperature. This was followed by calibration procedures to harmonize the extracted data from
satellite images with those measured in the field. For this purpose, field survey has been carried out on the selected sites (75 sites). Therefore, sampling was undertaken from each site for further water analysis.

The Principal Component Analysis (PCI) was applied and revealed the reliability of the applied approach.

For each parameter (i.e. turbidity, bacteria, nutrients and temperature), a thematic map was produced showing different levels. The sources of pollution were identified, which were almost attributed to anthropogenic impact. In addition, this work was applied on seasonal basis for one-year duration in order to monitor changes with different climatic conditions.
Managing Water Pollution in Urban India: Problems and Prospects

Author: Dr. Nandita Singh  
Royal Institute of Technology, Sweden

Co-Author: Mr. Om Prakash Singh  
Sweden

Keywords: water pollution, india, integrated approach, strategic communication, Yamuna

Introduction/Problem Identification

Pollution of water resources has emerged as a significant problem in urban India. Rapid growth of population, inadequate planning, and industrialization, generally lead to degradation of quality in surface as well as groundwater resources. This paper aims to explore the question of management of water quality in the mega-city Delhi, with a focus on river Yamuna.

Yamuna is an all-weather river in northern India with great mythological and practical significance for people. In post-independence period, it has supported growth of industries and urban centers, Delhi being the largest. The stretch of Yamuna in Delhi is only 2% of its total length but it receives over 70% of its pollution load here. After Delhi it is a dead river, with a white frothy appearance at the exit point and the water not even meeting bathing water standards. What are the primary causes of pollution of Yamuna and what has been done to manage it? Where lie the problems and how can these be effectively addressed?

Analysis/Results and Implications for Policy and/or Research

(1) Causes of pollution:
Domestic sewage and industrial waste have been identified as the main sources of pollution of Yamuna in Delhi, with a contribution of 75-80% from the former and the remaining from industrial and other sources. Among the other sources are dumping of solid waste (including dead animals) in the waters bringing chemical and microbial contamination, agriculture in the river bed that brings pesticides and fertilizers, and annual immersion of idols during religious festivals that adds more dangerous chemicals and metals to the water.

In terms of treatment options, the sewage treatment capacity has grown but failed to keep pace with the increase in population and waste. Further, the existing infrastructure itself remains under-utilized. 67% STPs function below capacity while 17% lie defunct. Among reasons for under-utilization are old and silted-up sewer lines and the absence of drains to transport sewage to the STPs that are generally built far-away from the source of origin.

On the whole, as much as 57% of the waste generated in the city is released completely untreated. This includes the unmeasured sewage generated by the 45% population that thrives in unauthorized, unregularised, and unsewered areas. From where sewage is either released through 22 storm-water drains into the river or transported into the river course through a mafia of sewage removal trucks that engage in regular cleaning of septic tanks connected to toilets in these colonies.
Regarding industrial waste, it is not known as to how many industries actually fulfill the legal obligations concerning environmental protection. For small-scale industries, a majority of the common effluent-treatment plants (CETPs) installed by government remain unused for similar reasons as above. The sludge from STPs and CETPs is piling near the river-bank, further polluting groundwater.

(2) Managing water quality in Yamuna:
There exists a strong legal framework for upkeep of environmental quality in India, water pollution being an important theme. Huge amounts of money have been invested in recent years to clean-up Yamuna through the Yamuna Action Plan (YAP). However, the state of pollution is worse than ever before. There are a number of gaps in the steps taken for managing the Yamuna water quality. First, the YAP has worked to only create ‘hardware’ – questions of how to holistically and sustainably operate and maintain the hardware has not been addressed. Second, it has lacked an integrated approach, not addressing all different sources of pollution and remaining unconnected to existing infrastructures and capacities. Third, a communication perspective is clearly lacking in the efforts, whereby different actors including the industries, common residents, farmers, religious groups, etc. have not been appropriately sensitized. Also, the politicians and administrative staff in government and municipalities are not sensitized enough to deal effectively with the cause.

Conclusions and recommendations:
It emerges from the study that though there have been attempts to protect and improve the quality of water in river Yamuna, the efforts are insufficient and ineffective. Different stakeholders can play different roles in the process of effectively managing the water quality in Yamuna. All these groups require different levels of sensitization, activation and resources to deal with the issue. The government agencies and municipalities together need to adopt an integrated approach in designing interventions grounded in the local realities. They also need to ensure effective implementation of interventions in the right spirit. Appropriate communication is a concern for all actors that would help remove attitudinal barriers which thwart realistic action. As a consequence of these barriers, industries fail to comply with legal obligations for river water protection, private tankers continue to pollute the river through direct disposal of sewage, and local citizens dump dangerous waste in the river, while the civil society groups remain mute spectators. Awareness and sensitization to water quality issues even amongst the educated citizens in Delhi is low. The various actors need to be sensitized differently to the water quality issues so that they can respond adequately and effectively.

Action for cleaning and upkeep of Yamuna’s water quality thus needs to include an integrated approach that would not only address the practical ‘hardware’-based limitations, but also, it must contain a ‘strategic communication framework’ as an integral component so that appropriate communication packages can be designed for different stakeholder groups in a way that it addresses their specific needs for attitudinal change. There is also need for more appropriate allocation of resources, and further research and development on appropriate and sustainable hardware options.
Introduction/Problem Identification
The recognition of emissions into the urban water cycle of hazardous substances from diffuse sources (i.e. construction materials, vehicular traffic, urban runoff) as well as consumer goods (i.e. textiles, electronics, and household chemicals) has steadily increased. Correspondingly the relative importance of point sources such as industrial discharges has declined due to successful preventive measures. The City of Stockholm has recently completed a project, “New pollutants–new tools”, aimed at indentifying the most important substances for the City to manage, based on the risk for negative environmental and/or human effects, the relevance of – and sufficient information about local sources and the possibility to introduce reduction measures. In this paper mitigation measures and source control options in general is discussed and the identified substances are used to demonstrate some of the tools more in detail.

Analysis/Results and Implications for Policy and/or Research
Within the project “New pollutants–new tools”, five groups of substances and their main applications have been identified: Alkylphenols and alkylphenol ethoxylates (AP/APEO); textiles and detergents. Antibacterial additives; triclosan in toothpaste, deodorants and sportswear and silver in washing machines, refrigerators, health care products, shoes and clothing. Brominated flame retardants (BFR); electronics, furniture, textiles, construction materials (polymeric foams). Phthalates; flooring, wall coverings, roofing materials, PVC products, traffic (vehicle underseal). Polyfluorinated compounds (PFC); impregnating agents (clothing, shoes, furniture, paper), fire extinguishing foam, floor polish.

Most of the five selected groups of substances are found in textiles. AP/APEO is banned within the EU but is present in textiles imported from countries outside the union. Clothes, shoes and sportswear are sometimes treated with antibacterial agents and carpets and curtains can be flame protected with BFRs. Phthalates are often included in PVC printings on T-shirts, etc. This together makes textiles an important issue to work with. Building materials are also important emission sources for BFRs and phthalates, and personal care products and household chemicals often contain antibacterial agents.

The mitigation concept discussed here is here is defined as upstream source control. Removal by waste water treatment methods is not covered. The main focus is on the possibilities that national, regional and local authorities as well as the waste water treatment plants (WWTPs) have to implement the reduction of hazardous substance emissions at their sources. But also businesses, non-governmental organisations and the general public are discussed.

The measures include green procurement, use of current and new legislation, voluntary agreements, cooperation, financial initiatives, information campaigns, ecolabelling, etc.

The benefits of mitigation compared to end-of-pipe solutions is that pollution is avoided before the pollutants are emitted thereby protecting the receiving waters but also the quality of the sludge pro-
duced in the WWTPs, making it more attractive for use in soil amendment. The microbial processes at WWTPs, the working environment and the sewerage network are also protected. Another benefit of mitigating chemicals at their sources is that the use of hazardous substances in materials and consumer products will decrease, leading to less direct exposure of humans.

The City authorities can significantly influence the contents of hazardous substances in purchased materials and goods through putting up criteria and requirements in the procurement process. The city of Stockholm makes annual purchases of goods and services worth €1,000,000,000 each year which indicate that the City has a good possibility to influence the market and contribute to the development of new, greener products.

Regulations are very effective and easy for public authorities to use in their supervision work, but the development and execution of new laws is a very time consuming process. REACH, the new European regulation on chemicals, will not be sufficient concerning chemicals in articles, and materials. The information requirement in REACH only applies if certain criteria are met.

With dialogue and cooperation between stakeholders it is possible to make voluntary agreements to reduce the use of hazardous substances. The challenge here is to make use of the willingness of those within a certain business domain or group of stakeholders who are willing to be pioneers and to subsequently implement the developed tool or agreement to a standard comprising other actors within the group.

Financial subsidies, taxes or fees, can bring about changes in behaviour. With the help of financial subsidies it is possible to encourage positive actions from industries, services or businesses.

Information campaigns and public awareness programmes can be successful but are not without problems when it comes to information on hazardous substances in materials and articles for which there is no legitimate demand to list the chemicals included. The consumers in general can not be expected to have the knowledge needed to avoid hazardous substances in purchased goods. Provided the campaign deals with a well defined group of articles containing a limited number of specific chemicals, it is still possible to achieve a good result, especially if the campaign is allowed to run long enough or is repeated several times.

The ecolabelling of products is a big help to consumers when they want to buy green and an expansion of ecolabelling to new groups of products and services would further promote greener shopping.

Other mitigation strategies include substitution and green chemistry which means that chemicals are manufactured in a sustainable way and are designed to be less toxic and better degradable.
Investigation of Heavy Metal Contamination and Assessment of Ground Water Quality in Nacharam Industrial Area, Hyderabad, India

Author: Dr. Bekkam Venkateswara Rao* et al.
* JNT University, India

Keywords: heavy metals, contamination, ground water, industrial area, pathways

Introduction/Problem Identification
The environment of the Hyderabad city, India is heavily polluted by the rapid industrialization and urbanization. Many industries are developed in and around the Hyderabad and released their effluents and wastes into the environment. The pollutants such as heavy metals, and other chemicals, which are present in the effluents are found in the groundwater and changed the groundwater quality. Groundwater is the source for industrial, domestic and drinking purposes in the city. The present study is to carry out an estimation of heavy metals in the study area and groundwater quality in terms of major ion chemistry. It is also aimed at finding the pathway of heavy metals from industrial effluents to groundwater. The selected study area is at Nacharam Industrial area, located in Hyderabad metropolitan city. This site stands as an example for many industrial activities that possibly influence heavy metal pollution in soil, sediment, and water as well as deteriorated the water quality in the study area.

Analysis/Results and Implications for Policy and/or Research
In the study area there are about 100 industries which are manufacturing chemicals, pesticides, paints, steel products, pharmaceuticals etc. Many industries release their treated or untreated effluents in unlined water streams or on open land polluting the surface as well as groundwater. 15 groundwater samples, 7 surface water samples, 6 soil samples and 5 sediment samples are collected in and around Peddacheruvu in the study area. Water samples are analyzed for heavy metals with Inductively Coupled Plasma Mass Spectrometer. Soil and sediment samples are analyzed for heavy metals with X-ray Fluorescence.

From the analytical data of heavy metals it is found that the soil samples are contaminated with heavy metals such as As (85.7ppm), Cu (678 ppm), Cr (88.5 ppm), Pb (215.2 ppm), Rb (141.5 ppm), V (171.8 ppm), Zn (305.2 ppm) and Zr (1388.7 ppm). The heavy contamination of soils with heavy metals may be due to anthropogenic sources since country rock of granite does not contain these heavy metals with such high concentration. The contaminated soils have contributed the contamination to both sediments and groundwater. For instance, the sediments have the heavy metals concentration of the order of As (23.7 ppm), Ba (1208 ppm), Cr (385 ppm), Rb (478.6 ppm), Pb (78.6 ppm), Zn (180 ppm) and Zr (1727 ppm). While the groundwater has heavy metals concentration of the order of Al (150 µg/l), Mn (2597 µg/l), Fe (588 µg/l), Ni (21.3 µg/l), Zn (3587 µg/l), Cu (604 µg/l) and Pb (21.3 µg/l). Interestingly, surface water has less contaminated with heavy metals of the order of Fe (370 µg/l), Mn (355 µg/l), Ni (22.7 µg/l) and Al (70 µg/l) when compared to the sediment and groundwater since these heavy metals are deposited on the sediment due to the heavy metal precipitation activity in the water body. It also observed that the heavy metals like As, Cr, Rb, V, Zr are within the permissible limits in the groundwater and in other words these heavy metals are not reaching the groundwater body due to their adsorption in the soil and sediments. The data is also analysed by preparing the contour map for each heavy metal to know their spatial distribution in the study area.
It appears that the pathway of the heavy metals is that there is an accumulation of heavy metals in the soil initially when the industrial effluents and domestic dumpings are spread on the ground. During the monsoon season the heavy metals are directly reaching the groundwater body by traveling along the infiltrated water from the soils. The heavy metals are also traveling to the near by water bodies through surface runoff generated from these contaminated soils. However the surface water body is not retaining the much of the heavy metals but, it is depositing in the sediments of the lake bed. Consequently some of these heavy metals from the sediments are reaching the groundwater body due to recharge from the lake waters.

Ground water samples are also analyzed with Ion chromatography for major cations such as Na⁺, K⁺, Ca²⁺, Mg²⁺ and major anions Cl⁻, F⁻, NO₃⁻, SO₄²⁻, HCO₃⁻. These ions are found in the groundwater more than permissible limits of drinking purpose. It is finally concluded that the groundwater in the study area is not suitable for drinking purpose in view of its heavy metal contamination and higher concentrations of major ions. Besides, suitability of water for irrigation is evaluated based on sodium adsorption ratio, residual sodium carbonate, sodium percent, salinity hazard and USSL diagram. It is found that groundwater in the study area is suitable for irrigation purposes.
The Distribution and Accumulation of Emerging Pollutants in Urban Waters of Eastern Ukraine

Author: Ms. Yuliya Vystavna* et al.
* National Academy of Municipal Economy, Ukraine

Keywords: pharmaceuticals, trace metals, urban river, Kharkiv city, Eastern Ukraine

Introduction/Problem Identification
Emerging pollutants can be defined as any synthetic or naturally occurring chemicals or any microorganisms that are not commonly monitored in the environment, but they have a potential to enter the environment and cause known or suspected adverse ecological and (or) human health effects. These pollutants found in various environmental components in trace levels (pg/l – ng/L). Some of them not or very slow degraded and most of emerging pollutants are man – made organic and nonorganic chemicals being introduce into the environment by anthropogenic inputs. Increasing standards of living, economic changes and human population growth leads to the rising of different chemicals consumptions in households, office, industries, agriculture. Ten thousands of man-made chemicals used in the society enter water resources and drinking water.

Analysis/Results and Implications for Policy and/or Research
Urban systems is the major source of the emerging pollutants in the water, as they use to export various contaminants mainly with run-off and wastewaters in rivers and other water bodies. Entering the water media, trace metals and pharmaceuticals are able to distribute in water resources and accumulate in the sediments and living organism. The research is focus on the distribution and accumulation of the pharmaceuticals and trace metals in the water and sediments of rivers in the Kharkiv city. The Kharkiv city is one of the biggest urban agglomeration in Eastern Ukraine with population c.a. 1.5 mln., well developed industrial infrastructure, but the city is limited in surface water resources. The aim of the study was (a) determine the distribution of pharmaceuticals and trace metals in the Udy and Lopan Rivers within the Kharkiv city; (b) identify the potential environmental and health risks of these substances accumulation in the water bodies; (c) propose the measures for the prevention and reduction of the pollution. The study has been done in the framework of the scientific French-Ukrainian collaboration within ERASMUS MUNDUS Lot 6/7 (Belarus, Moldova, Ukraine) financed by EU and “DNIPRO” project (2009/2010), supported by the Ministry of Education and Science, Ukraine and Ministry of Foreign Affairs, France. The results of the monitoring of emerging pollutants in the rivers of the Kharkiv city in 2008-2010 shows, that the urban area is significant contributor to the contamination of water bodies by trace metals and pharmaceuticals. Taking into account, that levels of these compounds vary daily and seasonally and considering therefore that using the grab sampling methods can be inefficient, the passive sampling with POCIS (Polar Organic Chemical Integrative Samplers) and DGT (diffusive gradient in the thin film) devices has been chosen for the water characterization together with standard techniques. The passive sampling method is based on the free flow of pollutants from the sampled medium to a receiving phase located on the sampling device. The net flow of the pollutants continues until the establishment of equilibrium or the interruption of the sampling period. Our study has targeted 21 pharmaceuticals and 8 toxic metals and Ag as urban tracer supposed to be present into the sampled rivers. It was detected 11 pharmaceuticals (aspirin, ibuprofen, naproxen, ketoprofen, diclofenac, nordiazepam, salbutamol, carbamazepine, caffeine, paracetamol, diazepam) in the Udy and the Lopan Rivers in the city. The pharmaceuticals were detected in sites downstream and upstream of the municipal wastewater treatment plants discharges.
The most prominent (found in more than 70 % passive sensors) were diclofenac, carbamazepine and caffeine. As, Cd, Cr, Cu, Hg, Ni, Pb, Zn and Ag were found in the riverine water and sediments on the territory of the Kharkiv city. Among the metals the highest rate accumulation in riverine sediments observes for the Ag, Cd, Cr, Pb, Ni, and Zn. The significant contamination of labile forms (the most bioavailable one) was for Cr, Pb, Ni and Zn. The comparison of the data with the different environmental quality guidelines shows that presences of Zn and Pb in water and sediments associates with highest environmental and health risks. The highest concentrations of almost all compounds have been measured in sites located downstream of the municipal wastewater treatment plant discharges. This is explained by the poor wastewater management facilities of the Kharkiv city, with low efficiency of treatments, mixing of untreated wastewaters from hospitals and lack of environmental education in the Ukrainian society. Most of the contaminants detected in wastewaters can reach ambient waters and represent a significant environmental concern.

Also, during the reduced river flow period the wastewater value is in 21 times higher the upstream water flow. All of these factors lead to the formation of urban pollution anomalies, where the level of contamination by trace metals significantly increases the regional baseline and inputs of pharmaceuticals result in the accumulation of these specific components in urban waters. It was also found that the presence of pharmaceuticals and trace metals exhibits seasonal variations. The anthropogenic inputs (wastewater discharges) affect the trace metal concentrations in a strong manner during the low flow summer period while increased flow conditions during the cold season provides a better dilution of pollutants. Fluxes of metals during the hot low-flow summer period were less compared to the cold high-flow winter period. This indicates that the metal release is continuous and at the same time seasonally variable depending on both natural and socio-economic conditions in the studied region. The seasonal variation of the pharmaceuticals was possibly related to the difference in the type of consumed medicaments and activity of living organisms in the water.
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