Comparative analysis of water quality for irrigation in River Antau and Mada, Nasarawa State, Nigeria

K I Samaila, Nasarawa State University, Keffi, Nigeria
J I Magaji, Nasarawa State University, Keffi, Nigeria

Available at: https://works.bepress.com/cjes_kogistateuniversity/48/
Comparative analysis of water quality for irrigation in River Antau and Mada, Nasarawa State, Nigeria

Samaila K.I and Magaji J.I.
Department of Geography, Nasarawa State University, Keffi, Nasarawa State
Email: ikunden@yahoo.com

Abstract
Water quality used for irrigation is essential for the yield and quality of crops, maintenance of soil productivity and protection of the environment. Water quality therefore should satisfy the requirement of standard set for a specific or general use. The study compared the quality of water in Rivers Antau and Mada and determined its suitability for irrigation in Nasarawa State, Nigeria. Ten water samples were collected along each Rivers Antau and Mada for both dry and raining seasons at thirty metres interval in two litres-plastic containers and preserved with four mills of nitric acid. The water samples were analysed using standard laboratory techniques. Results from this study showed the pH for both rivers for all the seasons were slightly alkaline and were within the range of 6.5-8.4 recommended for irrigation water. Electrical conductivity and total dissolved solids for both the two rivers were generally implying that the uptake of water and nutrients by plants will not pose serious problems in the use of the water in the rivers for irrigation. The mean dry season values of sodium adsorption ratio for River Antau was 0.45, River Mada 0.43 while the raining season values were 0.41 for River Antau, River Mada 0.25. Chloride, Lead, iron and boron were also available in concentrations for the rivers not above the threshold values considered for crop growth. Phosphate and nitrate were also generally low in water of the rivers and since they are important nutrients required by most plants for their developmental processes it should be raised in the soil on irrigated lands along the rivers. Comparing the water from River Antau and Mada for both dry and raining season therefore can be considered to be suitable for irrigation as most of the properties evaluated for this study mostly fell within the safe limits considered for irrigation. The study recommended that human activities especially along the two rivers should be checked, irrigation schemes should be established along the rivers and farmers should be encouraged to engage actively in irrigation.

Keywords. Salinity, sodicity, sodium adsorption ratio, toxicity and water quality

Introduction
Studies documented on water have indicated that hardly is pure water containing no minerals or chemicals exist naturally in the environment as all water contain dissolved ionic constituents from gaseous particulates from the atmosphere and other ionic concentrates from the earth surface (Ogunrombi, 1979, Ademorati, 1996 and Christopherson, 2006 and Samaila, et.al. 2011). Incompatible human activities have introduced to water bodies both in surface and underground sources substances at intensities above the threshold level considered safe for such sources culminating therefore in water quality problems (Samaila, 2005). The weathering of primary minerals from rocks and the subsequent release into water receiving sources may lead to accumulation of elements at intensities likely to be injurious to human health and reduce the productive capacity of soils (Obaje, et.al. 2007). The poor quality of most water in recipient sources suggests that to use such water for any purpose will require the evaluation of the water to determine if the concentrations of substances are within acceptable limit values considered safe.

In Nigeria the evaluation of water quality has not been considered as fundamental for most irrigation schemes both in rural and peri urban areas, even where such exist they have not enjoyed widespread application (Samaila, et.al. 2011). To address issues generating from use of poor quality water and improve on the health of the population proper monitoring of water quality will ensure improved quality of crops produced from irrigation water. Water therefore comprises of several substances some of which are necessary for human, animals and plants developmental processes. As observed by Hansen et.al (1980) small amounts of substances seen as
pollutants in water are not only harmless but stimulate good health and growth. The concentration of these substances in water at high intensity however has adverse and negative effects on humans and environmental systems.

The vulnerability of water to degradation depends on a combination of the natural landscape features such as, geology, topography, soils, climate and atmospheric contributions (Cunningham et al. 2007). The concentration of substances in water at high intensity is objectionable for use for a variety of purposes. Though irrigation may offer a viable option for management of otherwise low quality water, studies have shown that excessive concentration of ionic elements in water may lead to the build up of salts in the soil colloids which in turn may be detrimental to crops developmental processes. The quality of irrigation water therefore should fall within the recommended allowable limit considered safe for irrigation.

Water quality used for irrigation is essential for the yield and quality of crops, maintenance of soil productivity and protection of the environment. As observed by Abdulkadir, (1993) water quality should satisfy the requirement of standard set for a specific or general use. Where this condition is not met it is accompanied by serious after effects on the environment and endangers the users of such water. Water quality therefore should be evaluated in term of the properties that affect the acceptability of the water for irrigation. As viewed by Samaila et al, (2011) water quality is made up of many variables too numerous to evaluate, the choice of the variables will depend on nature of the water, geology, climatic condition, management practices and the intended use of the water.

According to Dusa, (2010), important properties affecting irrigation water is the presence of total dissolved salts and amount of sodium in water compared to ions of calcium plus magnesium. While Ibrahim, (2002) is of the view that carbonate and bicarbonate concentrations are as well important variables to consider in irrigation water. Ayoade, (2003) emphasized the need to evaluate irrigation water quality in-terms of the chemical, physical and biological properties. The first two may pose direct effect on the soil and the crops produced while the later is likely to be detrimental on the health of the users of the water. In addition to this is the presence of heavy metals, though minute in concentration are potentially harmful substances in irrigation water Ademorati, (1996). The concentration of substances in water should be a guide if water is to be used for irrigation successfully. The chemical, physical and biological properties in water most not fall above the threshold value limit considered for irrigation water. Where there is high concentration of properties in irrigation water it will have negative effect on the growth and yield of crops and may result in the built up in the soils of harmful ionic elements thus affecting the productivity of the soils and yield of crops.

The major concern in the use of water for irrigation is the possible concentration of high dissolved salts at intensities likely to impact negatively on the yields of crops degrade the soil and pollute groundwater resources. The suitability of water for irrigation with high salt content will depend largely on;

i. Salt tolerance of the crop.
ii. Characteristics of the soil under irrigation.
iii. Climatic condition, example, in arid regions high evaporation rates results in high accumulation of salts in the soil.
iv. Soil and water management practices.
The use of water with high salinity therefore will require soils which must be permeable, drainage must be adequate, water must be applied in excess to provide considerable leaching and crops that can withstand high salinity should be selected.

**Materials and Methods**

Nasarawa State is located within Central Nigeria and is characterized by seasonal distribution of rainfall. The seasonality in rainfall has resulted in few streams surviving into the dry season and where such exists the rivers provides ample opportunities for a variety of uses including domestic, recreational, fishing and irrigation. Irrigation is not new for most communities in the state as most surface waters in rivers, streams and ponds that survive into the dry season are having their water diverted for dry season agriculture. Among the rivers which, offer potentials for irrigation are River Mada and Antau. Both the two rivers lie on the basement complex formation of northern
portion of Nasarawa State with the lower part of Jos Plateau being their source. River Mada is one of the largest rivers of the state and almost bisects the state into halves. The river is perennial and the water regime is high in both seasons as such there is high water flow even during the dry season. Communities through which the river passes utilize the river for irrigation producing the crops that flush into nearby markets. River Antau on the other hand is seasonal but is fed en-route by domestic wastewater from Keffi town thus having a perennial outlook. The low volume and flow of water in the river result in the concentration of substances thus affecting its aesthetic value. Both the rivers are used for irrigation mostly on small land holdings by migrant labour from northern part of the country.

Fig.1: Sampling Points for Water and Soils along River Antau for Dry and Raining Seasons

Fig.2: Sampling Points for Water and Soils along River Mada for Dry and Raining Season
Data for the study were obtained from the field by collecting water samples along the two rivers for laboratory analysis. Ten water samples each were collected along the rivers where irrigation was practiced at thirty metres interval in two metres plastic containers and four mills of nitric acid added for preservation. The water samples were collected in Mid February the peak period of irrigation in the area and in August the peak of the raining season. The properties of the water were analysed using standard laboratory techniques. The properties analysed were mostly those that affect the irrigation use of water such as salinity by total concentration of dissolved salts, sodicity caused by excessive concentration of sodium over divalent cations of calcium and magnesium, carbonate and bicarbonate, pH and specific ion toxicity of chloride, nitrates, phosphates, lead iron and boron. Indices such as Sodium Adsorption Ratio (SAR) and Residual Sodium Carbonate (RSC) were also used for sodium hazards in the irrigation water. Recommended water standards for irrigation of Food and Agricultural Organisation, (FAO, 1985) and Ayers and Westcots (1994) were used to assess the suitability of the water for irrigation. The results generated by this study were summarized in tables and discussed mostly by descriptive statistics. Student T test was used to determine if there was significant difference in water quality between the rivers.

Results and Discussions

The results of the chemical properties of water in Rivers Antau and Mada are presented in table 1. The pH values slightly varied with the rivers for both seasons. The dry season values showed River Antau had a mean pH of 7.13 and River Mada 7.27. The mean pH for the raining season was 7.50 for River Antau while River Mada had 7.42. The mean pH values for the rivers were slightly high in the raining season which could had been as a result of increase in organic and chemical fertilizers into the water by agricultural return flow. The mean values recorded for the rivers for this study were however within the range 6.5 to 8.4 (FAO, 1985) recommended for irrigation. A similar trend in water pH was observed by Sarwara et.al (2007) for Jehlum River.

Mean electrical conductivity and total dissolved solids during the dry season were 280.9 uS/cm, 168.6 mg/l for River Antau, River Mada 58.5uS/cm and 34.2mg/l respectively. The raining season had means of 59.7 uS/cm and 35.8 mg/l for River Antau, 44.5uS/cm and 36.2 mg/l for River Mada for both electrical conductivity and total dissolved solids respectively. The highest values were recorded for River Antau dry season which was due to the discharge into the river wastes from domestic operations rich in ionic dissolved salts in the nearby Keffi town and the low flow of water in the river. The mean values for the rivers for raining season slightly varied. Electrical conductivity and total dissolved solids however dropped during the raining season. The relatively low values recorded for raining season water for rivers could be attributed in part to dilution from atmospheric precipitation and fast flow of water in the rivers. Ibrahim and Audu (2011) recorded high electrical conductivity for ponds and shallow wells of up to 1000 to 3532uS/cm in Minna and Kano and attributed this to pollution from industrial and municipal effluent discharges.

Carbonate was not detected for the rivers in both the dry and raining season. Carbonate is traceable in water at high pH above 8.5, since the means pH of water of the rivers were low, this could explain why it was undetected for both rivers. Bicarbonate was however, detected for the rivers with mean concentrations for the rivers highest for River Antau dry season recording 3.13me/l while River Mada had 0.96me/l. The mean raining season concentrations were 0.55me/l for River Antau, 0.45 me/l for Mada River. Low bicarbonate concentration was recorded during the raining season which was due to dilution with rain water during the period. The high mean value recorded for River Antau was likely as a result of domestic wastes from human operations getting into the river from the nearby Keffi town. Sarwaraet.al (2007) observed a similar low bicarbonate for the Jehlum River.

Mean negative values were recorded for residual sodium carbonate (RSC) for the rivers which, could be attributed to the high amounts of calcium and magnesium ions over that of carbonate and bicarbonate. The mean values of residual sodium carbonates for dry season were -29.8 me/l for River Antau, River Mada -17.0 me/l. The means raining season were River Antau-21.9 me/l and River Mada -22.5 me/l. River Mada recorded high mean during the raining season.

The mean concentrations of chloride as shown in table 1 were 25.9mg/l for River Antau while River Mada was 16.0 mg/l for dry season. The means for raining seasons were 20.9 mg/l for River Antau and River Mada 18.1 mg/l.
There was a drop in the concentrations of chloride in the raining season for the rivers which might be attributed to dilution with rain water and it is highly soluble in water thus, lowering the concentration in raining season water of the rivers. Idris et al. (2009) observed higher values of chloride of between 5.6 to 350mg/l in Awe town whose rocks are salt rich in sodium and chloride ions.

Iron concentration was generally higher for River Antau for the dry and raining seasons recording means of 2.58 mg/l and 2.51 mg/l respectively, River Mada 1.25 mg/l and 1.98 mg/l respectively. Slight higher concentrations were observed for River Mada during the raining season which was likely due to leaching of iron from the soil (Iron-pans), weathering of iron rich rocks and subsequently drained into the rivers. For water in Offa metropolis Jimoh and Sholadoye, (2011) recorded very low values of iron of between 0.025 to 0.13mg/l.

Lead showed very little difference in concentrations for both dry and raining seasons. The mean concentrations for the rivers during the dry season were 0.03 mg/l for Antau River and Mada River 0.04 mg/l. The mean raining season values were 0.03 mg/l for River Antau, River Mada 0.2 mg/l. Lead concentration was low for the rivers in both dry and raining seasons but showed slight increase in the raining season waters of River Mada.

Mean concentrations of boron for dry season were 0.52 mg/l for River Antau, River Mada 0.49 mg/l while raining season were 0.43 mg/l for River Antau, 0.33 mg/l for River Mada. The low mean values of boron observed for raining season water may be attributed to dilution of water and assimilation into growing plants during the season. The values of boron recorded for the rivers for the seasons were low and fall within the range considered safe for irrigation water. (Ayers and Westcots 1994). Uzaira et al. (2014) observed higher values of metals for dry season water of Challawa River.

Table 1: Mean concentrations of chemical properties of water in River Antau and Mada for dry and raining seasons

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Dry Season</th>
<th>Raining Season</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>-</td>
<td>7.13</td>
<td>7.50</td>
</tr>
<tr>
<td>ECw</td>
<td>uS/cm</td>
<td>280.9</td>
<td>59.7</td>
</tr>
<tr>
<td>TDS</td>
<td>mg/l</td>
<td>168.6</td>
<td>35.8</td>
</tr>
<tr>
<td>CO3</td>
<td>me/l</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>HCO3</td>
<td>me/l</td>
<td>3.1</td>
<td>0.6</td>
</tr>
<tr>
<td>Cl</td>
<td>mg/l</td>
<td>25.9</td>
<td>20.9</td>
</tr>
<tr>
<td>RSC</td>
<td>me/l</td>
<td>-29.8</td>
<td>-21.9</td>
</tr>
<tr>
<td>Fe</td>
<td>mg/l</td>
<td>2.6</td>
<td>2.5</td>
</tr>
<tr>
<td>Pb</td>
<td>mg/l</td>
<td>0.03</td>
<td>0.03</td>
</tr>
<tr>
<td>B</td>
<td>mg/l</td>
<td>0.52</td>
<td>0.43</td>
</tr>
<tr>
<td>Ca</td>
<td>me/l</td>
<td>22.8</td>
<td>20.3</td>
</tr>
<tr>
<td>Na</td>
<td>me/l</td>
<td>1.83</td>
<td>0.99</td>
</tr>
<tr>
<td>Mg</td>
<td>me/l</td>
<td>0.21</td>
<td>8.13</td>
</tr>
<tr>
<td>K</td>
<td>me/l</td>
<td>0.08</td>
<td>0.09</td>
</tr>
<tr>
<td>PO3</td>
<td>mg/l</td>
<td>1.72</td>
<td>1.04</td>
</tr>
<tr>
<td>NO3</td>
<td>mg/l</td>
<td>0.70</td>
<td>0.09</td>
</tr>
<tr>
<td>SAR</td>
<td>-</td>
<td>0.45</td>
<td>0.41</td>
</tr>
</tbody>
</table>

The mean dry season concentrations of calcium were 22.8 me/l for River Antau, River Mada 11.4 me/l while the raining season were River Antau 20.3 me/l and River Mada 22.6 me/l. For dry season water for River Kaduna, Samaila and Gimba (2007) observed a low mean calcium value of 1.6me/l and attributed it to low organic, chemical fertilizers used and assimilation into growing plants.
Sodium recorded for the rivers in the seasons was generally low when compared to calcium and magnesium ions. Low sodium in the soil implies that calcium and magnesium ions will not precipitate in the soil to result in sodium accumulation. The mean values for dry season water for the rivers showed River Antau had 1.83 me/l, River Mada 1.32 me/l. The raining season values were 0.99me/l for River Antau, 1.83me/l for River Mada. The values of sodium dropped for raining season for River Antau. River Mada however experienced a rise in sodium for raining season which might likely due to leaching of sodium from the soil and the use of sodium rich fertilisers and subsequent deposal into the water in the river. Akpan, (2012) observed major cations in Okpauku River to be generally low.

The concentrations of magnesium for the rivers during the dry season were10.21 me/l for River Antau, 6.52 me/l for River Mada. The raining season recorded 8.13 me/l for River Antau, River Mada 10.21 me/l. Except for River Mada magnesium dropped for River Antau. Magnesium for the rivers was relatively higher for the rivers in the seasons. Magnesium just like calcium helps to counter sodicity likely to occur in the soil from sodium accumulation.

Mean potassium in the dry season in the rivers were 0.08 me/l for Rivers Antau and Mada 1.39 me/l. Raining season mean values were 0.09 me/l for River Antau, River Mada 0.07 me/l. The concentration of potassium for the raining season rivers, decreased due to dilution effect in the rivers. High values of potassium (4.0 to 272mg/l) were recorded for Ghaggar River System by Kundu, (2012)

The mean concentration of phosphate for the rivers in the dry season was, 1.72 mg/l for River Antau, River Mada 0.05 mg/l. The raining season mean phosphate was 1.04 mg/l for Antau River and 1.72 mg/l for River Mada. There was a rise in phosphate for the raining season water of the River Mada. The high mean value recorded for River Mada was likely due to increase in the use of organic manure and chemical fertilizers rich in phosphates which drained into the river. For surface water in Zaria, Vincent, (2012) also recorded low phosphate values.

The mean concentration of nitrate showed River Antau had 0.70 mg/l while River Mada 0.07 mg/l. The raining season recorded 0.09 mg/l for River Antau and River Mada 0.06 mg/l. The mean values for nitrate dropped for the rivers in the raining season due to dilution during the period and high flow of water in the rivers. Tsado, et.al recorded a higher mean nitrate value for water in Minna.

Sodium adsorption ratio was generally low for the rivers in the seasons. The low mean values recorded were due to the high concentrations of calcium and magnesium ions over sodium in water of the rivers. The mean dry season values of sodium adsorption ratio for River Antau was 0.45, River Mada 0.43 while the raining season values were 0.41 for River Antau, River Mada 0.25. There was a slight drop in the sodium adsorption ratio for the raining season which was attributed to dilution by rain water and possibly low use of organic and chemical fertilizers during the period. Al Sabah, (2014), observed higher sodium adsorption ratio (3.63) for Tigris River in Iran.

**Suitability of water for irrigation**

The suitability of water of the two rivers was determined taken into consideration important variables affecting water for irrigation. The variables popular in assessing suitability of water include the proportion of sodium to divalent cations of calcium and magnesium expressed as sodium adsorption ratio, Salinity due to excess salts and specific ion toxicity of trace metals who though minute in irrigation water are potentially harmful in irrigation water.

The pH for the rivers for all the seasons were slightly alkaline and were within the range of 6.5-8.5 recommended for irrigation water. The use of water from these rivers will enhance solubility, nutrients and ionic substances in the soil will meet plants growth hence increase crop yields.
Salinity associated to concentration of dissolved salts as indicated by electrical conductivity and total dissolved solids were generally low for the rivers. The values of the dissolved salts fall within the limit that even sensitive crops will not be affected by the present level of dissolved salts in the water. This implies that the uptake of water and nutrients by plants will not pose serious problems in the use the water in the rivers.

Residual sodium carbonate was low for the rivers indicating that calcium and magnesium ions will not precipitate to complicate sodium hazard likely to occur from the use of the water for irrigation.

Sodium was low for the water in the rivers as indicated by the high proportion of calcium and magnesium ions. The sodium adsorption ratio of water in both of the rivers was also low. The low sodium adsorption ratio observed implies that internal structure of the soil will not be affected by the level of sodium in the irrigation water. Soil permeability will not be impeded to a level to inhibit the flow of water in the soil. Water therefore will be available for plants uptake to enhance metabolic activities and good growth.

Lead, iron and boron were also available in concentrations not above the threshold values considered for crop growth. This therefore will not result in these metals amplifying within the food chain to result in ailments to humans. Since chloride was also generally low for the water leaf burns likely to be associated to chloride toxicity will not impact negatively on plants grown in the area.

Phosphates and nitrate were also low and are important nutrients necessary for the developmental processes of most plants. The deficiency of this important plant nutrients indicated that there was the need to add this to the soil if plants in the area are to have sufficient for their growth. The water from the rivers therefore can be considered to be suitable for irrigation as most of the properties evaluated for this study mostly fell within the safe limits consider for irrigation.

Table 2: Classification of water quality for Rivers Antau and Mada in the dry and raining seasons

<table>
<thead>
<tr>
<th>Rivers</th>
<th>SAR</th>
<th>EC</th>
<th>Boron</th>
<th>SAR</th>
<th>EC</th>
<th>Boron</th>
<th>Class</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Antau</td>
<td>0.45</td>
<td>280.9</td>
<td>0.52</td>
<td>0.41</td>
<td>59.7</td>
<td>0.43</td>
<td>Class 1 suitable 1</td>
<td>Excellent</td>
</tr>
<tr>
<td>Mada</td>
<td>0.43</td>
<td>58.5</td>
<td>0.49</td>
<td>0.25</td>
<td>44.5</td>
<td>0.32</td>
<td>Class 1 suitable 1</td>
<td>Excellent</td>
</tr>
</tbody>
</table>

Table 2 shows the classification of water in the rivers covered by this study. The water in the rivers for both the seasons fall on class 1 suitable 1 and this was attributed to the low content of dissolved salts, sodium hazard as indicated by sodium adsorption ratio (SAR) and boron observed for the water. The class one 1 water is of excellent quality the water therefore can be considered good for irrigation for most crops and without unnecessary salinity accumulation in the soils or development of harmful levels of exchangeable sodium. The water therefore is suitable under most conditions and with little or no limitations to use for irrigation. The growth of plants from the use of water and the soil will be enhanced and will not result in obnoxious bio-amplification in plants to affect the consumers of the products.

Conclusion
The water quality of the rivers under review by this study has shown the water to have low pollution loads. The absence of industrial and human activities along most parts of the rivers could account for the low concentration of substances in the water in the study area. The assessment of the quality of water for the rivers have shown most of the chemical properties was low and within the limit considered safe for irrigation water. The water of the rivers therefore is of excellent quality as salinity, sodium hazards and specific ion toxicity were generally low. The water can be used for irrigation without restriction as it may not impair the soil or reduce crop yield or bio magnified within the food chain to affect the consumers of the crops produced.
Recommendations

Based on the findings of this study and since the water of the rivers investigated is rated as being suitable for irrigation, efforts should be directed towards ensuring proper irrigation practices to help maintain the present quality of water observed for the rivers.

Human activities especially along the rivers should be checked so as to ensure that that substances that are release into the rivers are such that will not raise pollution load in the water at levels likely to affect its use not only for irrigation but other productive purposes.

Farmers in the area should be enlightened about the quality of the water in the rivers to remove any fear of its possible harm to the soils, health of the irrigators and crop yields.

Since the water from the rivers are suitable for irrigation government should establish irrigation schemes along the rivers so as to encourage the farmers as this will raise their interest and provide employment to a sizeable portion of the unemployed restless youth in the area.

References


