History of Pharmaceuticals and Endocrine Disruptors in the Food and Water Supply

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Pure food and water have been legislated in the United States since 1906 with the passing of the Pure Food and Drug Act. In the last century, the Food and Drug Administration (FDA) has made great strides in regulating food additives including pesticides, enforcing labeling guidelines for water, and acting as the governmental “watchdog” for food adulteration (Law, 2010). The passing of the United States Food Quality Protection act (FQPA) of 1996 increased the rigor of surveillance regarding pesticide levels and led to the formation of a committee charged with developing strategies dealing with new and existing chemicals in the food and water supply.

In spite of regulations and enforcement, unintentional additives are still a part of our food and water supply. This paper addresses the issue of pharmaceutical residues and chemicals which act as endocrine disruptors found in the food and water supply in the US.

History

The mere presence of unintentional chemicals in the water supply is not a new issue. A review of the first few chapters of Rachel Carson’s book, Silent Spring (1962), reinforces the fact that materials used in the environment eventually end up in the water supply.

“Chemicals sprayed on croplands or forests or gardens lie long in the soil, entering into living organisms, passing from one to another in a chain of poisoning and death. Or they pass mysteriously by underground streams until they emerge and, through the alchemy of air and sunlight, combine into new forms that kill vegetation, sicken cattle, and work unknown harm on those who drink from once pure waters (p. 6).”
Since the 1960s, testing of water has become more sophisticated and sensitive; these highly sensitive tests indicate that man-made chemicals continue to be released into the environment. According to Kummerer (2009), over 160 different pharmaceuticals have been detected in the effluents from wastewater. These chemicals included endocrine disruptors, antibiotics, anti-inflammatories, and iodinated contrast media.

Sex steroids were first noted in the aquatic environment in 1989 (Aherne and Briggs, 1989). The findings of Aherne and Briggs stimulated many more studies on hormones in the water supply, both in the US and in foreign countries (Roig and Tourand, 2010). The realization that chemicals in the water supply had moved beyond pesticides and now included endocrine disruptors and anti-infectives was alarming. Additional research in the area of environmentally released pesticides showed that these pesticides had the possibility of being endocrine disruptors, broadening the list of known endocrine disruptor chemicals (EDCs) to include not just sex steroids but also phthalates which were associated with poor reproductive outcomes in females (Swan and Davis, 2003). Measuring the chemicals in raw and treated wastewater, surface water, groundwater, and drinking water provided information on the wide spread infiltration of chemicals in the water supply.

Over the last half century, the research question has changed from “Are there unintentional chemicals in our food and water supply?” to “How dangerous are these chemicals and at what level can they be considered safe”.

Environmental Exposure

After wastewater is treated, the water is returned to the water supply. It is estimated that the treated water has removed all but traces of (EDCs) and other drugs such as anti-infectives. This
is reassuring for humans who may have only limited direct contact with treated wastewater, but for aquatic plants and animals, this exposure to low levels of EDCs and anti-infectives takes place continually over the life span of the organism. In 2010, Fick et al. measured the plasma concentration of trout exposed to 25 different pharmaceuticals found in aquatic ecosystems and concluded that the uptake of sex steroids by the trout after just 14 days of exposure were at concentrations exceeding the human therapeutic plasma levels.

Wildlife and farm animals have also been found to have trace levels of EDCs in their milk, and in egg-laying animals, in their yolks (Rhind, 2002). The introduction of these organisms into the food supply then provides additional exposure to humans. The exposure to these different sources of chemicals makes estimating safety difficult. EDCs present in drinking water are almost negligible, but when all sources are examined and a mixed diet is taken into account, the level of ingestion may be much higher. This is really the crux of the issue in assessing the safety of unintentional chemicals in the food and water supply (Touraud, 2011).

Another growing source of unintentional chemicals enters the water supply from large farming operations. The prophylactic use of anti-infectives and EDCs in pigs, swine, and cattle enter the water system through manure, water runoff, and sludge. These chemicals continue their downhill travel into streams and rivers. In 2008, over 27% of US rivers contained anti-infectives (Garcia-Galan and Diaz-Cruz, 2008).

**Human Risk**

There is disagreement on whether trace amounts of pharmaceuticals in the food supply are dangerous to human health. In a review study of this question, Tang-Peronard et al. (2011) looked at 24 previous research projects dealing with human exposure to EDCs and the effect on
body size. Conclusions from their review indicated that dosage, gender and stage of development played a critical role in assessing risk of exposure. For example, girls appeared more susceptible to the influence of EDCs than boys; exposure during the neonatal time period was most critical in establishing risk; and counter-intuitively, at least in the context of today’s obesity crisis, chemicals at low exposure contributed to obesity, while a higher exposure of the same chemical contributed to weight loss.

The question of the safety of unintentional chemicals in our food supply was the topic of a Pew Health Group workshop held in April of 2011. Although the intent of the workshop was not to dwell on the controversies involving specific chemicals found in our food and water supply, it did provide insight on the current system the FDA uses to assure the safety of the US food supply. In the workshop proceedings, a substantial amount of time was spent on the discussion of EDCs. Current FDA guidelines do not require testing or direct assessment of changes in the function of the endocrine system related to EDC exposure. Currently, there are no standards in place to look at adverse effects in utero or at pre-pubertal exposure to EDCs. There are also no long term studies that look for adverse effects of endocrine disruptions after months, years, or decades following exposure to EDCs, especially exposure which occurred in the neonatal period. In fact, there is no agreement as to what should be considered an “adverse effect” in the context of EDC exposure. Because of the significance of the timing of EDC exposure in development, there are multiple end points that could be examined including plasma levels of EDCs, hormone-receptor binding or up regulation of sex steroids, and gene expression. More attention appears to be needed on validating biomarkers that are predictive of health effects (Maffini, 2011).
**Future Considerations**

With the continuing development of synthetic sex hormones and anti-infectives, the continued presence of unintentional pharmaceuticals in the food and water supply is essentially guaranteed. In order to continue surveillance of these chemicals, regulatory guidelines need to reflect the most current science in both laboratory methods and end point evaluations. Although there may be agreement in some circles that the low concentrations of drugs in drinking water is not a significant problem (Baran, 2011), a more cautious approach is stated by Tourand *et al.* (2011) “continuous exposure to trace levels (of EDCs) is a domain of toxicology that must be explored in order to assess the toxicological relevance of pharmaceuticals in drinking water and provide a robust human health risk evaluation”.

References


