PHARMACEUTICALS, PERSONAL CARE PRODUCTS, AND OTHER CONTAMINANTS IN THE ENVIRONMENT

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There is growing concern about increasing levels of pharmaceuticals, personal care products, and other currently unregulated contaminants in aquatic environments. In very small concentrations, many of these products can interfere with natural biological processes of several aquatic animals, resulting in less viable organisms and population declines. Two major sources of such contaminants in surface waters are wastewater treatment effluent and agricultural runoff. The former may contain hormones, vitamins, antibiotics or other pharmaceuticals associated with human intake while the later may contain pesticides, hormones, or other chemicals used to enhance animal or crop production.

The flow of many streams consists of municipal wastewater treatment facility effluents to a significant degree, especially during times of low natural flow. Mixing large volumes of wastewater upstream of drinking water and estuarine environments can expose humans and aquatic organisms to a variety of carcinogenic and endocrine-disrupting compounds. Many of these compounds are reduced with time as the water undergoes a combination of chemical, biological and physical processes. However, we know little about how to measure the compounds, how to effectively remove them, and the full range of their potential impacts on human populations and ecological assemblages.

The Problem

Bisphenol A acts like a hormone, estrogen-like. The chemical is used extensively in the production of certain plastics (e.g., polycarbonate plastic baby bottles; office water jugs; dental sealants; resin linings on the inside of most tin cans; etc). The manufacturers claim that the trace amounts leaching into food and drink are not dangerous to people, but recent studies reported in the Journal of Reproductive Toxicology raise serious health concerns. Bisphenol A is dangerous because, even at very low concentrations, it alters the normal functioning of genes, turning them on and off at inappropriate times. We do not know how bisphenol A discharged via wastewater treatment facilities affects aquatic animals.

Endocrine disrupters interfere with normal functions of the endocrine system. Several studies downstream of major sewage treatment facilities (e.g., Trinity River downstream of Dallas, Tx; Sacramento-Joaquin River in California; Japan; etc) have indicated potentially major environmental problems. Chemicals such as serotonin (from prozac), estrodiols (from birth control pills and other estrogen treatment) and steroid hormones (from pesticides) all significantly alter sexual development and sexual differentiation in fishes and invertebrates. There are documented examples of sexual reversal in fishes, feminization of salmon, reduction in fecundity of fish and shellfish, delays in crab metamorphosis, and fish population collapses from exposure to endocrine disrupters at low concentrations. They have also been implicated in interference with shedding in blue crabs, for example.

Overuse of antibiotics and vitamins results in the compounds interacting with aquatic

organisms and creating conditions for the presence of transferable genes that confer resistance to needed controls and stimulants. Crustaceans may be particularly susceptible.

The Source

Much of the introduction of endocrine disrupters arises through wastewater treatment effluents. Ubiquitous use of prozac and birth control/estrogen products results in the human body discharging significant amounts of endocrine disrupters through normal body functions. We are an "overdosed" society!

We flush huge amounts of unused and outdated medication down the toilet, right through the wastewater treatment facility, into the downstream environment. Pesticides are continuously swept into streams, lakes and estuaries via surface and subsurface runoff. Agricultural practices result in wholesale applications of antibiotics and vitamins in concentrated animal operations, resulting in runoff of steroid hormones to natural waters.

What Do We Know?

Unfortunately, we know little to nothing about the occurrence and range of these compounds in the streams, lakes and estuaries of North Carolina. The finding of more than minimum concentrations in an increasing number of aquatic systems downstream of major wastewater treatment facilities (e.g., Trinity River, San Francisco Bay, Columbia River, Boston Harbor, et al) argues that we need to sample some of our waters. A potential repository could be the Neuse River and estuary downstream of the heavily populated triangle area. Until we obtain feasible methodology and conduct monitoring in North Carolina, we can only speculate.

Traditional techniques for measuring steroid hormones in natural waters have been difficult and expensive. However, recent advances by researchers at the University of California at Berkeley promises a low-cost, accurate methodology using gas chromatography-tandem mass spectrometry (GC/MS/MS). Additional work at the University of South Carolina at Columbia has developed a new tool for identifying and quantifying endocrine-active contaminants in complex environmental mixtures and for defining endocrine disrupter exposure in sensitive estuarine systems.

What Do We Do?

We will need to develop targeted, quantitative analytical methods and bioassays for specific classes of endocrine disrupting chemicals, as well as steroid hormones, in environmental samples. When we determine where and in what concentrations these compounds are present in the aquatic environment, we will need to utilize sensitive laboratory bioassays to link exposure measurements to biological effects so that potential impacts may be assessed.

Conventional wastewater treatment facilities are not suited for effective removal of most chemicals in question. To upgrade and/or modify wastewater treatment systems to be effective at removal would be a very costly and inefficient "fix". While it may be possible to reduce concentrations of steroid hormones to acceptable risk levels by advanced treatment such as reverse osmosis and carbon filtration, this would require utilities to invest in expensive treatment systems, which may not be possible.

Recently developed information indicates that engineered wetlands provide a very cost-effective approach for reducing the concentrations of steroid hormones, especially in areas where enough land may be available. However, additional research is needed to quantify the roles of sorption, biotransformation and photolysis in such systems. Who knows, we may have the capability to engineer biological removal systems (e.g., bamboo, marsh grasses, reeds, etc) and use the resulting biomass as a cheap source of ethanol.

Obviously, the most effective means of reducing potential environmental impacts is to not introduce the chemicals into the environment in the first place. While it is unrealistic to assume that zero release is even remotely possible, we can work to reduce them by: 1) educating the public to discourage flushing unused medications down the toilet; 2) reducing the widespread and, often unwarranted, use of prozac; 3) developing alternatives to using bisphenol A in manufacturing plastics; 4) encouraging factory farms to reduce widespread use of antibiotics; and 5) educating consumers about the role and impact of chemicals in the environment.

Mechanism for Change

A multi-agency approach will be needed on this issue. The existing Coastal Habitat Protection Plan (CHPP) is a likely platform from which to launch and track progress on this effort. Active strategies for addressing both point source and non point sources should be incorporated under the CHPP Goal 4 " Enhance and Protect Water Quality". The CHPP research document references the need for research in this area: "Growing use and disposal of chemicals in support of modern lifestyles has undoubtedly had an effect on the viability of organisms in receiving waters. While there is some information available on the toxicity of certain chemicals to selected organisms, under certain conditions, more work is needed to fully evaluate the potential impact of chemical pollution on fisheries resources."

Several agencies should be solicited to participate in a cooperative coordinated approach, in addition to the Division of Marine Fisheries. The Division of Water Quality (Environmental Sciences Section, Aquatic Toxicology) may have technical expertise and has authority to monitor surface waters and advise the EMC regarding any needed rule making. North Carolina Sea Grant and North Carolina Department of Agriculture should also be included for public outreach and possible research and monitoring funding. This issue would be appropriate to address at the upcoming March 2008 Statewide Water Quality Monitoring Forum.

References available upon request.

Some Contacts for Research and Monitoring

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