PHARMACEUTICALS AND ENDOCRINE DISRUPTORS IN RIVERS AND ON TAP

Robert W. Masters
National Ground Water Association (NGWA)

Pharmaceuticals showing up in rivers downstream from sewage plants have raised concerns now that several public water systems have tested positive for drugs. Tap water in Wheeling, West Virginia, and the Ohio River tested positive for antibiotics according to USA Today November 7, 2000. A 17-year old high school student named Ashley Mulroy won the Stockholm Junior Water Prize for her project which found three common antibiotics (penicillin, tetracycline, and vancomycin) in the river and more alarming, on tap. She is not the first researcher to find drugs on tap. Thomas Heberer of the University of Berlin, Germany, presented his findings of various drugs in tap water in last year's National Ground Water Association (NGWA) international conference on emerging issues. The NGWA conference held in Minneapolis, June 7-8, 2000, was covered on Minnesota Public Radio on "Morning Edition" June 8. Keynote Speaker Janet Raloff, author of "Drugged Waters," and Dana Kolpin of the U.S. Geological Survey were interviewed. Pharmaceuticals and endocrine disrupting chemicals in water sparked international interest as scientists from the United States (U.S.), Canada, England, and Germany attended the ground-breaking conference at the Hyatt Regency, Minneapolis. Large-scale investigations are underway in over 100 of America's rivers and streams. Current drinking water standards do not require testing for any of the over 7,000 pharmaceutical compounds being prescribed, so why bother?

DRUG RESISTANT BACTERIA

One of the dominating concerns is the creation of "Superbugs." New strains of bacteria which are resistant to antibiotics are common near major cities and in rural areas and have been found in all 15 rivers from one study, including the Mississippi, the Ohio, and the Colorado. As bacteria is exposed to antibiotics they begin to adapt in order to survive, not unlike some of the drug resistant staph infections which have developed in hospitals. This is a concern, but like so many of today's environmental issues, more research is needed.

HOGS DON'T DRINK COFFEE

In a society alarmed over large-scale animal feedlots termed Confined Animal Feeding Operations (CAFO), Mad Cow, and hoof-and-mouth diseases, the animal drugs have also entered the picture. Differentiating between animal and man-made contamination becomes a challenge. Human pharmaceuticals and caffeine have been used as tracers of man-made nitrate contamination (Seiler et al., 1999). If you are deciding whether a large hog lot or subdivision on septic systems caused elevated nitrate level in water wells, you might consider testing for caffeine – hogs don't drink coffee. In Seiler's research caffeine and prescription drugs were used as evidence that household septic tank effluent was communicating with the well.

ENDOCRINE DISRUPTING CHEMICALS (EDC) AND WILDLIFE

EDC are compounds that interfere with natural production, release, transport, metabolism, binding, action, or elimination of hormones in the body (Ankley et al., 1998). We know that the normal functions of all organ systems are regulated by endocrine factors. Small disturbances in endocrine function, especially during certain stages of the life cycle, can lead to profound and lasting effects. There is evidence that specific populations of invertebrate, fish, avian, reptilian, and mammalian species have been, or currently are being, adversely affected by exposure to environmental contaminants that effect the endocrine systems. For example, there has been feminization of fish from waterbodies receiving discharges of municipal and some types of industrial effluents; there has been delayed or abnormal sexual differentiation in alligators exposed to organochlorine pesticides in lakes in Central Florida; and imposex (simultaneous presence of both male and female reproductive organs) in different species of marine gastropods has been strongly correlated with exposure to tributyltin. The major groups of animals potentially at risk include fish, birds, reptiles, marine mammals, and invertebrates (Ankley et al., 1998).

MALE FISH BECAME FEMALE

As early as 1963, a scientist by the name of Yamamoto and his colleagues did numerous studies on the Japanese medaka, a freshwater fish native to southeastern Asia, in which sexual differentiation was reversed after administration of natural and synthetic hormones (Metcalfe et al., 1999b). That's right – newborn male fish became female. While this work was done in the lab, the literature is quite clear that human sewage is altering the sex steroids in fish. Shane Snyder, a Ph.D. candidate at Michigan State, has tracked human estrogen Estradiol-17b from sewage in the Las Vegas Wash to vitellogenin induction in male fish. This protein, vitellogenin, is normally produced by reproducing females. According to Snyder, estradiol in water in the parts per trillion range can cause male fish to produce the egg making protein vitellogenin (Raloff, 1998). Vitellogenin is a recognized biomarker for exposure to estrogenic compounds. As analytical instruments become more and more precise, it is now possible to detect compounds at concentrations so minute that they were once considered insignificant. The Food and Drug Administration (FDA) requires that drug manufacturers must demonstrate that new medications have less than a part per billion concentration in the environment before they are approved or face much more stringent toxicity and risk testing (Masters, 2001).

IDENTIFYING EDC

EDC are high on the U.S. Environmental Protection Agency (EPA) radar screen. They can be natural hormones, pharmaceuticals such as birth control pills, estrogen replacement products and other steroids, and hundreds of organochlorine compounds found in pesticides and industrial chemicals like PCBs and DDT. EDC appears to be persistent in the environment and bioaccumulate, and exposures are widespread thoughout the entire globe. Examples are organochlorines, cadmium, tributyltin, alkylphenols, and estrogen. Compounds in the complex mixtures from pulp and paper mills and municipal effluents have been shown to be EDC. Actually, paper mill effluent has recently been determined to produce the male hormone Androstenedione and masculinized fish. The paper mill sludge contained the male steroid identical to the one made famous by baseball slugger Mark McGuire (Raloff, 2001). Based on recognition of the potential scope of the problem, the possibility of serious effects on the health of populations and the persistence of some EDC in the environment, research on EDC was identified as one of the six high-priority topics in the EPA Office of Research and Development Strategic Plan, U.S. EPA, 1996. U.S. EPA has developed a comprehensive plan to research endocrine disruptors (Ankley et al., 1998).

HUMAN HEALTH

The question becomes - is there a risk to human health or is there a disconnect between sound science and public perception? If you have ever heard a drug commercial on TV with a long list of side effects and "ask your doctor if it's right for you," it does make you wonder. Currently there are insufficient data to resolve the question of human health risk associated with pharmaceuticals in water. In general, it is thought that modest amounts of chemical exposure seldom compromise normal physiological functions. We know little about the concentrations of EDC that would induce effects in various populations. Some of the questions that must be addressed in the future are:

- What are the subtle effects occurring in low dose exposure by human and wildlife populations?
- What are the chemical classes of interest and their potencies?
- What about exposure to multiple EDC and drugs?

GROUND AND DRINKING WATERS

Is this only a surface water issue? We know from Seiler, Heberer, Ternes, and others that there is at least some data on ground water concentrations from bank infiltration at near-stream environments and septic systems. More sampling of septic tanks and wells for drugs is needed. What we do know is that drugs and EDC are in the sewage, in the rivers, and in some drinking water. Also, we want to emphasize the extremely low concentrations. We don't find any of the 7,000 plus pharmaceutical products on the primary drinking water standards. In the United States, the number one prescribed pharmaceutical is conjugated estrogen. And at last glance estrogen, testosterone, or any other steroid hormones are also unregulated in drinking water. Early tests on treatment show promise for granular activated carbon and reverse osmosis.

NGWA CONFERENCE TO COVER PHARMA-CEUTICALS AND EDC

This issue of *Water Resources Update* is comprised of an early edition of selected manuscripts from the upcoming ***2nd International Conference on Pharmaceuticals and Endocrine Disrupting Chemicals in Water,*** which will be held on October 9-11, 2001, in Minneapolis, Minnesota – on the Web at www.ngwa.org/-education/pharmconf.html. The conference keynote address will be given by Dr. Thomas Ternes from ESWE-Institut fur Wasserforschung and

Wassertechnologie, Wiesbaden, Germany, entitled "Pharmaceuticals as New Emerging Environmental Contaminants: A Survey."

AUTHOR

Robert "Bob" Masters is presently the Conference Coordinator at the National Ground Water Association and has produced 12 regional and international conferences on ground water. Bob is a member of the U.S. EPA National Drinking Water Advisory Council Research Working Group and the U.S. Geological Survey Advisory Committee on Water Information. He is a ground water hydrologist formerly with the U.S. Geological Survey and the former Director of the National Ground Water Information Center. He is a graduate of The Ohio State University, School of Natural Resources.

Bob Masters
National Ground Water Association
601 Dempsey road
Westerville, Ohio 43081
1-800-551-7379, fax 614-898-7786
rmaste@ngwa.org

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