Pharmaceuticals in Water

A White Paper

For Sigma Xi

Martha J.M. Wells, Ph.D.
Professor/Environmental Chemistry and
Councilor of the American Chemical Society
Center for the Management, Utilization, and
Protection of Water Resources and
Department of Chemistry
Tennessee Technological University
Box 5033
Cookeville, TN 38505
Phone: (931)372-6123
FAX: (931)372-6346
e-mail: mjmwells@tntech.edu

April 22, 2008

Recently, an Associated Press investigation focused attention on the occurrence of pharmaceuticals in selected drinking water supplies throughout the United States. For those of us scientists and engineers who have already been researching in this field over the past decade, this report was not news, but the public response ranged from one extreme to the other: either with it being dismissed as purely media hype or with it being taken as cause for total alarm. The appropriate response to this issue lies somewhere in the middle. The drinking water produced by municipalities in the United States is the best in the world, but with that said, there is room for improvement.

The world's water supply circulates in a cycle in which this precious commodity is constantly reused. Point sources of wastewater are either treated at a processing facility, routed into a septic system, or, in the minority of situations in the United States, do not undergo treatment. The effluent from wastewater facilities is discharged into U.S. waters. Non-point source runoff also contributes contaminants to our water supply. The cycle continues as surface water and groundwater are used to supply the intake to a drinking water plant. We consume the processed drinking water; our excrement ends up in wastewater; and so the cycle begins again. Unless you live at the North Pole, we are all downstream from someone else! If any contaminant, including a pharmaceutical, is not removed during wastewater treatment, and subsequently, is not removed during drinking water treatment, it will end up in our drinking water. The same chemical properties that make it possible for pharmaceuticals to be distributed in our bodies cause them to be difficult to remove from wastewater and drinking water. Conventional systems of wastewater and drinking water treatment that produce a 90, 95, or 99% removal rate of a contaminant may be insufficient.

Pharmaceuticals, and their metabolic products, potentially enter wastewater and surface water in four ways: from a pharmaceutical manufacturing facility (a point source), through excretion in our urine and feces (a point source), through flushing of unused medications (a point source), and through the use of veterinary medications (primarily a non-point source). The release of pharmaceuticals from manufacturing facilities is regulated and is not a major contributor to the problem. However, excretion of pharmaceuticals by humans and animals and flushing unused pharmaceuticals do contribute substantially to the ultimate occurrence of pharmaceuticals in drinking water.

Although occurrence of pharmaceuticals, with various modes of action—including antibiotics, analgesics, antidepressants, antacids, antihyperlipidemics, anti-inflammatories, endocrine disrupting steroids and hormones, etc.— is being reported in our water supply, the two biologically active categories of compounds perhaps receiving the most attention are antibiotic/antimicrobial compounds because they may lead to increased bacterial resistance to antibiotics, and endocrine disrupting compounds (EDCs), such as hormones, that can agonistically or antagonistically interfere with estrogenic, androgenic, and thyroid-related effects. Although the concern associated with pharmaceuticals in drinking water is that bioactive chemicals consumed in drinking water will exert the activity for which they were designed, to date, **no known human health effects** are attributable to the presence of pharmaceuticals in drinking water. That information, coupled with the knowledge that pharmaceuticals occur in drinking water at trace levels, has prompted some to respond that the issue is just media hype.

However, I believe that a justified level of concern (not alarm) is the appropriate response, and of course, as a scientist, I believe that further research and consideration of regulation is warranted.

Most toxicological impacts of chemicals are known for acute exposures at high levels, such as in situations of occupational exposure to chemical spills. However, environmental exposures to chemicals tend to be chronic, over long periods of time at trace concentrations. Less data exist on chronic exposures of chemicals at environmentally relevant concentrations.

After the initial shock of finding that pharmaceuticals are occurring in drinking water, the public has experienced the aftershock of learning that the levels of pharmaceuticals are unregulated. The most important effect of the Associated Press article was to heighten public awareness. If your water treatment facility cannot supply you with data regarding whether pharmaceuticals exist in your drinking water, they are not out of compliance. No regulations currently require monitoring or public reporting of the presence of pharmaceuticals in our water supply. Thus, a paucity of data exists on the occurrence of pharmaceuticals in drinking water. Regulations are based on several factors such as risk (undefined in this case), treatability, and costs. Also, political will factors into consideration.

Monitoring pharmaceutical occurrence in drinking water is very expensive—the workhorse instrument for this purpose is based on the analytical principles of liquid chromatography and tandem mass spectrometry (LC-MS-MS). Development and implementation of advanced wastewater and drinking water treatment processes necessary to remove pharmaceuticals and their degradation products from our water supply are actively being pursued by researchers and will also be expensive.

The best approach to disposing unused medications is complete destruction via incineration. However, this venue is not commonly available to the average citizen. In the absence of pharmaceutical take-back programs, currently, the best approach for discarding most unused medications is combining them with an adulterant, like coffee grounds or kitty litter, and disposing them in trash destined for a licensed landfill. However, when it is indicated on the medication label, the Food and Drug Administration recommends that certain medications, such as narcotics, be flushed. Guidance on disposal of unused prescription medications is available at the Web site http://www.whitehousedrugpolicy.gov/drugfact/factsht/proper_disposal.html. Additionally, the Environmental Protection Agency Web site on pharmaceuticals and personal care products (PPCPs) in the environment provides useful information on this topic and is located at http://www.epa.gov/ppcp/.

As a chemist, I am proud of my profession and its contributions to improving our quality of life. But a foreign chemical where it does not belong, such as a pharmaceutical in drinking water, or any other chemical inadvertently distributed in the environment, is not, in my opinion, a good thing. Some chemicals applied to the environment have yielded benefits. However, the inadequate treatment of pharmaceuticals in our water supply has resulted in an environmental problem. Meanwhile, I continue to consume municipally treated drinking water.

Additional reading:

Wells, M.J.M. 2006. Log D_{OW}: Key to Understanding and Regulating Wastewater-Derived Contaminants. *Environ. Chem.* 3:439-449.

Wells, M.J.M., L.J. Fono, M.-L. Pellegrin, A. Morse. 2007. Emerging Pollutants. *Water Environ. Res.* 79(10): 2192-2209.

Wells, M.J.M. 2007. Examination of the Mobility Scoring Hierarchy Used to Select Chemicals for the U.S. EPA Contaminant Candidate List Classification Procedure [CD-ROM pp. 86-98]. Proceedings of the Water Environment Federation 2007 Specialty Conference Series. Compounds of Emerging Concern: What Is on the Horizon? Providence, RI.