Drugs in the Water

Story and photo by Leah Eisenstadt

How our medicine cabinets are contaminating nature.

On a typical American morning, a woman takes a contraceptive dose of hormones, washing it down with a grande, non-fat cappuccino. She gives her young son a dose of an antibiotic to treat his ear infection. Her husband swallows a medication to control his high blood pressure and pops two pain pills for his headache. Their college-aged daughter, suffering from depression, consumes her daily dose of anti-depressant and lights up her first cigarette of the day.

Scenes like this one occur every morning in homes across the country. But most Americans rarely consider where the contents of this country's vast medicine cabinet will end up. We consume more and more drugs every year, in the form of caffeine, nicotine, and pharmaceuticals. But these chemicals don't magically disappear once they've entered our bodies – although we metabolize much of them, we excrete whatever our bodies don't use. Excess drugs in the bloodstream make their way out of the body through urine and fecal matter, and the excreted chemicals flow with the sewage out of our homes. These drugs can then pass through sewage treatment plants into streams and lakes, where they can be taken up by wildlife and drinking water supplies. Recent discoveries of pharmaceutically polluted waters and abnormal fish are raising fears that our abundant use of drugs may be harming the ecosystem in unforeseen ways.

What makes pharmaceutical pollution so worrisome is that the usual safeguards that protect us from bacteria and toxins, fail to rid sewage of these chemicals. Most treatment plants filter and chlorinate sewage to remove disease-causing microbes and excess organic matter, but do nothing to clean the water of pharmaceuticals, which slip right through traditional treatment processes. When plants release treated sewage into streams, they pump drug-tainted water directly into the aquatic habitat. And they aren't breaking any laws. So little is known about the health effects of these pollutants or their levels in U.S. waters, that federal and state governments have no solid data to refer to in deciding how to control their release into the environment.

Water quality experts and environmental toxicologists have steadily become more concerned about drugs in our waters since their discovery more than 25 years ago. In 1976 and 1977, U.S. researchers found clofibric acid, a cholesterol-lowering medication, in addition to nicotine, caffeine, and ibuprofen in samples of water from a sewage treatment plant in Kansas City. The issue was virtually forgotten until the early 1990s, when environmental scientists in Germany found clofibric acid, lipid regulators, and painkillers in groundwater beneath a sewage treatment plant. These findings sparked new attempts to measure pharmaceuticals in the water, which became possible with the advent of new testing equipment. In the past decade, researchers in Europe and Canada have found substances like antibiotics, blood pressure reducers, hormones, psychiatric drugs, and pain killers in treated water leaving sewage plants and in the rivers, streams, and lakes that many of the plants empty into.

These accumulating signs of a problem soon caught the interest of U.S. researchers. After a 1998 workshop to discuss the European findings, the United States Geological Survey began the first nation-wide study of pharmaceuticals in U.S. waters. During 1999 and 2000, a USGS research group tested water from 139 streams across 30 states. The researchers focused on the most suspect substances and locations – treated sewage water is often fed to streams near urban areas and runoff from livestock facilities adds antibiotics and growth steroids. So the team searched for pharmaceuticals, caffeine, and hormones near cities; and antibiotics in the runoff from livestock facilities.

The team, led by Herb Buxton, coordinator of the USGS Toxic Substances Hydrology Program, measured levels of 95 compounds in the streams. In 80 percent of the streams they sampled, they found one or more pharmaceutical contaminants. One location even tested positive for 38 of the 95 substances measured.

Buxton's team found these compounds at concentrations less than one part per billion, which is below the therapeutic level for humans, but they wondered whether these levels might pose a danger to fish. "We were finding [drugs] in the water," said USGS team leader Dana Kolpin, "but we also began to ask: Is there an impact?" Kolpin was particularly worried about a group of chemicals known as endocrine-disrupting compounds, which can lead to sexual abnormalities in fish, amphibians, and reptiles. These substances include steroids, hormones like estrogen (either estrogen found naturally, in birth control pills, or from hormone therapy), and even some detergents and pesticides.

Since the initial findings, USGS water quality experts have been collaborating with aquatic biologists around the country to test their theory that the endocrine-disrupting compounds damage the reproductive systems of aquatic life. David Norris is a University of Colorado physiologist who studied the effects of estrogen on fish downstream from water treatment plants in Colorado's Boulder Creek. Norris found ten female white sucker fish for every male in areas downstream of water treatment plants, compared to a one-to-one ratio upstream of the water treatment plants. Further proof of reproductive trouble, the mature females that he found downstream had smaller ovaries than those upstream.

The skewed gender ratio and abnormal female fish, downstream of treatment plants and pollution-control equipment, weren't the only alarming findings. The researchers also discovered many strange, inter-sex fish, which had both male and female reproductive tissue. "We can't tell from looking [at these fish] whether it's a male becoming a female or a female becoming a male," said Norris. Because of the high ratio of female to male fish, Norris suggests that the male fish are probably reacting to estrogen in the water and growing female tissue, so that they were counted as female fish during the census.

Any change in the gender ratio or abnormality in reproductive tissue can adversely affect a population of fish, potentially reducing it with each generation. During the summers of 2001 and 2003, a group led by University of New Brunswick ecotoxicologist Karen Kidd spiked the water of a Canadian lake with the type of estrogen found in birth control pills, to find out how the hormone might impact the number of aquatic animals. They added the hormone at a level of six parts per trillion, which is similar to levels that have been found in treated sewage water. The male fish they tested – from tiny minnows to trout – had some female sex tissue. The most alarming finding was that the lake's population of the common Fathead minnow plummeted from thousands to almost zero, because estrogen so thoroughly disrupted the minnow's reproductive abilities.

Norris and Kidd correlated high estrogen levels in the water with abnormal reproductive tissues and population decline – all of which points to estrogen as a suspect. But the hormone hasn't been convicted yet. Studies in the natural environment are subject to weather changes, other chemicals present in the water, temperature fluctuations, and a host of other variables. Only highly controlled studies in a laboratory or in a mobile lab in the field can eliminate other influences and answer the estrogen question directly. To show cause and effect, Norris will pump water from estrogen-tainted streams directly into fish tanks, in an attempt to reproduce the same problems found in wild fish.

Other scientists are testing estrogen's effects in the lab by spiking water with the substance and seeing how fish respond. David Walker, a research scientist at the University of Arizona, is exposing chubb fish in an aquarium to estrogen-containing wastewater. Walker will measure fish levels of vitellogenin, a hormone that is normally found at very low levels in male fish, but can be induced by estrogen and endocrine-disrupting compounds.

Estrogen and hormones provide a dramatic example of the potential for human pharmaceutical waste to harm an ecosystem, but they're not the only harmful drugs found in U.S. waters. Thousands of pharmaceuticals from Prozac to ibuprofen contaminate the aquatic habitat. Studies to determine the effects of those compounds on fish are currently underway.

If human waste is, in fact, causing these problems in the ecosystem, then we'll need to change the way we treat our waste. Reverse osmosis is one candidate technique, in which water is forced through a semi-permeable membrane, leaving behind unwanted

pollutants. “The technology is very effective, but it’s hard to implement because of the several-fold higher cost,” said Joel Pedersen, soil science professor at the University of Wisconsin-Madison. Until the link between drugs in the water and ecological danger is proven definitively, there will be no reason for the government to require this expensive filtration.

No one yet knows if this emerging problem will lead to a crisis for our environment and the threatened organisms within. It’s quaint to remember a time when industrial pipes were the only sources of pollution, but we can’t deny that individuals are now sources of pollution, as surreal as that may seem. The notion that drugs passing through our bodies might severely harm fish for generations to come is just another example of the dangerous resonance of human behavior, the echoes of which have yet to be fully heard.

http://www.bu.edu/sjmag/scimag2005/features/drugsinwater.htm