COASTAL SERVICES

Volume 13, Issue 1 • January/February 2010

LINKING PEOPLE, INFORMATION, AND TECHNOLOGY

PHARMACEUTICALS IN THE ENVIRONMENT: Coastal Managers Are

Discovering How to Respond

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PHARMACEUTICALS IN THE ENVIRONMENT: Coastal Managers Are Discovering How to Respond

When someone gets a headache, the typical response is to take an over-the-counter pain reliever—just one of tens of thousands of over-thecounter and prescription medicines on the market, with more being developed each year. The residue of these drugs and other products is being detected in rivers and coastal waters across the country, raising concerns about potential impacts to humans and aquatic species.

While there have been no indications of harm to human health, according to NOAA there is growing evidence that some of these chemicals may have negative effects on the reproduction of aquatic species,

"The fish are our canary in the coal mine."

Yo Chin, Obio State University

or may stimulate the development of antibiotic-resistant bacteria.

"The correct answer is that we don't know yet how much to be concerned," says Laura Jacobs, a former Old Woman Creek National Estuarine Research Reserve (NERR) graduate research fellow investigating the issue. "What we are seeing are very low concentrations—we're talking subparts-per-billion—but little is known about the effects of long-term, chronic exposure."

Coastal resource managers in Ohio are helping to find answers by funding research about how medications and hormones

break down in the estuarine environment and potential treatment processes. Managers in New York and elsewhere are addressing the issue by sponsoring events where the public can return unused medicines for safe disposal and by providing education and outreach.

"What most coastal managers are trying to do right now," says Jeff Reutter, director of the Ohio Sea Grant College Program, "is basically encourage people to not follow the old routine from years ago of flushing used drugs down the toilet, which turns out to be pretty bad advice."

Growing Problem?

Annual U.S. prescription drug sales hit \$291 billion in 2008, according to IMS Health Inc., a data-tracking firm. In 2010, the firm

predicts that about \$320 billion in pharmaceuticals will be sold in the U.S. and the value of the global pharmaceutical market will grow 4 to 6 percent, exceeding \$825 billion.

As detection techniques have become more sensitive, scientists are finding pharmaceuticals and over-the-counter medications, as well as veterinary medicines, in estuaries, rivers, streams, groundwater, and sediments.

One of the most extensive studies of medications in streams, lakes, and rivers was conducted in 2001 by the U.S. Geological Survey. A network of 25 groundwater and 49 surfacewater sources of public drinking water in 25 states and Puerto Rico was sampled and analyzed for 124 emerging contaminants. At least one emerging contaminant including acetaminophen, steroids, hormones, codeine, antibiotics, antimicrobials, and ibuprofen was detected in 96 percent of the samples (http://toxics.usgs.gov/ regional/emc/source_water.html).

System Flush

The primary way medications make their way from the bottle into the environment seems to come from people taking drugs and flushing them-unmetabolized or unusedinto wastewater treatment and septic systems, where treatment may not be adequate to remove all drug residues.

Medications can also leach into the environment from leaking landfills and runoff from lands where sewage wastewater and sludge have been applied. Veterinary pharmaceuticals can come from aquaculture and

animal feeding operations. Even "A huge part of the problem

the drugs given to pets find their way into the environment. comes from agriculture," explains Yo Chin, a professor at Ohio State University's School of Earth Sciences and an Ohio Sea Grant researcher. "Cattle are injected with growth hormones and other compounds that are not hormones, but are hormone-like. It is those hormonelike compounds that scare me more than anything else because we don't know exactly what they are doing."

Uncertain Risks

Once these compounds are in the environment, their risks to aquatic organisms and to scientists have found no evidence of adverse human health effects; that certain drugs—especially of growth and reproduction in species such as fish and frogs. According to the U.S. Environmental Protection Agency, effects can include the production of more females than males within a given population, the presence of both male and female reproductive organs in individual organisms, poor egg-hatching success, decreased fertility and growth, and altered behavior. "Reductions in the sperm counts of many fish have been well documented," notes Linda and the John C. Geupel Professor of Civil Engineering at Ohio State

humans are uncertain. To date, however, research suggests hormones-may cause ecological harm, including interference Weavers, a Sea Grant researcher

University's Department of Civil and Environmental Engineering and Geodetic Science. "There appears to be a linkage [to pharmaceuticals], but there are many, many factors that could be causing it... The critical issue is being able to pinpoint it down to one thing."

"The fish are our canary in the coal mine," says Chin. "They are an early warning sign that we need to be paying attention" to this issue.

Funding Research

Coastal managers in Ohio are paying attention. Ohio Sea Grant and Old Woman Creek NERR, for instance, have provided research funding to explore the issue.

For more than a decade, Chin has been conducting a series of investigations into how pharmaceutical compounds break down in the estuarine environment of Old Woman Creek. "What I'm interested in," he says, "is when these compounds are in the environment, what happens? Does it break down or hang out? What role does sunlight play?"

In her work as a graduate research fellow at Old Woman Creek, Laura Jacobs looked specifically at how quickly the sun breaks down ibuprofen and caffeine within the estuary. "The sun does degrade it naturally, which is good news if you are thinking about long-term assessment," she says. The bad news is that by-products are generated.

"An important question that remains unanswered is what are the compounds breaking down into," says Frank Lopez, manager of Old Woman Creek NERR.

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Naturally Breaking Down

Another important element of Chin's and Jacobs' work has been illustrating the "role wetlands have in breaking down organic pollutants and pharmaceuticals," Lopez says. "Their research further validates the filtering function of wetland systems."

"Most estuaries and coastal areas capture nutrients and break these compounds down," Chin says. "What we are demonstrating with our research is that maintaining and preserving estuaries and wetlands is doing a lot of good."

The underlying message for coastal managers, he says, is the importance of preserving and restoring natural wetlands. "Recreating a wetland somewhere else is not the same."

Potential Treatments

Weavers is taking another approach and is researching the potential use of sonication—or applying sound waves—to remove pharmaceuticals and other products from wastewater or drinking water.

"It's important that we find solutions to remove these compounds, and that we find a solution that is reasonably cost effective," she says.

Weavers notes that many wastewater treatment plants are already using the technology to break up sludge in wastewater and that her research is just using the technology in different ways.

Medicine Take-Back Program

One way to reduce the level of medications in coastal waters is to reduce the amount of medications entering the environment in the first place. This is the route

New York Sea Grant has taken, sponsoring a Return Unwanted Medicines event last spring, and educating residents and health care professionals about the issue.

The event, modeled after an Illinois-Indiana Sea Grant program, was the largest one-day collection of its kind on Long Island, says Larissa Graham, outreach coordinator for the Long Island Sound Study. Over 140 participants returned 496 pounds of unwanted medicines.

After the event, New York Sea Grant created a how-to-guide for other coastal managers.

Encouraging Action

While all those interviewed for this article urged a non-alarmist approach to the topic, most also cautioned that coastal managers should not wait to take action until science determines the answers to the myriad of questions.

"This should not be treated like a criminal court where it is innocent until proven guilty," says Weavers. "A huge body of research needs to be done to understand these things better."

Jacobs notes, "This issue could have a staggering amount of complications."

"The bottom line," says Reutter, "is what kind of strategies can we develop to keep unused drugs from getting into the system—period and what strategies can we develop to remove them from the system."

He adds, "This is an issue that people are only beginning to think about." 💠

For more information on coastal managers' role in addressing pharmaceuticals in the environment, contact Jeff Reutter at (614) 292-8949, or reutter.1@osu.edu, or Frank Lopez at (419) 433-4601, or Frank.Lopez@ dnr.state.oh.us. For research information, contact Yo Chin at (614) 292-6953, or yo@geology.ohio-state.edu, Laura Jacobs at (202) 334-2146, or LHelsabeck@ nas.edu, or Linda Weavers at (614) 292-4061, or weavers.1@osu.edu. For information on New York Sea Grant's Return Unwanted Medicines event, contact Larissa Graham at (631) 632-9216, or larissa.graham@cornell.edu.

ADDITIONAL INFORMATION

NOAA's efforts to address pharmaceutical compounds in the coastal environment, www.noaa.gov/features/protecting_1208/pharmaceuticals.html

U.S. Environmental Protection Agency (EPA) website on pharmaceuticals and personal care products as pollutants, www.epa.gov/ppcp/

New York Sea Grant how-to guide on holding a successful pharmaceutical take-back event without outside funding, www.seagrant.sunysb.edu/ article.asp?ArticleID=362

Taking a National Approach to Finding Local Low Impact Development Projects

Local officials may be intrigued by the idea of using low impact development (LID) to help curb stormwater and water quality issues, but they can be reluctant to implement LID without concrete examples of how other projects have been designed and implemented and their long-term success. A new Web atlas is filling this need by showcasing examples of innovative LID projects from across the country.

"When we would go out and talk to communities about LID, a lot of them can be really nervous about being the first ones to do it," says John Rozum, former director of Connecticut's Nonpoint Education for Municipal Officials (NEMO) project. "This [Web atlas] really came up as a way to help our target audience visualize what LID is, and see that the technology is being used successfully around their state and the nation."

"The other piece," says David Dickson, the National NEMO Network coordinator. "is to give them a contact they can talk to in other towns in their state and region. It's serving as a portal to help local officials learn more about LID practices and about specific examples."

The LID Atlas was recently launched by the National NEMO Network, a confederation of educational programs in 30 states dedicated to protecting natural resources through better land use and land-use planning. LID refers to a number of stormwater management

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practices—such as vegetated swales, The user-friendly atlas can "This is a grassroots tool

rain gardens, green roofs, rain barrels and cisterns, permeable pavement, and water conservation—that reduce runoff and help to protect water resources from the impacts of nonpoint source pollution. be searched for examples of a particular practice, projects from a particular state, or projects on a land-use type (commercial, industrial, residential, mixed use). There is also a keyword search for users looking for a specific project. that anyone can take and use," Dickson says.

Local in Approach

The atlas began as a Connecticut NEMO project to capture the LID projects in the state, says Rozum. It was quickly apparent that information from other NEMO programs could be added to the site to create a national resource.



The LID Atlas provides project summaries, photographs, and links to additional information.

"This is a grassroots tool that anyone can take and use."

David Dickson, National NEMO Network

When information about the Connecticut site was provided to the NEMO Network, the California NEMO program quickly signed on to add its inventory, Dickson says.

Connecticut's and California's data were combined using a "mashup" of each state's local LID practices on Google Maps imagery. A mashup is a combination of tools, programs, or data from two or more sources to make a separate, integrated product. The only drawback to the Google technology, says Rozum, is that the atlas does not work when viewed in the current version of Internet Explorer, although they are working on a way around that problem.

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