U.S. Geological Survey

Technical Announcement:
Understanding how Pharmaceuticals in the Environment Affect Fish

Results Show Impacts to both Juveniles and Adults

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Fish health may be affected by pharmaceuticals in treated wastewater released into streams and other water bodies, according to a recent laboratory and field study by the Aquatic Toxicology Laboratory at St. Cloud State University and the U.S. Geological Survey (USGS). This research is published in a special edition of *Environmental Toxicology & Chemistry* related to pharmaceuticals in the environment.

This study looked for effects from nine individual pharmaceuticals, as well as varying mixtures of these chemicals, on both juvenile and adult fathead minnows. The selected pharmaceuticals and corresponding exposure levels for the laboratory experiments were guided by previous USGS research (http://toxics.usgs.gov/highlights/PMFs.html) .

”Exploring the effects of multiple pharmaceuticals in mixtures at concentrations previous measured in the environment provided for immediate relevance of the study,” said St. Cloud State University scientist Heiko Schoenfuss, the lead author of the study. “The pharmaceuticals studied are highly prescribed and have been found in the environment in previous studies, including by our USGS co-authors.”

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Prior USGS research has also documented the release of pharmaceuticals is greater in areas where local sources of pharmaceuticals, such as medicinal manufacturers, may contribute a disproportionately larger amount of pharmaceuticals to wastewater treatment plants. In addition, one of the wastewater treatment plants receiving waste from pharmaceutical manufacturing was also used for the field component of this research.

Fathead minnows were used as they are a common laboratory model for studies of this kind and are also an ecologically important species that can be found throughout North America. The minnows were exposed to both individual pharmaceuticals and mixtures of these chemicals in a laboratory setting as well as to treated wastewater at a wastewater treatment plant to represent a real world setting.

“Including the field exposures was an important part of this study,” said USGS scientist Dana Kolpin, one of the study’s co-authors. “Our research documented that effects observed in the field are not always easily reconciled by laboratory studies because of the full complexity of real-world conditions. Because of this, it’s crucial to include a wide variety of conditions and organism life stages when assessing the effects of pharmaceuticals on aquatic ecosystem health.”

A comprehensive suite of symptoms of adverse health effects across minnow life stages were assessed for this study. Juvenile fathead minnows exposed to the pharmaceuticals suffered from reduced growth and altered escape behavior. This means that, when faced with a threat, the minnows did not escape as efficiently as they normally would, potentially increasing the chances they would be eaten and that could ultimately translate to population level effects.

Interestingly, adult females and males were found to react differently to pharmaceutical exposures. Adult females generally experienced an increase in relative liver size compared to control females, suggesting that the liver is reacting to the influx of pharmaceuticals.

Meanwhile, adult males exposed to the pharmaceuticals had a variety of reactions. Most did not defend their nests as rigorously as those that were not exposed to the pharmaceuticals. The males exposed to wastewater treatment plant effluent in the field component of this research ended up producing a chemical known as *plasma vitellogenin*, a protein associated with egg production in females and is an indicator of feminization of male fish.

The following pharmaceutical chemicals were studied:

1. Hydrocodone: an opioid pain reliever
2. Methadone: an opioid pain reliever
3. Oxycodone: an opioid pain reliever
4. Tramadol: an opioid agonist pain reliever
5. Methocarbamol: a muscle relaxant
6. Fluoxetine: an antidepressant
7. Paroxetine: an antidepressant
8. Venlafaxine: an antidepressant
9. Temazepam: a sleep aid

The paper describing the results of this study in detail can be found in *Environmental Toxicology and Chemistry*, and is part of a long-term effort to understand the fate and effects of contaminants of emerging concern and to provide water-resource managers with objective information that assists in the development of effective water management practices.