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USGS Home
Contact USGS
Search USGS

Environmental Health - Toxic Substances Hydrology Program

Environmental Health
- About
- Our Contacts
- Featured Science Activities
- GeoHealth Newsletter
- Science Teams
- Contaminant Biology Program
- Toxic Substances Hydrology Program
  - About the Program
  - Featured Science Activities
  - News Releases
  - Science Teams
  - Publications
  - Search Bibliography
  - Photo Gallery
  - Site Map

Mission Areas
- Land Resources
- Core Science Systems
- Ecosystems
- Energy and Mineral Resources
- Environmental Health
- Natural Hazards
- Water

Antidepressants in Stream Waters! Are They in the Fish Too?

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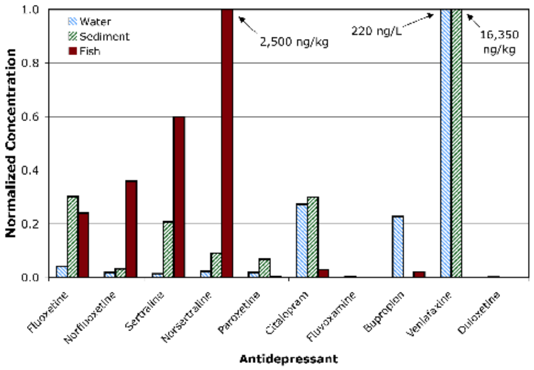
USGS scientist removing the brain from a fish (a white sucker) collected from Fourmile Creek near Ankeny, Iowa. The scientists tested the fish's brain for the presence of antidepressant drugs. Traces of antidepressant drugs were found in fish and also in the water from Fourmile Creek.

For some fish living downstream of sewage treatment plants the answer is yes. U.S. Geological Survey (USGS) scientists and their colleagues published a paper in *Environmental Science and Technology* documenting that specific antidepressants and their degradates found in wastewater discharged into streams by municipal wastewater treatment plants are taken up into the bodies of fish living downstream of the plants. The antidepressants were found in fish collected over 8 kilometers (approximately 5 miles) downstream of the location of the wastewater discharge. The scientists detected several commonly used antidepressants in water, streambed sediment, and the brain tissue of white suckers, a native fish species. Fish collected upstream from the wastewater discharge did not have antidepressants present in their brain tissues. The study was conducted in two streams, Boulder Creek near Boulder, Colorado, and Fourmile Creek near Ankeny, Iowa.

More of What the Scientists Found

- This study is the first to demonstrate that the concentrations of these antidepressants in stream waters do not necessarily correlate with the concentrations or presence of antidepressants that are found in fish tissue. Other factors come into play that determine which antidepressants are taken up by the fish.
- The most frequently detected antidepressants in wastewater and stream water were venlafaxine, bupropion, and citalopram. In contrast, the most frequently detected antidepressants in fish brains were fluoxetine, norfluoxetine (a transformation product of fluoxetine), sertraline, and norsertraline (a transformation product of sertraline).
- The scientists collected the brains of white suckers because antidepressants are designed to modulate the concentrations of brain chemicals called neurotransmitters (such as serotonin, norepinephrine, and dopamine). Thus, brains are the location in fish most likely to be affected by antidepressants.



Average concentrations of antidepressants in water, sediment, and fish neural tissue from Boulder Creek just below the point where wastewater from a sewage treatment plant is discharged (USGS Site ID 400305105103901). Since concentration units differed for each sample type, the concentrations were normalized to the highest single antidepressant concentration in each sample type (highest concentration was set to equal one). The graph shows that fish selectively absorb some antidepressants more than others.

The study was conducted in collaboration with scientists from the College of Wooster, Ohio; St. Cloud State University, Minnesota; and the University of Colorado at Boulder.

References

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Painter, M.M., Buerkley, M.A., Julius, M.L., Vajda, A.M., Norris, D.O., Barber, L.B., Furlong, E.T., Schultz, M.M., and Schoenfuss, H.L., 2009, Antidepressants at environmentally relevant concentrations affect predator avoidance behavior of larval fathead minnows (*Pimephales promelas*): Environmental Toxicology and Chemistry, v. 28, no. 12, p. 2677-2684, doi:10.1897/08-556.1.

More Information

- Emerging Contaminants in the Environment Investigation
- Ecological Effects, Emerging Contaminants in the Environment Investigation

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> *"The most important observation in our study is that you cannot necessarily predict which antidepressants are present in aquatic tissue from antidepressant concentrations in the water the organisms are living in. This study clearly documents selective uptake of specific antidepressants into fish brain tissue that were minor components in corresponding water samples. There are many reasons why this selective uptake may occur - including differences in fat versus water solubilities of the targeted antidepressants - but these results suggest other, as yet unidentified mechanisms may also be involved that warrant further study.*
>
> *We also do not yet fully understand the implications for fish health and populations*

from exposure to these antidepressants. However, we have collaborated in laboratory experiments (Painter and others, 2009) documenting a slowed predator avoidance behavior in larval fathead minnows exposed to antidepressant concentrations similar to those observed in this study. A slower response to predators is probably not helpful when you are on the lower end of the food chain."

Edward Furlong, USGS research chemist, corresponding author

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- Antibiotics in Groundwater Change Bacterial Ecology
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- Do Combined Sewer Overflows Increase or Decrease Wastewater-Related Chemicals in Receiving Waters?
- Hormones Degrade in the Environment!
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- Tackling Fish Endocrine Disruption
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- Biosolids, Animal Manure, and Earthworms: Is There a Connection?
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- Endocrine Disruption Found in Fish Exposed to Municipal Wastewater
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- Are Pharmaceuticals in Your Watershed? Understanding the Fate of Pharmaceuticals and Other Contaminants in Watersheds
- Book Chapter on Exposure Modeling and Monitoring of Human Pharmaceuticals in the Environment
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- USGS Scientists Contribute to New Book on Pharmaceuticals in the Environment
- USGS Scientists Develop New Method to Measure Pharmaceuticals in Water
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Understanding how Pharmaceuticals in the Environment Affect Fish

Release Date: NOVEMBER 13, 2015

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).

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.

”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.”

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.

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Partners

“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.

To learn more about the study, please see our science feature. To learn more about USGS environmental health science, please visit the USGS Environmental Health website and sign up for our GeoHealth Newsletter.

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