Level 3: Pharmaceuticals found in the Hudson River Estuary

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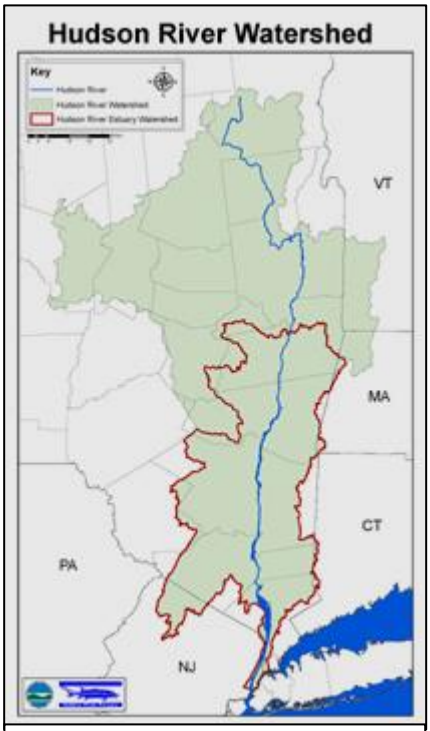
❖ Background Information

The Hudson River Estuary (HRE) incorporates over 61,000 acres of watershed. The area impacts the Hudson River in many ways. Understanding how human activity influences the Hudson is a prime concern for the maintenance of the river, especially as the human population grows. As population increases, the amount of waste that we produce also increases.



Map of Hudson River Estuary. Source: NYSDEC

The amount of pharmaceuticals that are prescribed has been on the rise, and the amount found in the waterways around the world has also increased. There are many types of pharmaceuticals, and they are used for many different purposes. In this dataset, the study authors tested for pharmaceuticals that come from medications for blood pressure, pain relief, bacterial infections, acid reflux, seizure medications, and cholesterol reducers. Concentrations of two non-pharmaceutical compounds (artificial sweetener and caffeine) are also included for comparison. In addition to pharmaceuticals, pesticides and personal care products also end up in our waterways, but they are not part of this dataset.

Pharmaceuticals can be released into the environment in many ways. They can be released during manufacturing, as part of human waste that travels through sewage treatment plants (STP), or anywhere in between. STP may have important differences in their mechanisms of processing wastewater, which may lead to higher or lower concentrations of pharmaceuticals that are released from them into the Hudson River. Differences may be due to various factors such as the age of the plant, the economics of the area, the population density served by the plant, and the plant location.

STP are designed to process large volumes of gray and black water from residential and industrial development. Additionally, they also process stormwater runoff. Sometimes during a large weather event such as rain or snowmelt, STP cannot handle the volume of water, and

combine runoff with sewer discharge from residential and industrial sources without treating it. These combined sewage outflows (CSO) are not treated and discharged directly into the waterbody.

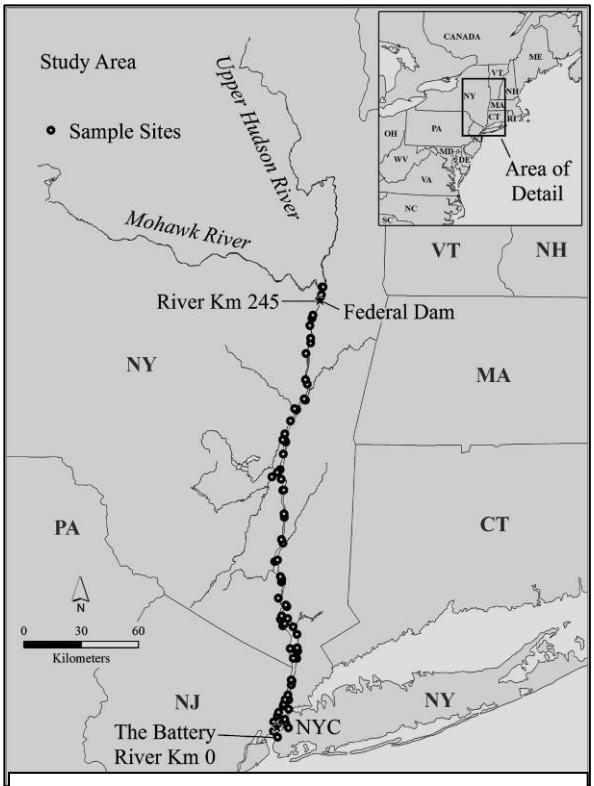
Uncertainty remains as to how pharmaceuticals affect aquatic organisms. Some pharmaceuticals have been shown to reduce algal growth and productivity in streams, and change the emergence and survival patterns of aquatic insects. Some compounds have also been shown to change the behavior of fish species such as perch. Further, antibiotics in water systems have been correlated with an increase in antibiotic-resistant bacteria, which is a threat to human health. More research is needed to better understand how these pharmaceuticals influence our ecosystem.

❖ Dataset Timeframe

- This dataset contains data collected by the Hudson Riverkeeper vessel *R. Ian Fletcher*. Samples were collected from July 12-16, 2016. No rain was reported during those 5 days of collecting.

❖ Data Collection Methods

- A single grab sample was collected from a depth of 0.25m from the surface at each site. Samples were stored on ice and in the dark until returned to laboratory to be processed.
- The compounds were quantified using high purity standards using a mass spectrometer (MS). MS work by sorting the compounds according to their mass-to-charge ratio, and then comparing that ratio to the mass-to-charge ratio of known compounds, called standards.



Sampling locations along the Hudson River.

❖ Dataset Variables

- **River Kilometer (RK)**: location of sampling site on the river**.**
- **River Location:** the location within the river transect where the sample was taken.
  - **Channel** samples were collected from the mid-channel.
  - **STP Outfall** samples were collected near sewage treatment plants.
  - **Near-Shore** samples were collected near shore.
  - **Dock** samples were collected near docks or jetties.

- **Tributary** samples were collected in the Hudson River near the mouth of tributaries.
- **Other** are samples where the location within the river transect was not specified.

➢ **Compound Type and Concentrations (ng/l)**: Compound amounts are measured in nanogram per liter. These medications are prescribed in milligram (mg) concentrations, which are a million times more concentrated than nanograms. Compounds are labeled in the following categories (drug names are given in parentheses):

- **Artificial sweetener** is not broken down in sewage treatment plants (STP), so it serves as a standard measure of the amount of treated sewage outflow.
- **Caffeine** is broken down in STP, so the relationship between caffeine and sucralose can serve as a measure of treated vs. untreated sewage outflow. *Sweetener and caffeine are not pharmaceuticals.
- **Pain reliever** is an analgesic medication that is used to relieve pain and reduce fever (Tylenol© is a common brand).
- **Anti-seizure** is a medication that prevents seizures by stabilizing electrical activity in the brain and nerves.
- **Antibiotics** are medications that are used to kill bacteria.
- **Blood pressure- BB** are beta-blocking medications used to reduce blood pressure. These work by blocking the effects of the hormone epinephrine, also known as adrenaline. Blocking epinephrine causes the heart to beat more slowly and with less force.
- **Blood pressure- Diuretic** is a medication that reduces blood pressure by causing the body to excrete more water and salt. They are often the first medications used to treat high blood pressure.
- **Blood pressure- CCB** are medications that reduce blood pressure by closing calcium channels and causing blood vessels to dilate.
- **Blood pressure- ARB** are medications that block angiotensin receptors, which also causes blood vessels to dilate.

Zantac©, one of the medications that was detected in the study.

- **Acid reflux** is a medication that blocks the production of acids in the stomach, which reduces the development of ulcers and acid reflux (Zantac© is a common brand).
- **Anti-cholesterol** is a medication that reduces the amount of fat that is produced by the liver.

❖ **Sources of Dataset:**

- Cantwell, M. G.; Katz, D. R.; Sullivan, J. C.; Shapley, D.; Lipscomb, J.; Epstein, J.; Juhl, A. R.; Knudson, C.; O'Mullan, G. D. *Spatial patterns of pharmaceuticals and wastewater tracers in the Hudson River Estuary.* Water Res. 2018, 137, 335−343.

❖ **Inquiry Idea Starters:**

Here are some sample questions you could ask using these data. These are just suggestions and we hope you'll come up with many interesting questions of your own!

- What pharmaceuticals are found at the highest concentrations in the Hudson River? What condition is treated by these pharmaceuticals?
- Is there a relationship between River Location (Channel, STP Outfall, etc.) and the concentration of Beta Blockers? What about other medication types?
- Is there are relationship between River Kilometer and the concentration of ARB medications?
- Do tributaries have higher concentrations of pharmaceuticals than other locations?

❖ **Additional Resources: Research**

- Target Screening for Micropollutants in the Hudson River Estuary during the 2015 Recreational Season **https://www.riverkeeper.org/wp-content/uploads/2016/07/Appendix-A-2015-progress-report.pdf**
- Widespread Micropollutant Monitoring in the Hudson River Estuary Reveals Spatiotemporal Micropollutant Clusters and Their Sources **https://www.riverkeeper.org/wp-content/uploads/2018/07/Carpenter-and-Helbling-2018.pdf**
- Pharmaceuticals Commonly Detected in Small Streams in the Southeastern United States **https://www.usgs.gov/news/pharmaceuticals-commonly-detected-small-streams-southeastern-united-states**
- Occurrence of Pharmaceutical and Personal Care Products (PPCPs) in Source Water of the New York City Water Supply (2009) **http://www.nyc.gov/html/dep/pdf/quality/nyc_dep_2009_ppcp_report.pdf**

❖ **Additional Resources: Video**

- TO THE CONTRARY. Hidden Health Hazards: Dr. Emma J. Rosi **https://www.pbs.org/video/hidden-health-hazards-dr-emma-j-rosi-xqmocx/**
- The Drugs We Wash Away: Pharmaceuticals, Drinking Water and the Environment https://www.youtube.com/watch?v=OYbRlJLBzn4&feature=youtu.be

❖ **References:**

Carpenter, Corey G., and Helbling, Daniel E. *Widespread Micropollutant Monitoring in the Hudson River Estuary Reveals Spatiotemporal Micropollutant Clusters and Their Sources.* 2018. School of Civil and Environmental Engineering, Cornell University, Ithaca, New York 14853 https://www.riverkeeper.org/wp-content/uploads/2018/07/Carpenter-and-Helbling-2018.pdf

Cantwell, M. G.; Katz, D. R.; Sullivan, J. C.; Shapley, D.; Lipscomb, J.; Epstein, J.; Juhl, A. R.; Knudson, C.; O'Mullan, G. D. *Spatial patterns of pharmaceuticals and wastewater tracers in the Hudson River Estuary.* Water Res. 2018, 137, 335−343.

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Lara-Martín, Pablo A., et. al. *Geochronologies of Pharmaceuticals in a sewage-impacted estuarine urban setting (Jamaica Bay, NY).* Environmental Science and Technology. 2017.

NYC Department of Environmental Protection. *Occurrence of Pharmaceutical and Personal Care Products (PPCPs) in Source Water of the New York City Water Supply.* August 2011. http://www.nyc.gov/html/dep/pdf/quality/nyc_dep_2010_ppcpreport.pdf

Richmond, E. K., Grace, M. R., Kelly, J. J., Reisinger, A. J., Rosi, E. J., & Walters, D. M. (2017). *Pharmaceuticals and personal care products (PPCPs) are ecological disrupting compounds (EcoDC).* Elem Sci Anth, *5*.