Assessment of Contaminant Levels in Ohio River Fish: A Participatory Science Study and Comparison with Historical Data and Guidelines

Participants lined up in a row fishing along the Ohio. Credit, University of Louisville, Lauren Anderson.

Project Partners

Humana Foundation & Humana Community Day Volunteers

Kentucky Waterways Alliance

Center for Healthy Air Water and Soil, Center for Integrative Environmental Health Sciences, and the Christina Lee Brown Envirome Institute at the University of Louisville

Kentucky Backcountry Hunters and Anglers, Falls of the Ohio Foundation, and Ohio River Valley Water Sanitation Commission

Report Prepared by: Eli Miller (KWA), Caison Black (UofL), and Lauren Anderson (UofL)

Table of Contents

Introduction

In August 2024, a unique participatory science event took place along the Ohio River. Volunteers from Humana's Community Day of Service and members of various environmental organizations gathered for a hands-on fishing activity to collect fish tissue samples: "Participatory Science Fishing Day: Monitoring Contaminant Levels in the Ohio River." Many people in the region may not interact regularly with the river or fully understand its environmental challenges. This event offered a unique opportunity to bridge that gap, allowing participants to engage directly with the river, witness firsthand the effects of pollution, and contribute to the collection of important scientific data. By getting involved, participants not only assisted in research but also gained a deeper appreciation of the waterway's significance and the need for its protection.

This project was made possible through the invaluable collaboration of multiple organizations dedicated to advancing environmental health. The partnership between Kentucky Waterways Alliance (KWA), the Center for Healthy Air Water and Soil, the Center for Integrative Environmental Health Sciences, and the Envirome Institute at the University of Louisville, Kentucky Backcountry Hunters and Anglers (BHA), the Humana Foundation, Falls of the Ohio Foundation, and ORSANCO was essential to the success of the endeavor.

What is Participatory Science?

Participatory Science, also known as Citizen Science, refers to the active involvement of the public in scientific research. In this approach, community members contribute to research by collecting data, participating in experiments, or providing insights that support larger research projects. Unlike traditional science, participatory science invites people to engage meaningfully in the research process, often providing them with training or raising awareness about the research goals, methods, and implications.

Figure 1: Participants walking in a single file line towards the river. Credit: University of Louisville, Tom Fougerousse

Goals and objectives

Fish tissue collection and analysis is an important practice for assessing the health of local fish populations, the quality of the water they inhabit, and safety risks for people who eat them. Sampling fish tissue allows for the measurement and monitoring of potentially harmful substances such as heavy metals, microplastics, PCBs, and other forever chemicals (PFAS and PFOA). These contaminants can significantly impact the health of the ecosystem where the fish live and pose risks to human health through fish consumption. The main objective of this project was to compare current contaminant concentrations in fish to historical data collected by the Ohio River Valley Water Sanitation Commission (ORSANCO). This analysis provides a valuable point of reference for understanding the trajectory of water pollution and its impact on local ecosystems, including the human populations that live near the Ohio River. Through this study, we aimed to assess change in contaminant levels over time and evaluate the human health implications of consuming fish from the Ohio River. Ultimately, this research should inform environmental policy, be used to promote water quality protections, and safeguard public health.

Methods

Study site

The Ohio River is one of the largest continuous waterbodies in the United States and the largest tributary of the Mississippi River system. The Ohio River flows nearly 1,000 miles through six states, provides drinking water for more than 5 million people, and transports approximately 35% of the United States' water-based commerce. The study site was in Clarksville, Indiana at the Falls of the Ohio State Park on the northern bank of the river, directly across from downtown Louisville, Kentucky (Figure 1). The park provides river access for 160,000 visitors annually and features the largest exposed Devonian fossil beds in the world. Anglers caught fish from the Ohio River immediately below the Fourteenth Street Bridge, near the Dam overlook site in Figure 1.

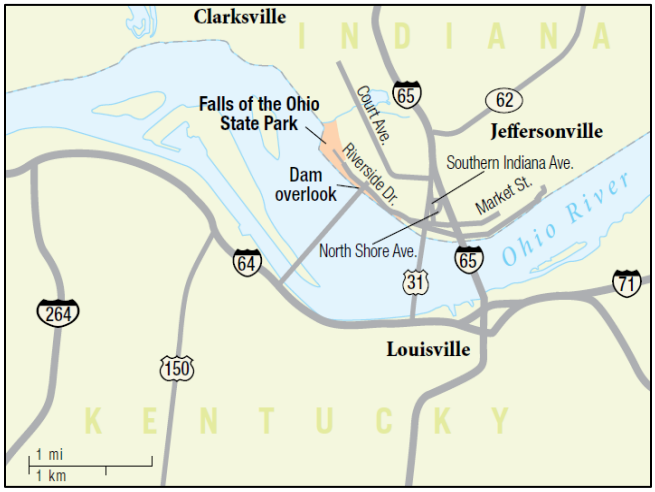

Figure 2: Falls of the Ohio State Park Map. Source: Birdwatching Magazine.

Sample collection

During the Participatory Science Fishing Day, fish samples were collected by volunteer anglers from Humana. Guided by experienced mentors from the Kentucky Chapter of the Backcountry Hunters and Angler, volunteers used line and tackle to fish along the northern bank of the river. When caught, BHA mentors handled each fish following strict protocols to ensure the legality of the catch and minimize contamination. Fish that were selected for sampling were euthanized with a swift cervical/cranial blow and their species, size, and weight were recorded. Volunteers removed filets from the fish and placed into plastic bags labeled with the species name

and a sample number according to ORSANCO protocol. Samples were kept on wet ice to maintain a temperature of approximately 4°C until they were transported to the University of Louisville for mailing. Volunteers collected two composite samples. Sample 1 contained filets from three channel catfish and Sample 2 contained filets from three freshwater drum. The University of Louisville mailed the samples on ice to Pace Analytical (Roseville, MN) for analysis of heavy metals (mercury, cadmium, lead, and selenium), polychlorinated biphenyls (PCBs, a group of industrial chemicals), and perfluorinated chemicals (PFAS, PFOS, PFOA, etc., sometimes known as forever chemicals).

Figure 3: The participants collecting fishing rods and receiving instruction. Credit: University of Louisville, Tom Fougerousse.

Figures 4-6: BHA mentor volunteers collecting data and preparing samples. Credit: University of Louisville, Lauren Anderson.

ORSANCO and EPA contaminant concentrations

Historical values for heavy metals, PCBs, and forever chemicals were retrieved from publicly available datasets from ORSANCO which included fish tissue data on various species from 1983 to 2023. Freshwater drum were not included in ORSANCO's monitoring program. White Bass levels were used as a proxy for Drum due to their similar habitat, size, and diet. Measured values for heavy metals and PCBs were averaged to create a baseline for comparison. Baseline data for forever chemicals was not available. Analysis results from Pace were reported in micrograms/kilograms and converted to milligrams/kilograms for direct comparison to ORSANCO's historical values. EPA and FDA guidance on risk thresholds and recommended screening values for contamination levels in fish tissue for the target contaminants was retrieved from publicly available EPA and FDA documents. Guidance for forever chemicals was not available. The specific risk thresholds for each contaminant were integrated into the results charts below to provide direct comparison between the concentrations found in fish tissue samples, historical ORSANCO data, and EPA and FDA recommended limits.

PCBs and **forever chemicals** both persist in the environment and pose health risks but are in different categories of pollutants.

PCBs (polychlorinated biphenyls) are synthetic industrial chemicals that were banned in the 1970s.

Forever chemicals specifically refer to a group of per- and polyfluoroalkyl substances (PFAS) and include compounds like PFOA and PFOS. PFAS are still in use have more widespread use in consumer products.

The main difference between the two is that PFAS is still actively used while PCBs are considered legacy pollutants.

Results

Heavy metals

The analysis of heavy metals in the collected fish samples revealed that most concentrations were lower than historical averages and screening value thresholds set by the Environmental Protection Agency (EPA). Mercury levels in channel catfish were lower compared to historical baselines and EPA limits, while selenium levels in freshwater drum were slightly higher than the recommended limits. Lead and cadmium were not detected in either species. These findings suggest an overall improvement in heavy metal contamination levels, although isolated instances of elevated selenium require further monitoring.

Table 1. Heavy Metals

Sample	*Mercury*	*Cadmium*	*Lead*	*Selenium*
Catfish	↓	⊘	⊘	↓
Drum Fish	↑	⊘	⊘	↑

Key:

Higher than previous data: ↓

Lower than previous data: ↑

Not detected: ⊘

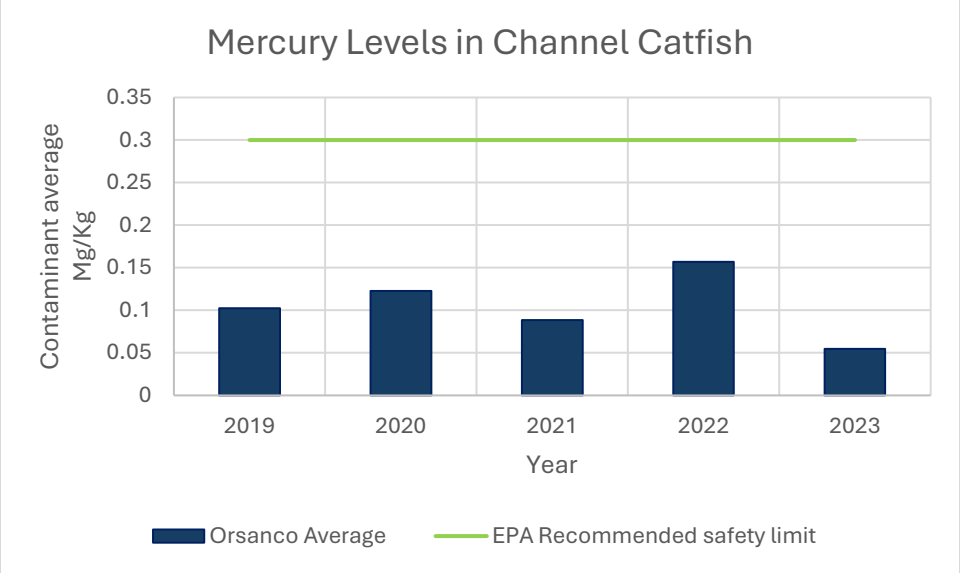

Figure 7: Mercury level comparison in Channel Catfish using the historical ORSANCO baseline (blue bars), and the EPA recommended safety limit (green line).

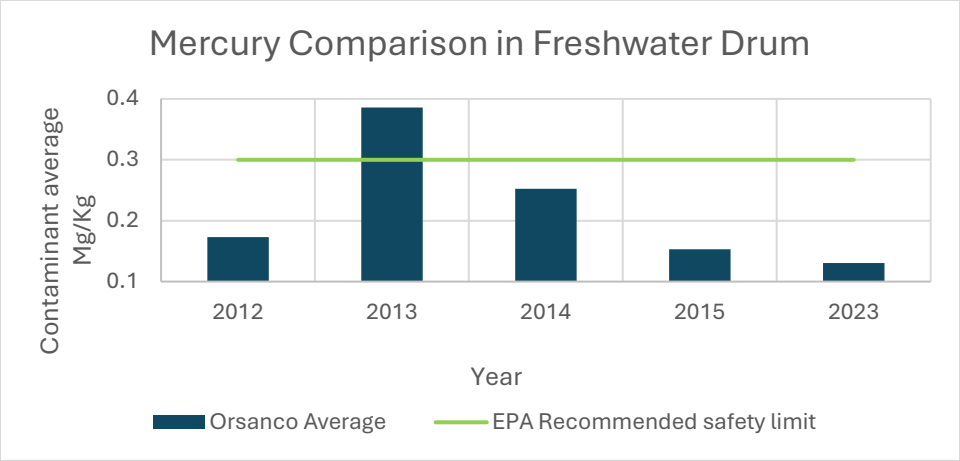

Figure 8: Mercury level comparison in Freshwater Drum using the historical ORSANCO baseline (blue bars), and the EPA recommended safety limit (green line).

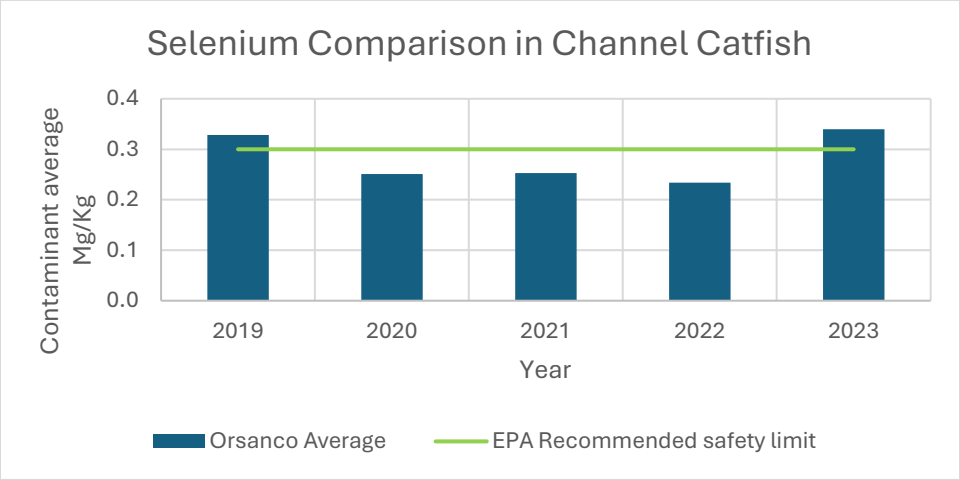

Figure 9: Selenium level comparison in Channel Catfish using the historical ORSANCO baseline (blue bars), and the EPA recommended safety limit (green line).

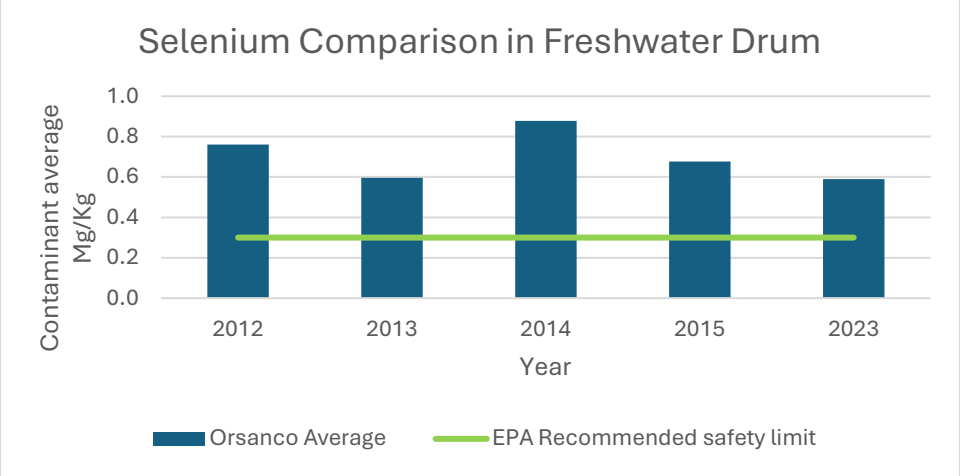

Figure 10: Selenium level comparison in Freshwater Drum using the historical ORSANCO baseline (blue bars), and the EPA recommended safety limit (green line).

Polychlorinated biphenyls (PCBs)

PCB concentrations in freshwater drum were consistently lower than historical data, while channel catfish showed slightly higher levels for two PCB types compared to past measurements. However, all PCB concentrations remained well below the Food and Drug Administration (FDA) safety threshold for fish consumption.

Table 3. PCB's

Sample	*PCB-1248*	*PCB-1254*	*PCB-1260*	*PCB Total*
Catfish	↑	↓	↑	↓
Drumfish	↓	↓	↓	↓

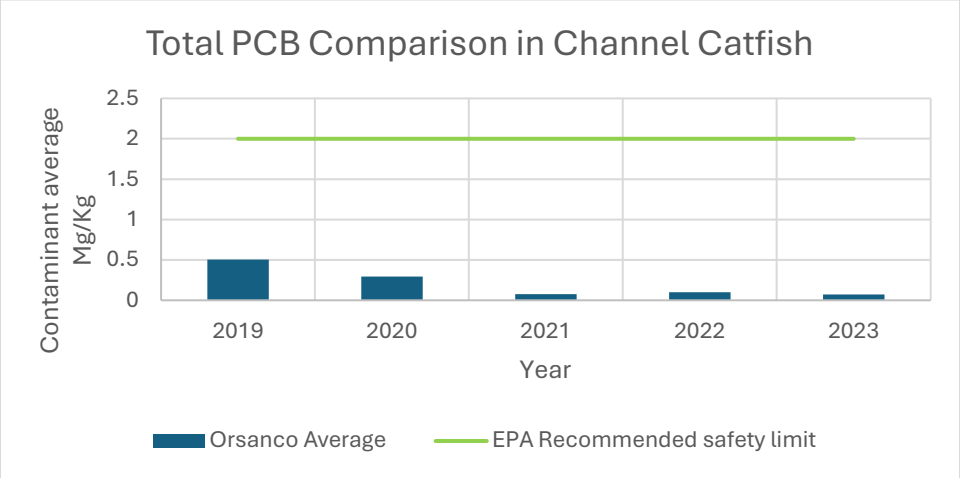

Figure 11: PCBs level comparison in Channel Catfish using the historical ORSANCO baseline (blue bars), and the EPA recommended safety limit (green line).

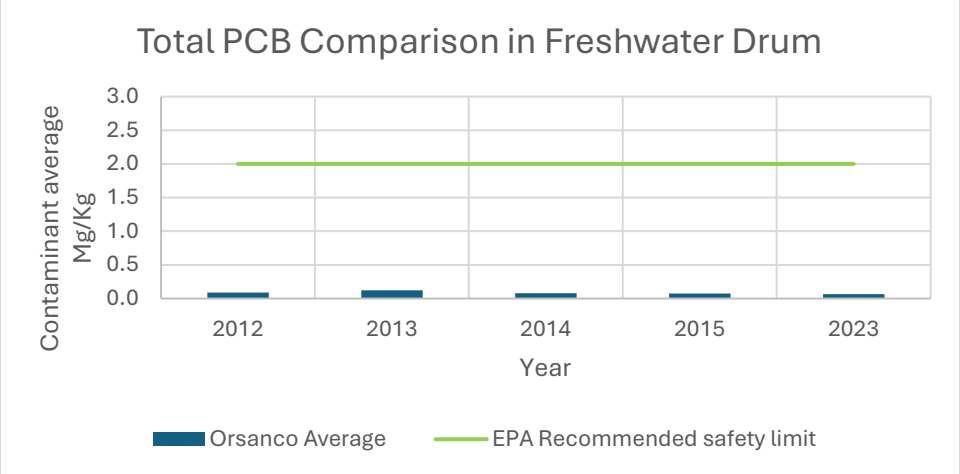

Figure 12: PCBs level comparison in Freshwater Drum using the historical ORSANCO baseline (blue bars), and the EPA recommended safety limit (green line).

Per- and polyfluorinated chemicals (forever chemicals)

Forever chemicals, specifically PFOS, were detected at concentrations exceeding EPA health advisory limits in freshwater drum but remained below thresholds in channel catfish. Other detected PFAS compounds were present at very low levels or below detection limits. Historical data for these chemicals was unavailable, making it challenging to determine trends over time. This underscores the importance of continued monitoring to establish baseline data for these persistent pollutants. (Table 4).

Table 4. Per- and polyfluorinated chemicals (forever chemicals)

Sample	11Cl-PF3OudS, 3:3 FTCA, 4:2 FTS, 5:3 FTCA, and 6:2 FTS	PFOS	PFNA	PFUnA
Catfish	⊘	↓	⊘	↓
Drumfish	⊘	⊘	↓	↓

Published Consumption Guidelines

Guidance on consumption levels is important for understanding local water quality and the health of fish populations. With a variety of guidelines on consumption and chemical levels in consumable fish available through the Environmental Protection Agency (EPA) and the Food and Drug Administration (FDA), individuals can consider how much locally caught fish they should consume. ORSANCO has also issued consumption guidance for fish commonly caught and consumed from the Ohio River (Table 7).

Table 7. ORSANCO Consumption Guidelines (Big Sandy River to J.T. Meyers Lock and Dam)

Species	*General Population**	*Sensitive Populations**	*Contaminant*
Channel Catfish (under 18”)	1 meal/month	1 meal/month	PCB
Channel Catfish (over 18”)	6 meals/year	6 meals/year	PCB
Drumfish	1 meal/month	1 meal/month	PCB
Flathead Catfish	1 meal/month	1 meal/month	PCB
Common Carp	1 meal/month	1 meal/month	PCB
Striped Bass	6 meals/year	6 meals/year	PCB
White Bass	1 meal/month	1 meal/month	PCB
All Suckers	1 meal/month	1 meal/month	PCB
Black Bass	1 meal/month	1 meal/month	Mercury
Flathead Catfish	1 meal/month	1 meal/month	PCB

*Note: general population are those without pre-existing health conditions, sensitive populations include those with pre-existing health conditions, women who are pregnant or might become pregnant, nursing mothers, and children six years of age and younger.

Health Risks of Identified Contaminants

Mercury (Hg): Mercury is a toxic metal that can accumulate in fish tissue that becomes more concentrated as it moves up the food chain. Larger, older fish, and predator fish tend to have higher mercury levels. Mercury is a neurotoxin and can cause damage to the brain and nervous system, with particularly harmful effects in children and pregnant women. Exposure to high levels of mercury can lead to symptoms such as memory problems, muscle weakness, vision and hearing issues, and impaired motor skills. The U.S. Environmental Protection Agency (EPA) advises limiting the consumption of fish with high mercury levels. Young children under six and pregnant women should avoid eating fish from species known to contain high mercury. Other adults should limit consumption to no more than one meal per week to minimize health risks.

Selenium (Se): Selenium is a natural trace mineral that is essential for good health in small amounts, but it can become toxic when consumed in excessive quantities. High levels of selenium intake can lead to a condition called selenosis, which can have harmful effects on hair, nails, and the nervous system. The U.S. Environmental Protection Agency (EPA) advises caution when consuming fish from areas with high levels of selenium. The safe threshold for selenium concentration in fish tissue is 0.3 mg/kg, and regular consumption of fish with selenium levels above this threshold should be minimized to prevent health risks.

Polychlorinated Biphenyls (PCBs): PCBs (polychlorinated biphenyls) are industrial chemicals that persist in the environment despite a ban in 1979 by the U.S. Environmental Protection Agency (EPA) under the Toxic Substances Control Act (TSCA). These chemicals accumulate in the body over time, leading to potential health risks such as liver damage, immune system suppression, and an increased risk of cancer and cardiovascular disease. Exposure to high levels of PCBs can result in skin conditions, liver issues, immune suppression, and reproductive problems. The FDA has set a tolerance level of two parts per million (ppm) for PCBs in fish. If fish samples exceed this threshold, the FDA issues a "Do Not Eat" advisory to protect public health. The EPA recommends minimizing consumption of fish from waters known to contain high PCB levels, particularly for vulnerable populations such as young children, pregnant women, and individuals with compromised immune systems.

PFOS (Perfluorooctane Sulfonate, a type of PFAS or forever chemical): PFOS is a long-lasting chemical commonly used in water-resistant and non-stick products, such as fabrics, carpets, and cookware. Over time, this chemical can accumulate in fish tissue. PFOS exposure is associated with liver damage, weakened immunity, and elevated cholesterol levels. Repeated consumption of such fish could increase the risk of health effects over time. EPA

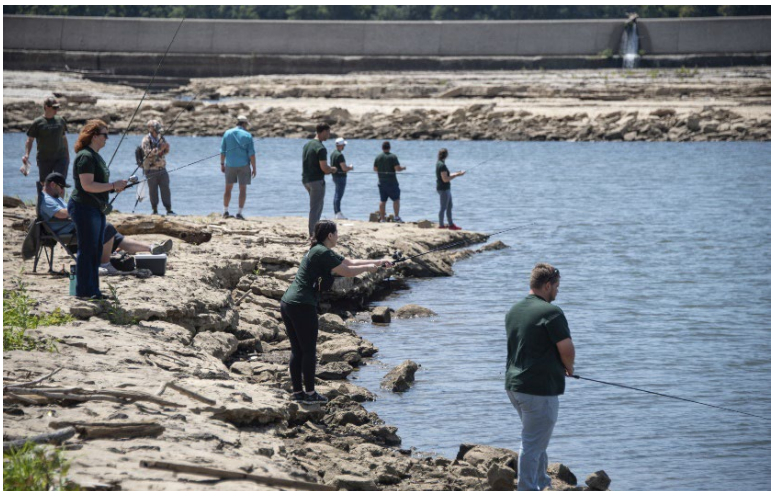

Figure 13: Participants fishing along the river. Credit: University of Louisville, Tom Fougerousse.

guidelines recommend avoiding frequent consumption of fish from waters that are known to contain high levels of PFOS. The increasing presence of various forever chemicals in the environment has drawn significant attention to their potential effects on water quality and animal and human health. Because forever chemical research is relatively new, established concentration levels for many compounds are not available. This study found that PFOS concentration in channel catfish tissue was below the EPA's recommended limit while the drum samples were slightly above. This difference underscores the need for continued research in order to establish comprehensive guidelines for fish consumption.

Discussion

The findings from the Participatory Science Fishing Day provide valuable insights into the current state of contaminant levels in Ohio River fish, offering important data that will aid in understanding the health of the ecosystem, particularly for the Louisville Metro region. The knowledge gained from this study will guide local communities in making informed decisions about the safety of their fish consumption and desired clean-up activities. These results contribute to a broader effort to safeguard public health by providing necessary benchmarks for future studies on contaminants like heavy metals, PCBs, and forever chemicals (PFAS).

Figure 14: A participant holding a fishing rod. Credit: University of Louisville, Tom Fougerousse.

Interpretation of Results in Context: The study results suggest that, while most contaminant levels in the fish sampled were below EPA screening value limits, species like the freshwater drum exhibited elevated PFOS concentrations. This highlights the varying levels of contamination across different species, indicating that future studies should prioritize specific fish species with higher risks to public health. The findings also underscore the need for more comprehensive data on forever chemicals such as PFOS and PFNA, as historical data for these chemicals in the Ohio River is lacking. This study provides the first available data on PFAS concentrations in local fish species, marking an important step toward establishing baseline levels for future comparisons. The results also showed that heavy metals, such as mercury, selenium, and cadmium, were generally under EPA screening values limits, although selenium concentrations in freshwater drum were slightly above the EPA threshold. These findings highlight the need for continued monitoring, as persistent contaminants continue to pose a potential risk to aquatic life and human health, particularly in species that are more likely to bioaccumulate these substances.

Health Implications and Consumption Guidelines: The public health implications of this study are significant, particularly with the elevated PFOS levels found in freshwater drum. Given the neurotoxic and endocrine-disrupting effects of PFOS, the results suggest that limited consumption of fish with PFOS concentrations above the EPA's recommended threshold is warranted. It is also

important to refine public health messages to ensure that high-risk groups, such as pregnant women, children, and those with compromised immune systems, are given tailored guidance on fish consumption. The study reinforces the importance of establishing clear, community-forward guidelines for safe consumption based on species and specific contaminant concentrations.

The Role of Participatory Science in Enhancing Community Engagement: One of the key strengths of this study is the use of participatory science to collect data. Involving community members directly in the research process not only increases public awareness of water quality issues but also fosters a stronger connection between people and their local environment, something that is often lost in large urban areas. Volunteers from local organizations were able to contribute firsthand to environmental monitoring while gaining valuable knowledge about the health of the Ohio River. This direct engagement with the river is a powerful tool for encouraging public participation in future environmental efforts. Participatory science also strengthens the relationship between the community and environmental organizations, promoting a deeper understanding of local environmental challenges. Additionally, the data collected from this event contributes to existing fish tissue contaminant databases held by ORSANCO and provides a valuable point of reference for future studies, particularly in areas where baseline data has been scarce.

Figure15: A participant receiving help with their fishing rod. Credit: University of Louisville, Tom Fougerousse.

Limitations

While this study provided valuable insights into contaminant levels in Ohio River fish, several limitations should be considered when interpreting the results. First, the timing of the fishing activity in August was not ideal for capturing a representative sample of fish populations. Fish behavior, including feeding patterns and migration, varies seasonally, and certain species may be abundant at different times of the year. Additionally, the time of day during which the fishing took place into midday and afternoon, not the most optimal times for fishing. The Day of Service schedule dictated the availability of volunteers, which limited the flexibility of sample collection. Another limitation was the sample size and the species representation. Participants collected only two composite samples, each consisting of three fish from two species. While this provided valuable data, a larger sample size and inclusion of a greater variety of fish species would have allowed for more robust conclusions and a broader understanding of contamination across different fish populations. A further limitation in this study was the lack of historical data on PFAS (forever chemicals) for comparison, particularly for freshwater drum. Without historical data, it is difficult to gauge how current contaminant levels compare to previous years, which would provide a clearer picture of the trajectory of pollution in the river. Future studies would benefit from the

development of a historical dataset for PFAS, allowing for direct comparison and a better understanding of long-term trends. Finally, the study was conducted at a single location near the Falls of the Ohio State Park. While this site was chosen for its accessibility and relevance to the Louisville Metro area, contaminant levels can vary across different parts of the river. Expanding the study to include multiple sampling locations would help account for spatial variability in contaminant concentrations and provide a more comprehensive view of the health of the entire Ohio River ecosystem.

Future Directions

Future iterations of this project should continue to use participatory science as a primary method for data collection. Expanding participation to include a broader cross-section of the community—including individuals from diverse backgrounds and interests—will ensure that the study reflects the diverse concerns and needs of the Louisville Metro region. Additionally, including a qualitative perception survey for volunteers would provide valuable insight into community views on environmental health, waterway access, and recreational activities. This could help guide future research questions and community outreach efforts.

Figure 16: A participant fishing. Credit: University of Louisville, Tom Fougerousse.

Future studies should expand the scope of sampling to include a wider variety of fish species, both in terms of size and habitat. This will help capture a more comprehensive view of contaminant levels throughout the water column. Special emphasis should be placed on metals that have known negative health impacts, as well as microplastics, which have historically been difficult to track but are emerging as an important environmental concern. Data from future studies should be made publicly available and shared with key governing organizations such as the Kentucky Department of Fish and Wildlife Resources and ORSANCO, ensuring that it can be used to guide further regulatory decisions and public health recommendations.

Conclusion

This project has advanced both understanding of the health of fish populations within the Ohio River and highlights the importance of participatory science and engaging the local Louisville Metro community. By involving community members in data collection, this study fosters a deeper connection to the river and provides a valuable foundation for ongoing environmental monitoring

and public education. The insights gained from this project will support existing river restoration efforts and contribute to future policies that promote both the economic and recreational value of the Ohio River.

The analysis of fish tissue collected by volunteers yielded varying results. However, overall, the findings indicate that most measured contaminants in channel catfish and freshwater drum were below established concentration limits set by the EPA and FDA. Selenium was the only metal found to exceed the EPA's recommended limit, though it is important to note that selenium is a naturally occurring substance in many fish species and can be influenced by factors such as age and diet. PCB levels in both the channel catfish and freshwater drum were below established limits, with all measured values falling well within FDA guidelines for safe consumption.

While the study found evidence of forever chemicals, official guidance for these contaminants is still under development, limiting the ability to compare these substances directly to established safety levels. However, the EPA health advisory for PFOS indicated that the catfish samples contained concentrations below the recommended screening value threshold, while the freshwater drum samples had concentrations just above the advised limit. This highlights the need for community awareness when consuming fish from this section of the Ohio River, especially regarding freshwater drum. Anglers and community members should continue to refer to posted consumption advisories to ensure they make informed decisions regarding fish consumption.

As the health of the Ohio River and its ecosystems remains a priority, community members can find additional information on fish health, consumption guidelines, and water quality through resources provided by the Kentucky Department of Fish and Wildlife Resources and ORSANCO. The continued collaboration between Kentucky Waterways Alliance, the Christina Lee Brown Envirome Institute at the University of Louisville, Kentucky Backcountry Hunters and Anglers, Falls of the Ohio Foundation, and ORSANCO will be essential in ensuring that the Ohio River's health and the wellbeing of its communities remain a priority in future studies and restoration projects.

Figure 17: A picture of the Ohio river basin with participants fishing in the distance. Credit: University of Louisville, Tom Fougerousse.

References

1. Environmental Protection Agency. (n.d.). *Choose fish and shellfish wisely*. Retrieved from https://www.epa.gov/choose-fish-and-shellfish-wisely
2. Environmental Protection Agency. (n.d.). *2018-2019 National Rivers and Streams Assessment: Fish tissue study*. Retrieved from https://www.epa.gov/choose-fish-and-shellfish-wisely/2018-2019-national-rivers-and-streams-assessment-fish-tissue-study#fillet2
3. Agency for Toxic Substances and Disease Registry. (n.d.). *Polychlorinated biphenyls (PCBs): Standards and guidelines*. Retrieved from https://www.atsdr.cdc.gov/csem/polychlorinated-biphenyls/standards.html#:~:text=FDA%20mandates%20tolerances%20of%200.2,per%20day%20%5BAAP%202003%5D
4. Environmental Protection Agency. (n.d.). *Aquatic life criterion for selenium*. Retrieved from https://www.epa.gov/wqc/aquatic-life-criterion-selenium
5. Environmental Protection Agency. (2021). *Selenium freshwater 2016-2021 revision*. Retrieved from https://www.epa.gov/system/files/documents/2021-08/selenium-freshwater2016-2021-revision.pdf
6. Environmental Protection Agency. (2024). *Technical support for fish tissue monitoring for implementing the EPA's 2016 selenium criterion (EPA 820-R-24-003)*. Retrieved from https://www.epa.gov/system/files/documents/2024-03/selenium-fishtissue-tsd.pdf
7. Environmental Protection Agency. (2024). *Technical support for adopting and implementing the EPA's 2016 selenium criterion in water quality standards (EPA 820-R-24-001)*. Retrieved from https://www.epa.gov/system/files/documents/2024-03/selenium-adopting-tsd.pdf
8. Environmental Protection Agency. (n.d.). *PFAS*. Retrieved from https://www.epa.gov/pfas
9. Environmental Protection Agency. (2024). *PFAS in Great Lakes fish: Spatial and temporal trends*. Retrieved from https://epa.figshare.com/articles/presentation/PFAS_in_Great_Lakes_Fish_Spatial_and_Temporal_Trends/21989573?file=39028718
10. Environmental Protection Agency. (n.d.). *EPA releases new science-based recommendations to help more states, tribes, and territories*. Retrieved from https://www.epa.gov/newsreleases/epa-releases-new-science-based-recommendations-help-more-states-tribes-and-territories#:~:text=These%20studies%20indicate%20the%20presence,Guidance%20for%20Developing%20Fish%20Advisories
11. U.S. Food and Drug Administration. (n.d.). *Technical information on FDA-EPA advice about eating fish*. Retrieved from https://www.fda.gov/media/80400/download
12. U.S. Food and Drug Administration. (n.d.). *Seafood resources*. Retrieved from https://www.fda.gov/food/resources-you-food/seafood
13. U.S. Food and Drug Administration. (n.d.). *FDA-EPA advice about eating fish for those who might become or are pregnant*. Retrieved from https://www.fda.gov/food/environmental-contaminants-food/technical-information-development-fdaepa-advice-about-eating-fish-those-who-might-become-or-are#:~:text=Any%20fish%20with%20an%20average,%E2%80%9CChoices%20to%20Avoid%E2%80%9D%20category

14. U.S. Food and Drug Administration. (n.d.). *Environmental contaminants in food*. Retrieved from https://www.fda.gov/food/chemical-contaminants-pesticides/environmental-contaminants-food
15. U.S. Food and Drug Administration. (n.d.). *Cadmium in food and food wares*. Retrieved from https://www.fda.gov/food/environmental-contaminants-food/cadmium-food-and-foodwares#:~:text=For%20the%20IRL%20for%20cadmium,kilogram%20body%20weight%20per%20day
16. Kentucky Department of Fish & Wildlife Resources. (n.d.). *Fish consumption advisories*. Retrieved from https://fw.ky.gov/Fish/Pages/Fish-Consumption-Advisories.aspx
17. Ohio River Valley Water Sanitation Commission. (n.d.). *Fish tissue data*. Retrieved from https://www.orsanco.org/data/fish-tissue/
18. Ohio River Foundation. (n.d.). *Ohio River quick facts*. Retrieved from https://ohioriverfdn.org/ohio-river/quick-facts/
19. U.S. Army Corps of Engineers. (n.d.). *Ohio River navigation information*. Retrieved from https://www.lrd.usace.army.mil/Water-Information/Navigation/Ohio-River/
20. Indiana Department of Natural Resources. (n.d.). *Falls of the Ohio State Park*. Retrieved from https://www.in.gov/dnr/state-parks/parks-lakes/falls-of-the-ohio-state-park/
21. Falls of the Ohio Foundation. (n.d.). *Discover the Falls of the Ohio*. Retrieved from https://www.fallsoftheohio.org/discover/
22. Law, E., & Gajos, K. (2020). *Theory and practice in citizen science. Citizen Science Association*. Retrieved from https://theoryandpractice.citizenscienceassociation.org/articles/301/files/submission/proof/301-1-3124-1-10-20200428.pdf
23. Coyle, T. R., & Cole, T. M. (2011). *The ecological society of America*. Retrieved from https://esajournals.onlinelibrary.wiley.com/doi/pdf/10.1890/110277