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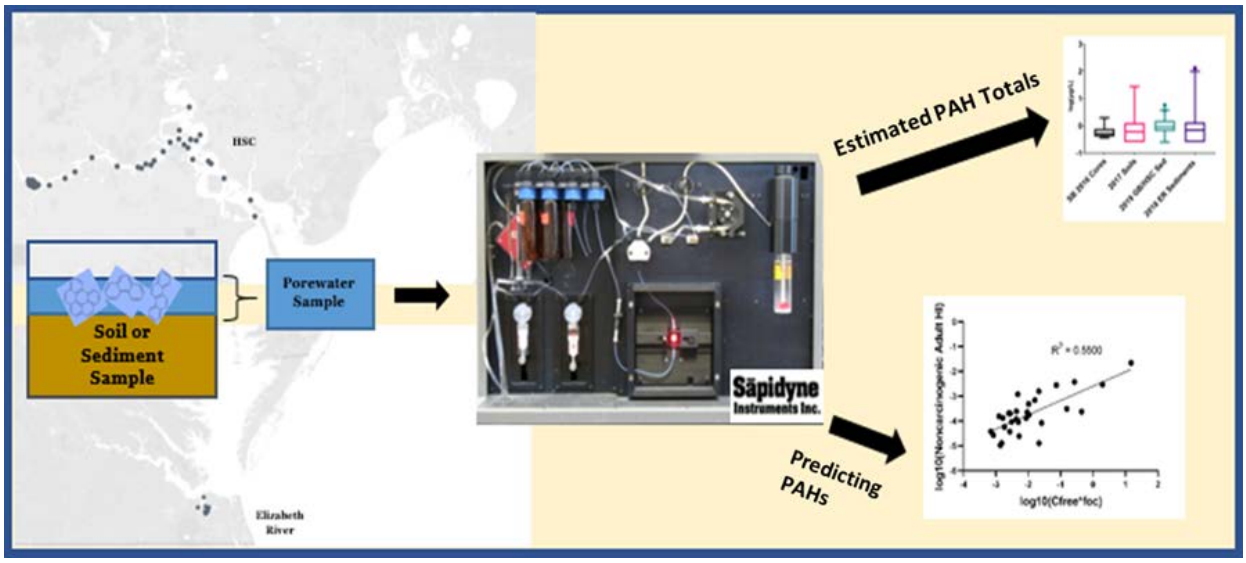
Biosensor Helps Characterize Contaminants and Health Risks Following Disasters

A sophisticated biosensor may provide information about contaminant distribution in the aftermath of natural disasters, according to an NIEHS Superfund Research Program (SRP)-funded study. Led by former Texas A&M University (TAMU) SRP Center trainee Krisa Camargo and Michael Unger, Ph.D., from the Virginia Institute of Marine Sciences, the team demonstrated this type of tool is useful for quickly characterizing and prioritizing environmental samples for further analysis, particularly in the context of disaster research response.



The biosensor characterizes PAH concentrations in diverse samples in real time while also serving as a predictive screening tool for potential health risks.
(Image adapted from Camargo et al., 2022, Environ Res)

Focusing on polycyclic aromatic hydrocarbons (PAHs), a complex mixture of suspected carcinogenic contaminants found in soil, sediment, and water, the team validated a biosensor previously developed by Unger as an alternative to expensive and time-consuming traditional approaches. This tool uses antibodies from mice to detect and quantify PAHs in real time. It also calculates total free PAHs in porewater, the liquid between sediment or soil particles. This information helps scientists determine how much of the measured PAHs can be taken up by the body and potentially cause harm.

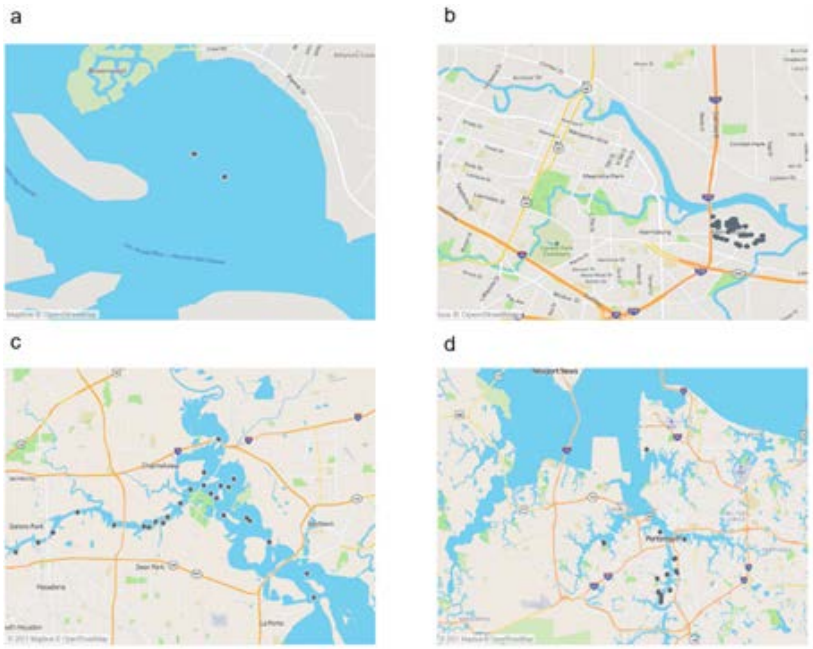
According to the researchers, this study supports the utility of the biosensor as a rapid and cost-effective tool to characterize PAH contamination and potential health risks to prioritize environmental samples for further analysis by more costly and time-consuming traditional methods. Such insight is valuable for future disaster research response efforts where time and resources are limited.

Documenting contaminants before and after the storm

Hurricanes and flooding can redistribute contaminants, such as from overflowing wastewater treatment plants or uncovering and redistributing contaminated soils and sediments. Consequentially, increased potential for exposure to hazardous substances makes it important to understand where contaminants come from and their movement during and after disasters.

Collaborators field tested the biosensor in samples collected from a river in Virginia with known PAH contamination and samples collected before and after Hurricane Harvey hit the Houston area, including samples collected from a residential neighborhood. They looked for differences in PAH levels and composition and identified potential sources of PAHs based on the chemicals detected.

The team found differences in PAH concentrations by sample location, with PAH levels being higher in Virginia compared to Texas, and distinct clustering for associated PAH sources. For example, in Virginia, PAHs were largely attributed to historical wood treatment facilities. The sediment core samples taken in Houston before Hurricane Harvey suggested PAHs originated from a mix of geological processes, crude oil, or combustion. In soil samples taken after the hurricane, PAHs were also attributed to biomass combustion and living organisms, which the researchers suggest may be related to organic matter in floodwaters.



Researchers collected sediment cores in the Houston Ship Channel in 2016 that served as baseline data (a). In 2017, after Hurricane Harvey made landfall, they collected soil samples from the Manchester Neighborhood in Houston (b). In 2019, additional surface sediment samples were collected from Galveston Bay, Houston Ship Channel, and Clear Lake (c). These samples were compared to surface sediments collected from the Elizabeth River in Virginia with known PAH contamination. (Image courtesy of Camargo et al., 2022, Environ Res)

Effectively Screening and Predicting Risks

After documenting PAH levels, the team sought to evaluate potential risks to human health and to animals using screening values from the U.S. Environmental Protection Agency. All samples were below risk thresholds for human health. However, concentrations of some PAHs in sediments collected after Hurricane Harvey and from Virginia were above risk thresholds for animals. Follow-up studies are needed to understand the underlying mechanisms by which these chemicals cause harm to animals and how exposure to mixtures of PAHs may alter toxicity, say the team.

Finally, the team assessed the ability of the biosensor to predict PAH concentrations measured by traditional methods and the corresponding health risks to humans and animals. The authors explained that the strong correlations between porewater PAH levels using the biosensor compared to traditional methods demonstrate the biosensor can effectively screen and predict PAH concentrations as well as potential health risks.

About the Authors

The study was made possible by a 2018 K.C. Donnelly Externship award to Camargo. Mentored by TAMU SRP Center researchers and co-authors Anthony Knap, Ph.D., Jose Sericano, Ph.D., Thomas McDonald, Ph.D., and Weihsueh Chiu, Ph.D., Camargo used her externship to work with Unger in Gloucester Point, Virginia. While there, she used Unger's biosensor to develop a screening method that could be used for rapid needs assessments during public health emergencies and to inform emergency responders in the aftermath of disasters like Hurricane Harvey.

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To learn more about this research, please refer to the following source:

Camargo K, Vogelbein MA, Horney JA, Dellapenna TM, Knap AH, Sericano JL, Wade TL, McDonald TJ, Chiu WA, Unger MA. 2022. Biosensor applications in contaminated estuaries: Implications for disaster research response. Environ Res. 204(Pt A):111893. PMID: 34419473

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