Researchers find high concentrations of microplastics in cave water and sediment

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Saint Louis University students sample the Cliff Cave system near St. Louis, Missouri, for microplastic debris. Microplastics can enter caves and groundwater during rainfall events and remain in sediment, threatening these fragile subsurface habitats and water resources. Credit: Liz Hasenmueller

In two recent papers, Saint Louis University researchers report finding

high concentrations of microplastics present in a Missouri cave system that had been closed to human visitors for 30 years.

Elizabeth Hasenmueller, Ph.D., associate professor of Earth and Atmospheric Sciences and associate director of the WATER Institute at SLU, and her team published findings in the journals, *Science of the Total Environment* and *Water Research*, finding significant microplastic levels in Cliff Cave in Saint Louis County, Missouri.

The research, which originated from Hasenmueller's research group and Karst Hydrology class, allowed students on the team to participate in field research and publish their findings.

Microplastics are characterized as plastic particles smaller than 5.0 millimeters and can be found across marine, terrestrial, and freshwater environments. Hasenmueller has previously studied microplastics in river systems, such as the Meramec River basin, but now wanted to look at the subsurface, an area that has not seen much research at all.

"A lot of research has been focused on surface water settings," Hasenmueller said. "Microplastics research initially started in the ocean because of the highly visible problem of large plastic pollution in this environment. Recently, more research efforts have gone towards examining rivers, lakes, and other surface freshwater systems.

"However, one of the most understudied areas in this field relates to what's happening to the subsurface in terms of microplastic contamination. These particles could be getting into groundwater, a common drinking water resource, or caves, where fragile ecosystems exist. During the last few years, my research team has been focused on trying to understand microplastic prevalence and transport in these subsurface environments."

Hasenmueller and her team selected Cliff Cave for their studies as the cave has been closed to the public since 1993, allowing them to eliminate human presence in the cave as a possible cause of any observed microplastic contamination. Their research showed microplastics were found throughout the cave, but the highest concentrations were located near the entrance and in sediment.

"Part of the reason we picked Cliff Cave is because St. Louis County Parks regulates access to the cave," Hasenmueller said. "We knew if we found microplastics in the cave, it's not going to be because somebody has just hiked back into the cave and shed fibers from their clothing or left food wrappers."

Through their research, Hasenmueller and her team discovered that flooding increases the amount of microplastics moving through the cave system. Microplastics move with water, and when flooding occurs, the excess water brings more microplastics with it to the cave.

Flooding also contributed to a higher diversity of microplastics in the cave water. When those flood waters receded, microplastics were likely deposited near the cave's mouth in higher abundances than in locations deeper in the cave.

"We weren't sure what to expect with the dataset, but we found that the cave's main entrance is where there's a lot of microplastic debris, either from flood deposition or possibly from microplastic particles suspended in the air being deposited near the opening of the cave," Hasenmueller said. "We know for sure that floodwaters are bringing microplastics into the cave because as we were traversing the cave passages and collecting samples, we found a plastic chip bag that was intertwined with leaves, acorns, and other flood debris from the surface."

Not only did flood waters contribute to higher levels of microplastics,

but Hasenmueller and her team also found that microplastics were almost 100 times more concentrated in sediment than in the water found in Cliff Cave. Microplastics were deposited into the cave's sediment by the cave's stream water and remained there even after the flood water receded.

"We were trying to figure out what fraction of the microplastics are actively moving through the cave stream right now versus what's being stored long-term in the cave's sediment," Hasenmueller said. "One of the really interesting things we found is most of the microplastics were in the sediment. So, 99 percent of the microplastic debris we found in the cave was stored in the sediment; only a very small fraction of the plastic was in the water."

"As the water levels go up during a flood, you see higher abundance and diversity of microplastic particles in the water," Hasenmueller added. "We think what is probably happening is that after the cave floods, particles in the water are deposited into the sediment. As the waters recede, that material remains in the cave sediment, potentially for decades or longer. And when the water level goes down, microplastic concentrations in the water are much lower."

Despite being blocked off from humans, the cave still feels their impact. Cliff Cave is located near residential areas that could be contributing microplastics to the system, a finding that aligns with previous research by SLU's WATER Institute showing that population density is the biggest factor determining where microplastics are found in nature. Hasenmueller said with these findings, there are some things people can do to limit the amount of microplastics they may be contributing to the environment.

"It's hard for us as individuals to deal with plastic pollution because of the pervasiveness of these materials, but it helps to be mindful of your

personal plastic use," Hasenmueller said. "Individuals can avoid buying plastic materials like synthetic textiles used in clothing, but doing so presents challenges to everyday consumers. On a larger scale, we, as a society, could move away from synthetic clothing, because a lot of the debris that we found in this cave was synthetic fibers from textiles. And of course, reducing our overall plastic production and consumption would help as well."

Microplastics not only potentially do damage to the cave environment, but they also affect wildlife that call Cliff Cave home. Bats, amphibians, and other animals move freely throughout the cave, and microplastics could disrupt their delicate habitat. Microplastics are not just a human problem, but also an environmental problem, and Hasenmueller calls for more research to ensure the contamination does not become worse.

"Understanding what level of threat microplastics pose to the unique and rare animals that only inhabit cave systems is really important," Hasenmueller said. "Only a handful of studies have assessed microplastics in these types of underground ecosystems. So, our work provides resource managers with the information they need to be thinking about to protect these fragile habitats from emerging contaminants like microplastics."

More information: Elizabeth A. Hasenmueller et al, Cave sediment sequesters anthropogenic microparticles (including microplastics and modified cellulose) in subsurface environments, *Science of The Total Environment* (2023). DOI: 10.1016/j.scitotenv.2023.164690

Teresa Baraza et al, Floods enhance the abundance and diversity of anthropogenic microparticles (including microplastics and treated cellulose) transported through karst systems, *Water Research* (2023). DOI: 10.1016/j.watres.2023.120204

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