Tubing and swimming change the chemistry and microbiome of streams

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With Labor Day approaching, many people are preparing to go tubing and swimming at local streams and rivers. These delightful summertime activities seem innocuous, but do they have an impact on these

waterways? Today, scientists report preliminary results from the first holistic study of this question, which shows that recreation can alter the chemical and microbial fingerprint of streams, but the environmental and health ramifications are not yet known.

The researchers will present their results at the fall meeting of the American Chemical Society (ACS).

The project stemmed from a conversation between Carsten Prasse, Ph.D., and James Ranville, Ph.D., about the impact of human activities on surface waters. "There's a lot of talk about things like wastewater getting into surface waters," Prasse says, "but one aspect that hasn't really been thought about is people swimming in surface water —especially in relation to climate change and hotter summers, as water levels drop."

So, the researchers teamed up to explore the effect of summer fun on freshwater streams. Ranville, who is at Colorado School of Mines, proposed nearby Clear Creek for the study. His group would examine inorganic contaminants, including metals and nanoparticles. Prasse's team at Johns Hopkins University would evaluate organic contaminants, such as pharmaceuticals. Ranville also enlisted the help of John Spear, Ph.D., at Colorado School of Mines to investigate the microbiome of the stream.

In 2022, the Colorado researchers collected water samples during the busy Labor Day weekend and on a quieter weekday afterward. On many weekends, as many as 500 people per hour use the stream for tubing and swimming at that part of Clear Creek. An undisturbed location upstream was sampled for comparison. The samples were then tested with state-of-the-art analytical approaches, including inductively coupled plasma-mass spectrometry and liquid chromatography-high resolution mass spectrometry. The main goal was to look for changes in chemicals that

could be detected in the water.

"We used software and high-level instrumental analysis to piece together a story of what people were doing to the stream," says Noor Hamdan, a graduate student in Prasse's lab who will present the work at the meeting. "We found a lot of human metabolites, a lot of pharmaceuticals, some illicit drugs and some sunscreens—really a whole slew of compounds that humans are associated with," says Hamdan. Those compounds presumably washed off people's skin or were released in sweat or urine, among other possible sources.

Preliminary results from Prasse's lab suggested the presence of cocaine, lidocaine (a topical anesthetic), fexofenadine (an antihistamine), lamotrigine (a treatment for seizures and bipolar disorder) and gabapentin (a medication for seizures and nerve pain), as well as polyethylene glycol (used in medications and numerous other applications) and phthalates (plasticizers). Organic sunscreens and UV filters were also detected.

Carmen Villarruel, a grad student in Ranville's lab, found that human recreation stirred up sediments in the creek, thereby raising the water's concentration of metals, such as copper, lead, zinc, aluminum and iron. "Much of the metal was in particulate form, which has implications for wildlife," Villarruel says. For example, these sediments could clog the gills of fish, making it harder for them to absorb oxygen from the water. In addition to the metal particulates, the team found some dissolved metals in the water, which could affect reproduction, species diversity and the health of aquatic species, Ranville notes.

Tubing and swimming also altered the creek's microbial profile, increasing the abundance of microorganisms commonly associated with human waste. Spear says that could impact species that live in the river, such as fish, as well as microorganisms that occur naturally in the water

and are key components of the ecosystem.

The team used Environmental Protection Agency software to run a risk assessment on the compounds in the river. They found that most of the compounds aren't particularly prone to bioaccumulate, Hamdan says. But the researchers also emphasize that there are no data available on long-term toxicity or persistence in the environment, and there are insufficient data to evaluate exposure risks for a lot of the compounds.

"So that's an important finding from this project," Hamdan says. "We now know that these compounds are in the river. But we don't know their concentrations or how they impact the fish or other species in the environment." In future research on this project, the team plans to collect more samples to track trends over time.

In the meantime, Prasse has some useful advice for people who want to have fun in the water. "Don't pee in rivers," he says half-jokingly. "When you urinate into a toilet, the water goes to a wastewater treatment plant before it is discharged into a river. But if you urinate into a river, all those chemicals go directly into the water. We know that things like pharmaceuticals can impact aquatic species, such as fish, even at very low concentrations." He also recommends using mineral sunscreens, such as zinc oxide, instead of sunscreens that contain UV filters, which can be toxic to aquatic organisms.

More information: Assessing the impact of recreational activities on a natural stream: a Colorado River case study, ACS Fall 2023.

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