Freshwater salt pollution threatens ecosystem and human water security

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Image of the Bull Run River that feeds the Occoquan Reservoir, an important source of water supply to Fairfax Water, a water utility serving about 2 million people in Northern Virginia and the home of Virginia Tech's Occoquan Watershed Monitoring Lab. Photo courtesy of Peter Vikesland for Virginia Tech. Credit: Virginia Tech

Water touches virtually every aspect of human society, and all life on earth requires it. Yet, fresh, clean water is becoming increasingly scarce—one in eight people on the planet lack access to clean water. Drivers of freshwater salt pollution such as de-icers on roads and parking lots, water softeners, and wastewater and industrial discharges further threaten freshwater ecosystem health and human water security.

"Inland freshwater salt pollution is rising nationwide and worldwide, and we investigated the potential conflict between managing freshwater salt pollution and the sustainable practice of increasing water supply through the addition of highly treated wastewater to surface waters and groundwaters," said Stanley Grant, professor of civil and environmental engineering in the Virginia Tech College of Engineering. "If we don't figure out how to reverse this trend of salt pollution soon, it may become one of our nation's top environmental challenges."

Grant and his collaborators have recently published their findings in the journal *Nature Sustainability*.

In a recent modeling study, it was predicted that salt pollution will increase over 50 percent in more than half of U.S. streams by 2100. Freshwater salt pollution is associated with the decline of biodiversity, critical freshwater habitat, and lack of safe drinking water.

"We found there are numerous opportunities that exist to reduce the contribution of salt pollution in the highly treated wastewater discharged to the Occoquan Reservoir and freshwater pollution more generally," said Peter Vikesland, professor in the Department of Civil and Environmental Engineering and affiliated faculty member in the Global Change Center, housed within Fralin Life Sciences Institute at Virginia Tech. "These efforts will require deliberative engagement with a diverse community of watershed stakeholders and careful consideration of the local political, social and environmental context."

From time-series data collected over 25 years, the researchers quantified the contributions of three salinity sources—highly treated wastewater and outflows from two rapidly urbanizing watersheds in Northern Virginia—to the rising concentration of sodium, a major ion associated with freshwater pollution.

The Occoquan Reservoir, a regionally important drinking-water reservoir in the mid-Atlantic United States, is located approximately 19 miles southwest of Washington, D.C., in Northern Virginia, and is one of two primary sources of water supply for nearly 2 million people in Fairfax County, Virginia, and surrounding communities. On an annual basis, approximately 95% of the water flowing into the reservoir comes from its Occoquan River and Bull Run tributaries.

"This study exemplifies the power of combining historical data and new computational tools; it underscores the incredible value of long-term monitoring," said Grant who is the Co-Director of the Occoquan Watershed Monitoring Lab and an affiliated faculty member in the Center for Coastal Studies at Virginia Tech. "It is a testimony to the vision of Virginia Tech and the Occoquan Watershed Monitoring Lab and their collaboration with stakeholders in the watershed, including Fairfax Water and the Upper Occoquan Service Authority, over the past two decades."

The researchers found that rising salt pollution in the reservoir is primarily from watershed runoff during wet weather and highly treated wastewater during dry weather.

Across all timescales evaluated, sodium concentration in the treated wastewater is higher than in outflow from the two watersheds. Sodium in the treated wastewater originates from chemicals added during wastewater treatment, industrial and commercial discharges, human excretion and down-drain disposal of drinking water and sodium-rich household products.

"Our study is unique because it brings together engineers, ecologists, hydrologists, and social scientists to investigate and tackle one of the greatest threats to the world's water quality," said Sujay Kaushal, a co-author on the paper, professor of geology at the University of Maryland, and an international expert on freshwater salinization.

The researchers envision at least four ways in which salt pollution can be reduced: limit watershed sources of sodium that enter the water supply (such as from deicer use), enforce more stringent pre-treatment requirements on industrial and commercial dischargers, switch to low-sodium water and wastewater treatment methods, and encourage households to adopt low-sodium products.

Drinking water supply and sewage collection systems contribute salt to the former ultimately contribute salt to the latter as well.

"Citizens can start today or tomorrow by thinking more critically about what they put down the drain and how that harms the environment, and in turn, their own drinking water supply," said Vikesland.

This research aligns with the One Water vision used nationally and globally by multiple water resource sectors, and it catalyzes robust stakeholder-driven decision making under seemingly conflicting objectives.

This research was part of a partnership between Virginia Tech, University of Maryland, Vanderbilt University, and North Carolina State University. It was funded by a recent multimillion dollar grant that Grant and his collaborators received from the National Science Foundation aimed at addressing freshwater salt pollution and is part of the National Science Foundation's Growing Convergence Research (GCR) program, which aims to catalyze solutions to societal grand challenges by the merging of ideas, approaches, and technologies from widely diverse fields of knowledge to stimulate innovation and discovery. Experience gained and lessons learned from this research will be upscaled nationally and globally in partnership with The Water Research Foundation.

"The collaborative effort by this highly interdisciplinary team exemplifies the type of paradigm shifting science that we seek to catalyze and promote," said William Hopkins, professor in the College of Natural Resources and Environment, director of the Global Change Center, and associate executive director of the Fralin Life Sciences Institute. "Freshwater salt pollution has become a major focus for diverse researchers at Virginia Tech because the problem is so widespread, getting worse, and affects both the environment and society. Fortunately, the team's research advances our understanding of important sources of salt pollution so that evidence-based interventions can be identified and implemented. The study has far reaching implications globally as we try to solve this complex environmental problem."

This study reflects the exciting convergent approach the NSF-funded project is taking.

"While the biophysical findings are front-and-center here, it acknowledges the complex socio-political contexts in which that information will be applied and foreshadows the collaborative, multi-stakeholder approaches to tackling the freshwater salt pollution problem that we are currently advancing," said Todd Schenk, assistant professor in the School of Public and International Affairs in the College of Architecture and Urban Studies and affiliated faculty member of the Global Change Center and Center for Coastal Studies.

More information: Shantanu V. Bhide et al. Addressing the

contribution of indirect potable reuse to inland freshwater salinization, *Nature Sustainability* (2021). DOI: 10.1038/s41893-021-00713-7

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