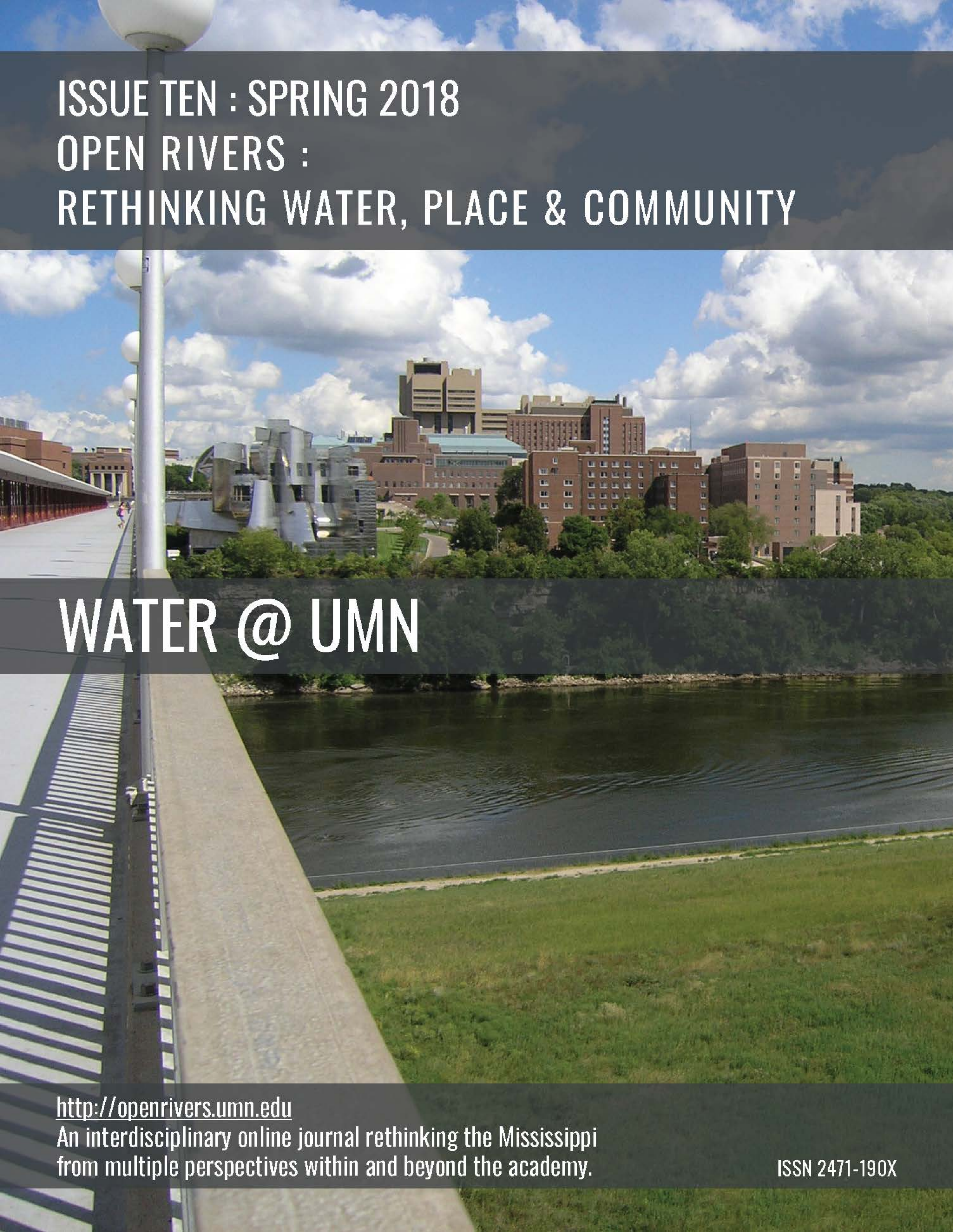

ISSUE TEN : SPRING 2018

OPEN RIVERS : RETHINKING WATER, PLACE & COMMUNITY

WATER @ UMN

http://openrivers.umn.edu

An interdisciplinary online journal rethinking the Mississippi from multiple perspectives within and beyond the academy.

ISSN 2471-190X

The cover image is of The East Bank of the Minneapolis campus of the University of Minnesota and the Mississippi River from the Washington Avenue Bridge. Image courtesy of Patrick Nunnally.

Open Rivers: Rethinking Water, Place & Community is produced by the University of Minnesota Libraries Publishing and the University of Minnesota Institute for Advanced Study.

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ISSN 2471-190X

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WATER @ UMN ROUNDUP

By Kate Brauman, Sharon Moen, Mary Sabuda, Cara Santelli, Ingrid Schneider, and Shashi Shekhar

As the editors put this issue on "Water @ UMN" together, we realized that the breadth, complexity, and variety of water-related work at the University of Minnesota could never be encompassed in a few articles. Accordingly, we sent a prompt out as widely as we could, asking water scholars to tell us, in a few paragraphs, what it was about their work that they were most excited about. The short pieces that follow contain some of their responses, in no particular order.

The University of Minnesota's Twin Cities campuses are both very close to the Mississippi River and offer unparalleled access for scientific inquiry close to home. Image courtesy of University of Minnesota.

Kate Brauman

Lead Scientist, Global Water Initiative, Institute on the Environment, University of Minnesota Twin Cities

How do we account for Nature's Contributions to People (NCP), especially when it comes to water? And where in the world are we getting more, or fewer, contributions from nature? I've been working with the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) to try to answer those questions, or at least start the process of figuring out how we should answer them. Not surprisingly, figuring out the answers isn't easy. And it's not just that there are lots of totally valid and wildly different ways to approach these issues. There is also a diversity of people, from countries and cultures all over the world and spanning disciplines from anthropology to hydrology, with voices that need to be heard. One of the main goals of IPBES is to be more actively inclusive than environmental assessments in the past have often been, with a particular emphasis on including Indigenous and Local Knowledge in our assessment and on including the perspectives of Indigenous and Local Communities.

This has been a huge challenge for me, and a good one. Much of my work is focused on the big scale and the generalizable. To assess NCP related to water, I've reviewed literature on how deforestation in different parts of the world affects runoff and sliced and diced global data sets of evapotranspiration from different biomes. But we know the way that people manage the landscape, and how they've been managing it for generations, affects how the water flows across it. And we need to find ways to integrate that specific, local knowledge into our global assessment. We know that when things are hard to count, we often don't account for them at all. We don't want to leave anything out, but we also don't want to change its value or importance by counting it the wrong way. It's a challenge. And our first attempts will probably be wrong. But we're going to try anyway.

Sharon Moen

Senior Science Communicator, Minnesota Sea Grant, University of Minnesota Duluth

Solving the St. Louis River Estuary’s Mercury Problem

Call it what you will—mercury, Hg, hydrargyrum, quick silver—this element isn’t supposed to be fish food. Yet unnatural levels of mercury accumulate in aquatic food webs after coal-fired power plants and other industrial activities send it swirling into the atmosphere. This heavy metal eventually falls back to Earth where sulfate-reducing bacteria can change it into nerve-damaging methylmercury (MeHg). MeHg accumulates up the food chain after sticking to algae, which are eaten by tiny aquatic grazers (zooplankton). The grazers are eaten by small fish, which in turn are eaten by larger fish, and so it goes … sometimes in a direction that damages human health.

See video “Solving the St. Louis River Estuary’s Mercury Problem” here.

In this video, graduate student Amber White explains how Sea Grant-funding is allowing University researchers to understand variable methylmercury levels in the St. Louis River and its estuary.

University of Minnesota Sea Grant scientists and their collaborators at the U.S. Environmental Protection Agency and Wisconsin Sea Grant are examining the processes leading to elevated MeHg levels in walleye and other sportfish in parts of the United States’ largest tributary to Lake Superior, the St. Louis River. Their work is poised to inform decisions concerning dredging materials, habitat restoration, and fish consumption advisories. The results of the study are helping to define why some waters are plagued with MeHg more than others. MeHg abundance reflects:

- wetland abundance
- water chemistry (temperature, dissolved organic matter, pH)
- landscape qualities (soil type, ground cover)
- microbe activity
- mercury abundance and form (it exists in three species that behave differently in the environment)

No method of cooking or cleaning can reduce the amount of MeHg in a meal of fish since it binds to proteins in animal tissues, including muscle. Enjoy fish without worrying about an unhealthy dose of mercury by following the Minnesota Department of Health fish consumption advisories, and by eating smaller fish and species lower on the food chain.

Mary Sabuda, Cara Santelli

Mary Sabuda, Graduate Student, Newton Horace Winchell School of Earth Sciences, University of Minnesota Twin Cities,

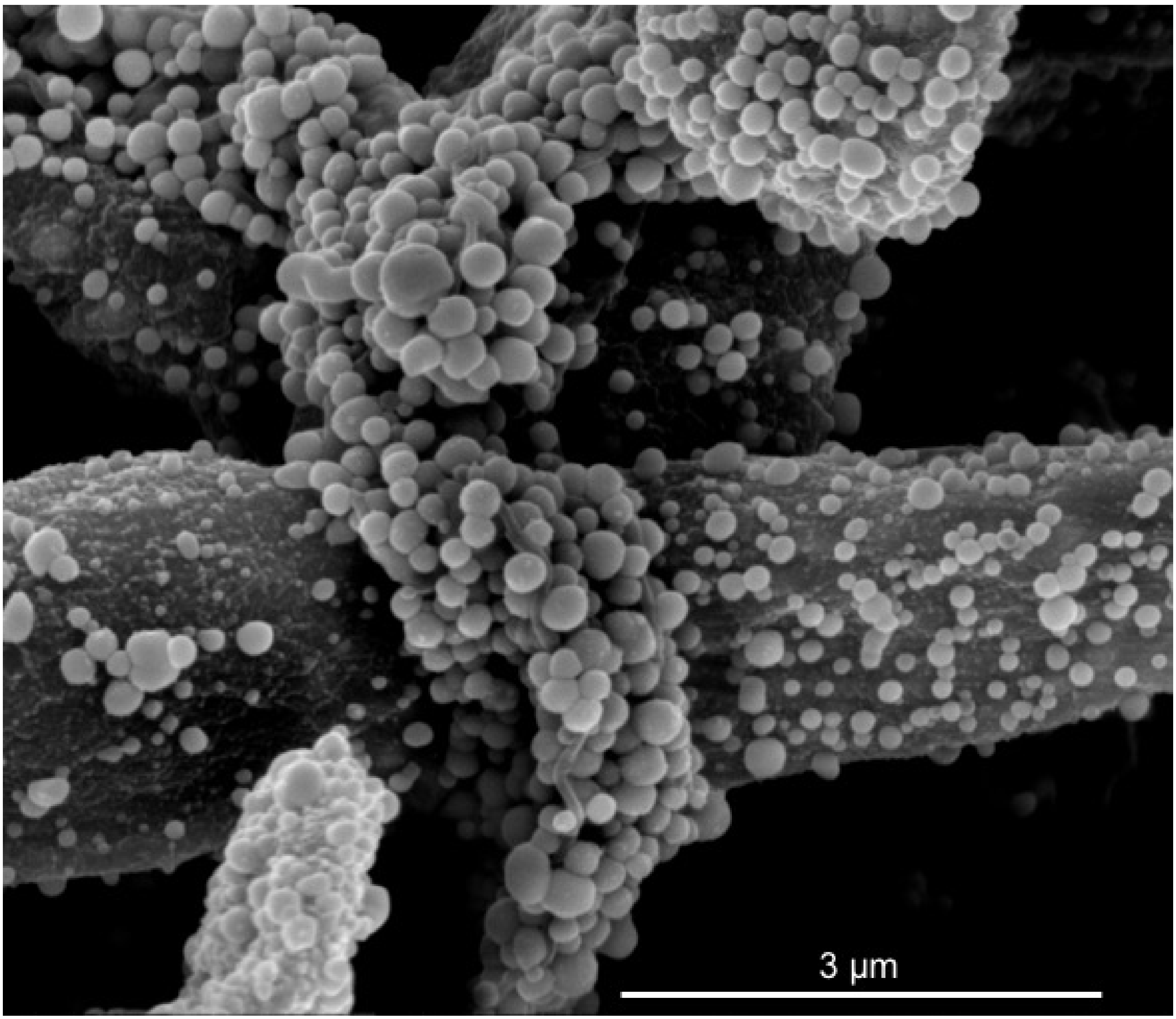
Cara Santelli, Assistant Professor, Newton Horace Winchell School of Earth Sciences, University of Minnesota Twin Cities

Clean water is essential for every organism on Earth, yet many freshwater sources are polluted with high concentrations of metals and metalloids from mining, agriculture, and other industries, which can cause adverse health effects in animals and plants. Selenium (Se), specifically, is a problem because it is essential in small doses to most organisms for survival, yet high concentrations

Mining of the Phosphoria Formation's phosphorus- and selenium-rich rocks in southeastern Idaho raises concerns about Se toxicity. Image courtesy of Carla Rosenfeld can be detrimental to life. Similar to how mercury can be stored for long time periods within organisms in an environment, selenium can also bioaccumulate, which renders upper trophic level species extremely vulnerable to the effects of selenium. Mining of shale beds for phosphate ores, coal, and oil can release selenium into the environment, which can then become available to organisms. This can also occur during refining of these extracted resources and via natural weathering and runoff from Se-rich rocks. Unfortunately, current clean-up strategies are expensive, time-consuming, and resource-heavy. To efficiently clean up elevated concentrations of metals within freshwater sources, the Santelli Lab at the University of Minnesota has identified six common species of fungi that are capable of chemically transforming metals and metalloids, such as selenium. Some of these fungi can convert water-soluble selenium to an immobile solid

The fungal species, Alternaria alternata, transforms Se from a water-soluble state to solid red Se nanoparticles. Image courtesy of Jennifer Kenyon.

phase or a volatile phase, while others perform similar transformations with other heavy metals such as manganese, copper, nickel, and cobalt. To better understand this process, the lab combines information about geology and water chemistries in the environment with genomic techniques to understand how these fungi perform this essential "detoxification" on a genetic level. Laboratory benchtop culturing experiments allow for a controlled environment in which to assess fungal gene functions and track the chemical transformation of selenium. Combined, these techniques provide the framework for designing and implementing an efficient engineering strategy for remediating metal(loid)-polluted areas.



Fungal selenium bionanoparticles (produced here by Paraconiothyrium sporulosum) imaged using a Scanning Electron Microscope. Image courtesy of Carla Rosenfeld.

Ingrid Schneider

Professor, Department of Forest Resources, University of Minnesota Twin Cities

Eight years strong, the University of Minnesota's Department of Forest Resources continues its experiential learning opportunities in select Minnesota National Parks: the Mississippi National River and Recreation Area and the St Croix National Scenic Riverway. Each spring students in the course Managing Recreational Lands (FNRM 4232/5232) work with park personnel to understand park visitor issues and apply their new-found knowledge and creative problem solving to inform park management. Park staff provide background information on select sites, host students on field trips, and constructively comment on final project presentations at the end of the semester. Students apply management frameworks and fresh ideas to perplexing real-world management problems while networking with agency personnel. The team-based approach contributes to the real-world application as does the final presentation to park staff and former students. Ideas from student projects are shared with park and regional staff and have informed project planning and ideation. Based on their success, the partnerships has been invited to share their work on a National Park Service panel on STEM learning at the 2018 National Center for Science and Civic Engagement Conference.

Shashi Shekhar

McKnight Distinguished University Professor of Computer Science & Engineering, University of Minnesota Twin Cities

Spatio-temporal Big Data Tools for Water Quality Monitoring

Water quality monitoring is usually based on infrequent (e.g., weekly) sampling and time-consuming (e.g., hours to days) testing methods, making it difficult to make timely decisions to protect water and environment in the face of pollution events. Recent advances include monitoring sensor networks to provide increased sampling frequency and associated big water-quality data. However, it is computationally expensive to analyze these big datasets due to their spatio-temporal nature, large volume, and high update rates. Our goal is to advance new scalable spatio-temporal big data mining tools[1], such as the flow anomaly miner, for water quality monitoring and early warning systems. Next, we describe the flow anomaly (FA) miner tool.

A flow anomaly miner identifies time-intervals with significant mismatch between the measurements of a pair of consecutive upstream and downstream sensors monitoring a flow. Mining FAs is computationally expensive because of the large number of time points of measurement and potentially long delays between consecutive sensors due to slow moving (e.g., wetland) water bodies. Traditional outlier detection methods (e.g., t-test) are suited for detecting transient FAs (i.e., time instants of significant mismatches across consecutive sensors) and cannot detect persistent FAs (i.e., long variable time-windows with a high fraction of time instant transient FAs) due to a lack of a pre-defined window size. In contrast, our Smart Window Enumeration and Evaluation of persistence-Thresholds (SWEET) [2] algorithm reduced computation cost by orders of magnitude using a smart counter and efficient pruning techniques. Experimental evaluation using a real dataset from Hydro-Lab sensors monitoring Shingle Creek (MN) showed our proposed approach outperforms baseline alternatives.

ACKNOWLEDGMENTS: This work was supported in part by the National Science Foundation, the U.S. Department of Defense, and the University of Minnesota.

Footnotes

[1] J. M. Kang, S. Shekhar, M. Henjum, P. J. Novak and W. A. Arnold, Discovering Teleconnected Flow Anomalies: A Relationship Analysis of Dynamic Neighborhoods (RAD) Approach, Proceedings of the International Symposium on Advances in Spatial and Temporal Databases, Springer LNCS 5644, 2009.

[2] J. M. Kang, S. Shekhar, C. Wennen, P. Novak, Discovering Flow Anomalies: A SWEET Approach, pp.851-856, Proceedings of the Eighth IEEE International Conference on Data Mining, 2008.

Recommended Citation

Brauman, Kate, Sharon Moen, Mary Sabuda, Cara Santelli, Ingrid Schneider, and Shashi Shekhar. 2018. “Water @ UMN Roundup.” *Open Rivers: Rethinking Water, Place & Community*, no. 10. http://editions.lib.umn.edu/openrivers/article/water-at-umn-roundup-i/.

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