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Pollution Solutions: Maximizing the Cleaning Power of Trees

It is hard to imagine the vast expanse of the Great Lakes being anything but pristine, yet trouble roils just beneath the surface. Along with an increase in the use of electronics, pharmaceuticals, and personal care products comes an increase in the pollutants that are pumped into the environment every day.

"In the Great Lakes region, we are used to having an abundance of fresh water," says Liz Rogers, a Pathways Intern at the U.S. Department of Agriculture, Forest Service's Northern Research Station (NRS). The Great Lakes contain roughly 90 percent of the surface freshwater supply in the United States—and 20 percent of the world's freshwater supply. "If pollution to the Great Lakes continues unchecked, the freshwater we drink, fish we eat, and recreation opportunities the lakes provide could all be affected, changing our ways of life as we know them."

Rogers and Ryan Vinhal, another USDA Pathways Intern, both work in the lab of Chung-Ho Lin, an associate professor at the University of Missouri's Center for Agroforestry. Lin, Rogers, and Vinhal are working with Ron Zalesny, an NRS scientist based in Rhinelander, WI, who leads the Station's research on phytotechnologies—technologies that use trees to solve environmental problems—in urban and rural areas. The work of this team to establish standardized, customizable approaches is setting a new standard for tailoring the phytoremediation process to the needs of communities anywhere in the world.

Zalesny with other NRS scientists in the Great Lakes region began studying and applying phytoremediation, a process that harnesses the power of trees to soak up and break down pollutants, back in 1995. Today, phytoremediation is among the most cost-effective approaches for capturing pollutants before they contaminate drinking water, disrupt recreation, or destroy essential wildlife habitat. In 2016, a team of NRS researchers established a 16-site system of trees for phytoremediation—the largest replicated field-scale phytoremediation network in the world. With funding from the Great Lakes Restoration Initiative, scientists are formalizing methods for identifying pollutants of greatest concern, selecting trees best suited for the specific job at each site, and measuring how the remediation process unfolds throughout the life cycle of the trees.

KEY MANAGEMENT CONSIDERATIONS

- The prioritization method developed by the team uses the most current pollutant toxicity information available to help site managers make important decisions about which pollutants to clean up.
- Poplar and willow trees have a longstanding history of successfully removing pollutants from soil and waterways. Trees chosen through a process called phyto-recurrent selection can help to optimize their effectiveness.
- Measuring how phytoremediation unfolds throughout the life cycle of the tree could help site managers make key tree selection and management decisions.
- Leading-edge planting methods developed by researchers could enhance the success of phytoremediation systems.

An agroforestry phytoremediation buffer system at a landfill in eastern Wisconsin. Courtesy photo by Paul Manley, Missouri University of Science and Technology, used with permission.

A Murky, Turbulent Past

Waste produced by people today contains more electronics, pharmaceuticals, and personal care products than it did decades ago. However, according to Lin, most of the pollutants currently monitored were selected over 25 years ago, meaning newer pollutants may not be adequately recognized or prioritized. So, Lin and Rogers are prioritizing pollutants of concern using a novel approach. Their process, published in an April 2021 article in Journal of Environmental Management, outlines a methodology any scientific team working on contaminant management could use. "No one has ever done this for landfills and phytotechnologies," Zalesny says. "It is a crucial advancement for phytoremediation."

Matchmaking Trees and Sites

In the field, the team is planting specialized poplar (*Populus*) and willow (*Salix*) trees known as short rotation woody crops (SRWCs). These fast-growing trees have extensive rooting and elevated water usage and are particularly popular for use in phytoremediation systems, including landfills, mine reclamation, brownfields, wastewater treatment, and agricultural buffers.

The team relies on a strategy Zalesny developed in 2002 to select superior SRWCs for site-specific remediation needs. The process, phyto-recurrent selection, involves testing candidate trees for multiple cycles using soil and wastewater collected from polluted sites and then identifying those with superior performance.

"Our final cycle is to plant the best varieties at landfills and other phyto sites where we will monitor their long-term performance," explains Vinhal. In 2019, Vinhal and Brent DeBauche, a fellow master's student in the Lin lab, designed a novel technique, the DeValix method, to establish willow for applications that combine phytoremediation with shoreline stabilization and restoration. And, Vinhal says, they are getting great results.

"We are also monitoring how phytoremediation works across the entire lifecycle, which has rarely been done before," says Vinhal. Typically, the SRWCs live for around 20 years at remediation sites, depending on the species and pollutants they encounter. Studying the process through time could help researchers better understand the long-term effectiveness of these systems to maximize environmental benefits.

Deep Roots

The research team's backgrounds in tree genetics, physiology, and bioremediation, along with their access to specialized trees and extensive partnerships, make them uniquely positioned to refine large-scale phytoremediation tactics. The adaptability of these new phytotechnology approaches is the team's biggest impact. "No matter where you are in the world, what trees you use, or what contaminants you have," Rogers says, "you can use our methods to get the results you need."

Poplar and willow trees being tested using phyto-recurrent selection to choose superior varieties for outplanting at a landfill for phytoremediation. USDA Forest Service photo by Ron Zalesny.

Project Leads

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FURTHER READING

Rogers, E.R.; Zalesny, R.S.; Lin, C.-H. 2021. A systematic approach for prioritizing landfill pollutants based on toxicity: applications and opportunities. Journal of Environmental Management. 284: 112031. https://doi.org/10.1016/j.jenvman.2021.112031.

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