Researchers develop technology allowing researchers to image wetland soil activity in real time

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Brian Scott imaging wetland soils with his new technology. Credit: Donald De Alwis (ENST alum), De Alwis Photography

Featured on the cover of the *Soil Science Society of America Journal*, researchers at the University of Maryland (UMD) and the Spanish National Research Council partnered to create a new camera allowing for the imaging of wetland soil activity in real time. This camera gives the classic IRIS (indicator of reduction in soils) technology a big upgrade. IRIS is used universally by researchers and soil assessors to determine if soils are behaving like wetland soils and should therefore be classified as such.

However, before this new camera, soil assessors couldn't quantify the rate of iron reduction in saturated wetland soils, and researchers had no way to visualize the process in real time. This technology opens up new research avenues in soil science, and gives a compelling peak at how biochemically active wetland soils really are.

"The interest in this paper has been really amazing, although it wasn't initially why I created the camera," says Brian Scott, doctoral candidate in Environmental Science and Technology at UMD. "The paper shows that this camera really works, but what interested people was the real time imaging and rates of iron reduction in wetland soils. But to be honest, the real reason I did it wasn't for the practical reason of calculating rates. It was more about trying to explore ways to visualize what's happening in the environment. I study soils, and everything is underground. So I developed this method to look at what is actually happening under the surface, which is really exciting to me."

"There are three major parameters needed to classify an area as a wetland: hydrology or water, the plant community, and soil properties," adds Martin Rabenhorst, esteemed soil scientist, professor in Environmental Science and Technology at UMD, and co-author on this paper. "These are all critical because wetlands are highly regulated and protected ecosystems. The soil is perhaps the most complicated piece of the puzzle because you have to confirm that certain biogeochemical processes are actually happening below ground where they are not easily seen."

Rabenhorst himself is an inventor of a greener method of IRIS, a technology used to measure the amount of iron reduction occurring in soils. The technology uses iron-oxide coatings on plastic tubes or films that are pushed into the soil and left for 30 days so the soil can react with the paint. As these reactions occur, the paint is partially dissolved from the tube. If 30 percent or more of the paint is stripped off, the soil is behaving like typical wetland soil.

"This is really because of the biochemistry of microorganisms in the soil," explains Scott. "The organisms I study breathe iron the same way we breathe oxygen. These microorganisms are anaerobic because they thrive in environments without oxygen and need the iron to respire. Oxygen is toxic to them, so they live in wetlands where the soil is often saturated with water and less oxygen rich. These organisms are so prevalent in wetland soils that they are the basis for our testing to see if a soil is hydric. IRIS testing has therefore become a focal point for biogeochemists that study wetlands."

While this technology has the potential to lead scientists down all sorts of new research avenues, it is unclear whether it might lead to improvements down the road for the typical soil assessor using classic IRIS technology.

But as Scott describes it, the real findings of the paper come in the methods used to create this camera, which he says is now reproducible by anyone for about $100. He converted a borescope camera used by plumbers and other industry professionals to image down pipes, and coupled that with a wireless system sending information in real time with just a small solar panel to see what is happening 24-7. "Some of the things that are the most important for this paper weren't really the findings; it was the process of development that opens up new applications and research avenues which is really exciting," says Scott.

The idea came to Scott while he was volunteering in Osvaldo Sala's lab at Arizona State University using a machine called a mini rhizotron that is used to count tree roots with a camera through a hollow tube in the ground. Scott thought, "If we can take pictures of roots, we should be able to take pictures of other things underground." So eventually, when Scott came to Maryland to pursue his Ph.D. and started working with

Rabenhorst, things all fell into place. The process, however, was not without its challenges.

"Once somebody has gone through this whole long process of how to make something work, then we can do it again and again easily, but it takes a long time to figure it out," says Scott. "It took a long time to figure out how to make this camera work, and I ran into roadblocks where I almost quit if it weren't for other people's input and ideas."

Scott particularly calls out a few people along the way that helped keep this process moving. An undergraduate assistant, Kristin Webb, helped sketch out the initial designs for the camera. Another undergraduate in Environmental Science and Technology and recent graduate, William Jacob Mast, helped design and print the camera shell using a 3-D printer. And Spanish collaborators at the Spanish National Research Council had a similar idea simultaneously and helped find ways to convert the video imagery into flat images that could be analyzed.

Scott stresses the importance of collaborative science throughout this process, and wants to make this technology available to others so that it can advance science and ultimately environmental health. "I'm not interested in patenting this particular technology because I want the science to benefit everyone," explains Scott. "It's not about money with this, it's about the impact for the environment. I spent my own money actually to help make sure that this could get built along with the support of the department, and I think that if it works, and if it helps another scientist make some even greater discovery, then that's worth it. It's about helping the world we live in."

Scott is pleased to be able to contribute to soil science and focus on the restoration of critical ecosystems like wetlands. "I was an environmental engineer for years, so I have an interest in taking care of the environment, and a lot of what environmental engineers do is clean up messes," says Scott. "Everything I do now is related to ecosystem recovery and restoration. I used to clean up messes, but it's a different animal to actually take ecosystems back to their former glory and restore their ecological functioning."

This paper, entitled "Macro and Microscopic Visual Imaging Tools to Investigate Metal Reducing Bacteria in Soils," is published in the *Soil Science Society of America Journal*.

More information: Macro and Microscopic Visual Imaging Tools to Investigate Metal Reducing Bacteria in Soils," *Soil Science Society of America Journal* (2021). DOI: 10.1002/saj2.20092

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