Data mining to protect water quality in southeast Ohio

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Credit: Ohio University

Tapping into its water-quality expertise, Ohio University's Appalachian Watershed Research Group (AWRG) is assessing data collected from regional mining operations in a first-of-its-kind study, to better predict how groundwater levels will respond to mining.

The research group, a multidisciplinary team of undergraduate and graduate students, staff, and faculty from across the Athens campus, have pulled together a team from Geological Sciences and the Voinovich School of Leadership and Public Affairs' Environmental Studies

program for the completion of this project. The goal is to create a geospatial tool to model potentially negative environmental impacts from mining operations in the future.

With funding from the federal Office of Surface Mining, the Ohio University team is digging through extensive datasets, compiling, analyzing and modeling both geological and hydrogeological information collected by Ohio-based mining companies and regulatory agencies throughout the last 40 years.

What's on the surface: A history of mines

The State of Ohio has a long legacy of resource extraction – and the land shows it.

Geographic Information Systems (GIS) maps created from state agency databases, including the Ohio Department of Natural Resources (ODNR) Divisions of Mineral Resource Management and Water Resources, as well as the Ohio Geological Survey, reveal the right-most portion of the state riddled with wells and boreholes in addition to a swath of surface mines and other oil and gas industry activity.

Ohio's rich mining legacy has had long-standing effects on the surrounding environment, most visibly as orange-red rivers via a chemical reaction called acid mine drainage. It's an issue that's plagued southeastern Ohio for more than 100 years.

Found throughout Appalachia, acid mine drainage occurs when pyrite, a mineral in coal, is exposed to both water and oxygen. The reaction often originates in underground pools that form in coal mines, which can then flood and discharge into the external environment. This discharge can adversely affect the biology or chemistry – or both – of surrounding waterways, thus impacting the region's surface water.

Regulators and mining companies do not currently have an accurate, technology-based mechanism for assessing the probability of the formation of these mine pools. Reclamation and remediation of acid mine drainage impacts can cost federal and state governments millions of dollars each year.

"We are aiming to improve predictions of post-mining water levels to prevent polluting discharges in the first place," Voinovich School Associate Professor Dr. Natalie Kruse, one of the project team leaders, said.

Multidisciplinary cohort explores acid mine drainage in the region

Rebecca Steinberg, a student GIS Technician on the mine-pool project, finished her first round of education at Ohio University with an undergraduate geology major and a GIS certificate.

"I was the kid with the random collection of rocks," Steinberg said. An Athens native, she decided to pursue geology in undergraduate because of its basis as the structure of the rest of the environment.

Now a first-year master of environmental studies (MSES) candidate at Ohio University's Voinovich School, Steinberg's multidisciplinary education is exemplary of the mine-pool team's diverse experiences in acid mine drainage issues.

"I'm on the GIS side of the project, but I know the geology," Steinberg said.

She and her MSES colleague Zachary Matthews work specifically on managing the large amounts of data collected for the team's eventual

map-based tool. Matthews studied archeology in undergraduate, also at Ohio University, where he explored the surrounding region in OHIO's Archeology Field School.

"I just really liked being outside – every day was pretty exciting, not knowing what you were going to find," Matthews said of his passion for outdoor field work.

After a year-and-a-half of traveling the country for contract work, Matthews decided to return to his alma mater and pursue a GIS certificate. He enrolled as an MSES candidate and joined the mine-pool project in the fall of 2017.

On the analysis side of the mine tool creation is Lindsey Shafer and Frederick Twumasi, two Geological Sciences graduate students under the direction of Dr. Dina Lopez.

Schafer's understanding of acid mine drainage began during her undergraduate courses as a chemistry major at Ohio University. She began working with Dr. Lopez, a faculty member on the Appalachian Watershed Research Group, during her completion of a geology minor. After graduating with her bachelor's degree in spring 2016, Schafer enrolled in the Geological Sciences program in the fall.

"With my chemistry background, I got excited because I understood the chemical reactions going on in acid mine drainage," Schafer said. "When I started working with Dina as a graduate student, I told her I wanted to work on an AMD project."

Schafer's Geological Sciences colleague on the surface mine-pool project, Frederick Twumasi, came to Ohio University after earning two degrees at the University of Ghana: a bachelor's in geology and a master's in mineral exploration. Twumasi's research work in gold mines

led him to explore other environmental issues, including acid mine drainage, in extraction-based activities more broadly.

"I love chemistry, I love geology – the combination of the two makes me who I am," Twumasi said. "So I asked myself, 'How can I relate that to the environment?' I really, really wanted to do environmental geochemistry because I feel the environment is all we have and its protection and management should be everyone's goal."

Together Steinberg and Matthews are organizing enormous amount of data – combing through hundreds of thousands of pages of mining permits and reports collected by ODNR – and entering it into an online database. Here, the MSES duo are looking for 'useable' data points – well and borehole coordinates, static water levels, and total depth of wells – for the later analysis and modeling aspects of the project's monitoring tool creation.

In addition to data entry and processing, Steinberg has also been the primary person for projecting data into files for GIS ArcMap – ultimately the way in which the GIS-based mine pool monitoring tool will be constructed as the team's final product.

Quality assurance is also an important task for the project's completion. The data management team diligently compares the entered data to the original ODNR permits, checking for patterns of error and correcting their spreadsheets accordingly.

"This process is meant to ensure consistency and correctness of all of our entered data," Matthews said.

The Geological Sciences team is next on the chain of command, with Schafer conducting multi-variable statistical analysis on the morphological and geological data mined from these extremely lengthy

datasets.

One of the challenges with unpacking this data, Schafer said, is determining the exact elevation and aquifer rock-layers identified in the surrounding region, with minimal geographic information on the wells based on years-old permits.

"In Ohio, sometimes they're very hard to identify because the layers are very thin, so it's hard to determine where those differentiating layers are," Schafer said.

Understanding where the water wells intersect with different layers of rock among different aquifers may help prevent drinking water contamination from the likes of acid mine drainage.

Potential for impact: An old problem, a new solution

The ultimate goal of the project, with guidance from the Appalachian Watershed Research Group's senior technological expertise, is to create a GIS-based prediction tool to prevent future environmental disruptions – and economic costs – from acid mine drainage impacts.

"Acid mine drainage is a very expensive reclamation problem in Ohio. Instead of spending all this money to fix it after the mine has already been exploited, it would be more beneficial to try and reduce the environmental impact of the mines before they go in and start mining," Schafer said.

In early December 2017, the Research Group team previewed their preliminary research findings to representatives from the Ohio agencies and mining industries whose data the project group has been utilizing for the past 6 months.

"It was more interactive," Twumasi said, reflecting on the meeting. "We told them what we found, they also told us what they really expect from us, and at the end of the day they were so happy at the progress we've made."

As the team prepares to advance into the tool-creation side of the project, the four students are motivated by the opportunity to make an impact on an environmental issue of regional significance.

"I always struggled with the idea of 'Why does the research matter?'" Steinberg said. "When you get into environmental studies, there's so many other aspects to it; there's an actual reason that we're studying the things we do."

Provided by Ohio University