UMSAEP UM-UWC Linkage Report
Visit to Cape Town May 24, 2018 to June22, 2018

An investigation into the influence placement technique has on the ability of mixed coal combustion byproducts to contain acid mine drainage

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1. Overview

I first participated in the UMSAEP during the summer of 2017 when I represented UMKC at the joint workshop on climate change at UWC. Besides falling in love with Cape Town, during that workshop I met Dr. Leslie Petrik. After listening to her students presentations and discussing research activities, we found a good deal of commonality between our research groups with work utilizing fly ash and with water treatment.

2. Description of Linkage Activities

When sulfur-bearing mine drainage comes in contact with air sulfuric acid forms and metals solubilize. Mixed coal-combustion byproducts (CCBs) has previously shown the ability to both neutralize but also block, over time, acid mine drainage migration from source locations. Placement can occur either hydraulically or mechanically at various moisture contents. Hydraulic conductivity varies substantially based on CCB dam placement technique and particle size distribution. We obtained fly ash from Kendal and Lethabo generating stations from Eksom (Figure 1). Dr. Petrik and myself coordinated research activities for three students investigating neutralization of acid mine drainage using waste fly ash from coal fired power plants. During which time she organized presentation and update of all her students' activities for reference (Figure 2).

Figure 1. Dumping fly as in ponds

Figure 2. Environment and Nano Sciences Students at UWC

In order to obtain the fly ash and acid mine drainage needed for the research, I flew to Johannesburg with one of the graduate students, rented a truck, and drove the necessary materials back to Cape Town. I enjoy a good road trip and driving across South Africa was a fantastic experience (Figure 3). The student that accompanied me on the trip was Rosicky Kalombe (Figure 4). He is quite possibly the only student anywhere with specific experience of designing, construction, and overseeing a full-scale water treatment facility for a coal-fired power plant. I

have a current project doing just that for Kansas City Power and Light. His unique experience was so special that he started on his PhD at UMKC in January 2019.

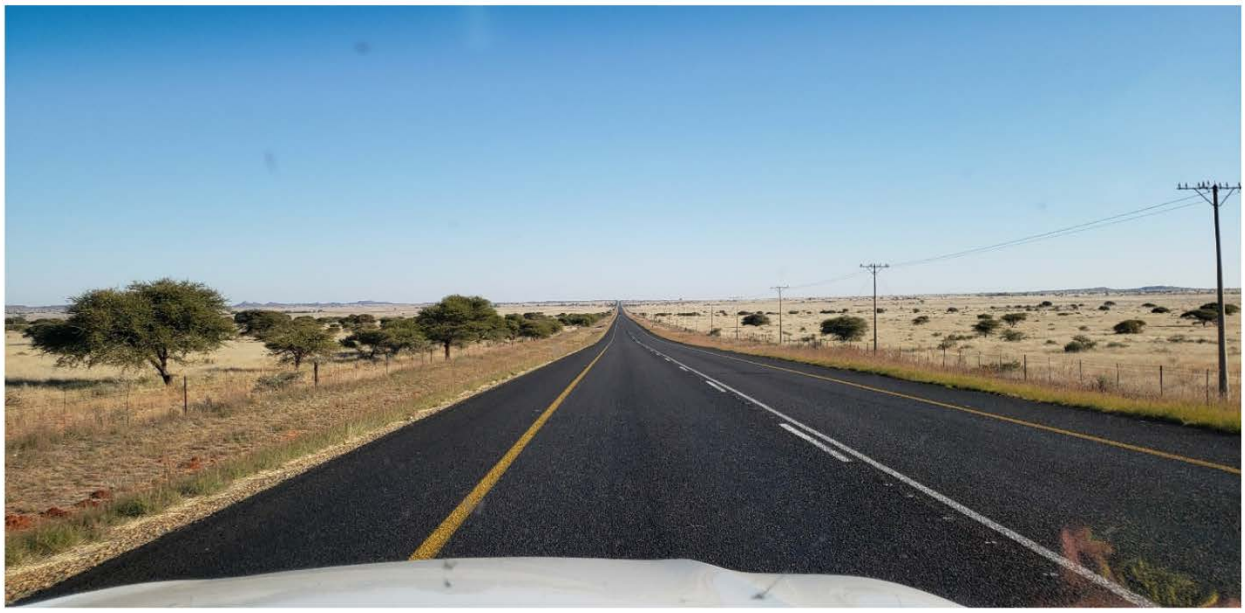

Figure 3. Taking the N1 from Johannesburg to Cape Town

Figure 4. Stopping to Stretch

Two papers have been submitted to the World of Coal Ash (WOCA) detailing the passive and active treatment strategies we investigated using waste fly ash to neutralize acid mine drainage. Figure 5 shows the test setup used at UWC to characterize neutralization potential and passive toxic metal reduction.

Figure 5. Acid mine drainage neutralization testing

The aim of this study was to investigate the neutralization capacity of columns of Kendal and Lethabo fly ash for the treatment of Eyethu AMD. The experiment was successful as it was proven that Eyethu AMD can be treated by passively flow through coal fly ash. The pH was raised from 2 to over 12 by the dissolution of oxide component in the ash and hydrolysis of the major and trace elements in AMD once in touch with coal fly ash. There was a substantial removal of metals including Fe, Al, Mn and Mg and removal of some other elements during this study as the pH was increasing over contact time. This study highlights three major parameters to take in consideration if passively treating AMD in columns with FA (AMD: FA ratio, the contact time, and the chemistry of the acid mine drainage). The bedvolumes of acid mine drainage used before the fly ash was exhausted was approximately 44 and show that the Kendal fly ash has a significant durability to act as a passive barrier.

3. **Products from Linkage Activities**
    - KCUR 89.3's Central Standard Radio Program, July 30, 2018 segment on Summer Vacation. https://www.kcur.org/post/summer-vacation#stream/0
    - Clean water solutions-UMKC Today https://info.umkc.edu/news/clean-water-solutions/

Clean Water Solutions

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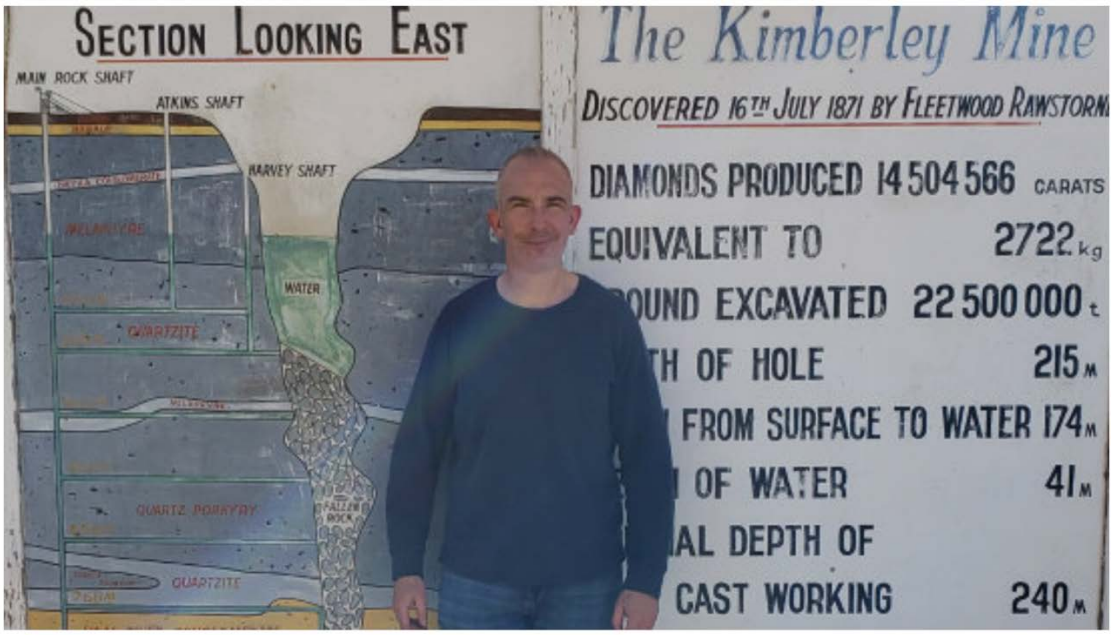

Photos provided by John Kevern, associate professor of civil engineering

Civil engineering professor works to increase access to clean water in Africa

Access to consistent and safe drinking water is arguably the biggest challenge facing humanity. That's especially true in Africa where the clean water shortage in many of the countries is getting worse. In Cape Town, South Africa, the crisis is called "Day Zero," the day the taps run dry.

John Kevern, University of Missouri-Kansas City associate professor of civil engineering, has been working alongside graduate students from the University of the Western Cape to help find a feasible solution for the crisis.

For more than 30 years, the University of Missouri South African Education Program has delivered on the goal of aiding South Africans disadvantaged by their government's former apartheid policies. Since 1986, the University of Missouri System has partnered with the University of the Western Cape in Cape Town, South Africa to advance mutual understanding between the institutions' faculties and foster cooperative teaching, research and service projects.

Water scarcity, or lack of safe drinking water, in South Africa is the result of multiple factors including climate change, growing population, and heavy metal contamination from abandoned mines. Kevern said the South African Department of Mineral Resources holds a list of 6,000 neglected mines filling with water and causing acid-mine drainage: the outflow of acidic water from metal or coal mines.

“Throughout its lifetime a mine can generate 2.5 million pounds of gold, silver uranium or other minerals, but South African mines are now a volatile wasteland.”

– Kevern

Kevern, a renowned expert in all things concrete, has worked with several other countries on the African continent, including Kenya and Ghana, to help solve waste issues. His passion for making a difference through resource and information sharing drives much of his willingness to work with disadvantaged communities.

Kevern and his team discovered that by using waste fly ash, a byproduct of coal combustion, from two regional power plants, they can neutralize the acid mine drainage and help generate more clean water for the country. The chemical composition of fly ash makes it a common—and cost effective—ingredient in treating acid mine water.

More about UMKC’s work with UWC:

Two Universities, One World

“In the Johannesburg area, with 10 million residents, at least 15 percent of the population lives in informal settlements, with many placed by former apartheid government near or even on top of these dumps. At Blyvooruitzicht, about 11,000 people live around the abandoned mine, many of them unemployed miners unable to afford housing elsewhere.

Fundamentally, social justice comes down to access to safe drinking water.”

– Kevern

When fly ash is inserted into the mine and mixes with acid water it creates a hard, non-porous material. That helps prevent any additional oxygen and water from getting into the mine and causing further pollution. Kevern spent much of the summer working at coal mines on the east side of the country, but UWC is on the west side so he and graduate student Rosicky Kalombe embarked on a cross-country road trip to collect coal to create fly ash.

Traveling across South Africa was a new experience for both Kevern and Kalombe, who migrated to South Africa as a Congolese refugee. They got to see the wealth of the country and made a pit stop along the way to see one of the world’s largest hand-dug excavations – The Big Hole in Kimberley, South Africa.

Since Kevern has been back in the states, he has been working remotely with Western Cape students who are continuing to conduct full-scale filter testing in the lab. The neutralization process, Kevern said, is fairly mature. The team’s next steps are to figure out what to do with the excess waste. Their idea is to use the waste to make a cost-effective geopolymer to fill the mine and prevent drainage from reoccurring.

The team will pilot the project this winter. If the project goes as planned, they hope to implement this solution across the continent. That means two things for Africa: more jobs for students and increased access to clean water.

Hear more about Kevern's summer in South Africa on KCUR's Central Standard.

- Petrik, L. and Kevern, J.T. (Kevern as a no-load PI) "Treatment of storm water using waste concrete as permeable reactive barrier," Proposal submitted to South African Water Resource Commission (WRC), 1005778, July 16, 2018.
- Katambwe, V.N., Kalombe, M.R., Nzadi, M., Bent, D., Nieuwouldt, G., Misheer, N., Reynolds-Clausen, K., Kevern, J., Ojumu, T.V., and Petrik, L.F. "Demonstration of 1000L jet loop pilot plant reactor in the treatment of acid mine water using South African coal fly ash," Paper accepted to World of Coal Ash, St. Louis, MO, May 13-16, 2019.
- Nkongolo, E.T., Katambwe, V.N., Kalombe, M.R., Kevern, J.T., Ojumu, T.V., and Petrik, L.F. "Passive treatment of acid mine drainage using South African coal fly ash, column leaching study," Paper accepted to World of Coal Ash, St. Louis, MO, May 13-16, 2019.
- Kalombe, M.R., Kevern, J.T., and Petrik, L.F. "Acid Mine Remediation using Hydrodynamic Fly Ash Cavitation," Manuscript in preparation for Journal of Environmental Technology and Management, submission for April 2019.

4. Summary

I appreciate the opportunity to participate in the UMSAEP. The program allowed me to interact with fantastic faculty and students at UWC and has resulted in several proposals and papers. One of the students I met during my visit is now a PhD student at UMKC and facilitating additional collaboration and information exchange. Participation during the summer of 2018 has been one of the most impactful and formative experiences of my career at UMKC. This experience has enriched both my teaching and research and constantly helps provide real context for my students why we as engineers strive to improve our built and natural environment.

Personal note: I cannot thank Leslie Petrik enough for her support and guidance before, during, and after my visit. I had a fantastic time and will definitely go back for professional and personal visits.