Runoff Water Quality from Highway Cut Slopes in Pyrite Geology: Characterization and Treatment

Principal Investigator Contact Information
John S. Schwartz, PhD, PE
University of Tennessee
Department of Civil & Environmental Engineering
413 John D. Tickle Engineering Building
Knoxville, Tennessee 37996
Tele: 865-974-7721 *Email*: jschwart@utk.edu

Synopsis of the Research Problem

Exposed pyrite geology (acid-producing rock or APR) combined with rainfall (water) generates sulfuric acid and can be transported as runoff. Runoff from these cut slopes may enter nearby streams, in which if acidified can potentially harm aquatic life. TDOT has encountered APR on several projects in the past decade, prompting the preparation of a guidance manual in 2007 for addressing APR at highway projects. TDOT routinely uses these manual design and construction protocols for proper handling of APR spoils from project sites, consisting of removal, disposal, blending, capping, and/or encapsulating APR materials. This approach to environmental mitigation is expensive, thus driving the need to better understand the extent of the potential environmental problems, and examine alternatives for engineering design, construction, and near-site passive treatment. Although much is known about acid mine drainage, little is known about the water quality generated from road cuts through APR at various ages, and what hydrogeological conditions may produce harmful levels of acidic waters containing sulfates and dissolved metals. To meet federal and state environmental regulations, TDOT needs better information on water quality (pH, sulfate, conductivity, dissolved metals) from road cut runoff which can be used to assess the extent of the problem, and what treatment options would be applicable. Various on-site passive treatment options are available for APR runoff, including limestone trenches to meet the state's pH water quality standard.

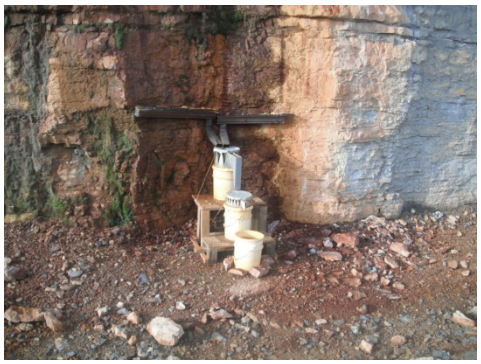
Project Objectives

The project consists of three task objectives; they are: 1) characterize runoff water chemistry from existing highway cut slopes; 2) quantify pollutant export over time from a pyrite geological formation, the Anakeesta shale formation, through an experimental design using simulated and natural rainfall; and 3) complete a literature review of treatment options for exposed road-cut APR. Project activities have been coordinated with the U.S. Geological Survey conducting a study of biogeochemical processes associated with acidified runoff from road cuts.

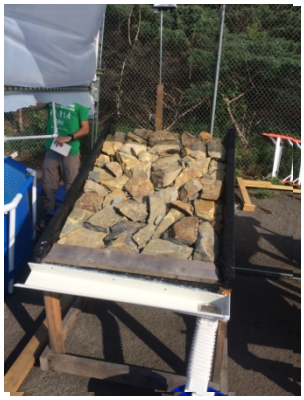
Project Description and Current Outcomes

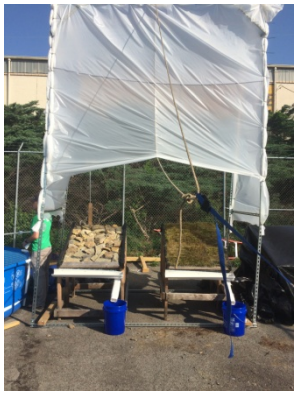
Monitoring equipment using Pinson samplers were constructed at ten sampling sites; they include: Jamestown (3) sites, Nashville (2) sites, Ocoee (3) sites, Grainger site, and Sevierville

site. Pinson samplers consist of a series of buckets with circumference weirs as show in the photos to the right, per the Nashville 2 site. Water quality samples were collected from June 2014 through August 2015. All chemical analyses have been completed on 200+ samples consisting of multiple runoff events per site. Among the 10 sites, preliminary results have found pH ranging from 3.85 to 7.43, conductivity ranged widely from 94 to 5,567 μS/cm, and dissolved aluminum ranged from non-detect to 15.7 mg/L. NOAA rainfall data has been compiled study site and the sampling day. A preliminary statistical analysis has been completed, but further data analyses are needed for the final report.



The second task objective includes exposing pyritic rock on experimental benches with three treatments to simulated and natural rainfall. In addition to the no treatment control bench, the three treatments consist of: 1) a geoliner, 2) soil and vegetation, and 4) shotcrete. Anakessta pyritic rock was collected from a land side in the Great Smoky Mountains National Park in June 2015 for the experiment and stored in a cool dry location until use. The outside experiment set-up was constructed on UT property on Middlebrook Pike, Knoxville, and was completed in April 2016. The treatment benches and rainfall simulator set-up is shown to the right. The rainfall simulation experiment was completed during May 2016, and natural rainfall exposure samples collected since that date though we have been in a drought since August. Water samples have collected and analyzed for both. Preliminary analysis of the data showed a rapid change from an initial pH of 3.5 to a pH 6 during the rainfall simulator experiment, and since that time the pH has remained about 6 and stabilized. Acid neutralizing capacity and sulfate concentrations have showed a similar pattern. Water samples collected from the other treatments initially start at a pH of 5 and equilibrate at a pH of 7.0. More analysis is needed to summarize the results.





Project Status

Data collected for objective tasks 1 and 2 data have been completed, but additional analyses and report writing need to be finished. Task 3 consists of a literature review on the potential effectiveness of various water quality treatment alternatives for APR and based on runoff data collected from tasks 1 and 2. A preliminary assessment of the data suggests that TDOT will be able to use on site treatment options post construction such as limestone check dams and or trenches to neutralize acidic runoff. This finding is significant because it potentially reduces the environmental management and construction costs at pyrite road cuts. The overall project will be completed with a final draft report to TDOT by March 2017, and any report revisions completed by May 2017.