Diurnal and Seasonal Fluctuations with the Subsurface: A 17-Week Survey of Groundwater and Sediment in 27 Contaminated Wells

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Project Goals: **ENIGMA (Ecosystems and Networks Integrated with Genes and Molecular Assemblies) uses a systems biology approach to understand the interaction between microbial communities and the ecosystems that they inhabit. To link genetic, ecological, and environmental factors to the structure and function of microbial communities, ENIGMA integrates and develops laboratory, field, and computational methods.**

Spatiotemporal variability of groundwater within contaminated wells greatly effects the geochemistry and microbial communities present. This survey of 27 wells at the DOE Oak Ridge Reservation (ORR) Y-12 Complex in Oak Ridge, Tennessee, set out to obtain diurnal and seasonal fluctuations within three levels (low, moderate, and high) of nitrate and heavy metal contamination. With this data, we created 3D geochemical models using RockWorks of these areas to study changes within the attached and unattached microbial communities in relation to groundwater geochemistry.

Measurements were gathered in 27 previously established groundwater wells, four days a week, for the span of 17 weeks (70 days total) spanning from July to December 2019 to build both diurnal and seasonal time series of geochemistry and microbial communities. In-field geochemical measurements were obtained using In-Situ Aqua TROLL 600s, including dissolved oxygen (DO), pH, conductivity, oxidation-reduction potential (ORP), and nitrate concentration. Samples were then taken from each well to measure 52 metals, anions, organic acids, and total organic and inorganic carbon/nitrogen. Throughout the study, results show diurnal and seasonal changes in geochemistry with wide variations between each well and levels of contamination. The subsurface geochemistry was also greatly affected by rainfall events, which was evident after two months of regional drought conditions. Additionally, one well in each level of contamination (3 wells total) was selected to complete a microbial analysis by sampling for

groundwater (unattached) and sediment (attached) microbial communities. Groundwater was filtered through 8µm and 0.2µm filters for 16S rRNA and metagenomic analysis (420 filters). In each of the three wells, 18 unamended sediment traps were placed to complete a time series analysis of the attached microbial community's sediment geochemistry.

Results of all analyses are linked to groundwater flow vectors (using the Geotech Colloidal Borescope) on-site weather data (using a HOBO RX300 Weather Station) to produce a correlation analysis between source water and flow paths, groundwater geochemistry, weather events, and levels of contamination on a spatiotemporal scale. With this data, we aim to establish a predictive model between groundwater geochemistry and microbial communities to inform future ENIGMA groundwater and sediment sampling in a planned subsurface observatory.

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