Temporal Variation in Groundwater Microbial Community Structure: Implications for Groundwater Monitoring

Andrea M. Rocha[1, 2*] (rochaam@ornl.gov), B. Adams[1,2], C. Paradis[1,2], Tonia L. Mehlhorn[1], Jennifer E. Earles[1], Kenneth A. Lowe[1], Dawn M. Klingeman[1], David B. Watson[1], Dominique C. Joyner[1, 2], Sindhu Jagadamma[1,2], Julian L. Fortney[1, 2], Jizhong J. Zhou[3], Joy D. Van Nostrand[3], Michael W. W. Adams[4], Romy Chakraborty[5], Dwayne Elias[1], Eric J. Alm[6], and Terry C. Hazen[1, 2], Adam P. Arkin[5], and **Paul D. Adams[5]**.

[1] Biosciences Division, Oak Ridge National Laboratory, Oak Ridge, TN; [2] University of Tennessee, Knoxville, TN; [3]University of Oklahoma, Norman, OK; [4]University of Georgia, Athens, GA; [5]*Lawrence Berkeley National Laboratory, Berkeley, CA;* [6]Massachusetts Institute of Technology, Cambridge, MA.

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Project goals: The overarching goal of the Ecosystems and Networks Integrated with Genes and Molecular Assemblies (ENIGMA) field microbiology component is to understand the interactions between environmentally relevant microbial communities and their environment. As part of this, we must understand the mechanisms that may potentially impact microbial community structure, function, and activity. At the DOE Oak Ridge field site, groundwater wells are subject to temporal and seasonal changes in groundwater hydrology and geochemistry, which may result in temporal bias in microbial community monitoring data. Here, we characterize the microbial community response to temporal variability to determine to what extent variation in groundwater geochemistry and hydrology impacts microbial community structure and function.

Large-scale groundwater sampling events, such as those associated with biomonitoring, may span the course of several weeks or months. Based on the sampling methods and time-scales involved, microbial community and geochemical data may contain significant temporal bias, as well as, biases attributed to external factors. In this study, we characterized the temporal dynamics of microbial groundwater communities at the background site of the Oak Ridge Field Research Center in Oak Ridge, TN to determine (1) if, and to what extent, temporal and/or seasonal variation of the groundwater geochemistry affects the microbial community structure and (2) to assess the impact of groundwater flow and transport of geochemical constituents on the microbial structure. To determine how resilient microbial communities are to daily and weekly changes in groundwater chemistry, the temporal dynamics of microbial communities from six groundwater wells were monitored and compared to geochemical and hydrological measurements. Of the six wells, we physically and chemically cleaned four wells to remove biofilm and attached particulates from the well casing. The remaining two wells that weren't cleaned served as controls. All wells were sampled prior to cleaning to establish a baseline microbial community profile. Post-cleaning, each well was sampled a total of twelve times from December 1, 2014 – January 12, 2015. For each well and time-point, groundwater samples were collected for geochemical and microbial community analyses using low flow sampling methods. Nucleic acids were collected by sequentially filtering water through a 10µm pre-filter and 0.2µm-membrane filter and then extracted using a Modified Miller method. A total of 6,959

OTUs were identified across all six wells and size fractions. Of the OTUs Proteobacteria represented a significant portion of the taxa. Analyses of microbial community data indicate overall diversity of the taxa did not vary significantly during time-course sampling. However, significant shifts in the population were observed between cleaning treatments and during sampling time point 01/5/15 for select wells. Additionally, daily and weekly variation in the relative OTU abundance within each well was detected. Throughout the study, groundwater geochemical measurements were relatively stable. However, shallow wells varied in concentrations of Na^{+}, K^{+}, Ca^{2+}, HCO_3^{-}, and CO_3^{-2} following rain events. The geochemical values for these ions are consistent with distinct differences in water types between deep and shallow wells. The stability of the geochemical measurements may indicate that groundwater chemistry is not a dominant factor in the observed daily and weekly variances, but rather contributes to taxonomic differences observed between well depths. However, further analysis of geochemical shifts at higher resolutions is necessary to understand the full impact of geochemistry on microbial response. Furthermore, analyses of groundwater results indicate that the pumping/sampling of wells did not contribute to sampling bias. Overall, results demonstrate that groundwater microbial community data contain temporal biases. As such caution must be used when designing large-scale sampling events.

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