

98. Groundwater-fed Bioreactors Show Distinct Colonization and Community-wide Response Dynamics to Perturbations

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ABSTRACT

Laboratory bioreactors have long been used for investigating the characteristics of a microorganism or simple synthetic community. However, for studying natural or in-situ microbial communities, discontinuous “snapshot in time” sampling has mainly occurred. In this study an in-field bioreactor system was developed to temporally monitor and manipulate the in-situ microbial community while maintaining the in-situ community structure.

Three above ground, in-field reactors were continuously fed microaerobic (0.2% O₂) groundwater directly from an existing well at the Oak Ridge Field Research Center, Oak Ridge, TN, for 12 weeks. Each bioreactor contained 800 ml of groundwater and 8 replicate biofilm coupons filled with sterilized site sediment to monitor both the planktonic and biofilm communities. Gas influx was varied from aerobic (weeks 1-7, & 9) to anaerobic (weeks 8 & 10) to confirm that manipulation of bioreactor microorganisms was tractable. Samples from the incoming groundwater and from each bioreactor were taken every two days to match the dilution rate of the reactors. Each sample was analyzed by 16S rRNA sequencing at an average of 10,000 reads and key biogeochemical properties were measured including pH, dissolved oxygen, ORP, conductivity, 12 organic acids 14 anions and 3 sugars. At every third time point 53 different metals were also measured.

Community structure and diversity was highly similar across all three bioreactors according to 16S rRNA sequencing, representing 30-65% of the groundwater OTUs overall and 50-85% of high abundance groundwater OTUs. Biofilm coupons captured a unique subset of the groundwater OTUs but on average were only 27% similar to groundwater and 48% similar to the bioreactor planktonic samples. Community beta-diversity patterns indicated bioreactors were more different to the groundwater than expected if no growth was occurring, thereby suggesting growth in the reactors.

Correlations between organic acid profiles and bacterial clades revealed that the metabolic function was conserved across all three bioreactors and the in-situ groundwater community.

Transitions to anoxic conditions and subsequent lowering of the pH at weeks 7 and 10 resulted in strong, repeatable bacterial community and individual clade shifts toward the groundwater composition. However, not all bacterial groups in the bioreactors mirrored those in the groundwater. In fact, known metal- and organic acid-metabolizing clades increased in abundance in the bioreactors when the incoming groundwater increased in solute concentration despite no change in the incoming clade abundance.

Similarly, co-occurrence relationships of OTUs known for syntrophic and predator- prey interactions were observed over time in the bioreactors. This type of in-field bioreactor system allows for discreet temporal monitoring of microbial community structure and function simultaneously while allowing community responses to be determined during the testing of new strategies for environmental amendment or restoration on a small and affordable scale.

Keywords. Bioreactor, Microbial Community, Groundwater, Diversity, Anaerobic, Time Course

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