# Closed System Synthetic Groundwater Mesocosm Study of Facultative Anaerobic Nitrate Biogeochemistry

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The onset of nitrate reduction at a groundwater remediation project site in Honolulu, Hawaii differed from the conditions suggested by the scientific literature. Measurements of the groundwater chemistry at the site indicated that inhibition of nitrate reduction in near zero negative oxidation reduction potential (ORP) conditions occurred at approximately 100 times less dissolved oxygen than for wastewater having much higher organic carbon loadings and thus more negative ORP. Inhibition of the nitrate reduction by low concentrations of dissolved oxygen is a concern due to the potential value of nitrate as a terminal electron acceptor in remediation projects, and also as the entry point (termed the “Nitrate Gate” into the facultative anaerobic metabolic regime of using various alternative electron acceptors of decreasing metabolic efficiency. The initial purpose of the mesocosm project is to define the redox conditions where nitrate reduction is initiated with respect to dissolved oxygen and ORP.

The mesocosm used in this study is an enclosed system intended to simulate a transect of groundwater from a defined source and then developing biogeochemical zones as it flows downgradient. The mesocosm is constructed of non-reactive materials, primarily polyvinyl chloride (PVC) piping assembled with epoxy adhesive. The length of the active portion of the system is 20 meters. Sampling ports are installed at one-meter intervals. The interior is filled with a uniform mass of PVC biofilm substrate between each sample port interval. The system was inoculated with a commercially available facultative anaerobic bacterial culture used for petroleum recovery and digestion.

The system allows for controlled management of the synthetic groundwater feedstock composition, flow rate, dissolved oxygen concentration, and dissolved hydrocarbon gas concentration (for Redox/ORP) to establish the groundwater conditions. The addition of nutrient media for the bacterial culture, and nitrate or other compounds of concern is independently managed at inlet ports within the system downgradient of the propane diffuser. The source water from the headworks through the hydrocarbon gas diffuser is mixed using purpose built static mixing plates that also inhibit back diffusion of soluble compounds into the headworks.

The presented paper will include a discussion of the mesocosm development and operating methods. The results of testing conducted to identify the “Nitrate Gate” conditions of dissolved oxygen and dissolved organic carbon (via ORP) concentrations will also be presented.

Keywords: Mesocosm, Nitrate, Facultative Anaerobic, Redox