Managing the Health of an Ex Situ Anoxic Bioreactor

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Background/Objectives. A groundwater extraction and treatment (GWET) system and barrier wall are used to control migration of groundwater impacted with chlorate and perchlorate. Groundwater concentrations of perchlorate have been observed as high as 119 mg/L. These ions are treated by chemical reduction to chloride in an anoxic fluidized bed bioreactor (FBR) to meet the discharge permit limit for perchlorate of 0.015 mg/L. A solids removal process (deep bed sand filter and bag filters) is used to manage biomass sloughed from the FBR. A planned shutdown and intentional starvation of the FBR provides the opportunity to obtain operational insights for trends and markers indicating poor biological health for this system.

Approach/Activities. An anoxic environment is maintained in the FBR to select for facultative anaerobes to carry out the reduction of chlorate and perchlorate to chloride. Bacterial population health is monitored via oxidation-reduction potential (ORP), pH, chemical oxygen demand, free ammonia, free phosphorous, and turbidity. Acetic acid, liquid urea, and phosphoric acid are fed into the reactor as the electron donor, nitrogen source, and phosphorous source, respectively. The pH is adjusted using hydrochloric acid or sodium hydroxide as needed. A blower adds supplemental air to the FBR once a day. During a planned shutdown, all nutrient dosing and influent streams were ceased while solids removal continued.

Results/Lessons Learned. Effective operation of the bioreactor for perchlorate reduction requires careful management of the reactor environment. Management of overall bacterial population growth and selection for facultative anaerobes is achieved through nutrient dosing. Continuous monitoring of the reactor pH and ORP and daily monitoring of residual nutrient levels provides feedback for required dosing adjustments. Target conditions are an ORP of -250 to -350 mV, and a pH of 7.5. The system shutdown period caused starvation of the bacteria and resulted in population die off. During this period, a significant increase in ORP and pH was observed. The drastic reduction in respiration resulted in an increase in available dissolved oxygen, raising ORP to +90 mV. The bacterial population die off allowed the release of bound basic nitrogen compounds, raising the pH to 9.9. The correlation between paired ORP and pH values, and anaerobic bioreactor health, provides useful insights for the management of nutrient dosing to achieve optimal population health in an anoxic bioreactor. Daily readings of residual nutrient levels provide a lagging indicator of population health. Several days are required to establish a trend indicating biological stress. But a concurrent increase in ORP and pH provides a rapid alert of poor bioreactor health for this system.