Sorption and Elution Behavior of Slow Release Electron Donor Used to Support Biodegradation of Chlorate and Perchlorate

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Background/Objectives. In the United States, perchlorate (ClO4-) contamination remediation is highly desirable because it impacts the drinking water of millions of people. Perchlorate health effect relates to its ability to interfere with iodine uptake by the thyroid gland, inhibiting thyroid hormone. In many contaminated areas, chlorate occurs as a co-contaminant together with perchlorate. Although ion-exchange is the technology of choice to treat low level contamination of perchlorate (i.e. parts per billion), biological reduction is preferred when perchlorate concentrations are at the part per million level. Biological reduction requires the addition of a substrate to serve as electron donor. Emulsified vegetable oil has been used previously as a substrate to support in-situ bioremediation. However, its sorption and elution behavior for various sediment types have not been fully investigated. It is important to understand how emulsified oil is eluted out of soils to estimate amounts and frequencies of applications. In this research, the sorption and elution of emulsified soil from actual soils of a site contaminated with chlorate and perchlorate are examined. In addition, batch bioremediation experiments are performed to determine the bioremediation potential of the site using actual soils and groundwater of the area.

Approach/Activities. Drill cuttings were collected from 9 to 52 ft depth boreholes drilled in the site. Soil horizons included sandy and clayey soils. Groundwater was also obtained from wells developed in the site. Batch biodegradation tests were performed using a composite sample of soil from the borehole drill cuttings. Dried soils were packed into clear PVC columns to mimic the groundwater aquifer with flow velocity and permeability. These columns were used for oil sorption and elution tests. Batch biodegradation tests were run in 125 mL bottles that were crimpled closed using an aluminum seal and a butyl rubber septum. In each microcosm, 100 mL of the desired groundwater was added to the wet soil along with desired amount of emulsified oil. The soils and groundwater contained sufficient number of bacteria, therefore bio-augmentation was not needed.

Results/Lessons Learned: In all batch biodegradation tests using both sandy and clayey soils, chlorate and perchlorate degraded completely within twenty days. Isotherm plots showed that the adsorption of oil obeys a Langmuir model. For sandy soils, the adsorption was found to have a coefficient qe-max=0.124 g/g dry soil and 0.1045 g/g wet soil. For clayey soils, the adsorption also fit a Langmuir model with coefficient qe-max=0.239 g/g dry soil and 0.184 g/g wet soil. On a wet soil basis, clayey soils can absorb 1.76 times more oil than sandy ones. Saturating sandy and clayey soils to 13% and 45% of their capacity produces eluates containing 100-200 mg/L of COD (chemical oxygen demand) and 600-1000 mg/L COD, respectively. On a pore volume basis, sandy soils will generate 4-6 mg COD and 20 mg COD, when loaded to 13% and 45% of their absorption capacity, respectively. It was found that, although higher amounts of oil adsorb to the soil when more oil is applied, the concentration of oil eluted is a function not only of the amount of oil applied, but also of the amount of water that is used in the elution.