Bioremediation of Perchlorate and Nitrate Using a Slow Release Electron Donor

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Background/Objectives. In the last two decades perchlorate (ClO4-) has been found in drinking water supplies of millions of people throughout the US and in other countries. Perchlorate health effect relates to its ability to interfere with the natural process of iodine uptake by the thyroid gland, inhibiting thyroid hormone. Perchlorate contamination of drinking water is not yet subjected to federal regulation, but several states have issued health advisory levels varying from 1 to 18 micrograms per liter (µg/L). Perchlorate contamination is associated mainly with the manufacturing and use of ammonium perchlorate for use as ammunitions and rocket fuel. Perchlorate is a highly soluble salt and dissociates into ammonium and perchlorate ions. In the environment, naturally occurring bacteria oxidize ammonium to nitrate and as a consequence most sites contaminated with perchlorate also contain nitrate. Both perchlorate and nitrate can be used as electron acceptors by bacteria and are therefore biodegradable if an electron donor (e.g., organic carbon source or hydrogen) is provided. The research reported in this study focuses on microcosm and column investigations to evaluate biodegradation of nitrate and perchlorate on an actual contaminated groundwater. The site is contaminated with mg/L level perchlorate and nitrate.

Approach/Activities. Both microcosm and column tests were performed using two types of emulsified oil as electron donor. Research approach for microcosms addressed acclimation times, biodegradation kinetics, optimal electron donor dosages, impacts of varying nitrate/perchlorate ratios, and the need for supplemental nutrients. Column testing used both actual sediments from the site and plastic media to simulate different groundwater velocities. Sediments and groundwater used were fully characterized. For fine sediments the columns were pressurized at 5-10 psi, using an in-house built pressure valve. The number and diversity of the bacteria present were also evaluated 16 S-rRNA analyses.

Results/Lessons Learned. Microcosm testing revealed that emulsified oil is an effective electron donor for both nitrate and perchlorate reduction; It also showed that there sufficient naturally occurring bacteria at the site and that no bioaugmentation is needed. Phosphate addition was necessary to supplement biodegradation. For low nitrate concentrations (< 5 mg N/L), degradation occurred within days while complete perchlorate degradation took weeks. In groundwater where nitrate concentrations is > 20 mg N/L it took four weeks before perchlorate degradation started. The impact of nitrate reduction competing with perchlorate degradation was clearly observed, Perchlorate reduction did not commence until nitrate concentrations were below 1 mg N/L. Perchlorate reduction was very fast, after nitrate was degraded; About 98% of perchlorate was degraded within 5 day. In column studies, the slow desorption of emulsified oil was documented showing its usefulness for remediation of fast moving groundwater. Bacteria detected in columns studies included 30-65% pseudomonas in soil columns and over 65% in plastic media columns. Soil columns contained 12-24% Beta-proteobacteria as compared to < 2% in plastic columns.