Enhanced Denitrification for Treatment of Nitrate Plumes Associated with Fertilizers: Laboratory and Pilot Studies

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Background/Objectives. Nitrates are produced for use as fertilizers in agriculture. Nitrate can be toxic and causes methemoglobinemia in infants. Nitrate when ingested is converted in the stomach to form N-Nitroso compounds that can be carcinogenic in humans. Nitrates can also disrupt thyroid function and cause birth defects. Nitrate can be converted to nitrogen gas by denitrifying bacteria. Anaerobic conditions are required for denitrification to occur therefore removal of nitrate can be achieved by enhancing anaerobic conditions. Three separate sites contained nitrate at elevated levels. Two of the sites also contained elevated levels of ammonia-nitrogen.

Denitrification occurs under anaerobic conditions. A carbon source such as emulsified vegetable oil (EVO) can be used to enhance anaerobic conditions. Degradation of ammonia-nitrogen occurs under aerobic conditions. Sodium phosphate and oxygen can be used to enhance aerobic conditions.

Approach/Activities. A treatability study was performed for each site to assess the potential for in situ enhanced biodegradation (ISEB) to treat the nitrate and ammonia-nitrogen in the groundwater at the sites. For each site, aerobic microcosm tests were used to assess the biodegradation or ammonia and anaerobic microcosm tests were used to assess the biodegradation of nitrate. For one of the sites which contained a nitrate plume, a field pilot study was performed after the laboratory study. EVO was injected at one location and nitrate concentrations were monitored in the surrounding wells.

Results/Lessons Learned. The assessment of the three sites showed that the addition of a carbon substrate can stimulate denitrification. The sites with ammonia-nitrogen required a two-step approach. First, an initial aerobic treatment with the addition of sodium phosphate and oxygen to treat the ammonia-nitrogen and then a second anaerobic treatment to treat the nitrate by denitrification with the use of EVO. The field pilot study showed that greater than 99 percent removal of nitrate was observed in the immediate area of the injection well, however reduction of nitrate diminished at wells further away from the injection wells.