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Natural Attenuation of Organic Pollutants in Groundwater: Anaerobic Biodegradation of Phenol Under Sulphate-Reducing Conditions

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Monitored Intrinsic Bio-remediation or "Natural Attenuation" is a low-intensity technology for groundwater cleanup that relies on natural degradation processes to remove contaminant mass and thus reduce environmental risk. Although costly pumping and ex situ treatment is avoided, reliable prediction of remediation performance demands a much higher scientific base for understanding and quantifying the in situ natural degradation processes.

The potential for natural attenuation of phenolic contaminants in a sandstone aquifer was assessed using laboratory microcosms with background groundwater composition, spiked with organic compounds of interest and inoculated with aquifer sediments. Results were compared with those obtained using an innoculum of anaerobic sludge from a wastwater treatment plant.

Anaerobic biodegradation of a simple organic substrate, acetate, occurred in the microcosms with sulphate as the dominant electron acceptor for microbial respiration. Iron reduction was also observed to occur, and contributed to the microbially-mediated oxidation of acetate. In comparison, results from microcosm studies of phenol (hydroxy-benzene) degradation indicated that in this case, iron reduction was more dominant than sulphate reduction. The presence of 2,3 di-methyl phenol (2,3 xylenol) inhibited, but did not prevent phenol biodegradation. Microcosms inoculated with anaerobic sludge showed an increased rate of biodegradation at 20ºC, compared with results obtained at 10ºC. However, microcosms inoculated with aquifer sediments showed an opposite trend with temperature, exhibiting more rapid biodegradation at the lower temperature. This result suggested that indigenous populations of phenol degraders were more effective at temperatures that are representative of groundwater.

These results suggest that phenol concentrations on the order of 100 mg/L are degradable within a period of a few weeks, indicating that a significant potential for natural attenuation exists for the pollutant concentrations, groundwater composition and indigenous microbial populations represented.