NATURAL REMEDIATION OF ARSENIC-CONTAMINATED GROUND WATER: SOLUTE- TRANSPORT MODEL PREDICTIONS

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Infiltration of leachate from a municipal landfill in Saco, Maine has resulted in a plume of anoxic groundwater containing high concentrations of arsenic(III), ferrous iron, manganese, and dissolved organic carbon. The source of arsenic appears to be reductive dissolution by organic carbon of arsenic-containing iron oxides in the bedrock and alluvium. The landfill was covered with an impermeable membrane in 1997 to eliminate the source of anoxic groundwater and allow natural flushing of the aquifer to decrease arsenic concentrations to acceptable levels.

Cores from the contaminated portion of the aquifer were collected and leached with uncontaminated groundwater in the laboratory to evaluate natural remediation of the contaminated aquifer. Results show that long-term leachate migration from the landfill has resulted in a large reservoir of organic carbon sorbed on the aquifer sediment, resulting in significant biological oxygen demand. In the laboratory experiments, this reservoir of organic carbon caused complete consumption of the influent oxygen (6 mg/L) for more than 200 pore volumes. Reductive dissolution of iron and manganese oxides was also observed. Leaching of arsenic from the cores was characterized by an initial rapid decrease in concentration in response to flushing with uncontaminated groundwater, followed by a more gradual decrease in concentration.

A one-dimensional reaction-transport model was used to simulate breakthrough curves from the laboratory cores. The dominant biogeochemical reactions used in the model were oxidation of organic carbon by dissolved oxygen, manganese oxides, and iron oxyhydroxides. These reactions were simulated using a modified form of Monod kinetics. Transport of arsenic was controlled by equilibrium sorption. Model parameters for Monod kinetics and arsenic sorption were adjusted to obtain the best fit to the observed breakthrough curves of constituents in the laboratory experiments.

The reaction-transport model was then used to predict the evolution of the contaminated groundwater plume for the first 60 years after the landfill was covered. The modeled flow path extends from the landfill to a stream where the plume discharges. Groundwater and sediment analyses from wells along the 112 meter flow path were used as initial conditions for the model.

Simulation results for the plume indicated that concentrations of major cations and anions in the landfill plume should rapidy decrease to near background levels within the next few years; however, the sorbed organic carbon in the aquifer was predicted to consume oxygen and maintain anoxic conditions for decades. Reductive dissolution of iron and manganese oxides was predicted to continue, maintaining concentrations of Fe(II) and Mn(II) above background. Arsenic concentrations were predicted to slowly decrease from a high of 650 micrograms per liter to the former drinking water standard of 50 micrograms per liter in about 30 years. After 60 years, arsenic concentrations were predicted to be greater than 10 micrograms per liter, the new drinking water standard set by the Environmental Protection Agency.