Remediation of arsenic-contaminated groundwater by oxidized sediments in Bangladesh

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High concentrations of arsenic (As) in shallow, geochemically reducing aquifers of Bangladesh and the neighboring state of West Bengal, India have resulted in increasing exploitation of groundwater from deeper aquifers having more oxic sediments that generally contain low concentrations of dissolved As. Pumping-induced infiltration of high-As groundwater could eventually cause an increase in As concentrations in these aquifers. Reactive solute-transport models can be used to estimate sustainable rates of groundwater withdrawal, provided the hydrology and geochemistry of the aquifer systems are known.

Laboratory column experiments were used to identify and quantify processes that control transport of As through deeper aquifer sediments at a site near Dhaka, Bangladesh. Constituents of primary concern in eluent groundwater were 650 μg/L arsenite As(III), 250 μg/L arsenate [As(V)], 6 mg/L Fe(II), 1.5 mg/L Mn(II), 49 mg/L SiO_2, 408 mg/L HCO_3, 3 mg/L PO_4, <0.005 mg/L O_2, and pH 6.84.

All As in the first 50 pore volumes of eluent was removed from solution. Arsenite was oxidized to As(V) by manganese oxide minerals in the sediment. Arsenate was extensively adsorbed by the sediment; however, there was competition for adsorption sites from PO_4 and to a lesser extent SiO_2 and HCO_3. Eluent Fe(II) was oxidized by MnO_2 to Fe(III), which subsequently precipitated as hydrous ferric oxide and a mixed Fe(II)/Fe(III) hydroxide (green rust). There was a net release of Mn to solution with concentrations in leachate as great as 5 mg/L. After 250 pore volumes, the influent half of sediment in the column had changed in color from yellow-brown to gray-greenish brown, indicative of green rust precipitation.

A one-dimensional solute transport model (PHREEQC) that incorporated adsorption, oxidation/reduction kinetics, and mineral precipitation/dissolution successfully simulated breakthrough curves for selected constituents from the column. Results from the laboratory experiments show that oxidized sediment has a significant but limited capacity for removal of As from groundwater. This indicates that placement of well screens in the low-As aquifers will need to be sufficiently deep to account for gradual contamination from above.