

Hydrogeochemical Study of Arsenic Contamination in Bangladesh Groundwater - the Role of Redox Condition

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Groundwater is the main drinking water source for the people of Bangladesh. In the past 30 years, millions of tubewells have been drilled in the Ganges-Brahmaputra Delta (GBD) to provide reliable, pathogen-free drinking water to villagers. However, since the early 90's it was discovered that the groundwater are contaminated with arsenic and over 30% of the wells probably exceed the Bangladeshi maximum contamination level (MCL) of 0.05 mg/L. It is estimated that at least 25 million people in Bangladesh have been exposed to toxic levels of arsenic and chronic arsenic poisoning is now widespread in the local population.

It is generally agreed that the arsenic in the GBD groundwater is naturally-occurring. Of several proximate sources proposed for the arsenic, the two that appear most plausible are arsenic-rich materials that occur in discrete layers, and/or dispersed arsenic associated primarily with iron oxyhydroxides (Nickson et al., 2000). Because organic carbon is abundant, reduction of iron oxyhydroxides and release of arsenic may be coupled with organic carbon oxidation. We hypothesize that redox reactions involving As, Fe, and S and mediated by microbial activity are the key factors controlling the fate and transport of As in the GBD region.

A detailed hydrochemical study is currently under way to characterize the occurrence of the As in the groundwater. High As concentrations are always accompanied by reducing conditions. Most of the As is present in the water in the form of the reduced species (As³⁺) and the As-rich water are generally characterized by absence or low levels of dissolved O₂, NO₃⁻ and high levels of PO₄³⁻, Fe²⁺ and Mn²⁺. The SO₄/Cl ratio in the

reducing water are lower than those in the oxic, As-free water and the sulfate concentration in many is <0.5 mg/L. Few representative analyses indicate that the reduced water contain few μM/L of sulfide, though H₂S cannot be identified by its odor.

We propose that the PO₄ is adsorbed on iron oxyhydroxides along with As and that it is released together with the arsenic during the reduction of the oxyhydroxides. Few sulfur isotopic analyses of oxic samples showed values (δ³⁴S=5.0-7.2‰) similar to those expected from surface water that have not dissolved sulfides. Because of the low sulfate concentration and low SO₄/Cl ratio, conventional isotopic analyses of sulfate is difficult. However, preliminary ³⁴S analyses of anoxic samples, carried out with a thermal ionization mass spectrometer following and modifying the method described by Paulsen and Kelly (1984), showed enriched isotopic value (δ³⁴S =40‰). Such values are explained as due to bacterial sulfate reduction and demonstrate the role of microbial activity in the determining the redox state and composition of the groundwater. Because of the high levels of dissolved Fe²⁺ in the water, the sulfide product from the sulfate reduction precipitates from the water as iron sulfides. It is still to be determined how much As precipitates with the iron sulfide and to what extent this precipitation controls and prevents even higher As concentrations in the groundwater.

Kelly (1984).

Nickson RT, McArthur JM, Ravenscroft P, Burgess WG & Ahmed KM, *App. Geochem.*, **15**, 403-413, (2000).

Paulsen PJ & Kelly WR, *Anal.Chem.*, **56**, 708-712, (1984).