

## Chemical forms of arsenic in the arsenic polluted groundwater aquifer sediment in Sonargaon, Bangladesh

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Health disease caused by the arsenic contaminated groundwater reported in the 1990s, is still serious all over the world, mainly in Asian countries. It is important to reveal the formation mechanism of the arsenic contaminated groundwater to establish the mitigation plan. Chemical weathering of detrital minerals such as pyrite, biotite and chlorite are also suggested as the arsenic host materials in the aquifers.

The study area, Sonargaon, Bangladesh is located in the Ganges delta, which is known to the largest affected area in the world. The study area including in the old Brahmaputra basin is located at the boundary between the Pleistocene terrace and the Holocene flood plain. Arsenic contaminated groundwater occurs in the Holocene sandy aquifer. The underlying Pleistocene sandy aquifer, separated by the Pleistocene impermeable clay layer, is free from the arsenic. The studied samples are the 38m long drilled core sediments taken from the highest arsenic contaminated groundwater appearing area, where active recharge of ground water occurs.

The major mineralogy and the major and the trace elements were analyzed using powder X-ray diffractometry (XRD) and X-ray fluorescence photometry (XRF).

After the sediments were decomposed by alkali fusion and dissolved into HCl solution, total arsenic concentration was determined using hydride generation atomic absorption spectrophotometry (HG-AAS). According to the BCR method, four different chemical forms of the arsenic was extracted; acid soluble form comprising carbonate mineral impurity and weakly adsorbed on the mineral surface, reducible form fixed in and strongly adsorbed on iron oxides/oxyhydroxides, oxydisable form mainly comprising organic matter and insoluble form comprising silicate and sulfide minerals. The extracted arsenic was determined with arsenic related metal ions using inductively coupled plasma mass spectrometer (ICP-MS).

The cored sediments consisted with medium to fine sand except uppermost 4m, which was land-fill. Major mineralogy was quartz and feldspar, and biotite, amphibole, chlorite, goethite and calcite were included as minor or trace minerals. Major chemistry, SiO<sub>2</sub>, Al<sub>2</sub>O<sub>3</sub>, Fe<sub>2</sub>O<sub>3</sub>, Na<sub>2</sub>O, K<sub>2</sub>O and CaO were 60-80wt%, 10wt%, 2-5wt%, 2-5wt%, 2-4wt% and 1-3wt% respectively. The mineralogy and chemistry are homogeneous throughout the sediment column, except the sediments from 10-15m depths, in which Fe<sub>2</sub>O<sub>3</sub>, MgO, Co and Ni were higher. Although the arsenic concentration was about 10mg/kg throughout the column, the slightly higher concentration was observed in the sediments at 6m, 14m, 24m and 35m depths.

Arsenic concentration of sequentially extracted solutions was 0.1-1.0mg/kg, 0.2-1.1mg/kg, 0.5-0.9mg/kg, a few-20mg/kg for each steps respectively. The chemical extraction analysis documented that the most of arsenic is fixed in the insoluble phases such as silicate and sulfide minerals. The arsenic concentration of reducible phases of the sediments at 3.8m and 35m depths are slightly higher, i.e., 4.3mg/kg and 6.9mg/kg respectively. The former is at the depth where groundwater level changes seasonally, and the latter is at where the underlying oxic Pleistocene sediment directly contacts to the Holocene contaminated aquifer sediment. The oxidisable phases are categorized as organic compounds, however, small amount of chlorite contribute to the extracted elements of this study.

u-XRF and XAFS analyses performed at Spring-8 in 2010 from the other sediment column in the studied area revealed that the chlorite was a source mineral of arsenic. Biotite was not the source mineral of arsenic.

As a conclusion, Fe-oxyhydroxides/oxides are not the host of As. Thus, the chemical weathering of chlorite occurring at around the groundwater level would be the mechanism to release As into the Holocene groundwater aquifer of this area.

Keywords: arsenic, chlorite, speciation