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Aquifer structure and groundwater flow related to arsenic contaminated groundwater in Sonargaon, Bangladesh

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Ganges delta plain has been known as the largest arsenic contaminated groundwater affected area in the world. Mechanism of the arsenic contaminated groundwater formation is explained by microbial reduction-dissolution of Fe-oxyhydroxides, which adsorb As. However, we proposed chemical weathering of As-bearing detrital biotite or chlorite was the mechanism to release As into the groundwater. Also, anthropogenic activity such as excess use of groundwater would promote the As release into the groundwater, although the relationship has not been revealed until present. In this study, actively recharging area in Sonargaon, Bangladesh was targeted to document groundwater aquifer structure, primary host mineral of arsenic, change of the As host in the aquifer sediments, recharging age of the contaminated groundwater, and the relation to anthropogenic activity.

Core drilling and test tube well drilling were performed at the area close to the highest arsenic polluted well (1.2mg/L As). In this area, the arsenic contaminated groundwater occurs in the Holocene aquifer divided by the underlying impermeable clay layer at -30 to -40 m depth from the uncontaminated Pleistocene aquifer. While, the impermeable clay layer lacks and the two aquifers directly contacts beneath this site. Recharging age of $>$800 mg As contaminated groundwater is after 1990, implying that the lowering hydropressure due to excess use of groundwater of the Pleistocene aquifer promotes vertical infiltration of surface water to release arsenic into the Holocene aquifer.

Arsenic in the contaminated aquifer is mostly fixed in insoluble phases including silicate and sulfide minerals, and the primary host phase is chlorite. While, the arsenic in and adsorbed onto the Fe-oxyhydroxides increases at the depth where the groundwater level changes. The As(III)/As(V) (0.4:0.6) of groundwater at -5m depth is the same as those of the chlorite, indicating that the arsenic is released via concordant dissolution of this mineral. The As(III) ratio becomes 0.95 below -10 m depth, and the reduction of groundwater promotes the reduction of arsenic. The release of arsenic is most active between -5 and -10 m depth, where the oxygen penetrates into the uppermost part of the groundwater.

Thus, the arsenic contaminated groundwater of the study area was formed via chemical weathering of detrital Fe(II) enriched and As-bearing chlorite promoted by the recently activated infiltration of aerobic groundwater. Reductive condition of the groundwater prompts the reduction of arsenic, however, is not essential as a release of arsenic. Since the chlorite is known as a major mineral in the arsenic contaminated groundwater aquifer sediments, this mechanism can be the generally earliest stage of arsenic contaminated groundwater in the Ganges delta plain.

Keywords: Ganges delta, arsenic contaminated groundwater, chlorite, chemical weathering, sequentially extracted chemical analysis