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Chemical forms of arsenic in the arsenic polluted groundwater aquifer

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To identify the host phase(s) of arsenic in eolian sediment taken from the Punjab, Pakistan, where arsenic polluted groundwater is found in an aerobic environment, concentration of arsenic and the related elements and chemical forms of the arsenic were analyzed.

To analyze the chemical forms of adsorbed arsenic onto the sediment particles, the sediment samples were shaken in a centrifugation tube with the solution, of which pH was adjusted using hydrochloric acid or nitric acid and sodium hydroxide. Filtrated supernatant was used to quantify total arsenic concentration using ICP-MS and different chemical forms of the arsenic using HPLC/ICP-MS, and the related elements (Fe, Si, and Al) were analyzed by ICP-AES. Sequential extraction of arsenic was also tried; the sediments were shaken with 6M hydrochloric acid and the residual sediments were shaken with the mixture of 1M sodium hydroxide and 0.1 M sodium chloride at room temperature. The extracted arsenic in hydrochloric acid and sodium hydroxide solutions were analyzed using HPLC/ICP-MS. Mineral composition of the residual sediments was analyzed by XRD. Ionic valency of arsenic of the bulk sediment and separated chlorite were determined using XAFS at SPring-8.

Total arsenic concentration of bulk sediment was 35.4 mg/kg. As(III):As(V) ratio of the bulk sediment was 0.14:0.86, and that of goethite bearing chlorite was 0.31:0.69. Extracted arsenic in the solution of pH 1 to 14 was only arsenate. Although the arsenic concentration extracted in the solution pH ranging 4 to 8 is less than 1 mg/kg, it increases in the solutions pH <3 and >9, in which the arsenic concentration is >8 mg/kg, and 31 mg/kg at the maximum when the pH was 14. Only arsenate was extracted in the 6M hydrochloric acid solution, however, arsenite was also extracted in the sodium hydroxide and sodium chloride mixing solution. The concentrations of As(III) and As(V) were 2.6 and 4.0 mg/kg. Most of arsenate is not adsorbed onto Fe-oxyhydroxides and/or the other particles, since it is not extracted in the solution ranging pH 2 and 8, where the arsenate is most preferable to be adsorbed.

Goethite can be dissolved in hydrochloric acid solution, as noted by the previous researchers, while it cannot be decomposed in neutral and alkaline solution. Chlorite was decomposed in alkaline solution, assured by XRD. Iron (0.3% as Fe₂O₃) was dissolved in the solution pH <2, while it does not considerably dissolved in the solution pH >3. Silicon (1% as SiO₂) was dissolved in the solution pH <2 and >11. Aluminum gave the similar trend of dissolution; 0.4 % of Al₂O₃ was dissolved in the solution pH <2 and >11. Thus, the goethite was decomposed in the solution pH <2, and chlorite was pH >11. Arsenic concentration is higher in the solution pH >11 than in that <2, indicating that a part of arsenic is fixed in the chlorite.

Based on the above results, the As(V) is fixed in both Fe-oxyhydroxides and chlorite, while the As(III) is fixed only in the chlorite.

Keywords: arsenic, pH