Hydrogeochemistry and health risk of arsenic in groundwater wells of rural Punjab, Pakistan

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Globally, arsenic (As) contamination of groundwater presents a severe threat for human and environmental health due to its toxic and carcinogenic nature. While partially understood, in this study we examined possible factors controlling As release/sequestration by characterising geochemical data of groundwater, total and speciated As concentrations and other health related water quality parameters for assessing health risk of As from groundwater. Totally, 123 groundwater samples were collected from five previously unexplored villages of Punjab, Pakistan. Total As concentration spanned between BDL and 200 μg L^{-1}, which was significantly greater than the WHO safe limit of As (10 μg L^{-1}) in drinking water for 65% of groundwater wells. Speciation of As (n = 29) was achieved using an IC-ICP-MS, which indicated that arsenite (As(III)) and arsenate (As(V)) constituted 13 to 80 % and 20 to 100 % of total As, respectively. Geochemical modeling revealed that the presence of iron-bearing mineral phases such as goethite, hematite and magnetite may be carriers of As and control As mobilization/immobilization in aquifers of study area. Piper-plot indicated that hydrogeochemistry of groundwater was Na-Ca-SO_4 > Na-Mg-SO_4 type; correlation analysis demonstrated a possible role of salinity and alkaline pH in desorbing adsorbed As from mineral surface to aquifers. For As health risk assessment, hazard quotient and cancer risk values were higher than the US-EPA limit (1.00 and 10^{-6}, respectively). This study highlights that high salinity and alkaline pH of groundwater controls release/sequestration of As, and elevated As concentration is an emerging health threat to the communities in rural Punjab, Pakistan.