

Arsenic and Fluoride Contamination in Lahore, Pakistan: Spatial Distribution, Mineralization Control and Sources

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Abstract : This study investigated the spatial variations of groundwater chemistry used by communities in Lahore city with emphasis on arsenic (As) and fluoride (F) levels. A total of 472 tubewell samples were collected from 7 towns and analyzed for physical and chemical parameters, including pH, turbidity, electrical conductivity (EC), total dissolved solids (TDS), total hardness, HCO₃, Ca²⁺, Mg²⁺, Na⁺, K⁺, SO₄²⁻, Cl⁻, NO₃⁻, NO₂⁻, F⁻ and As. There were significant spatial variations observed for total hardness, TDS, HCO₃, NO₃ and As. In general, the south-east of the city displayed higher TH and HCO₃ while the north-east showed significantly higher As concentrations attributed to the heterogeneity of the aquifer and industrial activities. In most cases, As was higher than WHO limit value. Indiscriminate disposal of domestic and commercial wastewater into River Ravi is the cause of elevated NO₃ observed in the north-west compared to other places in the area. Investigation of the groundwater type revealed facies in the order: Ca-Mg-HCO₃-SO₄ > Mg-Ca-HCO₃-SO₄ > Ca-Mg-HCO₃-SO₄-Cl > Mg-Ca-HCO₃-SO₄ > Ca-HCO₃-SO₄ > Ca-Mg-SO₄-HCO₃. The plausible mineralization control mechanism seems to be that of carbonate weathering, although silicate weathering is probable. Moreover, PHREEQC model results showed that the groundwater was under saturated with respect to evaporites (anhydrite, fluorite, gypsum and halite) while generally equilibrium to saturated with respect to aragonite, calcite and dolomite. The Hierarchical Cluster Analysis (HCA) showed that pH significantly affected As, F, NO₃ and NO₂ while HCO₃ contributing most to the observed TDS values in Lahore. It is concluded that inherent mineral dissolution/ precipitation, pH, oxic conditions, anthropogenic activities, atmospheric transport/ wet deposition, microbial activities and surface soil characteristics play their significant roles in elevating both As and F in the city's groundwater.

Keywords : Lahore, arsenic, fluoride, groundwater

Conference Title : ICGES 2016 : International Conference on Geology and Earth Systems

Conference Location : Miami, United States

Conference Dates : March 24-25, 2016