Abnormal fluoride concentration in groundwater causing dental and skeletal Fluorosis in South of Lahore, Punjab, Pakistan.

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Fluoride disaster of groundwater was reported first in 2000 at a small village Kalalanwala, where 72 under 15 years old children had contracted bone deformity disease. The village is located in Punjab, southeastern part of Pakistan, where is a flat alluvial plain formed along the Ravi, one of the tributaries of Indus River. In order to characterize the distribution of fluoride-contaminated groundwater, 150 groundwaters in the Kalalanwala and its surroundings were analyzed for the major chemistry and stable isotopes of oxygen and hydrogen.

Judged from the well depths, there are at least three aquifers in the studied area; shallow (20-27m), middle (40-150m) and deep (60-200m). High fluoride concentrations over 1.5 mg/L, which was the maximum limit of permitted fluoride concentration in Pakistan (MCL), were found in the fourteen investigated villages among the fifteen distributed in approximately 23-24 square km area. The Ravi River is flowing in the western edge of the investigated area from the northeast to south. Highly fluoride contaminated area was found in the east from the Ravi river (2.2-24 mgF/L). The most fluoride concentrated groundwaters were found in Kalalanwala in this area. Towards the east from this area, fluoride concentration becomes low (up to 9.5 mg/L). Southeastern industrial area was topographically higher than the highly contaminated area and the fluoride concentration ranges within 2.7-14 mg/L. Towards the south from the Kalalanwala, the fluoride gradually decreases to the range within 3.5-6.2 mg/L. The only village where very low fluoride (0.32-0.6) was found , is located near the low active flooded plain of Ravi River, at the northwest from the Kalalanwala. Distribution of the high fluoride concentration area suggests that the topography would not be a major controlling factor on the fluoride concentration.

The groundwaters from middle and deep aquifers have F contents of 0.57-3.0 and 0.3-1.5 mg/L with high Ca up to 70 and 40-90 mg/L, respectively. These waters give the electric conductivity 0.88-1.98 mS/cm with pH 7.6-7.8 and 0.2-1.01 mS/cm with pH 7.3-7.8, respectively. On the contrast, the shallow groundwaters contain higher F- (2-21.1mg/L), accompanying with lower Ca (less than 50mg/L), higher SO4 (250- 960mg/L), chloride (80-409mg/L), HCO3 (up to 1281mg/L), and Na (up to 2806mg/L) than those of middle and deep aquifers. The electric conductivity of the shallow groundwaters was high up to 4.38mS/cm.

56% of the fluoride contaminated waters of this study gives the alkaline pH above 8 and 97% above 7.5. Negative correlation was found between F and Ca and positive correlations were found between F vs. HCO3 and Na. In acidic solutions, F is absorbed on clays; however, it is desorbed in alkaline solution. Thus, the alkaline pH is more favorable for F dissolution. Although the F dissolution process is unknown at present, such an alkaline condition with lack of Ca permit the high concentration of fluoride in the studied groundwaters and the fluoride concentration would be controlled by fluorite solubility.

Oxygen and hydrogen isotope ratios of shallow ground waters (20-27m) give slightly wider ranges of oxygen isotopes (-9.6 to –7.1) and hydrogen (-61 to -41) than those of middle (40-150m) and deep wells (60-200m), which are in the similar ranges within oxygen isotopes (-8.9 to –7.5) and hydrogen (-59 to -46). Comparison of Oxygen and Hydrogen isotopes with global meteoric water line shows that the studied water is recharged mostly by the local precipitation. A slight positive correlation was found between chlorides and oxygen isotopes in shallow ground waters, while negative ones in the middle and deep waters. Evaporation and condensation would cause the high concentrations of soluble components such as Cl and F in shallow ground waters, although the change of major chemical compositions seems to show seasonal variations.