Aquifer structure of fluoride and arsenic contaminated groundwater in Punjab, Pakistan

Harue Masuda[1]; Muneki Mitamura[2]; Masafumi OWA[3]

[1] Dept. Geosci., Osaka City Univ.; [2] Geosci., Osaka City Univ.; [3] Earth science, Osaka city Univ.

Punjab province, located on a plain developed along the Indus River system in Pakistan, is one of the largest cultivated areas in the world. In a rural area located at the suburb of Lahore, second largest city in Pakistan, serious fluoride and arsenic contaminated groundwater appears via air and soils in association with industrial waste waters, combusted coal at kilns and fertilizers distributed on the cultivated field (Farooqi et al., 2006). Since the occurrence of contaminated groundwater appears in different areas from the pollutant source areas, we presumed that the aquifer structure was deeply concerned with the extent of the contaminated groundwater. Thus, we investigated the underground geological profiles and structure of the groundwater aquifers in the most contaminated area, Kalalanwara and its surroundings by observing recovered sediments from six drilling wells and analyses of undisturbed sediment cores taken from one of the drilled wells.

The studied area is located at boundary between Holocene flood plain of Ravi River and Pleistocene terrace deposits. Most of the residential area are located on the terrace deposits and the local people depend on the groundwater for daily purpose water. The uppermost sediments on the terrace about up to 15 m depth are Aeolian deposits. Impermeable layer is intercalated at about 8-10 m depth, and the layer above this depth corresponds to the unconfined aquifer. The unconfined groundwater flows out along the upper boundary of the impermeable layer into the flood plain in the dry season, and the unconfined aquifer is dried up at the end of dry season. There are at least two confined aquifers divided by 3 m thick impermeable layer at about 30 m depth in this area. The upper confined aquifer comprises the Aeolian deposits and underlying freshwater sediment composed of quartz dominant fine sand. Both of the two impermeable layers are not well developed and the groundwater can flow into the lower aquifers. Most of the wells used for the local people are installed into 24-27m depth at the lowermost part of the upper confined aquifer, and the groundwater taken from these depth is most contaminated by fluoride and arsenic. However, the lower aquifer is also contaminated, especially all of the wells installed into the lower aquifer are contaminated by arsenic.

The lowermost part of upper confined aquifer is depressed at Kalalanwara about 5 m compared with east and west villages. Since the aquifer from Walanpirawara, located 500 m west from Kalalanwara, is also highly contaminated, and trifluoroaceticacid is detected in the studied sediments, industrial wastewater recharged at Walanpilawara must migrates and is stagnant in the aquifer at Kalalanwara.

Arsenic contents in the sediments shallower than 15 m depth range within 9-40 mg/kg, which is comparably higher than those usually known in freshwater sediments. Clay rich sediments contains high arsenic, however, clay fractions and arsenic contents do not give good correlation. Arsenic contents are rather homogeneous in the unconfined aquifer, probably because the groundwater flushes out the arsenic to leave 9-11 mg/kg. While, arsenic contents are high in the upper confined aquifer.

The contaminant sources are widely distributed in the studied area, although the contaminated groundwater appears in the limited areas, suggesting that the location of recharging area and aquifer structure are important to form highly contaminated groundwater. Also, the change of groundwater flow caused by excess use of groundwater would accelerate the extent of contaminated groundwater.