Japan Geoscience Union Meeting 2010
(May 23-28 2010 at Makuhari, Chiba, Japan)

AHW018-02 会場:展示ホール7別室2 時間: 5月28日09:15-09:30

バングラデッシュ、ソナルガオのヒ素汚染地下水の形成についての地下水流動の影響

Effect of Groundwater Flow on Forming Arsenic Contaminated Groundwater in Sonargaon, Narayanganj, Bangladesh

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Large-scale natural arsenic contamination of groundwater has been a serious problem in a number of areas around the world, especially in Asian countries, in many cases having a major impact on potable water.
Throughout a series of our studies in Sonargaon, Nayakaganj, Bangladesh (Mitamura et al., 2008; Itai et al., 2008; Seddique et al., 2008), vertical infiltration of surface water into the shallow aquifer would promote the As contaminated groundwater. In those studies, Mitamura et al. (2008) reported that the highly As contaminated wells are occasionally installed into the finer and micaceous sediment, and that the geological structure of the aquifers is an important control on the formation of As-contaminated groundwater in Bangladesh. Seddique et al. (2008) pointed out that the detrital biotite is a primary source of As, and chemical weathering of this mineral is an essential mechanism forming chemical composition of groundwater including As concentration. Heterogeneous distribution of major chemical component and oxygen and hydorogen isotopic ratios of the groundwaters indicated vertical infiltration of surface groundwater into the shallow sediments (Itai et al., 2008).
In the present study, changes of groundwater flow for thirty years in the same area is modeled, focusing on the relationship between the spatial distributions of high-As areas and the groundwater flow paths in the shallow groundwater system. The three-dimensional and unsteady-state groundwater flow is simulated numerically under more realistic assumptions of hydraulic constants and the boundary condition in the three-dimensional hydrogeological structure, which aquifers shallower than 90 m depth in the study area consist of Holocene upper sand formation (shallow aquifer) and Plio-Pleistocene lower sand formation (deep aquifer) separated by a Upper Pleistocene mud formation (aquitard). To evaluate where the water pumped up at each tube well has derived from, the groundwater flow paths toward the each screen of 126 tube wells surveyed in the shallow aquifer (above about -20m A.S.L.) are estimated by particle tracking of only water migration using spatiotemporal distribution of velocities calculated by 3D groundwater flow analysis.
The present model predicts that vertical infiltration of surface groundwater into the shallow sediments often occurs, water recharged from ground surface (about 4-10 m A.S.L.) in flood plain moves approximately 10m to 20m downward vertically and the groundwater flow gradually changes toward horizontal direction with approaching the middle mud layer (aquitard), the

drinking water pumped up at tube wells is derived from the groundwater that has downward flow path from ground surface toward tube well, and the several recharging zones of surface groundwater appear in the shallow aquifer. Recharge appears in and around levees and terrace except the stagnant zone in rainy season, while, in dry season, recharge due to irrigation occurs in the stagnant zone of rainy season. The highest As concentrated hotspot and moderately As concentrated spots are located in the recharging area in rainy season. Such a relationship between local groundwater flow and As concentration must be important to explain the formation mechanism of As contaminated groundwater. The model also predicts that the higher As concentrated spots (> 700 ?g/L) have shorter flow path length than 200 m and shorter travel time than 10 years. Therefore, the present model supports the view that chemical weathering of detrital minerals in Holocene sediment (shallow aquifer) is an essential mechanism forming chemical composition of groundwater including As concentration. The simulated flow characteristics are consistent with the observed chemical data, confirming that the hydrological cycle, hydrogeological structure and spatial distribution of As bearing sediments are essential governing the spatial variability in groundwater As concentration in the studied area.

キーワード:ヒ素,汚染,地下水,バングラデシュ

Keywords: Arsenic, Contamination, Groundwater, Bangladesh