Biogeochemical cycling of arsenic in sedimentary basin of southwestern Taiwan

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Abstract

High arsenic (As) contents in groundwater were found in two neighboring catchments of southwestern Taiwan- the southern Choushui river alluvial fan and the Chianan plain. To investigate the sources of As in groundwater, a total of 655 geological core samples from 13 drilling wells situated at the southern Choushui river alluvial fan of Taiwan were collected and analyzed. High As contents were found primarily in aquitards, to a maximum of 590 mg/kg. The contents were correlated with the locations of the marine sequences. Additionally, strong correlations among the As concentrations of core samples, the clay, and the geological age of the Holocene transgression were identified. Most of the As in groundwater originated from the aquitard of the marine sequence. The high As content in marine formations with high clay contents may be attributable to the bioaccumulation of As in the sea organisms, which accrued and were deposited in the formations. A preliminary geogenic model of the origin of the high As concentration in the shallow sedimentary basin of the Choushui river alluvial fan of Taiwan is proposed. Furthermore, the groundwater quality, the redox potential and the As distribution of the Chianan plain were characterized using factor analysis, redox zoning and a geochemical program, PHREEQC. The results were compared with those of the southern Choushui river alluvial fan to allude the possible release mechanisms of As in groundwater of the southwestern Taiwan. Factors 1 and 2 determined by the factor analysis of the

groundwater in the Chianan plain - the salinization factor and the As pollutant factor - are similar to those in the southern Choushui river alluvial fan. However, the spatial distribution of reductive tendency in the Chianan plain is different from that in the Choushui river alluvial fan, yielding spatially distinct hydrogeochemical environments in these two neighboring areas. The reduction potential in the Chianan plain is stronger than that in the Choushui river alluvial fan. The difference of the reduction potentials between these two vicinal areas affects the distribution of As concentrations in groundwater. The reductive dissolution of As-rich iron oxyhydroxide is postulated to be the major mechanism of the release of As to the groundwater in the Chianan plain and the Choushui river alluvial fan of Taiwan. The release mechanism is generally driven by reducing bacteria. Experiments approach was carried out by coupled synthetic As-contained amorphous iron oxide (HFO) and inoculation of iron-reducing bacteria (IRB) to evaluate the contribution of IRB on the mobilization and transformation of As. The results of respective HFO and As^{5+} reducing experiments show that both of the reduction reactions are promoted by IRB. However, the rate and extent of As^{5+} reduction are similar with different treatments of organic substrates. In As-contained HFO reducing experiment, both the IRB and the competition of organic carbon play important roles on As desorption and mobilization. Sequentially, aqueous As^{5+} becomes an electron acceptor after that the solid phase of ferric iron has been reduced, but the conversion of As^{5+} to As^{3+} were affected by different treatments of organic substrates. Hence, Fe-related reducing bacteria may be capable of reducing aqueous As^{5+} after the reduction of iron minerals. The working hypothesis model of As biogeochemical cycling proposed by this study sets up the framework for investigation of the fate and transport of As in the groundwater of the southwestern Taiwan.