

Leaching behavior of As, Pb, Cd and Se in subsurface marine and nonmarine sedimentary environment in central Kanto plain, Japan

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Leaching behavior of trace element and heavy metal strongly depends on the physicochemical form termed as chemical speciation in soil and sediment. So that, sediment and soil act as scavenger to transfer naturally or anthropogenically occurring element to subsurface environment with changing environmental conditions. In this research, total 25 boring core sediment samples were investigated at 1 m interval from lowland valley of Yono area, Saitama in Kanto Plain for chemical speciation and potential risk assessment of arsenic (As), lead (Pb), cadmium (Cd) and Selenium (Se) with other metals. Samples were kept in near natural or not oxidized condition applying special preservation technique. A four steps sequential extraction method was adopted to determine chemical speciation. Boring core consist of surface clayey silt, peat, organic rich silt and clay, tuffaceous clay and medium to coarse sand with gravel layer of nonmarine sediment up to 17 m depth, where as from depth of 17 to 20 m transitional sediment are underlain by marine sediment up to 26 m. Total metal concentration, mineral content and chemical speciation concentration were determined by using X-ray Florescence(XRF), X-ray diffractometer (XRD), Inductively coupled plasma mass spectrometer (ICP-MS) and Inductively coupled plasma atomic emission spectrometer (ICP-AES) respectively. Clay minerals distributions were determined specially after application of heat and ethylene glycol treatment and XRD peak analysis. Pore water were collected from each samples and element concentration were measured by ICP-MS and ICP-AES. Under natural condition, pH of the leachate from sediment are not significantly different in nonmarine and marine environment which are ranged from pH 6.55 to 8.04. However, the electrical conductivity (EC) concentration range 53.9 to 72.1 $\mu\text{S}/\text{cm}$ in marine and 77.9 to 104.7 $\mu\text{S}/\text{cm}$ in surface silty clay sediment, that is quite higher than (7.83 to 25.4 $\mu\text{S}/\text{cm}$) of nonmarine fluvial, peat and tuffaceous clay. Chemical speciation trend for As in marine and nonmarine sediment is Fe-Mn oxide bound > Carbonate bound > Ion-exchangeable bound > water soluble where more than 95-98 % are consist of residual and organic bound in all samples indicates their occurrence are of natural origin. The potential mobile fractions (Fe-Mn oxide bound + Carbonate bound + Ion-exchangeable bound + water soluble) of Se and Cd are less than 5 % of total concentration whereas for Pb, it is less than 1%. Chemical speciation trend for Se is Fe-Mn oxide bound > Carbonate bound > Ion-exchangeable bound > water soluble in fluvial nonmarine sediment differs from the trend in marine environment which seems more bioavailable. For Cd, the trend is Carbonate bound > Ion exchangeable bound > Fe- Mn oxide bound >> water soluble. The speciation trend of Pb and As is similar. In pore water also, the concentration trend is As > Se > Cd > Pb. However, only As conc. in pore water exceeds several times from environmental standard (10 $\mu\text{g}/\text{l}$) of WHO and Japan in leachate and drinking water of both non marine and marine sediment. The highest concentration is 116.42 $\mu\text{g}/\text{l}$ at depth of 17.2-17.4 m, 86.14 $\mu\text{g}/\text{l}$ at 24.2-24.4 m and 63.12 $\mu\text{g}/\text{l}$ at 10.2-10.4 m in transitional, marine and fluvial environment respectively. Pore water concentration of Pb, Cd and Se have not exceeded the environmental standard of leachate and drinking water quality. According to risk assessment, the bioavailable fraction of As, Pb, Se and Cd in both marine and nonmarine sediment is less than 1-5 % of the total concentration indicating low or no risk. However, results suggest that leaching behavior of As differs from Se, Cd and Pb even though according to risk assessment on speciation, they have similar conditions. Pore water as well as groundwater As in fluvial aquifer shows higher concentration which is related to higher potential mobile fractions and enrichment.

Keywords: Trace element, Chemical speciation, Marine sediment, Risk assessment