ベンガルデルタの農村における泥炭質堆積物から地下水（井戸水）へのヒ素溶出のメカニズム

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論文題名　：　Mechanism of Arsenic Release from Peat Sediments into the Groundwater of Wells in the Rural Villages of the Bengal Delta（ベンガルデルタの農村における泥炭質堆積物から地下水（井戸水）へのヒ素溶出のメカニズム）

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論　文　内　容　の　要　旨

Groundwater arsenic (As) contamination in the Bengal Delta is one of the most severe environmental problems in Bangladesh. Millions of village people, who drink the As-contaminated groundwater of wells, are suffering from As poisoning. The main source of As is of geological origin, i.e., the As is contained in the sediments accumulated in the Bengal Delta. The problem has become apparent in the last 20-30 years, to which the release of As from the sediments into groundwater of wells is concerned. However, the mechanisms of the As release are still not well understood. The peat sediment, originated from decayed plant material, is often present in the sediments of the As-contaminated area. In addition, the chemical fertilizers are applied massively in recent decades in the rural villages of the delta. Therefore, this study was made to clarify the mechanism of As release from sediments into groundwater in the rural villages of the delta, considering the effects of peat sediment and massive chemical fertilizers application.

For the sediments bored from the As-contaminated village, the As concentration in the peat sediment was higher than in the other sediments, i.e., the order of the As concentration of sediments was peat>peaty clay> clay>silty clay>sand. A positive relationship between the As concentration, %C and %N was identified in these sediments. The N and C in the peat sediment were identified to be sourced from the chemical N fertilizer and aquatic plants, respectively, according to the $\delta^{15}N$ and $\delta^{13}C$ analyses. Thus, it is thought that As concentration in peat sediment is increased by the absorption of As by aquatic plants that had grown there long time ago, and the C concentration was increased by the accumulation of the decayed material of the plants. The positive correlation between %C and %N observed for the peat sediment may have been induced by the mechanism that the C absorbed N sourced from the chemical N fertilizer with a comparatively weak chemical bond. The peat sediment had a thickness of 0.6-1.8 meters and was located in a shallow layer in between the groundwater table and the bottom of the well at the As-contaminated village. In contrast, peat sediment was not observed in the sediments bored from the non-As-contaminated village, where a thin peaty clay layer was observed at a deeper layer.

From the measurement of groundwater quality at the As-contaminated village, the As concentration of groundwater was maximally as high as 30 times the Bangladeshi drinking water standard. There was a positive relationship between the concentrations of As and ammonium-N. According to the $\delta^{15}N$ analysis on the groundwater, the inorganic-N, most of

which was the ammonium-N, was identified to be sourced from the chemical N fertilizer, i.e., the same source as that of the peat sediment. The ORP of the groundwater was found to be low, showing a reducing condition of the groundwater. The release of As from peat sediment into groundwater was thought to be induced by the mechanism of "the reduction of iron hydroxides and release of involved As from the peat sediments," based on the fact that the groundwater As concentration was high when the groundwater was in the reducing condition. A large concentration of ammonium-N in the groundwater observed at a high As concentration may have been sourced from the N in the peat sediment. In the non-As-contaminated village, the concentrations of As and ammonium-N of the groundwater were very low, and the ORP showed that the groundwater was in non-reducing or oxidizing condition. The result of the $\delta^{15}N$ analysis showed that the source of the inorganic-N in the groundwater was not the chemical N fertilizer, but animal or human waste. Hence the above-mentioned release of As under the reducing condition did not occur in the village.

From the above comparisons, it was concluded that peat sediment is important and plays a critical role in groundwater As contamination. Concerning the substances of peat sediment to affect the As contamination, As is the most important substance, followed by N. The peat sediment is a place to preserve a lot of As and N. In addition, C and inorganic substances in the peat sediment are important to bond N and inorganic As, respectively. Concerning the groundwater quality parameters to affect the As contamination, ORP is the most important parameter, followed by ammonium-N. Both of them could prompt the release of As into groundwater. A substance of peat sediment can affect a groundwater quality parameter, i.e., N in peat sediment contributes to create the reducing ORP of groundwater through the microbial activity that consumes oxygen by using N as a nutrient. Chemical N fertilizer, i.e., the source of N in peat sediment, eventually contributes to provide the reducing condition. The release of As is prompted by the reducing condition.

Thus, it was concluded that the concentrations of As, C and N, and the source of C and N in the peat sediment, and groundwater parameters of ORP and ammonium-N affect groundwater As contamination. Based on the results, the mechanism of As release from peat sediment into groundwater of wells was clarified in the villages of the Bengal Delta. For further study, it is important to clarify the topographical conditions favorable for the formation of peat sediment, and the kinds of microorganisms living in peat sediment and their activity in terms of the release of As.