Behavior of Arsenic in the Red River, Northern Vietnam

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The samples were collected from main channel and branches of Red River in Vietnam territory in rainy season (2013.7.26 - 8.4) and dry season (2014.4.10 - 21); river water (Rainy season: 29, Dry season: 45), and sediment (Rainy season: 4, Dry season: 18).

Ranges of total arsenic concentration of the main channel waters were 1.4-9.1 μg/L in the rainy season, 2.2-92.9 μg/L in the dry season. Arsenic concentrations were the maximum at the uppermost sampling point, close to border with China; 9.1 μg/L and 33.9 μg/L respectively. The value of the dry season was 3 times higher than the WHO standard (10 μg/L). Arsenic concentration decreased toward downstream, and was not exceeding the WHO standard in the all river water from the channel in the Red River Delta. Range of arsenic concentration of branches were 0.2-1.6 μg/L, 0.3-4.5 μg/L in the rainy and dry season respectively, and is lower than those of main channel. The main channel water was diluted by the inflow from the branches.

In the Red River, dissolved arsenic was more abundant than the absorbed one onto suspended particle. The dissolved phase of 50% was the lowest in the uppermost water. The rate of dissolved As increased toward downstream. The range of arsenic concentration in the rainy season is lower than in the dry season. It is suggested that arsenic concentration was diluted by abundant runoff derived from basement flow into the branches.

Arsenic concentration of 5 sediment samples collected from the main channel was 30.0-33.6 mg/kg and 2 samples gave 21.1 and 55.6 mg/kg. Unlike river water, arsenic concentration did not decrease toward downstream. There is no difference in arsenic concentration between the uppermost sediments from Lao Cai (30.0 mg/kg) and around that from the river mouth (31.6 mg/kg). Arsenic concentration of sediments from branches were lower than those from the main channel, and 2.8 mg/kg at the maximum.

Insoluble and oxidizable forms of arsenic was accounted for approximately 80%. The insoluble arsenic decreased toward downstream, while the oxidizable arsenic increased.

Arsenic and lead concentrations of sediments showed good positive correlation (R^2=0.92), suggesting the same origin. The lead isotope ratios were analyzed to estimate source materials. Lead isotope ratios of sediments (n=6) were $^{206}Pb/^{204}Pb$=18.572-18.766, $^{207}Pb/^{204}Pb$=15.727-15.739, suspended matters (rainy season:n=14, dry season:n=1) were $^{206}Pb/^{204}Pb$=18.516-18.667, $^{207}Pb/^{204}Pb$=15.701-15.737 in rainy season and $^{206}Pb/^{204}Pb$=17.611, $^{207}Pb/^{204}Pb$=15.586 in dry season. Relation between $^{206}Pb/^{204}Pb$ and $^{207}Pb/^{204}Pb$ showed that the most parts of lead in sediments and suspended maters had the similar origin. However, the correlation of sediments showed an positive inclination, on the other hand, that of suspended maters in rainy season showed negative inclination. This suggests that the suspended maters contained the lead from another source supplied from the branches to the single source of sediments in the main channel. The lead isotope ratio of sediments was different from those of ore minerals including lead (galena, sphalerite, pyrite) collected Yunnan where source area of Red River. Thus, these ores can not be source of arsenic and lead of Red River water.

Arsenic concentration of river water was in μg/L order, while those of the river bed sediments were in mg/kg order. Therefore, the most of arsenic is transported by the clastic particles, derived in the upstream China.

Keywords: Red River, Arsenic, Lead

