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Natural toxic metals in sediments and their environmental effects on ground waters in Sendai and Aomori cities

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The Soil Contamination Countermeasures Law was legislated to prevent health damage from toxic metals such as As, Cd, and Pb in soils and sediments. In order to prevent the health damage caused by oral ingestion of these metals leached into ground water, the regulated level of metal leachability from soils and sediments is determined to be 0.01mg/L, which is identical to quality level of Japanese drinking water. The regulated toxic metal concentration level is determined to be 150mg/kg. This concentration level is obtained using toxic metal leachabilities by 1M HCl, assuming health damage is caused by digestion of these metals in stomach. This paper shows As, Cd, Pb concentrations of sediments and their leachabilities in the Sendai and Aomori areas, for understanding how geological setting of these areas control As, Cd, Pb concentrations and leachabilities. This paper also shows As, Cd, Pb concentrations of groundwater, for evaluating the potential mobility of these toxic metals from sediments to ground water.
The geology of the Sendai areas is dominated by marine and terrestrial Pliocene sediments with overlying Quaternary terrace deposits and alluvium. Although, As, Cd, and Pb concentrations of most sediments are similar to their average concentrations (15mg/kg for As, 0.2mg/kg for Cd, and 20mg/kg for Pb), the As and Cd leachabilities of some marine sediments are significantly higher than the regulated level (0.01 mg/L). Arsenic, Cd, and Pb leachabilities are increased by oxidation of sulfide minerals in sediments, because these metals are released from sulfide crystals during their oxidation and subsequent decomposition. Furthermore, the sulfide oxidation generates sulfate ion which make sediment pore water acidic (pH<3). Clay minerals and humus in sediments are not capable to adsorb enough As, Cd, and Pb in such acidic environment and their leachabilities are also to be increased.
Arsenic and Cd concentrations of most ground water with water level >10m are less than 0.01 mg/L. Therefore, there is almost no ground water contamination caused by the leaching of As and Cd in sediments, as long as the water level is deep enough. However, As concentrations of some ground water with water level <5m are much higher than 0.01 mg/L, suggesting that As in sediments contaminates ground water. These ground waters are not suitable for drinking.
The geology of Aomori area is characterized by Quaternary volcanic ash and alluvium. Arsenic concentrations of some alluvium samples from Aomori area is characterized by very high (>150mg/kg) As concentrations. These As is assumed to be volcanic origin, because As concentrations of hot spring water associated with Hakkoda volcanoes are extremely high (27 to 1.7mg/L). These hot springs contaminate downstream river waters (As concentration over 0.01 mg/L) seriously. Therefore, As originated from Hakkoda volcanoes is carried by river water (As concentration over 0.01 mg/L) and is accumulated in alluvium in the coastal plain of Aomori city.
Humus in organic materials of alluvium possess functional group to be bonded with As, although the bonding of functional group and As is not so strong under acidic environments. Therefore, when oxidation of sulfide minerals produce acidic condition (pH<3) in pore water of alluvium, humus are not capable to adsorb enough As and their leachabilities are to be increased. Arsenic leachabilities are also increased by oxidation of sulfide minerals in sediments, because As in sulfide mineral crystals are released from sulfide minerals by the oxidation. Therefore, As leachability

become very high (up to 1.9mg/kg).
The leachable As in alluvium causes As contamination of ground water with water level <5m. Our on site stripping voltanmmetry (SV) analysis of ground water suggests that arsenic is reduced to arsenite under reducing condition where sulfide mineral consumes oxygen. Such a ground water is not suitable for drinking, because aesenite is very toxic.

Keywords: Soil contamination, ground water contamination, arsenic, cadmium, lead