Speciation and solubility of arsenic, lead, and cadmium in contaminated soils from Kamegai mine tailing, Toyama, Japan

Gankhurel Baasansuren[1*], Keisuke Fukushi[2], Akitoshi Akehi[1], Yoshio Takahashi[3], Natsumi Takeda[1], Xiaolan Zhao[4] and Kazuo Kawasaki[5]

[1]Graduate School of Natural Science and Technology, Kanazawa University, [2]Instutute of Nature and Environmental Technology, Kanazawa University, [3]Department of Earth and Planetary Science, The University of Tokyo, [4]Faculty of Science, Chang'an University,[5]School of Sustainable Design, University of Toyama

Mining extraction and processing generate large volumes of metal-rich waste tailings. This tailing is considered to be a principal cause of soil contamination in mining areas. Once these toxic metals are introduced into soils with surface water, they can be transported deep into the soil and into groundwater, threatening environmental health. The objectives of the present study were to determine the speciation of As, Pb, and Cd in soils from the mine tailing area, by employing a sequential extraction (SEP) and X-ray absorption fine structure (XAFS) so as to better understand the solubility of these heavy metals in that area.

The study area is located south of Toyama city, Japan. The Kamegai mine is an abandoned silver mine and operated from 1596 to 1680 and again from 1887 to 1898. After the closure of the mine, the mine tailings from the ore processing were left in mount Hachibuse. A total of 32 soil samples were collected in September 2016 along two sampling transects near the mine tailings. A total of 5 water samples were taken from the Oguchi river and its tributaries at sites near the Kamegai mine tailing area in October 2018. Soil samples were analyzed by using six-step sequential chemical extraction and XAFS for chemical speciation of As, Pb, and Cd. The major cation and anion concentrations of the water sample were analyzed using inductively coupled plasma optical emission spectroscopy (ICP-OES; ES-710, Varian Inc., Palo Alto, CA, USA) and high-performance liquid chromatography (8020 Series: Tosoh Corp., Tokyo, Japan). The trace elements of water samples were analyzed by using an inductively coupled plasma mass spectrometer (ICP-MS; iCAP RQ, Thermo Inc., Waltham, MA, USA).

The results revealed that most of As in the soil is pentavalent oxidation states and is adsorbed on primarily goethite and secondarily ferrihydrite. The As(V) favorably can adsorb to the ferric oxides under acidic conditions, while it prefers to desorb from the minerals under alkaline conditions. Results showed most of Pb was adsorbed on goethite which is rich in the soil sample. Based on the SEP, the high ionic strength and/or slightly lower pH solution can lead to the significant release of Pb to solutions. Cd is mainly adsorbed on clay minerals. Due to the high cation exchange capacity of clay minerals, Cd placed in the interlayer can be released with the other cations with high concentrations in the surrounding solutions.

The river water in this area is characterized by low ionic strength and slightly alkaline pH. The concentrations of Pb and Cd in the river are always less than 0.07 ug/L, while that of As in the river sometimes exceeds 10 ug/L but the concentrations of Pb and Cd were low. The solubilities of heavy metals in the river in this area are consistent with those predicted by the chemical speciation.

Keywords: arsenic, cadmium, lead, solubility, contaminated soil

*Corresponding author: gbaasnsrn@gmail.com