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Arsenic and uranium in the surface sediments in the Ningyo-toge uranium mill tailings pond: speciation and mechanisms for retaining in solid phases

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The Ningyo-toge area, located at the boundary between Okayama and Tottori prefectures in Japan, has uranium (U) mines. At the Ningyo-toge Center in Japan Atomic Energy Agency (JAEA), groundwater is in contact with U ore-forming minerals, contaminated with toxic and/or radioactive elements, such as U and arsenic (As), and flowed into a mill tailings pond to decrease the concentrations of those elements. Since the groundwater contains iron (Fe) in the form of Fe(II), Fe(III) (hydr)oxides are formed over the mill tailings pond after the exposure of groundwater to the atmosphere. The concentrations of the aqueous contaminants in the mill tailings pond water are lower than those in the groundwater and the regulatory concentrations to flow out into river. It is assumed that the iron (hydr)oxides, such as ferrihydrite, goethite, and hematite, precipitated in the mill tailings pond remove the contaminants from the contaminated groundwater. However, the detailed mechanism of heavy metals retention in the sediments in Ningyo-toge mill tailings pond has not been fully understood.

The purpose of this study is to elucidate the solid phases responsible for As and U retention. This study investigated the host phases of As and U in surface sediments using X-ray absorption fine structure (XAFS) spectroscopy. These analyses showed that (i) ferrihydrite is the major form of Fe, and goethite, and siderite are the minor ones, (ii) As and U occur as As(V) and U(VI), respectively, and (iii) ferrihydrite and goethite are the host phases of As and U in the surface sediments. These results indicate that As and U flowing into the Ningyo-toge mill tailings pond are removed from the groundwater mainly by adsorption on ferrihydrite and goethite in the field. These findings would help remediate contaminated soils and predict the long-term behavior of As and U in the natural environment.

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