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Geochemical modeling of a natural remediation of an acid mine drainage from an abandoned mine in northern Japan

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From an abandoned sulfur and limonite mine in northern Japan, acid mine drainage (AMD) rich in dissolved Fe, As, Pb, and Cd come to mix in the nearby rivers. Chemistry in two nearby rivers, hereafter referred to river A and river B, are affected by the acid mine drainage from two neighboring abandoned mines. However, river A is self-remediated, and the concentration of the above contaminants decreases to that below the environmental regulation standard at the monitoring point. In contrast, there is no self-remediation in the river B. If the geochemical process of natural remediation in river A is well understood, the lesson learned at river A would be quite valuable for geochemical passive-treatment in river B. Thus, this study aims to understand the natural remediation and its implication of river A by geochemical modeling.

The acid mine drainage contains high ferric iron concentration from the source with pH 2.6 and toxic elements such as As, Pb, and Cd. After the AMD mixes with the rivers, river A's pH dropped from 6.9 to 3.1 while river B’s pH decreased from 7.1 to 2.9. In river A, schwertmannite formation was observed just after mixing with wastewater. On the other hand, schwertmannite formed in river B at the midstream after the pH increased to above 3.1. The surface complexation modeling in Geochemist's Workbench was conducted to understand the partitioning of As, Pb, and Cd onto schwertmannite. The results indicated that arsenic was removed from river A by schwertmannite, but Pb and Cd were reduced by dilution. The modeling results suggested that schwertmannite could scavenge Pb and Cd only if pH is increased to 4.5 for Pb and 7.5 for Cd to reduce their concentrations to lower than the environmental regulation standard. Dilution by inflowing river water to river A is a factor controlling the process for rising pH and reducing Pb and Cd concentrations. Consequently, increasing pH and dilution by the introduction of another river with high buffering capacity (alternatively limestone channel) are recommended in river B.