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Adsorption of heavy metals in mine wastewater by Mongolian natural zeolite

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Abstract

In the first, Mongolian natural zeolites, whose base components were clinoptilolite, mordenite, and chabazite, were characterized in terms of element content, cation exchange capacity, and the like. Since the molar ratios of aluminum relative to silicon contained in Mongolian natural zeolites used in this study were lower than those of pure zeolites, the natural zeolite samples contained substantial amounts of impurities. The cation exchange capacity of the natural zeolite sample relatively increased with increasing aluminum content in the zeolite sample. Secondly, the batch equilibrium adsorptions of heavy metals, i.e., copper, zinc, and manganese, from model aqueous wastewater by Mongolian natural zeolites were carried. The natural zeolites could adsorb and remove the heavy metals in the aqueous solutions. The precipitation of metal hydroxide affected the results of adsorption in some cases. The saturated adsorbed amounts of the heavy metals estimated by Langmuir equation were almost same with one another, increased with solution pH and with cation exchange capacity of the natural zeolite.

Keywords: Mongolian natural zeolites; mine wasteater; heavy metal adsroption

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1. Introduction

In Mongolia, the large deposits of gold, copper ores, etc. have been found in 2000 by Ivanhoe Mines Ltd. of Canada. The deposits of the metals were estimated as 340 tons for gold and 15 million tons for copper and they may have great influence on the commodity market in the world. For the future, Oyu Tolgoi copper deposit and so on will be developed and the trade of these metals is planned to drastically increase from around 2013.

On the other hand, environment around metallic mine is seriously contaminated by mine wastewater, if without any appropriate treatment. The mine wastewater is acidic water, such as, mine drainage and infiltrating water. The mine drainage is generated, when crushed and/or broken minerals in ore deposit contact with air and water. The sludge of low metal content waste gives the infiltration water. These acidic wastewaters are discharged into environment not only in the period of mining but also after the mine is closed. In the development of metallic mine, the treatment of this mine wastewater should be taken into account, as well. Although the neutralization is widely employed to treat mine wastewater, it has been pointed out that this method has a lot of problems, e.g., generation of huge amount of sludge, necessity of large scale facilities.

Mongolia is also abundant in natural zeolite resource which is expected to be developed. Tsagaan Tsav deposit of natural zeolite is prospected to have a potency to produce about 4.8 million tons of minerals containing zeolite. Zeolite is well known as a microporous material having cation exchange ability and is used to adsorb and remove cations including metal cations from aqueous solutions.

Motsi, *et al.*[1] studied the actual treatment of mine wastewater from Wheal Jane Mine by adsorption using Turkey natural zeolite. They showed that the natural zeolite had the potential to effectively remove heavy metals from relatively dilute mine wastewater. Authors[2][3][4] studied the treatment of tannery wastewater containing chromium using Mongolian natural zeolites, where this natural zeolites with modification could remove hexavalent and trivalent chromiums from solutions at same time.

In this study, we applied Mongolian natural zeolite to removal of heavy metals from mine wastewater. In the first, several samples of Mongolian natural zeolites were characterized in terms of base mineral components, element content, cation exchange capacity, and the like. Secondly, the batch equilibrium adsorptions of heavy metals from model aqueous wastewater by the natural zeolites were carried.

Nomenclature

C_i	molar concentration of metal i in aqueous solution [$\mathrm{kmol \cdot m^{-3}}$]
CEC	cation exchange capacity of zeolite [$\mathrm{keq \cdot kg\text{-}Zeo^{-1}}$]
$K_{\mathrm{L},i}$	adsorption coefficient in Langmuir equation of metal i [$\mathrm{m^3 \cdot kmol^{-1}}$]
$K_{\mathrm{sp},i}$	solubility product of ion of metal i and hydroxide ion [$\mathrm{kmol^3 \cdot m^{-9}}$]
K_w	ion product of water [$\mathrm{kmol^2 \cdot m^{-6}}$]
L	volume of aqueous solution [$\mathrm{m^3}$]
n_i	valence of ion of metal i [–]
pH	pH in aqueous solution
q_i	adsorbed mole of metal i per unit mass of adsorbent [$\mathrm{kmol \cdot kg\text{-}Zeo^{-1}}$]