PROSPECTIVE REMEDIATION OF ANTIMONY MINE AREA

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Introduction

Xikuangshan mine (Hunan, China) is the world's largest antimony mine. The mine tailings occupy about 16 km^2 and are a source of soil and water pollution by As, Cd, Cr, Hg, Pb, Ni, Sb, and Se (Liu et al., 2010). The remediation of tailings area and the purification of mine waste-water require special technologies, as a rule rather expensive. To develop low-cost technologies is critically important for both environment safety and economics of mine. One of the ways to reduce remediation cost is based on using local inexpensive materials.

During last decade, numerous researches have demonstrated potential of such Si-rich substances as zeolites, diatomites, and industrial slags or fly ash to be used for resolving different ecological problems (Beh et al., 2012; Lin et al., 2012). The theoretical investigation has shown that soluble Si forms, monomers and polymers of silicic acid, can precipitate heavy metals from solution and reinforce the plant resistance against different types of contaminants (Biel et al. 2008; Vaculik et al. 2009). Zeolite and Si-rich by-products (slag and fly ash) also have an ability to adsorb and fix heavy metals and metalloids (Feng et al., 2004; Imad et al., 2006). Several mechanisms of detoxification of pollutants by Si-rich materials with high solubility can be distinguished.

The main aim of this study was to investigate the possibility to reduce the mobility and toxicity of mine wastes (waste-water and tailings) using local Si-rich industrial by-products (slag and fly ash) and their activated forms.

Methods

Waste-water and tailings were sampled from a slope of the mine area (South Mine) near Lengshuijiang city (Hunan, China). Original and treated local Si-rich by-products were used in the investigations: iron slag from metallurgical enterprise and fly ash from power station. These by-products were treated by colloidal Si and used in column, incubation, and greenhouse tests. In the column test, Si-rich materials were used as a filter for waste water purification. Percolated solutions were collected and analyzed for As, Cd, Hg, Pb, and Se. In the incubation test, tailings and Si-rich materials after mixing in proportion of 10:1 were incubated under moisture level 20-25% and temperature +24^{o}C during 2 weeks. After that, the samples were extracted with 0.1 n HCl and 2n HNO_3 and extracts were analyzed for mobile and potentially mobile As, Cd, Hg, Pb, and Se. The greenhouse test was conducted in a climatic chamber at 30^{o}C and day/night regime 12/12 hours. Rice (*Oryza Sativa* L.) was grown in plastic pots filled with 200 g of pure quartz sand. Mine site material was added at the rate 20 g pot^{-1}. The Si-rich substances were added at the rate 5 g pot^{-1}. After a 3-week growing period, rice was harvested and the biomass was recorded. The total contents of As, Cd, Hg, Pb, and Se were determined in the roots and leaves or rice. As, Cd, Hg, Pb and Se were tested by ICP-OES Perkin Elmer Optima 5300 DV.

Results

The obtained results have shown that slag and fly ash untreated and treated can be used as a filter for purification of mine waste-water (Table1).

Table 1. The content of As, Cd, Hg, Pb, and Se in percolated solutions in column test without and with application of Si-rich substances, ppm.

Material	As	Cd	Hg	Pb	Se
Mine tailings (MT)	15.2-15.6	0.33-0.37	0.23-0.27	2.2-2.6	26.2-26.6
MT + Slag	9.2-9.5	0.22-0.25	0.14-0.15	1.4-1.5	12.4-12.7
MT + Fly ash	12.2-12.4	0.24-0.28	0.12-0.13	1.9-2.0	10.4-10.6
MT + treated Slag	6.0-6.2	0.05-0.06	0.08-0.09	0.4-0.5	4.3-4.5
MT + treated Fly ash	7.1-7.4	0.06-0.08	0.05-0.06	0.5-0.6	3.2-3.5

The incubation and greenhouse experiments have demonstrated that local Si-rich industrial wastes (slag and fly ash untreated and treated) provided a reduction in mobile and potentially mobile forms of As, Cd, Hg, Pb, and Se in mine tailings, thus reducing the risk of chemical pollution from the antimony mine. The mobility and toxicity of tested heavy metals and metalloids was reduced more than 10 times. The pollutant contents in the leaves and roots of rice were decreased as well. The pollutant reductions in the leaves were more significant than in the roots. The treated slag and fly ash had more significant reducing effect on the pollutant mobility and plant uptake than untreated ones.

Conclusions

The obtained results evidence that Si-rich industrial by-products (slag and fly ash) can be used for remediation of the Xikuangshan mine tailings and for purification of waste-water. The efficiency of remediation can be increased as a result of the treatment of Si-rich materials by colloidal Si.

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