TECHNICAL PAPER

Immobilization of antimony waste slag by applying geopolymerization and stabilization/solidification technologies

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During the processing of antimony ore by pyrometallurgical methods, a considerable amount of slag is formed. This antimony waste slag is listed by the European Union as absolutely hazardous waste with a European Waste Catalogue code of 10 08 08. Since the levels of antimony and arsenic in the leachate of the antimony waste slag are generally higher than the landfilling limits, it is necessary to treat the slag before landfilling. In this study, stabilization/solidification and geopolymerization technologies were both applied in order to limit the leaching potential of antimony and arsenic. Different combinations of pastes by using Portland cement, fly ash, clay, gypsum, and blast furnace slag were prepared as stabilization/solidification or geopolymer matrixes. Sodium silicate–sodium hydroxide solution and sodium hydroxide solution at 8 M were used as activators for geopolymer samples. Efficiencies of the combinations were evaluated in terms of leaching and unconfined compressive strength. None of the geopolymer samples prepared with the activators yielded arsenic and antimony leaching below the regulatory limit at the same time, although they yielded high unconfined compressive strength levels. On the other hand, the stabilization/solidification samples prepared by using water showed low leaching results meeting the landfilling criteria. Use of gypsum as an additive was found to be successful in immobilizing the arsenic and antimony.

Implications: Despite the wide use of antimony for industrial purposes, disposal options for an antimony waste such as slag from thermal processing of antimony ore were not reported in the existing literature. This study aimed to develop a disposal strategy for the hazardous antimony waste slag. The findings of this study would contribute to understand the immobilization mechanisms of antimony and arsenic and will also be of interest to the owners of the antimony ore processing plants and to researchers investigating the efficiency of stabilization/solidification and geopolymerization technologies.

Introduction

Metal mining is the base industry in the economic development of numerous countries. Rising demands for metals from countries like China and India have caused an enormous increase in metal production in recent years. This increasing trend has carried an evolving waste management problem along with it. Therefore, it has become necessary to consider the environmental impacts of mining activities and to introduce waste management approaches. In Europe, the European Commission started to implement new directives in 2006 on the management of waste from extractive industries including mine waste (Directive 2006/21/EC and amending Directive 2004/35/EC: European Community, 2006).

Antimony is one of those metals that has an increasing production trend and brings environmental problems during extraction. Antimony and its compounds have a wide range of industrial applications, particularly as additives in flame retardants, which account for about 90% of global antimony trioxide consumption (Klein et al., 2009). Industrial uses of antimony also include the manufacture of semiconductors, diodes, lead hardener, batteries, small arms, tracer bullets, automobile brake linings, and pigments (Filella et al., 2002). Antimony has been produced from ores in more than 15 countries (Anderson, 2012). World reserves of antimony are estimated to be about 1.8 million metric tonnes (Carlin, 2012). Turkey is among the countries producing and exporting antimony. It has been reported that Turkey produced 50,357 tons of antimony in 2008, which had increased from 28,000 tons in 2007 (Mobbs, 2013).

The antimony content of the ore determines the pyrometallurgical method of antimony recovery from ore. In general, antimony trioxide (Sb_2O_3), which is considered to be the most important antimony compound, is produced by volatilizing antimony metal in an oxidizing furnace (Anderson, 2012). Antimony enters the environment during the mining and processing of its ores and in the production of antimony metal, alloys, antimony oxide, and combinations of antimony with other substances (Agency for Toxic Substances and Disease Registry [ATSDR], 1992). Antimony ore and impure metals can be brought for processing into the countries where antimony is not mined.

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