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Leaching characteristics of solid wastes from thermal power plants of western Turkey and comparison of toxicity methodologies

Alper Baba[a,*], Abidin Kaya[b,1]

[a]Department of Geological Engineering, Canakkale Onsekiz Mart University, 17020 Canakkale, Turkey
[b]Department of Civil Engineering, Dokuz Eylül University, Kaynaklar Yerleskesi, Buca, 35160 Izmir, Turkey

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Abstract

Use of lignite in power generation has led to increasing environmental problems associated not only with gaseous emissions, but also with the disposal of ash residues. In particular, use of low quality coals with high ash content results in huge quantities of both fly and bottom ashes to be disposed of. A main problem related to coal ash disposal is the heavy metal content of the residue. In this regard, experimental results of numerous studies indicate that toxic trace metals may leach when fly and bottom ashes are in contact with water. In this study, fly and bottom ash samples obtained from thermal power plants, namely Yenikoy, Kemerkoy and Yatagan, located at the southwestern coast of Turkey, were subjected to toxicity tests such as the extraction (EP) and toxicity characteristic leaching (TCLP) procedures of the US Environmental Protection Agency (USEPA) and the so-called 'Method A' extraction procedure of the American Society of Testing and Material (ASTM). The geochemical composition of ash samples showed variations depending on the coal burned in the plants. Furthermore, the EP, TCLP and ASTM toxicity tests showed variations such that the ash samples were classified as 'toxic waste' based on EP and TCLP results whereas they were classified as 'non-toxic' based on ASTM results, indicating test results are pH dependent. When the extraction results were compared with the chemical composition of water samples obtained in the vicinity of the thermal power plants, it was found that the results obtained using the ASTM procedure cannot be used to predict subsurface contamination whereas the EP and TCLP procedures can be used.

Keywords: Bottom ash; Fly ash; Leachate; Solid waste; Thermal power plants

1. Introduction

Coal is a major source of energy in Turkey, and its consumption is predicted to increase in the future in order to meet the continuous demand for electric power generation. With the increasing use of coal, especially in industrialized areas, coal combustion waste products become a serious important environmental problem due to their leachable toxic trace element contents. The thermal power plants located in Mugla, western part of Turkey, are good examples of such a problem. Fig. 1 shows the location map of the thermal power plants. There are three large thermal plants, named Yenikoy, Kemerkoy and Yatagan, which use low quality lignite, having an ash content of approximately 30%, to produce electricity.

When the low quality lignite is burned, its fly and bottom ashes contain several toxic elements, such as Lead (Pb), Zinc (Zn), Cadmium (Cd), Nickel (Ni) and Cobalt (Co), which can leach out and contaminate soils as well as surface water and groundwater. The extent of the heavy metals in fly and bottom ashes depends on both the mineralogy and particle size distribution of the raw material being burnt and the combustion temperature. Although the extent of the heavy metals can be optimized by controlling the particle size and burning temperature, such procedures could be costly. Furthermore, since the coal mineralogy is generally constant for a given coal deposit, not much can be done to control the heavy metal content in both fly and bottom ashes. However, leaching of heavy metals from fly and bottom ashes can be prevented

* Corresponding author. Tel.: +90-286-218-00-18x1212; fax: +90-286-218-05-41.
E-mail addresses: alperbaba@comu.edu.tr (A. Baba), abidin.kaya@deu.edu.tr (A. Kaya).
[1] Tel.: +90-232-453-1008x1071; fax: +90-232-453-1191.

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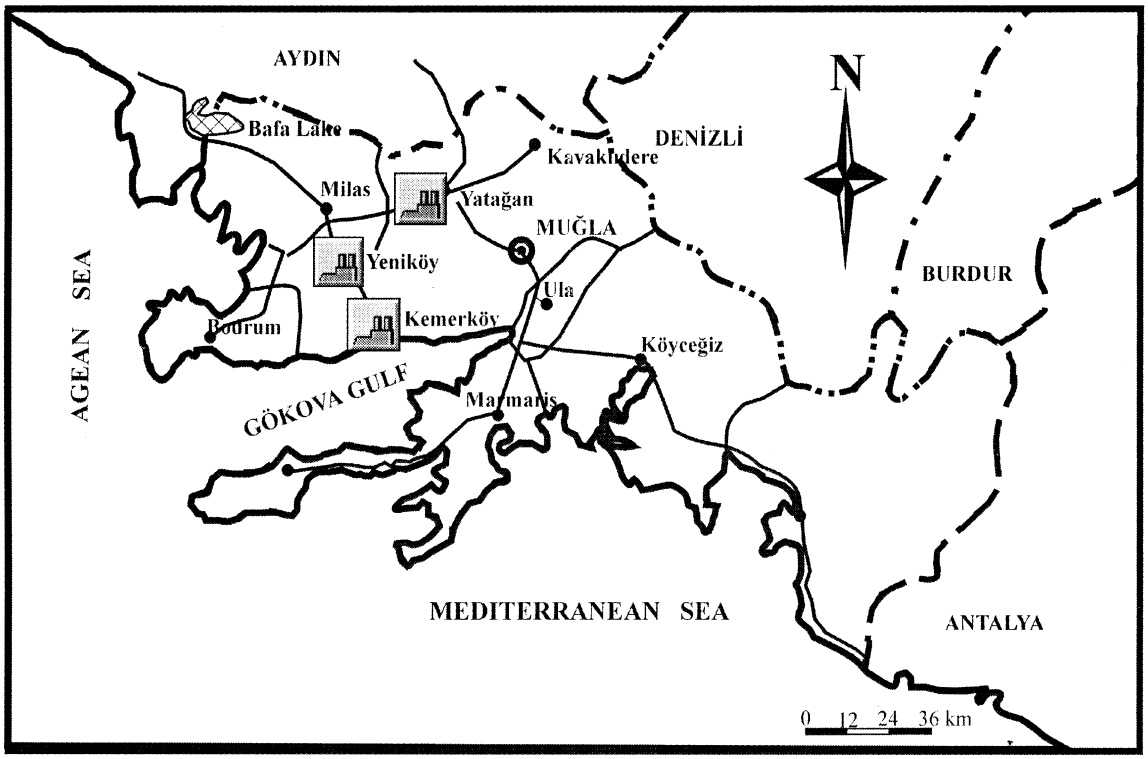

Fig. 1. Location map of study area.

by adequate waste disposal techniques. The leached heavy metals from both fly and bottom ashes may become a hazard to the environment because of their contribution to the formation of toxic compounds. This can lead to health, environmental and land-use problems (Gehrs et al., 1979; Laumakis et al., 1996; Inyang, 1992; Georgakopoulos et al., 1994; Fernandez-Turiel et al., 1994; McMurphy et al., 1996; Kamon et al., 2000; Baba and Turkman, 2001; Georgakopoulos et al., 2002a; Mandal and Sengupta, 2002; Baba, 2003; Baba et al., 2003). Not only are gaseous and particulate emissions from coal-fired power plants of environmental concern, but also fly ash may lead to contamination because of the possible release of both major and trace elements from combustion by-products.

Although there are serious efforts to use both fly and bottom ashes as construction materials or soil amendments, the amount of the stocked waste ash increases because production is much more than the amount that can be used in the construction industry. Waste ash that cannot be used in above-mentioned industries needs to be disposed of. The safe deposition of waste ashes requires adequate identification and classification of their heavy metals as well as their toxicity levels (Kress, 1993; Lee and Hahn, 1997; Georgakopoulos et al., 2002b).

The purpose of this study is to evaluate the established procedures that classify ashes for safe disposal by determining the concentrations of major and trace elements in coal combustion solid products, namely fly and bottom ashes, in the vicinity of the thermal power plants located in Mugla-Turkey. This study focuses on the results of laboratory-scale toxicity testing procedures carried out to determine the general leaching properties of the fly and bottom ashes produced by the thermal power plants.

2. The thermal power plants

At the Yenikoy plant, 12,000 tons of coal are burnt and approximately 4500 tons of fly and bottom ash are produced each day. The produced solid wastes are transported to the disposal site, which is located on alluvium and limestone, by the use of conveyor belts, nearly 1.5 km in length. The Yenikoy plant is made of two units with original energy capacity of 420 MW consuming low-quality lignite reserves from the Husamlar-Sekkoy-Ekizkoy-Karacahisar basin. The annual production capacity of this power plant is 2.7 billion KWh.

In the Kemerkoy plant, 15,000 tons of coal, provided from the low quality lignite reserves of the Husamlar-Sekkoy basin, is burnt and approximately 6000 tons of fly and bottom ashes are produced per day. The produced solid wastes are transported to a karstic and fractured dolomitic and cherty limestone disposal site. The plant has three units each having an energy capacity of 630 MW with an annual production of 4.1 billion KWh.

The Yatagan Thermal Power Plant burns 15,000 tons of low quality lignite, obtained from the reserves of the Eskihisar, Bagyaka and Tinaz Basins, and produces approximately 5000 tons of fly and bottom ash per day. The produced solid wastes are transported to a schists