Sandy soil contamination with coal fly ash by long term leaching test

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Abstract

Toxic elements can cause impact on soil environmental quality and represent risks to human life. Coal ashes, considered as a source of toxic elements, are commonly disposed of inadequately on the soil surface around thermoelectric plants. The aim of this study was to evaluate the contamination of a clayey sand by As, Cd, Mo Pb and Zn from coal fly ash of Figueira Power Plant. Experiments with coal fly ash added on soils columns were carried out to simulate contamination by acid leaching. Results indicate that the soil was mainly contaminated by As, which exceeded the intervention value for maximum protection area (APmax) established by the Environmental Protection Agency of the State of São Paulo (CETESB).

Keywords – Coal, Ash, Soil, Leaching, Toxic Elements.

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1. INTRODUCTION

One of the environmental problems of coal thermoelectric plants is the generation of ashes. It is estimated that in Brazil 4 million tons of these ashes are generated every year, of which only fifty percent are reutilized [1].

Coal ashes are composed of toxic elements. Inadequate disposal on soil surface can cause these elements to be leached and transported to underground water or to be absorbed by plants and animals, representing a risk to human health.

The aim of this study was to evaluate the contamination of a clayey sand by As, Cd, Mo Pb and Zn from coal fly ash of Figueira Power Plant.

2. MATERIAL AND METHODS

Coal fly ash from Figueira Power Plant of Paraná State, Brazil, was used on this study.

Surface soil (0–20 cm depth) was collected in Estiva Gerbi city in the State of São Paulo, Brazil, in an area covered by native vegetation or ancient reforestation. The soil sample was air-dried at room temperature and sieved (< 2 mm). The pH was determined in KCl (soil: solution ratio 1:2.5) [2]; aluminum, Mn and Fe oxides were determined after extraction with 9 mol L^{-1} H_2SO_4 [2]; soil physic fractionation was performed according to the densimeter method [2]; cation exchange capacity (CEC) was determined by saturation with $BaCl_2$ and exchange with $MgSO_4$ followed by EDTA titration [2]. Soil organic matter (OM) was determined by combustion at 375^{o}C.

A mass of 324g of homogenized soil was compacted at in-situ density in eight acrylic columns with an inner diameter of 8 cm. On the top of four soil columns, denominated as SCA, 50 g of coal fly ash were added; other soil columns without coal fly ash application were denominated as SC.

Columns were leached during one year with a solution composed of HNO_3 and H_2SO_4 mixed on 1:1 proportion and pH 4.5 (typical pH value of precipitation waters in the city of São Paulo). The volume applied to the columns was based on monthly rainfall data from 1933 to 2008 in the city of São Paulo.

Arsenic, Zn, Pb and Mo in coal fly ash were measured using an X-ray fluorescence spectrometer (XRF). Cd was not determined by XRF on coal fly ash because of limitations

of the equipment.

Arsenic, Cd, Zn, Pb and Mo concentrations were measured in the soil. Duplicate aliquots of soil (0.5 g) were microwave digested in concentrated HNO_3 (9 mL) – HCl (3 mL) mixture [3], and elements concentration was determined by means of a coupled plasma optical emission spectrophotometer (ICP-OES) for Cd, Zn and Mo and an absorption atomic spectrometer (AAS) for As and Pb.

3. RESULTS AND DISCUTIONS

Table 1 shows results of **s**oil characterization. The physic fractionation results indicated that the soil has a texture of a clayey sand. The soil is acid (pH=3.7), with low OM and low CEC, suggesting low retention of cations. The presence of oxides of Al, Fe and Mn in acid soils may indicate retention of oxy-anions such as AsO_4^- and MoO_4^{2-} [4].

Table 1 – Physical-chemical characteristics of soil.

pH_{KCl}	OM (%)	Sand (%)	Silt (%)	Clay (%)	Fe_2O_3 (%)	Al_2O_3 (%)	MnO (%)	CEC ($mmol_c\ Kg^{-1}$)
3.7	2.66	80	2	18	2.00	7.24	0.100	100.4

Table 2 shows elements concentration in coal fly ash. The decreasing order of elements concentration in coal fly ash according to the results is As>Zn>>Pb>>>Mo.

Table. 2: Elements concentration in coal fly ash determined by X-ray fluorescence.

Element	As	Mo	Pb	Zn	Cd
Mass (mg of element per Kg of coal fly ash)	1439	67	557	1284	nd

nd: not detected.

Only Zn was detected in blank columns soil, average concentration 5.663 mg kg^{-1}.

Table 3 shows the average concentration obtained for the analyzed elements after leaching in columns SCA, as well as reference and intervention values for soils of the State of São Paulo according to CETESB [5]. Cadmium and As concentrations in soil were above the Quality Reference Value (VRQ) and Zn and Pb concentrations were below the VRQ. It was not possible to evaluate Mo concentration because of the quantification limit of ICP-OES for this element. According to CETESB, VRQ is the maximum concentration of a substance in the soil which defines a soil as clean. Arsenic was the only element exceeding the Intervention Value (VI) for maximum protection area (APmax). According to CETESB, a substance with concentration above the VI in the soil can represent a potential risk to human health indicating the need of actions for soil remediation.

Table 3 – Average concentration values in soil of columns SCA after leaching and guidelines values.

Element	Guidelines values for soil (CETESB, 2005) (mg Kg^{-1})		Concentration in soil of columns SCA (mg.Kg^{-1})
	Quality Reference Value (VRQ)	APmax Intervention Value (VI)	
As	3.5	35	60.475 ± 1.765 (n=8)
Cd	<0.5	3	1.240 ± 0.055 (n=6)
Zn	60	450	8.513 ± 1.325 (n=8)
Pb	17	180	13.400 ± 2.546 (n=2)
Mo	<4	50	< 20 (n=8)

n : number of replicates

4. CONCLUSION

- ✓ Arsenic concentration in the soil exceeded the intervention value for maximum protection area.
- ✓ Cadmium concentration exceeded the quality reference value.
- ✓ Concentrations of Pb and Zn in the soil did not represent environmental concern.

5. ACKNOLEGEMENTS

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