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Characterization of Catalagzi Fly Ash for Heavy Metal Adsorption

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Abstract**—**Fly ash is a significant waste that is released of thermal power plants and defined as very fine particles that are drifted upward with up taken by the flue gases due to the burning of used coal [1]. The fly-ash is capable of removing organic contaminants in consequence of high carbon content, a large surface area per unit volume and contained heavy metals. Therefore, fly ash is used as an effective coagulant and adsorbent by pelletization [2, 3].

In this study, the possibility of use of fly ash taken from Turkey like low-cost adsorbent for adsorption of zinc ions found in waste water was investigated. The fly ash taken from Turkey was pelletized with bentonite and molass to evaluate the adsorption capaticity. For this purpose; analyses such as sieve analysis, XRD, XRF, FTIR and SEM were performed. As a result, it was seen that pellets prepared from fly ash, bentonite and molass would be used for zinc adsorption.

Keywords**—**Fly ash, heavy metal, sieve, adsorbent.

I. Introduction

FLY ash is a significant waste that is released of thermal power plants and defined as very fine particles that are drifted upward with up taken by the flue gases due to the burning of used coal [1].

Heavy metals [4] are one of the most important contaminants in water and soil. Heavy metals are discharged to the environment by several industries, such as mining, metallurgical, electronic, electroplating and metal finishing. The removal of heavy metals from wastewaters is of critical importance due to their high toxicity and tendency to accumulate in living organisms [5].

Studies on the country and the world of fly ash usage has increased in the last 25 years and as a result of these studies have been identified that fly ash for adsorption of heavy metals from waste water [6, 7] can be used as adsorbent materials.

The aim of this study is to investigate the possibility of use of Catalagzi fly ash like low-cost adsorbents for heavy metal adsorption. Analysis such as sieve analysis, X-Ray Diffraction (XRD), X-Ray Fluorescence (XRF), Scanning electron microscope (SEM) and Fourier Transform Infrared Spectroscopy (FT-IR) were performed to characterize Catalagzi fly ash. Depending on the results of the analysis, morphology and chemical composition of Catalagzi fly ash was investigated.

II. Experimental

A. Materials

The Catalagzi fly ash was acquired from Zonguldak Thermal Power Plant.

B. Equipments

Equipment used for characterization in the present study is listed below:

XRD analysis: Crystalline structures of solids were determined by XRD technique.

Fig. 1 XRD

The X-ray analysis was carried out at an ambient temperature by using a Philips Panalytical X'Pert-Pro diffractometer with CuKa radiation (k = 0.15418 nm) at operating parameters of 40 mA and 45 kV with step size 0.02°

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and speed of 1°/min. Phase identification of solids was performed by inorganic crystal structure database (ICSD) (Fig. 1).

A Panalytical-Minipal4 equipped with an array of 12 analyzing crystals and fitted with a Rh X-ray tube target was used. A vacuum was used as the medium of analyses to avoid interaction of X-rays with air particles (Fig. 2).

Fig. 2 XRF

Cam Scan-Apollo 300 Scanning Electron Microanalyzer was used to take the micrograph of the sample. Sample was mounted on aluminum stubs using conductive glue and was then coated with a thin layer of carbon (Fig. 3).

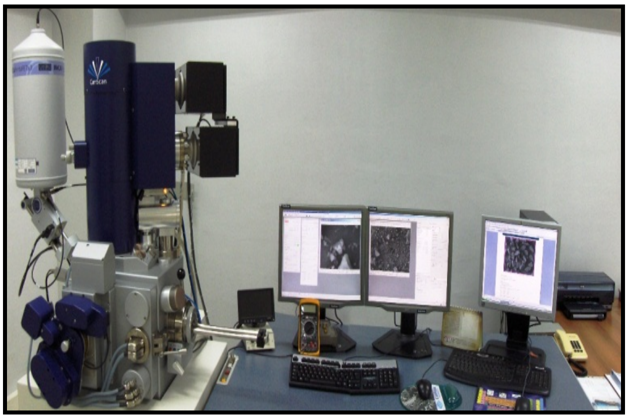

Fig. 3 SEM

FT-IR analysis: Attenuated total reflectance (ATR) of FT-IR spectroscopy (Perkin Elmer Spectrum One) was used in identification of chemical bonds of samples.

Before the analysis, the crystal area had been cleaned and the background collected; the solid material was placed over the small crystal area on universal diamond ATR top plate.

The FT-IR spectrum was achieved after force was applied to the sample, pushing it onto the diamond surface. The IR spectrum was recorded in the spectral range of 4000 to 650 cm^{-1} at ambient temperature and the resolution used was 4 cm^{-1} (Fig. 4).

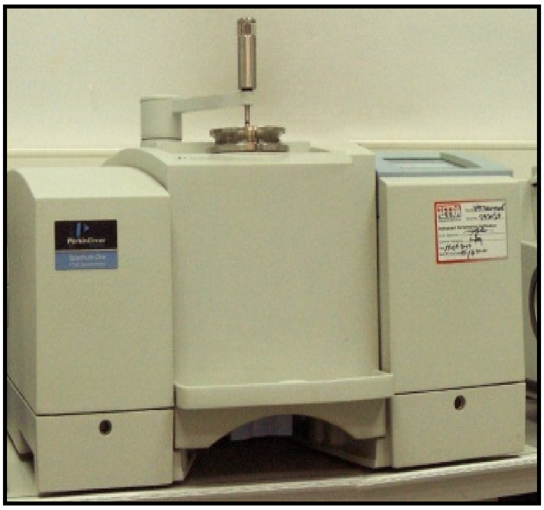

Fig. 4 FT-IR

C. Methods

Fly ashes were characterized by XRD, XRF, SEM and FT-IR to use in adsorption for waste water. Firstly, Catalagzi fly ash (Fig. 5) was sieved by using 0.841 mm, 0.250 mm, 0.15 mm, 0.075 mm and fly ash was dried at 105°C for 24 hours.

Fig. 5 Catalagzi fly ash

III. Results and Discussion

A. Characterizations

XRD, XRF, SEM and FT-IR analyses were carried out by using Philips Panalytical-X'Pert Pro, Panalytical-Minipal4, Cam Scan-Apollo 300 and Perkin Elmer-Spectrum One

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instrument, respectively.

XRD analysis showed that Quartz (SiO_2) and Mullite ($3Al_2O_32SiO_2$) were determined in structure of fly ash (Table I) (Fig. 6).

TABLE I
XRD RESULTS OF CATALAGZI FLY ASH

PDF no	Mineral	Formula
03-065-0466	Quartz	SiO_2
01-079-1454	Mullite	$3Al_2O_32SiO_2$

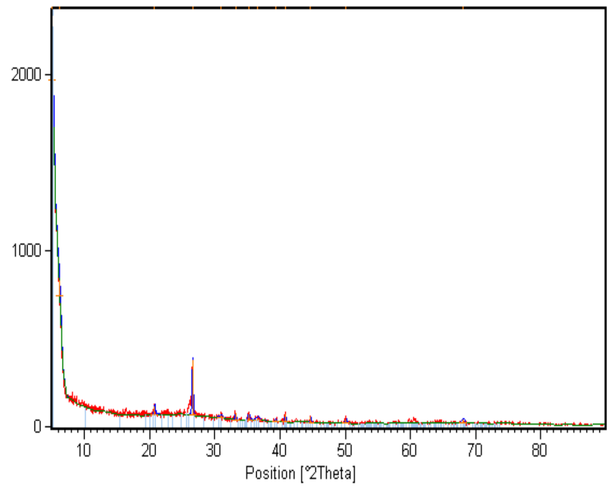

Fig. 6 XRD analysis of Catalagzi fly ash

Chemical composition of Catalagzi fly ash was given in Table II. The fly ash is substantial with silicium dioxide. XRF analysis of Catalagzi fly ash for major and minor components and pellet for XRF analysis are given in Fig. 7 and Fig. 8, respectively.

TABLE II
CHEMICAL COMPOSITION OF CATALAGZI FLY ASH

Fly Ash	Compound	Amount (%)
Catalagzi	Na_2O	0,5
	MgO	2,2
	Al_2O_3	29,2
	SiO_2	57,5
	SO_3	0,28
	K_2O	3,44
	CaO	0,95
	TiO_2	1,03
	Fe_2O_3	4,85

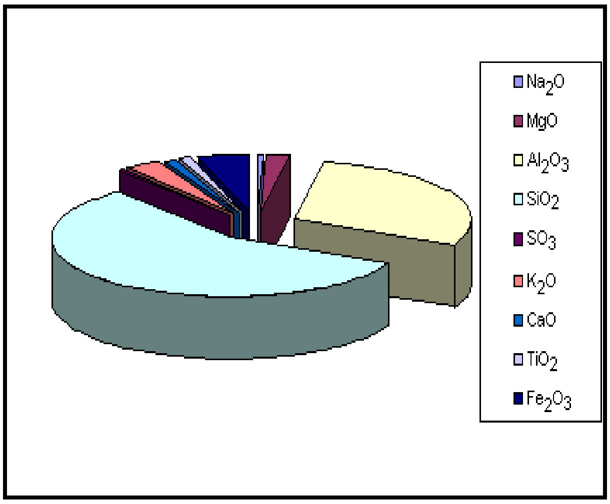

Fig. 7 XRF analysis of Catalagzi fly ash for major and minor components


Fig. 8 Pellet for XRF analysis

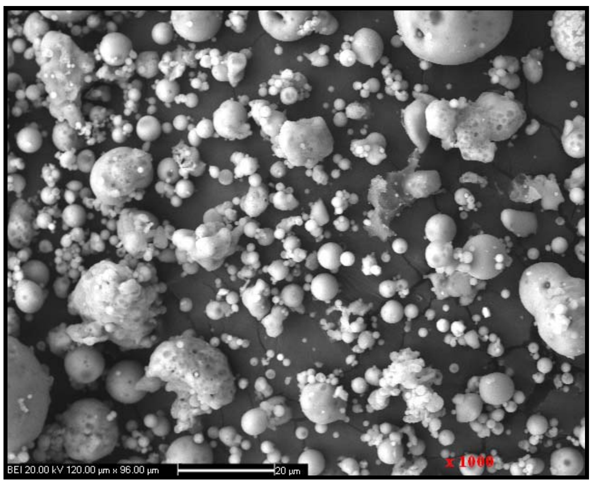

Fig. 9 SEM analysis of Catalagzi fly ash

SEM is one of the best and most widely used techniques for the chemical and physical characterization of fly ash. SEM was used to determine morphological structure of product. The particle size of fly ash changed in range of 1.46 µm and 5.67 µm (Fig. 9).

Before the experimental studies, sieve analysis was performed with ASTM standard sieves (20, 60, 100 and 200 mesh) and the mechanical shaker was used for sieve analysis (Fig. 10). The result is presented in a graph of percent retained in each sieve versus the sieve size as shown in Fig. 11.

These results indicate that size 20-200 mesh of the particles is the main fraction of Catalagzi fly ash.

Fig. 10 Sieving procedure

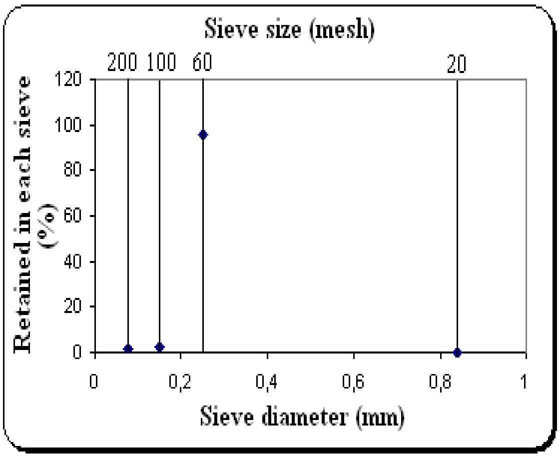

Fig. 11 Sieve analysis of Catalagzi fly ash

The FTIR spectrum of the fly ash is shown in Fig. 6. The results show a broad band 776 cm^{-1}. Three characteristic band centered at around 1023 has been identified. The strong and broad band at 1023 cm $^{-1}$ is due to (Si-O-Si) asymmetric stretching vibration.

Catalagzi fly ash sample centered at this band has the highest SiO_2 content. The band at 776 cm^{-1} can be described for the SO_4^{-2} group (Fig. 12).

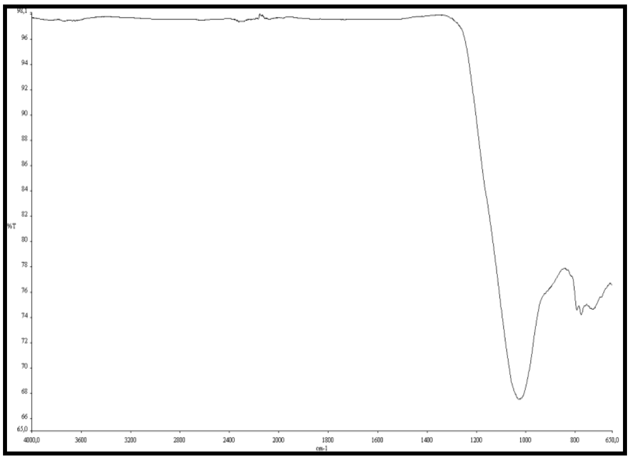

Fig. 12 FT-IR analysis of Catalagzi fly ash

IV. Conclusion

In this study, Catalagzi fly ash will be used in heavy metal adsorption by preparing pellets. Therefore, the selection of proper fly ash is very important. Sieve analysis, XRD, XRF, SEM and FT-IR analysis results showed that Catalagzi fly ash can be used as an adsorbent material for heavy metal adsorption. By this means, Catalagzi fly ash is convenient for adsorption by pelletization.

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