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Comparison Study on Characterization of Various Fly Ashes for Heavy Metal Adsorption

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***Abstract*—**Fly ash is a waste material of coal firing thermal plants that is released from thermal power plants. It was defined as very fine particles that are drifted upward which are taken up by the flue gases. The emerging amount of fly ash in the world is approximately 600 million tons per year. In our country, it is expected that will be occurred 50 million tons of waste ash per year until 2020. The fly ashes can be evaluated by using as adsorbent material. The purpose of this study is to investigate the possibility of use of various fly ashes (Tuncbilek, Catalagzi, Orhaneli) like low-cost adsorbents for heavy metal adsorption. First of all, fly ashes were characterized. For this purpose; analyses such as XRD, XRF, SEM and FT-IR were performed.

***Keywords*—**Adsorbent, fly ash, heavy metal, waste.

I. Introduction

FLY ash is one of the significant waste [1]. Large amounts of fly ash consist by burning of coal in thermal power plants. In recent years, different application areas started to be investigated due to the nature of fly ash waste and polluting the environment. The fly-ash is capable of removing organic contaminants in consequence of high carbon content, a large surface area per unit volume and contained various elements. Therefore, fly ash is used as an effective coagulant and adsorbent [2]-[4].

Heavy metals [5] 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. Heavy metals cannot be degraded nor destroyed [6].

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

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II. Experimental

A. Materials

The fly ashes were acquired from various Electricity Generation Companies.

B. Equipments

One of the equipments used for characterization in the present study is XRd where in this equipment crystalline structures of solids were determined.

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

A Panalytical-Minipal 4 equipped with an array of 12 analyzing crystals and fitted with an 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 [7] (Fig. 2).

Fig. 2 XRF

Cam Scan-Apollo 300 Scanning Electron Microscope 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).

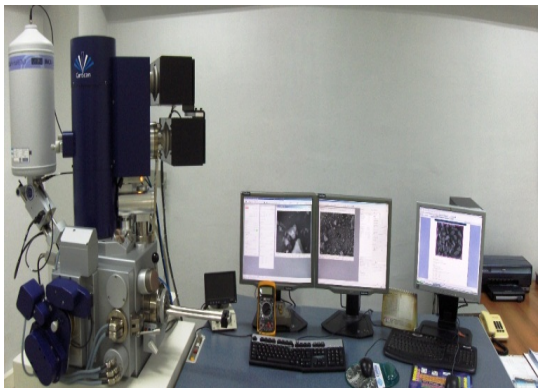

Fig. 3 SEM

Attenuated total reflectance (ATR) of FT-IR spectroscopy (Perkin Elmer Spectrum One) was used in identification of chemical bonds of the 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} [8] (Fig. 4).

C. Methods

Fly ashes were characterized by XRD, XRF, SEM and FT-IR to before using for in the adsorption for waste water. Firstly, fly ashes (Fig. 5) were 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. 4 FT-IR

Fig. 5 Fly ash sample

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 instrument, respectively.

XRD analyses were showed in Tables I-III. The results showed that the structures included Quartz. Chemical compositions of fly ashes were given in Tables IV-VI. The fly ash is substantial with silicon dioxide.

TABLE I
XRD Results of Tuncbilek Fly Ash

PDF no	Mineral	Formula
01-089-1961	Quartz	SiO_2
01-073-0603	Hematite	Fe_2O_3

TABLE II
XRD Results of Catalagzi Fly Ash

PDF no	Mineral	Formula
01-085-1780	Quartz	SiO_2
00-022-0018	Silimanite	Al_2SiO_5
01-089-7194	Iron	Fe

TABLE III
XRD RESULTS OF ORHANELI FLY ASH

PDF no	Mineral	Formula
01-089-1961	Quartz	SiO_2
01-073-0603	Hematite	Fe_2O_3
01-083-1566	Silimanite	Al_2SiO_5

TABLE IV
CHEMICAL COMPOSITION OF TUNCBILEK FLY ASH

Compound	Amount (%)
MgO	3,70
Al_2O_3	22,0
SiO_2	61,5
SO_3	0,84
K_2O	1,40
CaO	1,90
TiO_2	0,72
Fe_2O_3	8,00

TABLE V
CHEMICAL COMPOSITION OF CATALAGZI FLY ASH

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

TABLE VI
CHEMICAL COMPOSITION OF ORHANELI FLY ASH

Compound	Amount (%)
SiO_2	52,9
Al_2O_3	25,5
Fe_2O_3	8,7
CaO	4,75
MgO	3,1
SO_3	2,1
K_2O	2,0
TiO_2	0,63
Na_2O	0,4

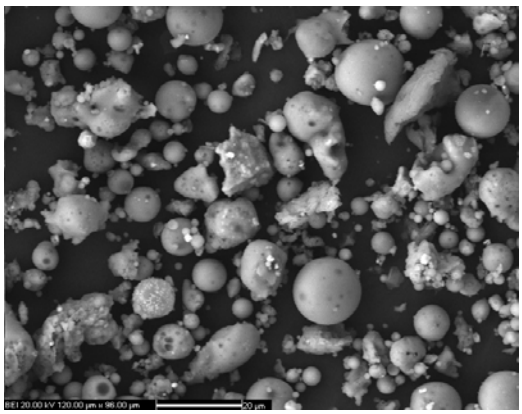

Fig. 6 SEM analysis of Tuncbilek fly ash

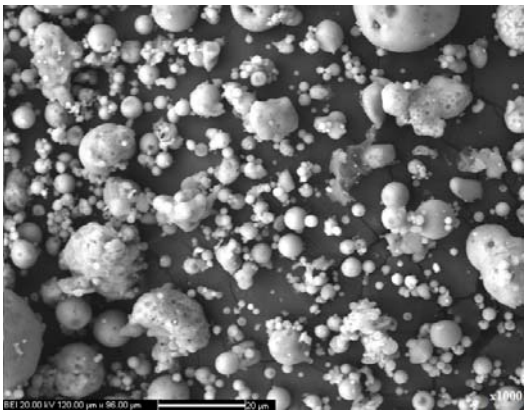

Fig. 7 SEM analysis of Catalagzi fly ash

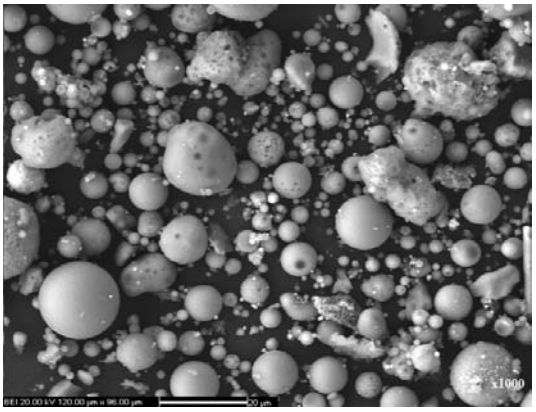

Fig. 8 SEM analysis of Orhaneli fly ash

SEM was used to determine morphological structure of products. The particle size of Tuncbilek changed in range 1.35 µm to 6.45µm (Fig. 6). The particle size of Catalagzi changed in range 1.46 µm to 5.67µm (Fig. 7). The particle size of Orhaneli changed in range 1.12 µm to 18.30 µm (Fig. 8).

The FT-IR spectrum of the fly ashes is shown in Fig. 9-11. The results show a broad band 800 cm^{-1}. Three characteristic bands centered at around 1100 has been identified. The strong and broad band at about 1100 cm^{-1} is due to (Si-O-Si) asymmetric stretching vibration.

Fly ash samples centered at this band has the highest SiO_2 content. The band at 850 cm^{-1} can be described for the SO_4^{-2} group (Figs. 9-11).

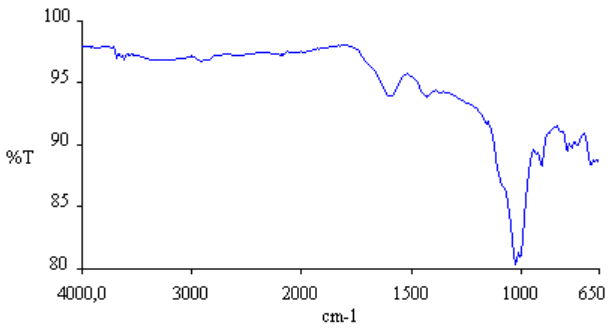

Fig. 9 FT-IR analysis of Tuncbilek fly ash

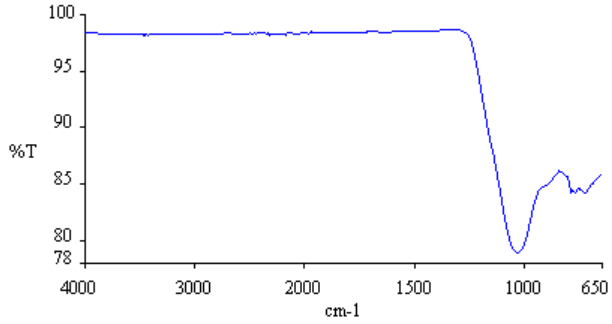

Fig. 10 FT-IR analysis of Catalagzi fly ash

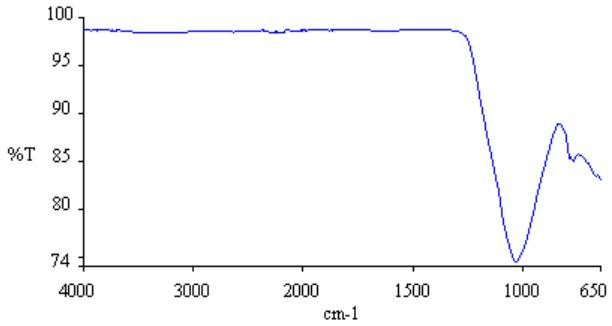

Fig. 11 FT-IR analysis of Orhaneli fly ash

Before the experimental studies, sieve analysis was performed with ASTM standard sieves and the mechanical shaker was used for sieve analysis (Fig. 12). These results indicate that size 20-200 mesh of the particles is the main fraction of fly ashes.

Fig. 12 Sieving procedure

IV. Conclusion

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

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