

Study on Characterization of Tuncbilek Fly Ash

A.S. Kipcak, N. Baran Acarali, S. Kolemen, N. Tugrul, E. Moroydor Derun, S. Piskin

Abstract—Fly ash is one of the residues generated in combustion, and comprises the fine particles that rise with the flue gases. Ash which does not rise is termed bottom ash [1]. In our country, it is expected that will be occurred 50 million tons of waste ash per year until 2020. Released waste from the thermal power plants is caused very significant problems as known. The fly ashes can be evaluated by using as adsorbent material.

The purpose of this study is to investigate the possibility of use of Tuncbilek fly ash like low-cost adsorbents for heavy metal adsorption. First of all, Tuncbilek fly ash was characterized. For this purpose; analysis such as sieve analysis, XRD, XRF, SEM and FT-IR were performed.

Keywords—Fly ash, heavy metal, sieve, adsorbent

I. INTRODUCTION

FLY ash is a significant waste. It is released of thermal power plants and defined as very fine particles. The particles are drifted upward with up taken by the flue gases due to the burning of used coal. Emerging the amount of fly ash in the world is approximately 600 million tons per year [2].

Large amounts of fly ash consist by burning of coal in thermal power plants. In recent years, the various 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 Al, Fe, Ca, Mg, and Si elements. Therefore, fly ash is used as an effective coagulant and adsorbent [3]-[5].

Heavy metals [6] 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.

A. S. Kipcak, is with the Yildiz Technical University, Department of Chemical Engineering, Davutpasa Campus, 34210 Esenler, Istanbul, Turkey (phone: 0090-212-3834751; fax: 0090-212-3834725; e-mail: skipcak@yildiz.edu.tr / seyhunkipcak@gmail.com).

N. Baran Acarali, is with the Yildiz Technical University, Department of Chemical Engineering, Davutpasa Campus, 34210 Esenler, Istanbul, Turkey (phone: 0090-212-3834766; fax: 0090-212-3834725; e-mail: nbaran@yildiz.edu.tr / nilbaran@gmail.com).

S. Kolemen, is with the Yildiz Technical University, Department of Chemical Engineering, Davutpasa Campus, 34210 Esenler, Istanbul, Turkey (phone: 0090-212-3834790; fax: 0090-212-3834725; e-mail: seymakolemen@hotmail.com).

N. Tugrul, is with the Yildiz Technical University, Department of Chemical Engineering, Davutpasa Campus, 34210 Esenler, Istanbul, Turkey (phone: 0090-212-3834776; fax: 0090-212-3834725; e-mail: ntugrul@hotmail.com).

E. Moroydor Derun, is with the Yildiz Technical University, Department of Chemical Engineering, Davutpasa Campus, 34210 Esenler, Istanbul, Turkey (phone: 0090-212-3834756; fax: 0090-212-3834725; e-mail: moroydor@gmail.com).

S. Piskin, is with the Yildiz Technical University, Department of Chemical Engineering, Davutpasa Campus, 34210 Esenler, Istanbul, Turkey (phone: 0090-212-3834729; fax: 0090-212-3834725; e-mail: piskin@yildiz.edu.tr).

The removal of heavy metals from wastewaters is of critical importance due to their high toxicity and tendency to accumulate in living organisms. Moreover, heavy metals can not be degraded or destroyed [7].

The aim of this study is to investigate the possibility of use of Tuncbilek 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 Tuncbilek fly ash. Depending on the results of the analysis, morphology and chemical composition of Tuncbilek fly ash was investigated.

II. EXPERIMENTAL

A. Materials

The Tuncbilek fly ash was acquired from Electricity Generation Company.

B. Equipments

Equipment used for characterization in the present study are 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 CuK α radiation ($k = 0.15418$ nm) at operating parameters of 40 mA and 45 kV with step size 0.02° and speed of $1^\circ/\text{min}$. 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 [8] (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} [9] (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, Tuncbilek 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 Tuncbilek fly ash

III. RESULTS AND DISCUSSION

A. Characterizations

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

XRD analysis showed that Hematite (Fe_2O_3) and Quartz (SiO_2) were determined in structure of fly ash (Table I) (Fig. 6).

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

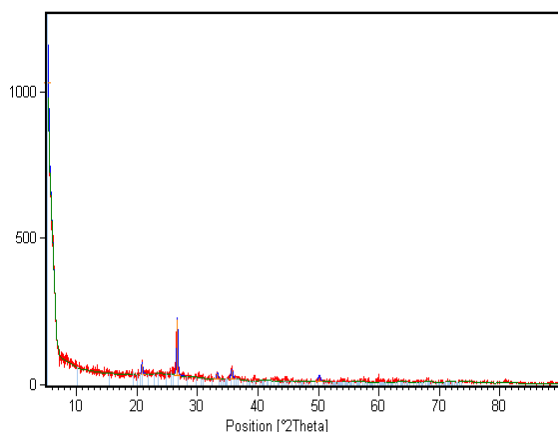


Fig. 6 XRD analysis of Tuncbilek fly ash

Chemical composition of Tuncbilek fly ash was given in Table II. The fly ash is substantial with silicium dioxide. XRF analysis of Tuncbilek fly ash for major and minor components is given in Fig. 7.

TABLE II CHEMICAL COMPOSITION OF TUNCBILEK FLY ASH		
Fly Ash	Compound	Amount (%)
Tuncbilek	MgO	3,70
	Al ₂ O ₃	22,0
	SiO ₂	61,5
	SO ₃	0,84
	K ₂ O	1,40
	CaO	1,90
	TiO ₂	0,72
	Fe ₂ O ₃	8,00

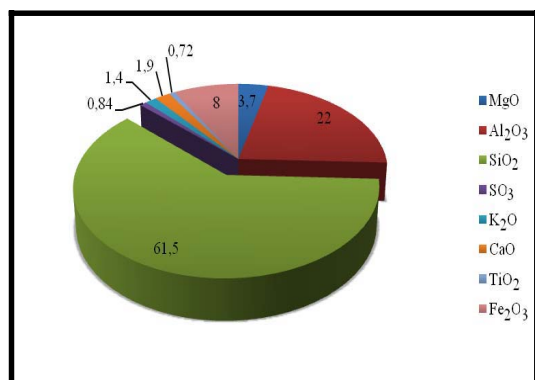


Fig. 7 XRF analysis of Tuncbilek fly ash for major and minor components

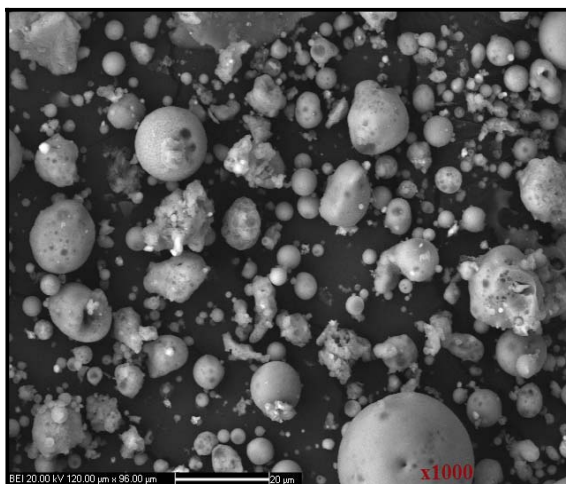


Fig. 8 SEM analysis of Tuncbilek fly ash

SEM was used to determine morphological structure of product. The particle size of fly ash changed in range of 1.35 μm and 6.45 μm (Fig. 8).

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. 9). The result is presented in a graph of percent retained in each sieve versus the sieve size as shown in Fig. 10.

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



Fig. 9 Sieving procedure

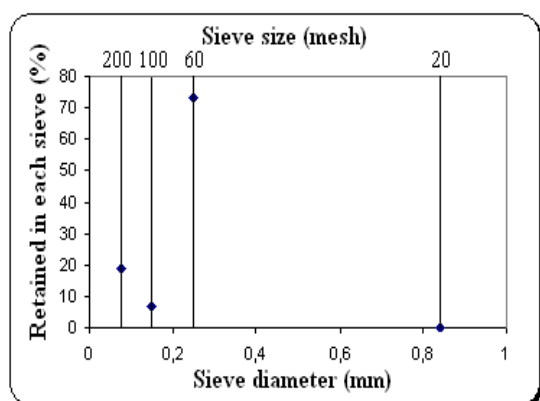


Fig. 10 Sieve analysis of Tuncbilek fly ash

The FTIR spectrum of the fly ash is shown in Fig. 6. The results show a broad band 800 cm^{-1} . Three characteristic band centered at around 1100 cm^{-1} has been identified. The strong and broad band at 1100 cm^{-1} is due to (Si-O-Si) asymmetric stretching vibration.

Tuncbilek fly ash sample 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 (Fig. 11).

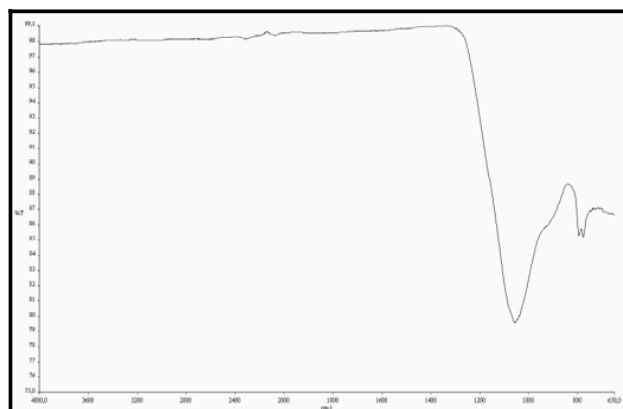


Fig. 11 FT-IR analysis of Tuncbilek fly ash

IV. CONCLUSION

In this study, Tuncbilek 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 Tuncbilek fly ash can be used as an adsorbent material for heavy metal adsorption. By this means, Tuncbilek fly ash is convenient for adsorption by pelletization.

ACKNOWLEDGMENT

This work is funded by YTUBAPK project no 2011-07-01-KAP01.

REFERENCES

- [1] http://en.wikipedia.org/wiki/Fly_ash

- [2] A. Bilodeau, and V. M. Malhotra, "High- volume fly ash system. Concrete solution for sustainable development", *ACI Mater.J.*, vol. 97, pp. 41-49, 2000.
- [3] P. K. Deb, A. J. Rubin, A. W. Launder, and K. H. Mancy, "Removal of COD from wastewater by fly ash", *Proceedings of 21st. Ind. Waste Conf., Purdue Univ., Indiana, Ext.Ser.*, vol. 121, 1967, pp. 848-860.
- [4] P. Cheremisinoff, "Coal fly ash: power plant waste or by-product", *Power Eng.*, vol. 92, pp. 40-41, 1988.
- [5] M. B. Vandebusch, and N. J. Sell, "Fly ash as a sorbent for the removal of biologically resistant organic matter", *Resour. Conserv. Recy.*, vol. 6, pp. 95-116, 1992.
- [6] H. Polat, and D. Erdogan, "Heavy metal removal from waste waters by ion flotation", *J. Hazard. Mater.*, vol. 148, pp. 267-273, 2007.
- [7] M. J. González-Muñoz, M. A. Rodríguez, S. Luquea, and J. R. Álvarez, "Recovery of heavy metals from metal industry waste waters by chemical precipitation and nanofiltration", *Desalination*, vol. 200, pp. 742-744, 2006.
- [8] http://www.waternet.co.za/we/docs/vernon_removal_of_mercury_and_lead_ions.pdf
- [9] <http://www.scribd.com/doc/40053128/NaBH4-ulexite>



Azmi Seyhun Kipcak was graduated from Department of Chemical Engineering in Ege University in 2002. After completing the university studies he graduated from Bilgi University from the department of Master of Business Administration in 2004. He worked in Kultur University from 2003 to 2007 as a research assistant then he transferred to Yildiz Technical University in 2008, where he started his M.Sc. studies about Chemical Engineering in 2006. He completed his M.Sc. studies at Yildiz Technical University in 2009 and started to Ph.D. studies at the same year. He studied on neutron shielding with boron minerals and the characterization of boron minerals by using XRD, XRF, FT-IR, Raman, DTA/TG, DSC and ICP-OES at the graduate studies now he is studying on the synthesis of magnesium borates from different raw materials and wastes. Also he is improving the neutron shielding studies with the synthesized materials and working on the element analysis of Turkish Teas and Coffees. Another research field about the studies is the fly ash characterization.



Nil Baran Acarali was graduated from B.Sc in Food Eng. Department at Trakya Univ., Edirne in 2000, both M.Sc. and Ph.D. in Chemical Eng. Department at Yildiz Tech. Univ., Istanbul in 2003 and 2008, respectively. The major field is boron technology. She has published six articles in science citation index, over twenty nine studies in international conference proceedings and national proceedings. Her articles have forty two cited references. The research interests are supercritical fluids technology, polymer technology and boron technology. The research field in boron technology is zinc borate production. Dr. Baran Acarali is an online member of boron research.



Seyma Kolemen was graduated from Department of Chemical Engineering in 2010. She started her M.Sc. studies about Chemical Engineering in 2010. She studies about boron minerals and fly ashes.



Nurcan Tugrul was born in Gaziantep in 1973. Tugrul was graduated from B.Sc., M.Sc. and Ph.D. in Chemical Eng. Department at Yildiz Technical University, Istanbul. Her research interest is in the area of chemical technologies, evaluation of industrial wastes, food drying. She has many articles and studies in international and national conference proceedings and articles.



Emek Moroydor Derun was born in Istanbul in 1976. Moroydor Derun was graduated from B.Sc. in 1998, M.Sc. in 2000 and Ph. D. in 2005 from Chemical Engineering Department at Yildiz Technical University, Istanbul. Her research interest is in the area of waste management, lightweight concrete, semi conductive materials and boron technology. She has many articles and studies in international and national conference proceedings and articles.



Sabriye Piskin graduated from Istanbul Technical University on Chemical Engineering with M.Sc. degree in 1974. She completed a Ph.D. degree at the same department in 1983. Her research interests include boron minerals and compounds, hydrogen storage technologies, fuel cell applications, materials characterization, coal, waste management, corrosion, implants and synthetic materials production.