

Multi-Elemental Characterization of Coal and Coal Ash Samples by Non-destructive Particle Induced X-Ray Emission Technique

Shashank Singh^{1*}, Mumtaz Oswal^{1,2}, Ashok Kumar¹, B.R. Behera¹, S. Santra³ and K.P.Singh¹

¹Physics Department, Panjab University, Chandigarh, 160014, INDIA

²Dev Samaj College for Women, Sector 45 B, Chandigarh, 160014, INDIA

³Nuclear Physics Division, Bhabha Atomic Research Centre, Mumbai - 400085, INDIA

* email: shashank8005@gamil.com

Introduction

Particle Induced X-Ray Emission Technique (PIXE) is an online non destructive accelerator based technique which is best suited for the multi-elemental analysis of the variety of the samples. It covers a wide range of elements $13 < Z < 92$ without any destruction of the sample.

In this study, we have chosen coal and coal ash samples which have complex matrix. These samples contain a variety of toxic elements up-to part per million ranges [1]. The coal ashes are used in cement making, soil stabilization, concrete, metal matrix composites, bricks and many other areas [2]. Besides, all these importance of coal ash it effects our environment in many ways. It contaminates water, soil and air with its toxic elements. So for the safer use of these ashes, elemental characterization is needed.

Sample Collection and Target Preparation

Coal, coal fly ash and coal pond ash samples were collected from three thermal power plants in Haryana. For making target conducting, each air dried sample was homogeneously mixed with the graphite into the ratio 2:1. The mixture was then pressed into pellet of diameter 12 mm using a hydraulic press. The targets of NIST reference material coal bituminous 1632a, coal sub-bituminous 1635 and coal fly ash 1633a were used as standard samples.

Experiment Details

The experiment was carried out using 3 MV horizontal Pelletron accelerator (9SDH-2, NEC, USA) at Institute of Physics, Bhubaneswar. The thick targets of samples were mounted on a steel ladder in the scattering chamber having vacuum

of the order of the 10^{-6} torr. The target ladder was placed at 45° to the beam direction. The proton beam of 3 MeV energy with current ~ 10 -15 nA was used to bombard the targets. Si(Li) detector having an active area 30 mm^2 with a resolution of 165 eV at 5.9 keV with beryllium window of 12.3 micron was placed at 90° with respect to the beam direction at a fixed distance of 8.5 cm from the target ladder to detect the characteristic x-rays emitted from the targets. The obtained spectrum was analyzed using GUPIXWIN software package.

Result and Discussion

Fig.1 shows the typical X-ray spectrum of the coal fly ash sample.

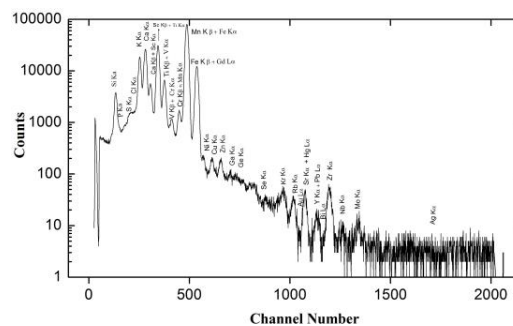


Fig. 1 Typical PIXE Spectrum of Coal Fly Ash

Table:1 represents the elemental concentration of the coal, coal fly ash and coal pond ash samples which were collected from the Rajiv Gandhi Thermal Power Station (Yamunanagar, Haryana). Total 29 elements were determined in these samples in which Si, K, Ca, Ti and Fe were found in major concentration and P, S, Cl, Sc, V, Cr, Mn, Ni, Cu, Zn, Ga, Se,

Kr, Rb, Sr, Y, Zr, Nb, Ag, Gd, Au, Hg, Pb and Bi were present at trace level.

Table : 1 Results of the elemental concentration in part per million (ppm)

Elements	Coal	Coal Fly Ash	Coal Pond Ash
Si	10184.1	23312.1	21927.4
P	59.7	23.4	110.3
S	450.4	7.7	143.4
Cl	34.8	36.2	21.7
K	523	1184.8	1424.7
Ca	993.3	1702.9	1524.4
Sc	31.7	59.0	56.6
Ti	2032.3	3178.4	4053.7
V	113.7	203.5	275.5
Cr	43.6	50.0	69.2
Mn	63.3	222.0	250.8
Fe	10278.2	23178.8	28784.0
Ni	16.4	46.1	75.4
Cu	39.8	67.9	107.5
Zn	28.1	92.4	256.7
Ga	22.4	38.2	120.3
Se	9.6	12.1	18.2
Kr	1.6	44.1	99.2
Rb	49.4	131.0	210.3
Sr	128.2	314.1	365.2
Y	29.1	91.8	120.7
Zr	326.0	619.5	625.3
Nb	16.7	61.0	73.2
Ag	72.1	49.5	0
Gd	26.2	127.5	61.8
Au	0	36.7	0
Hg	11.9	24.6	30.8
Pb	65.8	92.9	166.5
Bi	16.8	44.0	16.6

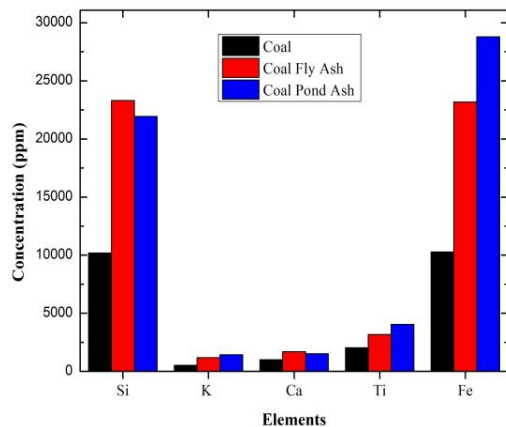


Fig. 2 Variation of major elements in coal, coal fly ash and coal pond ash

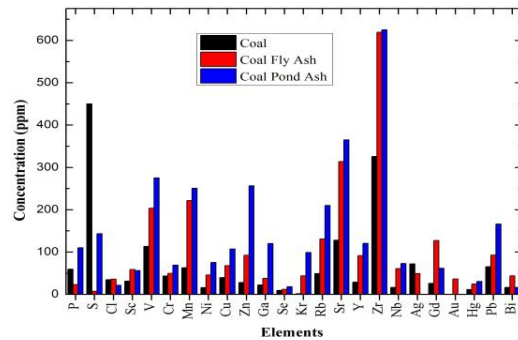


Fig. 3 Variation of minor elements in coal, coal fly ash and coal pond ash

The variation of major elements (Si, K, Ca, Ti and Fe) is shown in Fig. 2. These elements are present approximately twice in coal fly ash and coal pond ash sample as compared to the coal. The variation of trace elements (P, S, Cl, Sc, V, Cr, Mn, Ni, Cu, Zn, Ga, Se, Kr, Rb, Sr, Y, Zr, Nb, Ag, Gd, Au, Hg, Pb and Bi) is shown in the Fig. 3. The trace elements are also find in the higher concentration in fly ash and pond ash. This variation in elements is due to the high temperature during the coal combustion [3]. The toxic elements V, Cr, Mn, Ni and Sr are also present in significant concentration.

Conclusion

Due to the presence of the toxic elements in coal fly ash and coal pond ash, a suitable chemical process is needed before using it in various fields like agriculture and construction.

Analysis of coal and coal ashes is very difficult due to their complex matrix and fine particle size. PIXE works as a realistic tool to determine simultaneously multi-elements in the coal and coal ash sample with a high level of precision without affecting the sample.

References

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 [3] International Journal of Coal Geology **86** 349-356.