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RESEARCH ARTICLE

CHARACTERIZATION OF WARDHA VALLEY COAL ASH

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ABSTRACT

Wardha Valley Coalfield is known to be the oldest coalfield in Maharashtra state and is ideally situated in the centre of India. The properties of coal fly ash are strongly dependent on the geological origin and the combustion process of the coal. It is important to characterize fly ash in detail to ascertain its potential uses as raw material in the production of high value products. A study conducted for the characterization of Wardha valley coal ash sample using scanning electron microscopy (SEM) and energy dispersive spectroscopy (EDX). Both the surface and internal structure of fly ash particles were analyzed. The elemental concentrations, as determined by EDS, were consistent with X-ray diffraction data.

INTRODUCTION

Coal is the primary source of energy. Coal accounts for over 50% of India's commercial energy consumption and about 78% of domestic coal production is dedicated to power generation. The inventory of Coal in India is estimated to be around 285.86 Billion Tonnes (as on 1st April, 2011), which constitute about 0.8% of the Global Coal reserves, whereas it's production contribution is around 7%. India today is one of the major coal producers in the World and ranks at 3rd position after China and USA. Coal deposits in India are mainly occurring in lower Gondwana formation of permian period and eocene / oligocene formation of tertiary period. About 99.5% of Indian coal belongs to Gondwana formation. Gondwana coal fields belong to period of Gondwana age. Nearly 3/4th of coal deposits are found in Damodar valley (Damuda series). Godavari, Mahanadi. Son and Wardha valley.

Major part of these reserves is bituminous coal, occurring in basins, lying east of 78°E Longitude and above 20oN Latitude, along prominent present day rivers. Coal deposits of tertiary period are best developed in North Eastern Region while Lignite deposits in Southern & Western part of the country. The first published reference of Coal Mining in India dates back to 1774. However, in the beginning of the 20th Century, the national coal production reached to a level of around 6 Million Tonnes. The industry got significant boost during the two great wars. With the advent of Independence, the need for larger and efficient coal production was stressed. This led to formation of National Coal Development Corporation Limited in 1956, which in turn stepped up production in States like Maharashtra, Madhya Pradesh and Orissa, where at that point of time, the mining conditions were not as favourable as in Bengal -Bihar belt.(WCL, 2011) When burning hard coal or bio fuels in a boiler, heat, flue gases and ash are produced. The heaviest and largest ash particles fall down in the furnace, and are called bottom ash and are usually extracted below the furnace. The particles of the bottom ash are generally large and often have a certain amount of unburned organic material in it, often it is wetted in the process. The smaller ash particles are suspended in the flue gases, are removed through Electrostatic precipitators, Bag filters, flue gas desulphurization etc and remaining fly ash leave the plant with flue gases from stack. The lighter and smaller particles of ash caught in Electrostatic precipitators (filter), this ash is called fly ash. The component of fly ash varies significantly, which depends on the makeup of coal being burned. But all the fly ash includes some amount of silicon dioxide (SiO2) both amorphous and crystalline and calcium oxide (CaO). Coal contains various trace elements in various quantities and during combustion process of coal they all get enriched as a result of carbon loss as carbon dioxide and trace elements get associated on the surface of ash particles due to evaporation and condensation.

The characteristics of the coal used and the type of installations used for the generation of a fly ash have a direct influence on chemical and mineralogical composition of fly ash (Benito *et al*., 2001).Fly ash material solidifies while suspended in the exhaust gases and is collected by electrostatic precipitators or filter bags. Since the particles solidify while suspended in the exhaust gases, fly ash particles are generally spherical in shape and range in size from 0.5 µm to 100 µm. They consist mostly of Silicon dioxide (SiO_2), Aluminium oxide (Al_2O_3) and Iron oxide (Fe_2O_3). which is present in two forms: amorphous, which is rounded and smooth and crystalline, which is sharp & pointed. Fly ashes are generally highly heterogeneous, consisting of a mixture of glassy particles with various identifiable crystalline phases such as quartz, mullite, and various iron oxides (en.wikipedia.org). Two classes of fly ash are defined by ASTM C618: Class F fly ash and Class C fly

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Table 1 Chemical Analysis of Wardha valley fly ash.

	Minerals in form of Oxides in FLY ASH	
Sr. No	Minerals	Percentage (%)
1	Silica as SiO2	64.03
2	Aluminium as Al2O3	24.18
3	Iron as Fe2O3	4.04
4	Titanium as TiO2	2.72
5	Calcium as CaO	1.50
6	Magnesium as MgO	0.84
7	Sodium as Na2O	0.20
8	Potassium as K2O	0.79
9	Sulphite as SO3	0.77
10	Phosphorous Pentaoxide as P2O5	0.28

ash. The chief difference between these classes is the amount of calcium, silica, alumina, and iron content in the ash. The chemical properties of the fly ash are largely influenced by the chemical content of the coal burned i.e., anthracite, bituminous, and lignite ("ASTM C618 - 08 Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete").

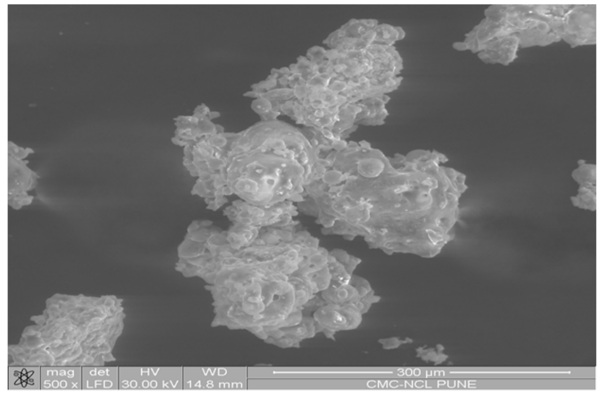

Fig. 1 SEM Micrograph of Wardha valley fly ash.

Class F fly ash

The burning of harder, older anthracite and bituminous coal typically produces Class F fly ash. This fly ash is pozzolanic in nature, and contains less than 20% lime (CaO). Possessing pozzolanic properties, the glassy silica and alumina of Class F fly ash requires a cementing agent, such as Portland cement, quicklime, or hydrated lime, with the presence of water in order to react and produce cementitious compounds. Alternatively, the addition of a chemical activator such as sodium silicate (water glass) to a Class F ash can lead to the formation of a geopolymer.

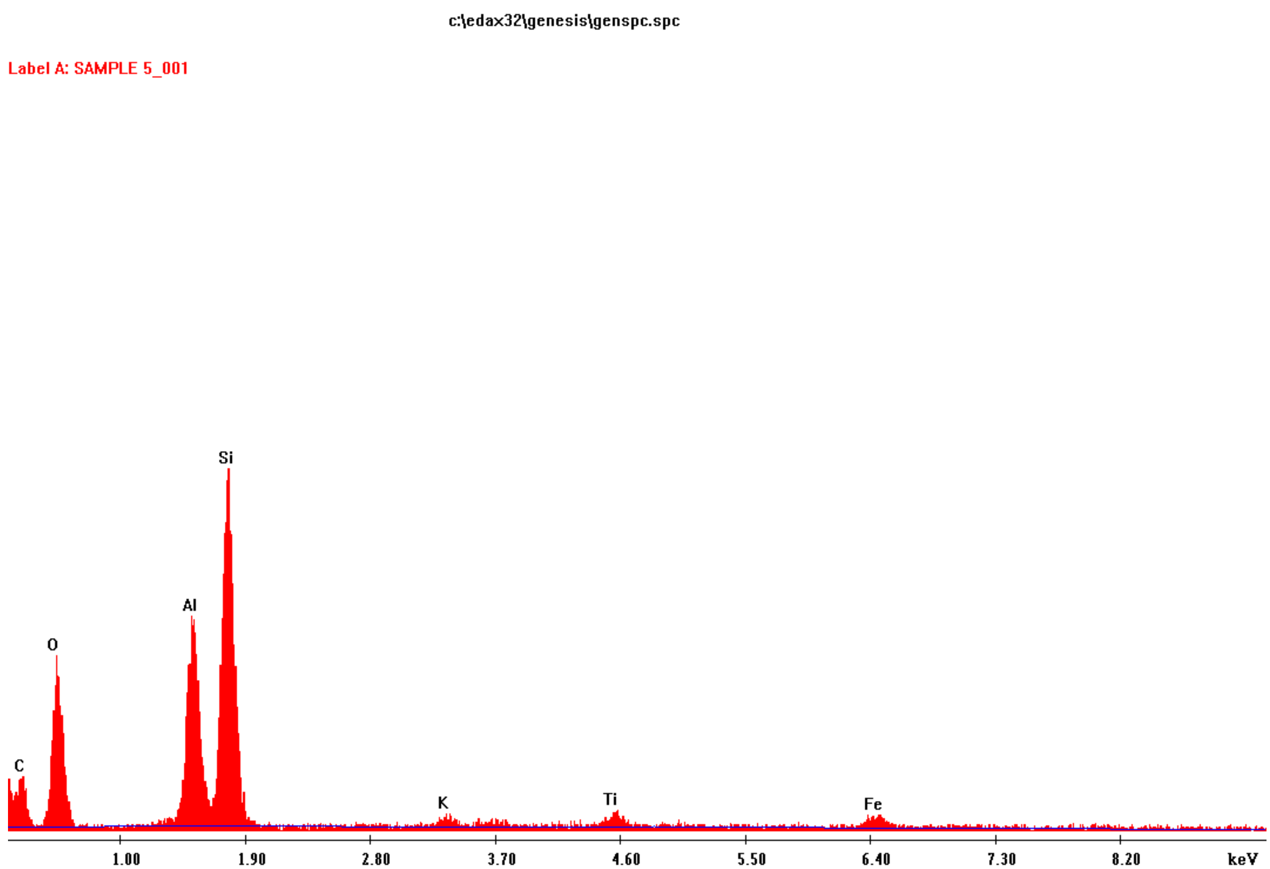

Fig. 2 EDX of Wardha valley fly ash.

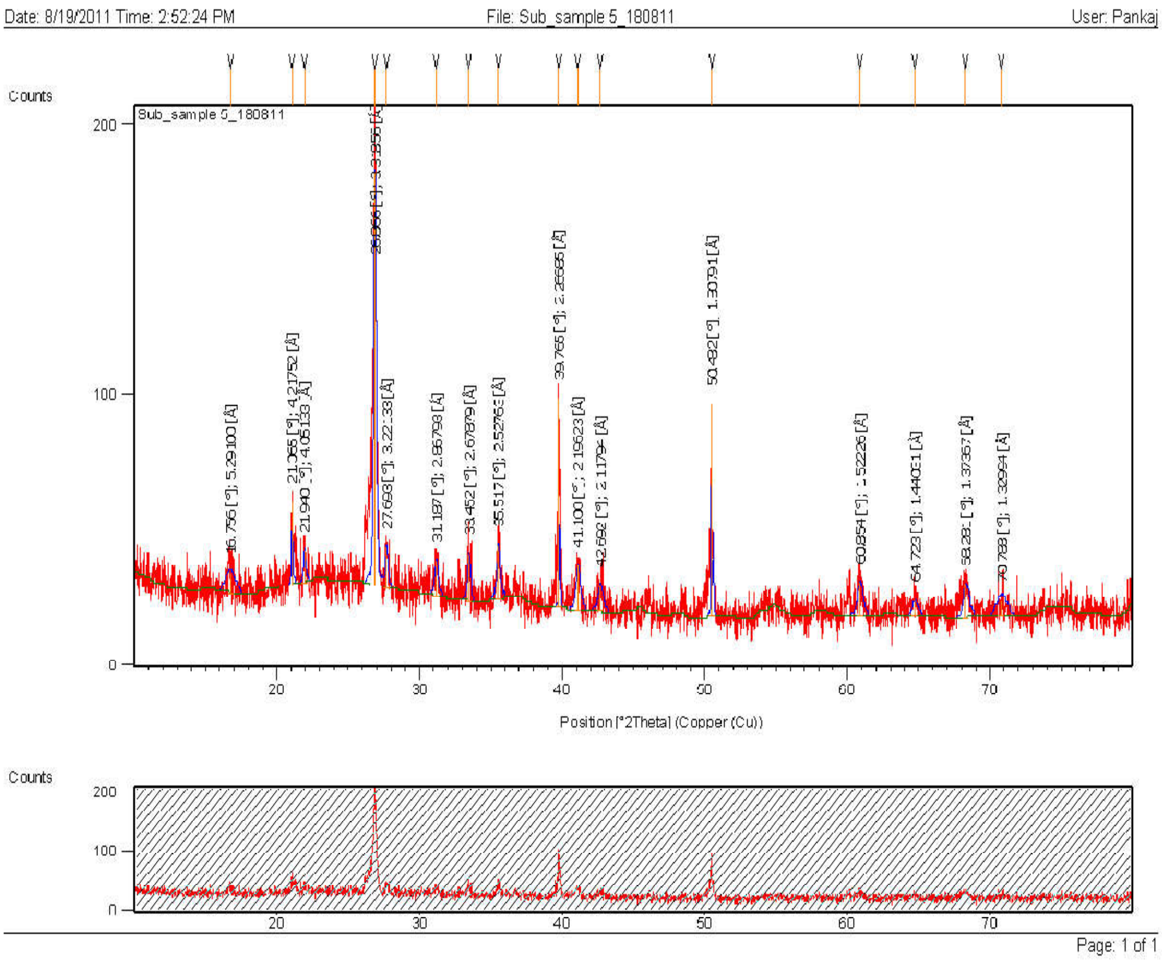

Fig. 3 X-ray diffraction pattern of Wardha valley fly ash.

Class C fly ash

Fly ash produced from the burning of younger lignite or sub bituminous coal, in addition to having pozzolanic properties, also has some self-cementing properties. In the presence of water, Class C fly ash will harden and gain strength over time. Class C fly ash generally contains more than 20% lime (CaO). Unlike Class F, self-cementing Class C fly ash does not require an activator. Alkali and sulfate (SO_4) contents are generally higher in Class C fly ashes.

MATERIAL AND METHOD

Fly ash sample was collected from thermal power plant. Morphological analysis using SEM- EDX has been carried out. SEM- EDX analysis is done using Scanning Electron Microscope Model S-440 LEO Electron Microscopy Equipped with an Oxford link-Isis Energy Dispersive X-ray analyser (EDX).Morphology shown in Figure 1 & 2. Mineralogy of the fly ash was studied using a Phillips PW-1710 X-ray diffractometer (XRD) employing Cu *Kα* radiation at 1.2º/minute scanning rate. Mineralogy shown in Figure 3. Chemical Analysis of Wardha valley fly ash shown in Table 1.

RESULTS

From Figure 1, it is revealed that the amorphous nature of Wardha valley fly ash. From Figure 2, 3 and Table 1, it is revealed that presence of high percentage of Silicon dioxide (SiO_2), Aluminium oxide (Al_2O_3) and Iron oxide (Fe_2O_3). The diffractogram (Figure 3) shows the X-ray diffraction pattern for particle size $\leq$ 30 μm. It was found that the fly ash consisted of crystalline minerals mullite, quartz, hematite and small amounts of calcium oxide with large characteristic peaks of quartz (SiO_2). This result is similar to that reported for a fly ash investigated by (Sarkar A *et al*, 2006). The intensity of quartz is very strong, with mullite forming a chemically stable and dense glassy surface layer. The low calcium oxide intensity is characteristic of low-Ca Class-F fly ash and similar to the result reported by (Giere R. *et al*, 2003).

Conclusion

XRD (X-ray diffraction), SEM (Scanning Electron Microscopy) and EDX (Energy Dispersive Spectroscopy) analysis showed that low calcium fly ash is a better source for long term soil stabilization due to its alkaline nature also it has good potential for use in geotechnical applications. Its low specific gravity, freely draining nature, ease of compaction due to amorphous nature, good frictional properties, etc. can be gainfully exploited in the reclamation of low-lying areas with value addition of soil texture. This not only solves the problems associated with the disposal of fly ash (like requirement of precious land, environmental pollution, etc.) but also helps in conserving the precious top soil required for growing food.

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