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A STUDY OF FLY ASH OF TALCHER (MAHANADI BASIN) & SINGARENI (GODAVARI BASIN) COALS OF INDIA

(With Special Reference to its Chemistry &Management)

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Abstract:

Thousands of coal fired thermal power plants working all over the world. These are to produce electricity, leaving coal ash as waste. The coal ash produced every day is not taken seriously in the beginning .But now with few millions of tons of ash being generated every day, the disposal of ash is the burning problem of today for the scientists all over the World. As the other energy sources are limited, usage of coal is increasing year after year. Hence more attention is paid on the usage of coal ash. In this coal ash, the bottom ash left in the boiler will be about 20%. The remaining is the fly ash collected through the electrostatic precipitators. So the importance of fly ash. This fly ash problem is more in India due to high (40%) ash content of the Indian coals so the problem of chemistry and management of fly ash has been taken up. The microscopic, X-ray, chemical, engineering and beneficiation studies were identified.With regards to ashes we have deliberately chosen the captive thermal power plant of Visakhapatnam steel plant as it uses the coal from Talcher coal Fields. The Talcher coal fields are in north India (Orissa state) and formed in the Mahanadi river basin. To represent a south India coal field the captive thermal power plant of Kothagudem is choosen which gets coal from the Singareni coal fields formed in the Godavari river basin in Andhra Pradesh state.

Key Words: *Disposal, Microscopic, Talcher coal Fields.*

I. INTRODUCTION:

In any Country, Electricity is the major energy source for domestic, industrial and agricultural fields. For India, the unreliability of the monsoon & the uncertainty of hydelpower, the meagre oil reserves, the problems associated with safety and disposal of nuclear waste and the high technology needed for tapping non-conventional energy resources single out coal as the primary and principal source of electricity.Combustion of coal for power generation leaves large quantities of ash. Increasing dependence on coal as an energy source and high ash content of Indian coals has resulted in vast quantities of fly ash production. This ash is produced in furnace of the boiler at temperatures in the range of 1100o-1450o C in the presence of nearly 20% excess air.In thermal power stations the bottom ashconstitute approximately 20% of the total ash content of the coal. The remaining enters the convective zones of the boiler. This is called FLY ASH. This ash is collected through electro static precipitators (ESP), sometimes in association with mechanical arrestors. However, about 1% of fly ash escape into the atmosphere through chimney and contributes to air pollution.India has produced approximates 450 million tonnes of coal for 2011-12 year. Nearly 65% to 70% of this coal (with 40% ash content on average) is being utilized for power generation. Therefore approximately 180 million tonnes of ash is produced during 2011-12. The disposal of this waste poses a big problem now days. A-200 MW power station generates almost 1600 tones of fly ash per day and requires 250 hectares of land with a depth of 7 meters for an ash pond. Realising the seriousness of this issue, attempts have been made to find ways and means of understanding the fly ash produced in the country, with the ultimate goal of utilizing the ash in large quantities. Hence the study of characterization of fly ash from the point of view of optical, physical, chemical and mineralogical properties, besides applied studies like beneficiation, brick making and zeolite production has been taken up.

II. SCOPE OF THE PROBLEM

(A). With low grade ore and cost escalations in all spheres, mineral economics is gaining considerable importance in the present day earth science studies. Applying the mineral economics to the mineral wastes is the aim of the present study.

(B). In India, though the problems of disposal and utilization of fly ash have been in focus since 1955, very little of this waste has been used. The problems of pollution of air and water by fly ash have not been sufficiently recognized as to become factors for accelerating utilization of fly ash. The disposal as well as its effects on the environment is increasingly alarming the researchers in this field of study.

© According to Rene Dubos (1969), "we shall soon experience on environmental collapse unless a grassroot movement makes it imperative that public and the scientific establishments give high priorities to the study and control of the forces that are rapidly making the earth a place unfit for human life".

(D) As part of waste utilization and pollution prevention, the fly ash is studied to understand its mineralogy, chemistry and engineering properties. It is processed to beneficiate some of the elements like aluminium and toxic elements like cadmium, cobalt, nickel, copper, lead and zinc and mercury. Ash is treated for zeolite production. Agro-chemical studies are carried on fly ash.

(E). The study was limited to two coal fields, one in the Orissa state (Talcher) and the other in the Andhra Pradesh state (Singareni). Both formed in different basins and with different geological settings (Fig.1)

III. Recent Review of the study:

[i]There is an enormous stress on the coal-based thermal power plants (TPPs) to meet the energy requirements of our country. Currently 82 coal-fired TPPs exist in India and disposal of the increasing amounts of coal ash is becoming a serious concern to the environmentalists as the re-use/utilization rate is too low and inadequate or unscientific management results multi-furious geo-environmental degradation. Fly ash disposal and management of Bakreshwar Thermal Power Plant (BkTPP), the 3rd largest TPP in West Bengal has become a major issue of concern. This is because; the fly ash dumping ponds at Panuria and Raipur village has got filled-up about a year ago. The slurry from these ponds directly flow into the surrounding land and to the river Chandrabhaga and Bakreshwar leading to air, water and soil pollution. Overflow and blow-off the ash towards residential areas is causing unnecessary human exposure and has serious health risks. The villagers are even more affected as the ash is deposited in the fields and farmers use ash-laden water to irrigate. Due to huge siltation the river hydro-morphological serene have totally changed even upto 15 kilometer downstream. The river bed and banks resembles a cemented floor rising about 0.8 metre in some places. Recently (Nov, 27, 2014) the Eastern bench of the National Green Tribunal (NGT) directed the state-run Bakreshwar TPP to clean up the Chandrabhaga and Bakreshwar rivers within 15 days or face coercive measures. This article attempts to highlight the multifarious geo-environmental problems arising out of the overflow of fly-ash pond and management options for fruitful utilization of this solid waste.

[ii]Fly ash (FA)-a coal combustion residue of thermal power plants has been regarded as a problematic solid waste all over the world. India has some of the largest reserves of coal in the world. Indian coal has high ash content and low calorific value. Nearly 73% of the country's total installed power generation capacity is thermal of which coal-based

generation is 90%. Some 85 thermal power stations, besides several captive power plants use bituminous and sub-bituminous coal and produce large quantities of fly ash. High ash content (30% - 50%) coal contributes to these large volumes of fly ash. Current annual production of Fly ash, a by-product from coal based thermal power plant (TPPs), is about 112 million tones (MT). Some of the problems associated with Fly ash are large area of land required for disposal and toxicity associated with heavy metal leached to groundwater. Fly ash, being treated as waste and a source of air and water pollution till recent past, is in fact a resource material and has also proven its worth over a period of time. The present paper reviews the potential applications for coal fly ash as a raw material: as a soil amelioration agent in agriculture, use, in highway embankments, in construction of bricks, as an aggregate material in Portland cement, filling of low lying areas etc in the manufacture of glass and ceramics, in the production of zeolites, in the formation of mesoporous materials, in the synthesis of geopolymers, for use as catalysts and catalyst supports, as an adsorbent for gases and waste water processes, and for the extraction of metals. Thus fly ash management is a cause of concern for the future. This article attempts to highlight the management of fly ash to make use of this solid waste, in order to save our environment

[iii]Energy requirements for the developing countries in particular are met from coal-based thermal power plants. The disposal of the increasing amounts of solid waste from coal-fired thermal power plants is becoming a serious concern to the environmentalists. Coal ash, 80% of which is very fine in nature and is thus known as fly ash is collected by electrostatic precipitators in stacks. In India, nearly 90 mt of fly ash is generated per annum at present and is largely responsible for environmental pollution. In developed countries like Germany, 80% of the fly ash generated is being utilized, whereas in India only 3% is being consumed. This article attempts to highlight the management of fly ash to make use of this solid waste, in order to save our environment.

IV. GEOLOGY OF THE AREAS

Representative samples of fly ash were collected from the captive thermal power plants of Visakhapatnam Steel Plant, Visakhapatnam and Kothagudem thermal power Plant, Kothagudem. For Kothagudem thermal power station, coal is supplied from Singareni coal fields of Andhra Pradesh where as Visakhapatnam Steel Plant's thermal power plant is getting the coal from Talcher coal fields of Orissa.

Table 1. MEAN MINERAL/GLASS PHASES OF VISAKHAPATNAM AND KOTHAGUDEM FLY ASHES

Mineral Name	Visakhapatnam Fly Ash (%)	Kothagudem Fly Ash (%)
Glass Content	53.86	54.29
Quartz	7.34	6.92
Mullite	10.51	9.64
Magnetite	6.12	5.59
Feldspar	1.61	1.58
Heamatite	1.25	1.22
Pyrite	0.61	0.52
Spinels	3.12	3.25
Sillumanite	1.25	2.61
Gypsum	1.01	1.03
Kaolinite	6.61	7.25
Zeolites (Wairakite, Laumontite Chabazite, Edingtonite etc)	5.15	4.75
Baddeleyite	0.81	0.62
Graphite	0.12	0.11
Others	0.61	0.62

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With the moderate CaO content in the studied fly ashes, it is unusual to observe anhydrite (CaSO4). The availability of CaSO4 in these ashes promotes the self pozzolanic reactions such as ettringite (Ca6A12(SO4)(OH)12 25 H2O) formation which is responsible for the stored ash to set-up, upon contact with water. Mineral ettringite was identified in both the studied fly ashes through X-ray studies.

Moderate X-ray intensity reflections of Sodalite are observed in the coarser fraction (0.090mm) of Kothagudem fly ash sample. Sodalite is generally observed as a major devitrification product along with heamatile, pyroxene and plagioclase phases (Diamond, 1984). The mechanism of sodalite phase formation may have the reaction of Na and Ca sulphates with the aluminosilicate glass. X-ray study of magnetic separated fraction of studied fly ashes reveals presence of heamatite and iron spinels (ferrite spinel). Certain trace elements that were partitioned into pyrite in the coal may also remain partitioned in the ferrite spinel phase in fly ash (Lauf, 1981).

Opaque spheres of magnetite, translucent brownish black spheres with finer inclusions of iron oxides, internal recrystallites of mullite and transparent spheres of low relief alkaline silicates are commonly observed during optical studies of both Visakhapatnam and Kothagudem fly ashes (Plates). X-ray patterns of bottom ashes of both the studied areas indicate that graphite is present with moderate intensities. Graphite peaks are partially attributed to the presence of unburnt carbon in the fly ash (Henry and Knapp, 1980).

V. X-RAY STUDIES

Fly ash samples of both Visakhapatnam and Kothagudem contain a number of new minerals which occur as minute segregations. These mineral occurrences are identified only through x-ray studies. The occurrence of such mineral assemblages from the studied fly ashes are reported for the first time. These zeolites and other minerals may have recrystallised minerals due to temperature conditions at thermal power station.

Gismondine:

Rare zeolite, gismondine (CaA12Si2O84H2O) is identified from fly ash samples of both the studied areas. X-ray data (Table No.4.2) is similar to that of JCPDS file number is 20-452. X-ray patten reveals that the mineral crystallizes in monoclinic system with possible space group P21/C. The unit cell parameters were determined as ao=10.021Ao(VF) and 10.028 Ao (KF); bo = 10.562 Ao (VF) and 10.565 Ao (KF); Co= 9.828 Ao (VF) and 9.841Ao (KF);V=1039.15Ao3(VF) and 1041.65Ao3(KF); β =92046'(VF) and 92.465'(KF) with Z=4. The density calculated from the x-ray data is 2.222 (X) (VF) and 2.226 (X) (KF). The strongest intensities are from (300), (121), (202), (004) and (015) hkl values.

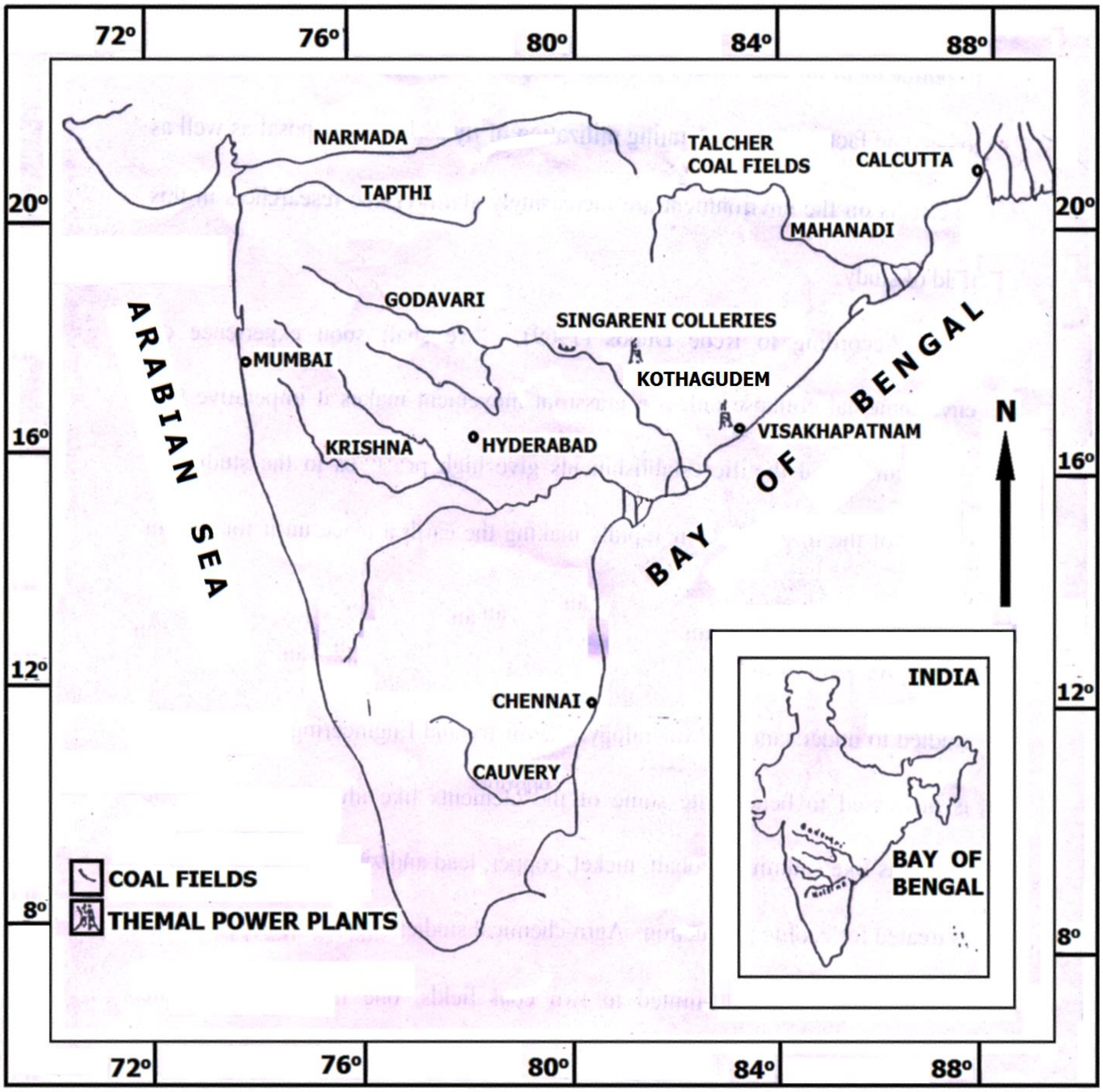

FIG. 1 LOCATION MAP

VI. FLY ASH MANAGEMENT METHODS:

Fly ash utilization in India is of very low order. It can be divided into three classes.(Rajender,1988)

Low value high volume utilization is in applications like land and mine fills, and in the control of spontaneous combustion of coal in underground mines.High value low volume utilization is where special characterstics of fly ash are used, as for example, for waste water treatment and soil treatment for agriculture purposes and as soil stabilizer for embankments,pavements roads.

Medium value utilization is where its pozzilona cement, ready mixed fly ash concrete, sintered fly ash light weight bricks, cellular concrete, fly ash – crushed dust – lime building bricks, etcAvailability of waste as raw materials.

An attempt has been made, for manufacturing bricks with fly ash, hydrated lime, blast furnace slag and calcined gypsum. The raw materials used in the brick manufacture were thoroughly characterised from the point of size analysis, mineralogy and chemistry including reactivity. Hence they arre described individually as follows.

Fly ash :

It is a fine grained powder produced after the combustion of coal while producing electricity. It is characterised by the presence of glass, amorphous silica, quartz,feldspar and mullite and other minerals. Glass and quartz are responsible for the pozzolonic activity in fly ash. (Prasad et.al., 1986). The detailed chemical composition of fly-ash has been given (Table No.6.21). Availability of fly ash is enormous in Visakhapatnam as the captive thermal power plant of Visakhapatnam Steel Plant is producing 2200 - 2500 tonnes of ash per day. Another firm M/s. Mc DowelI & Co. Ltd., (polymers division) also has a captive power plant and is producing 600 tonnes ash per day. If the brick plants are set up nearer this ash source, transportation cost will be reduced greatly. It is considered inadvisable to use ash containing more than 5% carbon. The ash should be dry as the dry ash is found to be more suitable for brick making Chakrabarthi, 1977). Wet ash is loosing, to some extent, its reactibility.

Bulk density of Visakhapatnam Steel Plant's fly ash is relatively low (0.96 grams/cubic cm). Cope (1962) recorded that the bulk density of fly ash is in the range of 0.56 grains/cubic cm. to 1.13 grams/cubic cm. Low bulk density makes fly ash a good material for light weight blocks. However, it is also responsible for the incrementation of dust formation, which creates problems in the transportation and storage of dry fly ash (Mishra and Shukla, 1986), besides polluting the atmosphere.

Electric conductivity of fly ash has been determined with water extracted from it. Of Visakhapatnam Steel Plant's fly ash, it is relatively high. For soils, electric conductivity is 2.5±0.1. Townsend and Hodgson (1973) reported a range of electric conductivity of fly ash extracts of 8 to 13 in mhos/cm.

VII. CONCLUSIONS:

1. Large amounts of zeolites are produced by treating fly ash with NaOH.This helps in establishing the ash as a water purifier.

2. The fly ash contains exchangeable cations of Zn, Fe, Ca, Mg, Na and K.So the ash can be used as agro-chemical material for difficient and acidic soils.

3. High strength bricks are commercially made from this fly ash inassociation with other industrial wastes like slag, hydrated lime, red mud, quarrydust and industrial gypsum.

4. Fly ashes proved to become a raw material for a variety of uses and maynot be called a "Waste" in future.

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