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# Petrological and biological studies on some fly and bottom ashes collected at different times from an Indian coal-based captive power plant

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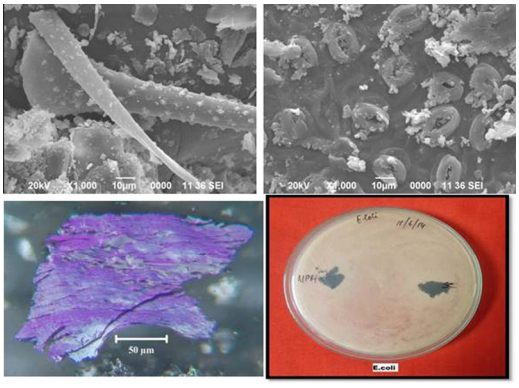
## HIGHLIGHTS

- Petrological and biological aspects of Indian coal-derived fly ash are addressed.
- The petrology of coal-derived fly and bottom ashes is dominated by glass and spinel.
- The deposition of coal fly ash over the plants leaves reduces the photosynthesis rate.
- Coal-derived fly ash affects the stomatal conductance in plants leaves.

## GRAPHICAL ABSTRACT

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## ABSTRACT

India has about a tenth of the world's coal reserves, much of it with high mineral content. These coals produce a large amount of fly ash, which can affect human health and environmental quality aspects during utilization. In this paper, the petrological and biological aspects of some industrially important Indian coal fly ash (CFA) from a coal-based captive power plant are addressed. The petrology of the CFAs is also studied for the samples collected in different times. The study has revealed that the CFAs contain mainly glass fragments, spinel, quartz, and other minerals in lesser quantities. Fly ash carbons were present as chars, possibly from the incomplete combustion of the coals (bituminous and/or subbituminous) used in the power plant. The deposition of CFAs over the leaves of different plant species reduces the photosynthesis rate by about 95% within a period of 2 h. The CFAs also show minor effects to some test microbes. This investigation will be useful in assessment of the environmental impact of a coal-based power plant.



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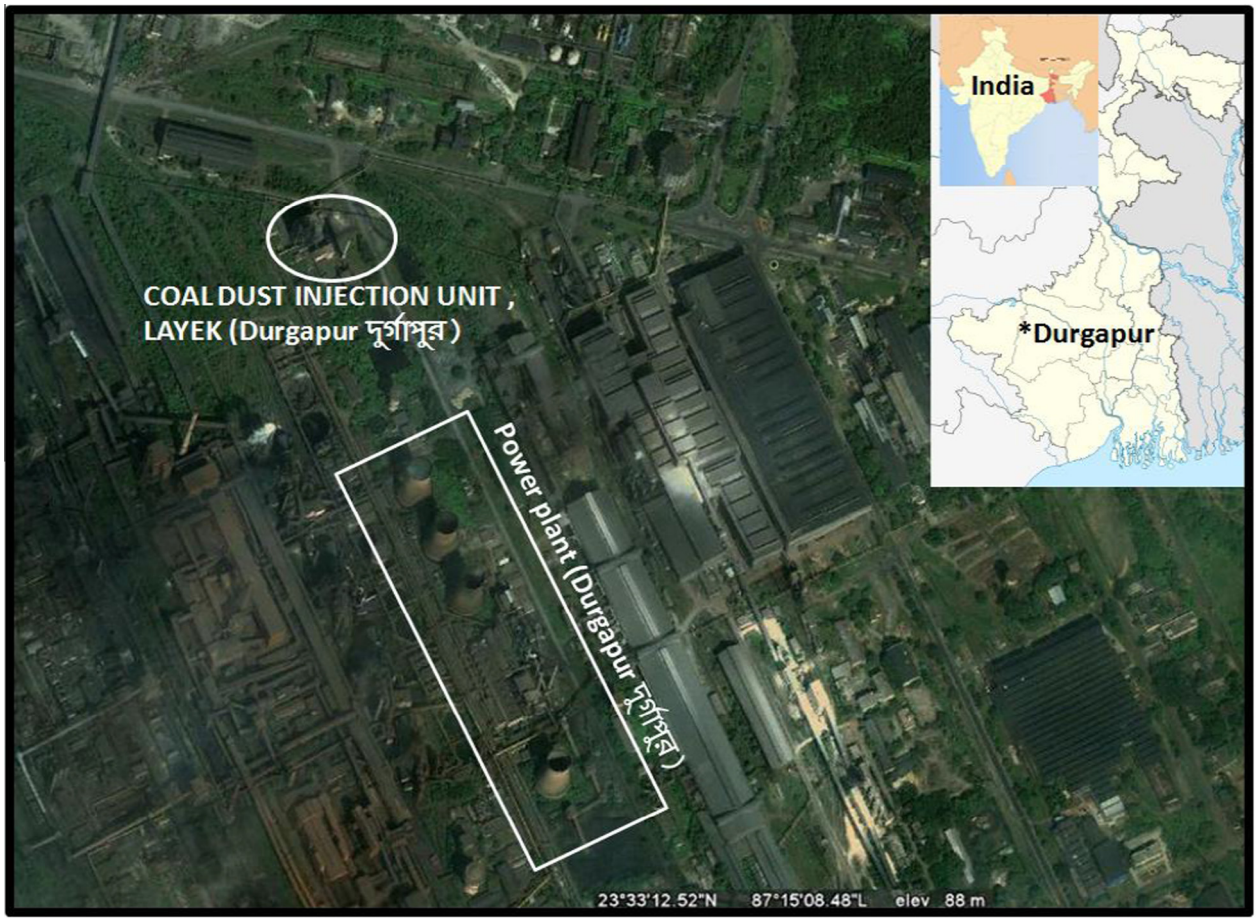


**Fig. 1.** Area illustration of the coal-based power plant.

## 1. Introduction

There are about 88 coal-based power plants in India, which form the major source of fly ash in the country. The generation of fly ash from coal-based power plants in India was 131 MT/year in 2012–13 and, with the commissioning of new thermal power plants and with the increasing use of low-grade coal of high ash yield, the production of ash is likely to go up to 300–400 MT/year by 2016–17 [1]. The coal-derived fly ashes pose serious environmental and ecological problems if present in sufficient quantities [2–5]. However, fly ash can be either an industrial waste material and ecological nuisance or a valuable raw material [6]. A large number of technologies have been developed for gainful utilization and safe management of this fly ash under the concerted efforts of "Fly Ash Mission" of the Govt. of India since 1994. For all these purposes, characterization needs to be done before their further processing [7].

Coal combustion ash consists of two distinct products: bottom ash (CBA) and fly ash (CFA). Depending upon the source and makeup of the coal being burned, the components of fly ash vary considerably, but all Indian fly ash includes substantial amounts of silicon dioxide ($SiO_2$) (both amorphous and crystalline) and calcium oxide (CaO), both being endemic ingredients in many coal-bearing rock strata [8]. Fly ash is a potential substitute for cement, the most common form of fly ash utilization, and other industrial and agricultural applications [9]. Fly ash contains trace elements such as Zn, As, Se, and Pb [10]; adsorbs Hg from the flue gas stream; and also has also been considered as a source of base metals, Ga and Ge, and rare earth elements [11–18].

The aspects of mineralogical studies of coal-derived fly ash are very much important for minimization of their environmental pollution. Thus, pre-characterization of coal fly ash may lead to better environmental management. In this paper, we describe the petrological characterization of some CFA and CBA from an Indian

**Table 1**
Chemical characteristics of feed coal and coal fly ash (as received basis; wt.%).

| Samples | Ash | M | VM | FC | C | H | N | $S_{total}$ | O |
|---|---|---|---|---|---|---|---|---|---|
| Feed coal | 43.00 | 5.5 | 13.5 | 38.0 | 81.3 | 4.49 | 0.86 | 1.37 | 11.98 |
| Fly ash | 89.6 | 1.72 | – | – | 6.0 | 0.36 | – | 0.15 | – |
| | $SiO_2$ | $Al_2O_3$ | $Fe_2O_3$ | CaO | MgO | $Na_2O$ | $K_2O$ | Others | |
| Feed coal | 60.12 | 26.66 | 4.24 | 3.73 | 1.27 | 0.76 | 0.86 | 2.36 | |
| Fly ash | 62.76 | 25.53 | 3.41 | 0.90 | 0.60 | 0.13 | 0.05 | 6.62 | |

M: Moisture, VM: Volatile Matter, FC: Fixed Carbon, C: Carbon, H: Hydrogen, N: Nitrogen, $S_{total}$: Total Sulfur, O: Oxygen.