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Description of Physical and Biological Properties of Fly Ash and Scope of Its Various Use in Agriculture Crop Production

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In the last few decades, various alternate energy sources have come into the limelight, but the hyperbolic use of coal as a prime energy source cannot be counterbalanced especially country like India where plenty of coal reserves are found. This coal combustion produces lots of byproduct whose management and disposal had become an unsolved problem hence it is the need of the hour that different method must be discovered for its proper disposal or its utilization for alternate purposes. Fly ash is disposed either by wet or dry method. In wet method the fly ash is washed out with water in artificial lagoons and is called Pond Ash, while in dry method it is dumped in landfills and fly ash basins. Both of these methods lead to degradation of soil and are harmful to human health also these methods of disposal are very costly so there is an urgent need for the techniques for safe and profitable utilization of fly ash.

Use and Scope of fly ash in agriculture

- **Impact on yield:-** Yield increase has been reported for all crops with application of fly ash. The crops include cereals, pulses, oil seeds, cotton, sugarcane, fodder crops, horticultural crops, ornamental & medicinal plants. The increase in yield of cereal crops have been reported 10-15%, in case of pulses and oil seeds 20-25% and in vegetable as well as in other crops up to 40%.
- **Impact on soil health:-** It has been observed that the addition of fly ash to the soil results in multi-beneficial effects including (i) improvement in the available N, available P_2O_5 and available K_2O, as also in the contents of available secondary nutrients like Ca^{++} & Mg^{++} and available micronutrients such as Zn, Mn, Cu, in soil, and (ii) significant improvement in the physico-chemical properties (like bulk density, maximum water holding capacity, pH, electrical conductivity, etc.) of various kind of soils resulting in better soil health.
- **Fly ash as a source of silicon:-** The fly ash in general reacts with soil and releases Si which can be effectively used as a source of nutrient for crops. The benefit of Si was highlighted by scientists as spotlight wherever the Si sources of material viz., rice straw, rice hull ash, sugarcane baggasse ash and other available industrial bye products. In recent years the importance of Si fertilization has been realized in view of intensive cultivation of crops where depletion of Si occurs in rice soils which responded to Si sources.

- **Fly ash as an insecticide and pesticide:-** carrier extensive studies made so far in India have concluded that the fly ash could be a good insecticide and an active carrier in chemical and herbal insecticides for use against various kinds of pests infesting different crops like, rice, vegetables, oil seeds, fruit plants including at store grains. There is also scope for application of the fly ash as a carrier in developing insecticides to check house-hold pests like, cockroaches etc.
- **Fly ash as a water conserver:-** One of the studies showed that fine pond fly ash when incorporated@ of 25t/ha in a highly percolating sandy loam soil increased the average grain yield of rice and wheat by 3.9% and 4.12% respectively over the control. Cultivation of rice required 14 to 17% less irrigation whereas in case of wheat it required 14 to 20% less irrigation water.
- **Vermin composted fly ash:-** Among different methods of composting of organic materials, vermin composting technology is recently emerging as an important one owing to simplicity as well as high efficiency of this technology in producing better quality compost, as compared to traditional methods of composting. Use of fly ash with organic and mineral wastes will not only help in extracting more amount of plant nutrients into available forms from insoluble mineral fractions in fly ash, but will also enrich the material with organic matter for improving the soil health.
- **Use of fly ash for reclamation of sodic soil:-** Fly ash has also been successfully demonstrated for reclamation of sodic soil. The effect of pond ash alone and in combination with other amendments on eradication of sodicity is found suitable for replacement of gypsum at much lower cost. The application of fly ash and gypsum either alone or with farm yard manure had a synergistic positive effect in increasing the yield of paddy, wheat and mustard in highly sodic soil. Results of all the fields' experiment/trials indicate that based on the degree of alkalinity/salinity pond ash can effectively substitute 50% gypsum requirement. Application of pond ash at 1.5% (30t/ha) can substitute 50% gypsum requirement and about 6% (120t/ha) pond ash can replace 100% gypsum requirement.
- **Use of fly ash in forest plantation:-** The bio-metric parameters such as germination rate, height and girth of the plant and sapling grades of various species grown with fly ash have found significantly improved as compared to control without exhibiting any adverse effect.

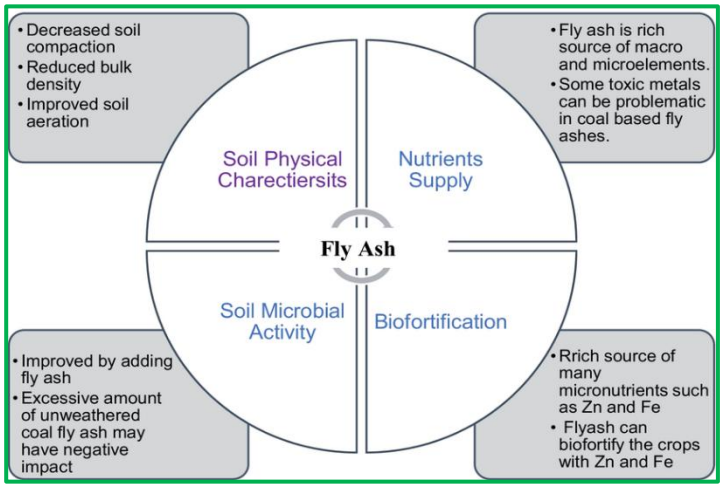
Types of fly ash

The quality of coal depends upon its rank and grade. The coal rank arranged in an ascending order of carbon contents is: Peat << Lignite << sub-bituminous coal << bituminous coal << anthracite. Indian coal is of mostly sub bituminous rank followed by bituminous and lignite (brown coal). The ash content in Indian coal ranges from 35 % to 50 % and the methods of fly ash transfer i.e. dry, wet and/or both are present There are generally three categories of coal ashes available from thermal power stations and are mentioned below:

1. Dry fly ash:- Collected from different rows of electrostatic precipitator in dry form. The fly ash produced from the burning of pulverized coal in a coal-fired boiler is a fine grained, Powdery particulate material that is carried off in the flue gas and usually collected from the flue gas by means of electrostatic precipitators, bag-houses, or mechanical collection devices such as cyclones.
2. Bottom ash:- Collected at the bottom of the boiler furnace and is characterized by better geotechnical properties.
3. Pond ash:- Fly ash and bottom ashes are mixed together with water to form slurry which is pumped to the ash pond area. In the ash pond the, ash gets settled and excess water is decanted. This deposited ash is pond ash.

Physico-chemical properties

Fly ash is often characterized by a number of mineralogical, physical and chemical properties, which are further governed by factors like the nature of the parent coal, conditions of combustion, type of emission control devices and storage and handling methods (Carlson and Adriano, 1993). Therefore, ash produced by burning anthracite, bituminous and lignite coal has different compositions. Fly ash generally occurs as ultra-fine particles with an average diameter of <10 µm, with distinctive properties like low to medium bulk density, high surface area and light texture The specific gravity of fly ash ranges from 2.1 to 2.6 g cm^{-3}. Mean particle density for non-magnetic and magnetic particles is 2.7 and 3.4 g cm^{-3}, respectively (Natusch and Wallace, 1974). Bulk density of fly ash varies from 1 to 1.8 g cm^{-3} while the moisture retention ranges from 6.1% at 15 bar to 13.4% at 1/3 bar. Fly ash addition alters the physical properties of soil such as texture, bulk density, water holding capacity and particle size distribution. Chemically, 90–99% of fly ash is comprised of Si, Al, Fe, Ca, Mg, Na and K with Si and Al forming the major matrix. There are mainly two types of ash: Class F (low lime) and Class C (high lime) based on silica, alumina and iron oxide content of fly ash. Al in fly ash is mostly bound in insoluble aluminosilicate structures, which considerably limits its biological toxicity .It is substantially rich in trace elements like lanthanum, terbium, mercury, cobalt and chromium. Many trace elements including As, B, Ca, Mo, S, Se and Sr (Page *et al.*, 1979) in the ash are concentrated in the smaller ash particles. The Fe-oxide content of spheres influences their color, which ranges from water-white to yellow orange to deep red or brown to opaque. Ca was found to be the dominant cation in ESP ash and fly ash collected from dump sites, followed by Mg, Na and K. The pH of fly ash varies from 4.5 to 12.0 depending largely on the sulphur content of the parent coal, and the type of coal used for combustion affects the sulphur content of fly ash. The coal produced in India is low in S but high in ash content (40%), whereas the coal produced in US is rich in S (2%) and contains only 5–10% ash.



Biological properties

The effects of fly-ash amendment on soils were affect biological properties of soil. The microbes mediated processes in the soil disturbs by the application of pollutants such as fly ash leads to the imbalance of ecosystem . It has been found that a significant increase in the rate of CO2 evolution and the activity of soil enzymes (protease and dehydrogenase) in fly ash amended soil from a pot culture experiment. Increases in enzyme activity and CO2 evolution in soil have been reported as favourable for soil microbial activity. It was reported that no significant inhibition of soil respiration and enzyme activities was found in up to 2.5% fly ash amendment. In that situation further addition of fly ash caused a decrement of above-mentioned microbial activities. On the other hand, significant stimulation of soil respiration and microbial activities was observed in up to 5% fly ash amendment when the soils contained earthworms. Both fluorescein diacetate assay and denitrifiers showed an increased trend up to application of fly ash at 40% but with a concomitant decrease in alkaline and acid phosphatase activities. Fly ash has also showed its positive role in controlling soil borne plant diseases. The application of lignite fly ash reduced the growth of seven soilborne pathogenic

microorganisms. The population of both fungi and actinomycetes decreased with the application of fly ash (Nayak *et al.*, 2015).

Demerits of fly ash

- Reduction in bioavailability of some nutrients due to high pH (generally from 8 to 12) high salinity and
- high content of phytotoxic elements, especially boron.
- Ground water contamination due to carrying ill-treated fly ash.

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