INDIA has a vast coal reserve of 211 billion tonnes, making coal one of the most extensively used fossil fuels for generating power. However, ash content of forty to fifty per cent in Indian coal presents an inherent problem of ash disposal. More than 175 million tonnes of fly ash are expected to be generated in the country by the year 2012. The Ministry of Power, Govt. of India estimates that 1800 million tonnes of coal use every year leading to generation of 600 million tonnes of fly ash by 2031-2032.

Not only does this huge amount of fly ash create environmental problems it also eats up large tracts of land required for dumping of this waste. Since fly ash is a fine powder, it could cause respiratory problems when inhaled. It may also lower agricultural yields by settling on leaves and crops. When added to soil indiscriminately, toxic metals such as chromium, silicon, mercury, lead and arsenic contained in fly ash could enter the food chain harming animals and humans.

There is, therefore, an urgent need to adopt technologies for gainful utilization and safe management of fly ash.

**Composition of Fly Ash**
Fly ash occurs as very fine particles, having an average diameter of less than 10 μm, low to medium bulk density, high surface area and very light texture. The chemical composition of fly ash varies depending on the quality of coal used and the operating conditions of the thermal power stations. Approximately 95% to 99% of fly ash consists of oxides of silicon, aluminum, iron and calcium. About 0.5% to 3.5% consists of sodium, phosphorous, potassium and sulphur, and the remainder of the ash is composed of trace elements. Thus, fly ash practically consists of all the elements present in soil except organic carbon and nitrogen.

**Benefits in Agriculture**
Fly ash holds the potential to improve the physical health of the soil. It serves as a soil modifier and also enhances the water-retaining capacity and fertility of the soil. It improves the plant’s water and nutrient uptake, helps in development of roots and soil binding, stores carbohydrates and oils for use when needed, protects the soil from soil-borne diseases and detoxifies contaminated soil.

Use of fly ash in agriculture has been shown to increase the yield of cereals, oil seeds, pulses, cotton and sugarcane by 10-15% and vegetables by about 20-40% as observed in experiments carried out under varied climatic conditions and soil types across the country with different...
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FEATURE ARTICLE

Fly Ash Risk in Agriculture

- Uptake and accumulation of toxic heavy metals by crop plants.
- Fatal effects on humans and cattle due to consumption of heavy metal contaminated crops.
- Ground water pollution due to heavy metal percolation down to earth.
- Higher doses of FA in agriculture field may cause soil infertility.
- The radiochemical pollution present in FA.

Doses of fly ash and pond ash with and without organic manure in various crops. Field experiments were conducted in villages around the National Capital Power Project, Ghaziabad, Uttar Pradesh and Indian Agriculture Research Institute (IARI) Farm, New Delhi to evaluate the effects of fly ash incorporation on soil properties and the growth and yield of wheat, mustard, rice and maize.

It was found that the fly ash application caused changes in soil properties due to modifications in macro- and micro-pore size distribution, which contributed to the increased crop yields. Yields of groundnut, sunflower, safflower, maize, paddy etc., have also been shown to increase (Figure 1).

It has recently been reported that paddy grain yield differed significantly due to treatments. The most effective treatment noted for paddy grain yield was the combination of FA+FYM (92% increase over control) followed by FYM and FA (Figure 2).

Apart from enhanced agricultural yields, successful reclamation of wastelands, degraded lands, acid and saline alkaline soils, eroded soils etc., has also been demonstrated. Since fly ash has physical and chemical properties similar to those of soil, it can be used directly on the soil, or in land reclamation, with organic matter, lime or gypsum, in composts, or made into granulated materials or potassium silicate fertilizers. Fly ash improves the physical properties of the soil, increasing moisture retention in poor soils and aeration. It provides the micronutrients for plant growth, but lacks potassium and only supplies a limited amount of nitrogen.

Agricultural lime application contributes to global warming as Intergovernmental Panel on Climate Change (IPCC) assumes that all the carbon in agricultural lime is finally released as carbon dioxide to the atmosphere. However, use of fly ash instead of lime in future agriculture practices can reduce net carbon dioxide emission, thus reducing the problem of global warming.

Also, less fertilizer, gypsum and irrigation are required after fly ash treatment, which reduces costs (as long as the ash does not need to be transported for long distances). For example, a fly ash treatment of 100 tonnes per hectare on sandy soils in Australia reduced the water consumption of the soil by around 75%. Improved water retention also reduced the rate of leaching of any fertilizers used.

Synergistic effects have been shown between coal ash and organic substances that improve the soil and promote plant growth. Various biosolids, including treated sewage sludge, have been shown to complement fly ash in composts. Fly ash composted with earthworms improves yield so that expensive chemical fertilizer applications could be reduced.

Fly ash dispersed in powdery form in various crop fields (paddy crop, mustard etc.) kills pathogenic microbes and other harmful insects and pests. Scientists of Annamalai University, Tamil Nadu, have developed fly ash-based herbal pesticide with turmeric, neem, eucalyptus, pepper and chilli dust and found them effective against several pests in rice and vegetables. The recommended level of harmless use of fly ash pesticides is forty kilograms per hectare. The pesticides are applied through dust, spray and manual spread. It has been found effective on various insect pests, viz. A. gossypii, C. insolitus, and U. hystricellus and T. neocaledonicus.

Risks of Fly Ash in Agriculture

There are certain risks too. Fly ash has particle per million (ppm) level concentration of heavy metals. When applied to soil these elements may get absorbed by plants grown on it and may ultimately enter into the food chain. Despite fairly intensive research over the last few years, the data on trace element accumulation in plants is rather sketchy and inconsistent. Boron in fly ash is readily available to plants and investigators consider Boron to be the limiting factor in unweathered fly ash utilization for agriculture.

Trace and heavy metals in fly ash may also percolate into the soil and pollute ground water. The solubility of these elements is less than ten percent. It has been observed in laboratory experiments on leaching potential that 5-30% of toxic elements, especially Cadmium, Copper and Lead, are leachable. At least 10% of total Cadmium would be solubilized in the acidic pH range of 3 to 5. It is unlikely that these will have any major effect on the quality of ground water. However, monitoring of these parameters is advisable.

There have been several reports of the presence of radionuclides in fly ash but studies on their impact have been limited. The radiochemical pollution of Uranium and Thorium series is always present in fly ash. Radium is another common constituent of fly ash. The half-

Rather than exempting fly ash from hazardous waste regulations (as is the current practice), it should instead be managed commensurate with the actual metal levels measured in each batch of fly ash.
life of radium is more than a thousand years. Think about basements put on land where fly ash had been previously disposed! Thus, soil amendments on the periphery of expanding cities are potentially hazardous.

Several crops grown in quantities of fly ash (5 to 20 % of soil weight) have been found to absorb toxic metals according to a study by Indiana State University researchers. When the amount of fly ash increased, the crops absorbed higher concentrations of arsenic and titanium. Basil and zucchini contained potentially toxic amounts of arsenic exceeding 6 parts per million. Concentrations of greater than 2 ppm had severe effects on vegetables, damaging the plants and decreasing production, wrote the scientists in a 2004 paper published in *Environmental Geology*.

Other possible impacts that have been overlooked include what might be moving into streams via runoff; levels of heavy metals making it into groundwater; and, metal-laced soil particles blown about by the wind.

**Future Perspectives**

The use of fly ash in agriculture is a craft-like practice, because it depends on several factors. The source and quality of fly ash needs to be matched with the soil or spoil being treated, the crop being grown as well as the local climate. Regulation needs to account for these findings. Rather than exempting fly ash from hazardous waste regulations (as is the current practice), it should instead be managed commensurate with the actual metal levels measured in each batch of fly ash.

Fly ash has great potential in agriculture due to its efficacy in modification of soil health and crop performance. However, since there is a potential for harming the environment and human health, long-term confirmatory research is necessary before planning agriculture as a venue for fly ash utilization.

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