



Using Fly Ash In Agriculture: Converting A Difficult Situation Into An Opportunity

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Abstract

Our country is based on coal for energy production will give rise to huge quantity of fly ash which leads to environmental pollution, especially in causing respiratory diseases due to its small size light weight. Now, it is being utilised in manufly ashcturing building materials like bricks etc. But a very small quantity is being used and rest is disposed of in ash lagoons, which poses problem in the form of land use, health hazards and environmental dangers. Hence the is a need to manage the rest of the fly ash waste to protect the environment. As fly ash has unique physical and chemical properties, it can be utilised for agriculture also. As our country is second largest in the world and has consistently been the highest contributor to agriculture. Hence, our country can try to change its challenge of fly ash pollution as an opportunity of utilising it for agriculture. Hence the author made an attempt to bring awareness among the people in this aspect of utilising fly ash for agriculture.

1. Introduction

fly ash is the by product which is obtained from the thermal power plants by the combustion of coal which is in pulverized form. There is a chamber called as dust collection system which separates the fly ash as particulate residue from the gases that are later discharged into the atmosphere. The particles of fly ash are mostly spherical in nature and there diameter (<1 to 150 micrometer).

Globally, Coal is still an irreplaceable component that contributes around one-third of global electricity generation, 53% of energy is generated only from coal in world. In India also, coal is the most dominant source of energy, contributing around 49% of total energy generation. As per the report of Central Electricity Authority, New Delhi, 142.07 million tonnes of fly ash were produced from 175 thermal power stations and about 78% of it was utilised in the first half of 2022-23 year. fly ash generation is increased from 2021-22 to 2022-23 from 133.9 million tonnes to 142.07 tonnes, but utilisation of fly ash is decreased from 81.65 % to 78.14%. About 3.5% of extra fly ash was left into fly ash pools which causes pollution. On the other hand,

India ranked seventh worldwide in agricultural land area. As per the reports of world bank, 60.05% of the country's total land area is agricultural land. So, our country has a chance to utilise the fly ash for agriculture to reduce the environmental pollution due to this fly ash¹.

2. Methodology

a) Characteristics features of Fly ash

Ojha *et al.*² reported that fly ash obtained as a coal byproduct is concentrated in SiO₂, Al₂O₃, and a little quantity of Fe₂O₃, as well as Ca, Mg, P, and Ti oxides; According to Kumar *et al.*³, the main components of ash are crystalline quartz and mullite. Fly ash is a pulverized waste produced by thermal power plants during coal combustion. Initially, the rocks, clay, and vegetation show varying inorganic concerns. Physically, it takes the form of spherical particles ranging in diameter from a few microns to 100 microns, with a low to medium bulk density and a sandy silt or sandy loam texture. Chemically, fly ash is an amorphous ferroaluminosilicate mineral with Si, Al, and Fe, as well as Ca, Mg, P, K, and S in abundance. Most field soils have similar physicochemical characteristics, such as trace/heavy metals and radioactivity, as well as texture. Kumar *et al.*⁴ discovered that fly ash is high in macro and microvitamins and contains all of the minerals produced by coal combustion. This potential has the ability to alter the physical properties of the soil while also acting as an effective soil conditioner. The basicity of fly ash is due to the presence of Na, Mg, and OH ions, as well as other trace elements. Fly ash contains a range of heavy metals, such as Zn, Fe, Ni, Mn, Pb, Cu, Cr, B, Al, and Si. This ion contributes to the higher electrical conductivity of fly ash. According to Vitekari *et al.*⁵, fly ash, also known as coal combustion product (CCP), is a finely divided byproduct of pulverized coal in an energy generation fly ash facility. The fly ash component is determined by the coal's source and kind. In general, all fly ash is made up of both crystal and amorphous forms of silicon oxide and calcium oxide, both of which are essential components of coal-bearing layers.

b) Effect of fly ash on physicochemical properties of soil

Several tests have been done in various parts of the country to demonstrate the use of fly ash for agricultural applications. Many studies were conducted on a global scale to evaluate soil physical parameters such as texture, structure, consistency, temperature, color, B.D, particle density, pore space, and water holding capacity. The physical qualities of soil are determined by the amount, size, shape, arrangement, and mineral content of its particles, the kind and amount of organic matter, the volume and shape of its pores, and how they are occupied by water and air at any given time. The application of fly ash improves yield and productivity while also increasing moisture and land fertility. Chang *et al.*⁶ said that incorporating fly ash into soil reduces B.D, which improves two crucial properties: water holding capacity and hydraulic capability. In general, many qualities change over time. Adding 25-50% fly ash increased the B.D, but adding more decreased it. Sale *et al.*⁷ found that in most cases, B.D was reduced. Further research found that there are other significant fly ash factors that distinguish fly ash and mine soil plots. When compared to fly ash plots, mine plot soil has higher B.D (1.25-1.45) g/cm³ and lower porosity (38 to 46%). According to Gorman *et al.*⁸, the use of fly ash can reduce particle density and B.D while increasing water holding capacity and porosity. Soyabean plants grew and yielded better throughout the rainy season⁹, as the addition of fly ash reduced B.D, which decreased porosity, and increased both macro and micro pores in the soil. Yeledhali *et*

*al.*¹⁰ found that increasing pore space leads to an increase in soil water holding capacity, and the opposite is also true.

The water holding capacity increased from 64 to 67.5 after applying pond ash at a rate of 40t/ha. Fly and pond ash had only little effects on soil physiochemical characteristics. Fly ash has a higher alkaline capacity but a lower water holding capacity than pond ash, making its use less efficient. Not only is water holding capacity used as a measure for optimum crop production, but it also provides good aeration and drainage of surplus water, both of which are considered physical qualities of fine textured soil. Clay soils with a fine texture and a low infiltration rate can cause waterlogging and impair soil biological activity.

Water logging situations in clay soil can be alleviated by applying fly ash, however water holding capacity in sandy soil is increased by applying fly ash, as determined by Dhindsa *et al.*¹¹. Fly ash has significant potential in agriculture due to its ability to improve soil health and crop performance. However, multiple studies have proposed that fly ash can be utilized as a soil ameliorant to improve the physical, chemical, and biological aspects of deteriorated soils while also providing easily available plant macro and micronutrients. The high concentration of macro and micro components in fly ash boosts the productivity of many agricultural crops. According to the US Department of Agriculture textural class, the application of fly ash at 200 tons per hectare improved the physical qualities of soil and changed the textural class from sandy loam to silt loam. Sahu *et al.*¹². Several studies have shown that fly ash can be utilized to improve soil quality since it includes critical macro and micro nutrients. The study of fly ash found that it can be efficiently employed as soil amendments and fertilizers, resulting in improved soil fertility. Their use also solves the dumping problem with fly ash and aids in the development of future strategies for its use¹³.

Soil chemical properties include inorganic soil matter, organic soil matter, colloidal properties of soil particles, soil reactions and buffering action, acidic soils, and basic soils, all of which can be affected directly or indirectly by the application of fly ash and other organic and inorganic amendments. The chemical makeup of fly ash is determined by the original material that was utilized for burning. The application of fly ash, which is basic in nature, will invariably raise the pH level in soil. The use of 30% fly ash dramatically changes the pH level from higher to lower when compared to the control¹⁴. Invigorating soil with fresh fly ash is more effective on soil pH, boosting alkalinity and attaining more plant growth and development than dump one from long time.

The physicochemical and mineralogical features of fly ash vary depending on the source of coal and thermal plant. Fly ash contains several components found in the earth's crust, such as ferroaluminosilicate mineral¹⁵, and when utilized as a soil amendment¹⁶, it provides additional supplies of Ca, Mg, K, Na, and other trace elements to soil, as reported by Fisher *et al.*¹⁷. The physical, chemical, and biological aspects of damaged soils can be enhanced by adding fly ash as an amendment. Fly ash is an important source of readily available macro and microplant nutrients. Kishor *et al.*¹⁸ found that fly ash plays a significant role in agriculture because it improves soil health while also promoting beneficial crop responses. The combustion of coal in thermal power plants produces a residue known as fly ash, which is high in minerals and vitamins such as calcium, magnesium, salt, potassium, and sulfur, as well as heavy metals such as boron, mercury, lead, chromium, cadmium, and arsenic, among others.

c. Effect of fly ash on biological properties of soil

Experiments have shown that introducing fly ash into soil changes the characteristics of microorganisms. Adding fly ash to soil reduced nitrification and microbial respiration in sandy and silty soils. The fly ash had toxic substances that reduced the microfloral population of fungus, bacteria, and Actinomycete. Additionally, it inhibited enzymatic activities such as dehydrogenase, phosphates, sulphatase, and invertase. Adding fly ash to organic materials reduces nutrient levels and slows its decomposition. Enzymatic activities such as amylase, invertase, protease, and dehydrogenase increased with fly ash dosages up to 10 t ha⁻¹. However, additional increases impeded these activities. The fly ash did not significantly affect Catalase activity. Using a lower proportion of fly ash and earthworms in acidic soil promotes biological activity and nutrient cycling. Incorporating fly ash and soil combination with sludge led to increased enzymatic activity. The natural process of leaching reduces trace elements and soluble salts due to weathering of fly ash.

A study found that applying 20% fly ash reduced microbial populations of bacteria, fungus, and actinomycetes by 57, 86, and 80%, respectively. Using fly ash at a rate of 15 t ha⁻¹ increased enzymatic activities such as dehydrogenase, amylase, invertase, and protease. However, continued application of fly ash decreased these activities. fly ash was composted for 90 days with wheat straw and 2% rock phosphate, resulting in a better compost mixture. According to Vitekari et al¹⁸., applying fly ash can improve soil qualities both physically and chemically. The usage of fly ash boosted soil microbial population, nutrient levels, and enzyme activity. Using graded coal fly ash, with or without appropriate fertilizer, improved soil macro and micronutrient quality, as well as organic carbon levels. Fungi concentrations fell, whereas bacterial and Actinomycete populations increased. Using NPK fertilizers increased alkaline phosphate activity and microorganisms, including Actinomycete. Yeledhali et al¹⁰. found that using graded fly ash disrupted the microbiological balance and enzymatic activity of Alfisol soils, resulting in increased nutrient content such as N, P, K, S, Ca, Mg, Zn, and Cu. The application of fly ash boosted crop productivity and soil quality. fly ash is an effective soil amendment due to its silt particle size, low bulk density, high water holding capacity, micronutrient content, and suitable pH. The study found that fly ash has different applications that improve wastelands, mined soils, landfills, and cultivable land. The abandoned fly ash ponds can potentially be used for agriculture and forestry activities. Using fly ash as an amendment improves the physical, chemical, and biological qualities of soil. A study found that the release of soluble salts and trace elements from fly ash can be adjusted according on the demand. The use of fly ash as an amendment depends on its restoration, phytoremediation, and as an economical fertilizer for agriculture¹⁹.

3. Recommendations

1. The use of fly ash in Agriculture and waste land development has large potential but the utilization is below expectation. This may be attributed mainly to reservations in various quarters for use of fly ash in agriculture because of presence of heavy metals and radioactive elements in fly ash however, findings of research projects funded by Fly Ash Unit under Ministry of Science & Technology and studies carried out by other organizations indicate that there are no adverse effects in using fly ash in agriculture. Therefore, these concerns are required to be addressed for increasing the fly ash utilization.

2. There is a need to encourage 'Industry–Institute Interactions' for entrepreneur development, creating awareness and organizing training programmes and workshops.

3. In view of large quantity of fly ash generation, utilization of fly ash may be introduced as construction material in academic curriculum of Engineering, Architecture, Mining, Agriculture etc.

4. Conclusions

Fly ash's unique physical and chemical qualities make it a valuable agricultural resource. It is rich in vital nutrients that promote plant growth and development. Adding fly ash to soil improves its physical and chemical properties, including texture, WHC, buffering capacity, aeration, percolation, and water retention. It also optimizes pH, reduces macro and micro nutrients, reduces heavy metal mobility and availability, and has insecticidal properties. Additionally, it improves soil quality and crop productivity. The amount and technique of applying fly ash vary depending on crop variety, climate, and fly ash qualities. fly ash usage in agriculture has both advantages and downsides. fly ash contains harmful components such as heavy metals and radioactive isotopes, as well as high concentrations of dissolved salts. It may be leached from fly ash. Leaching can promote soil and water salinity, enhance heavy metal mobility and availability, and accumulate them in plants. Most fly ash soil treatment research found that improving fly ash affects the soil's microbiological characteristics. Excessive use of soil amendments, particularly alkaline fly ash, might harm soil microorganisms. On the other hand, physiological and biological features promote growth. Crop plant yields increase as a result of fly ash application. Plant biochemical components can have both beneficial and negative impacts because of the fly ash application. We use both organic and inorganic fertilizers in our soil. Organic additives, such as compost, can improve soil fertility and biochemical characteristics. Household composts have much higher microbial biomass, carbon, and nitrogen levels. This paper summarizes the physical, chemical, and biological aspects of soil, which are crucial for improving agricultural productivity.

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