# "WASTELAND RECLAMATION: Fertilizing the Wasteland using Flyash as a Soil Ameliorant to Grow Energy Crops for generation of Biogas"

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***Abstract*- Disposal of high amount of fly-ash from thermal power plants (i.e. for power generation) absorbs huge amount of water, energy and land area by ash ponds. In order to meet the growing energy demand, various environmental, economic and social problems associated with the disposal of fly-ash would continue to increase. In order to reduce disposal problems of flyash, flyash can be used for reclaiming the problem soil and enhance the crop productivity depending upon the nature of soil and flyash. It may improve physical, chemical and biological properties of problematic soils and enhance the available macro and micronutrients for plants. And, Currently some 80% of the world's overall energy supply is derived from fossil fuels. Nevertheless roughly 10–15% of this demand is covered by biomass resources, making biomass by far the most important renewable energy source used to date. Therefore, to reduce the flyash disposal problems and to relay on renewable energy resource, flyash can be used as soil ameliorant for problematic soils as a part of wasteland reclamation and after reclamation of soil, Energy crops can be grown for generation of biogas using anaerobic digestion**

## I. INTRODUCTION

Flyash(FA)–a coal combustion residue of thermal power plants has been regarded as a problematic solid waste all over the world. In India 75% of electricity is generated by coal based thermal power plants, according to the data provided by Government Of India (Jamwal 2003), 112 million tonnes of this kind of waste is produced in India and out of which the utilization of flyash is 38% (Kalra et al, 1997). The majority of flyash utilization throughout the world occurs in cement and concrete products, structural fills, and embankments and road base. However several studies proposed that Fly-ash has great potentiality in agriculture due to its efficacy in modification of soil health and crop performance. But compared to other sectors, the use of fly-ash in agriculture is limited.

Flyash is disposed of either in wet slurry process or dry disposal process. In wet process, flyash is disposed in wet slurry form to a nearby ash pond site in which the ash settles and clear water is allowed to overflow from the ash pond. In dry disposal, flyash is stored in the large area assigned for the disposal of waste material (Kalra *et al*. 1999 and Jala & Goyal). In both the methods, flyash is dumped in open land, which degrades the soil and enhances the air and water pollution and ultimately affects the human health.

Below **Fig.1** shows the different options of flyash utilization in order to reduce the harmful health effects due to exposure of flyash.

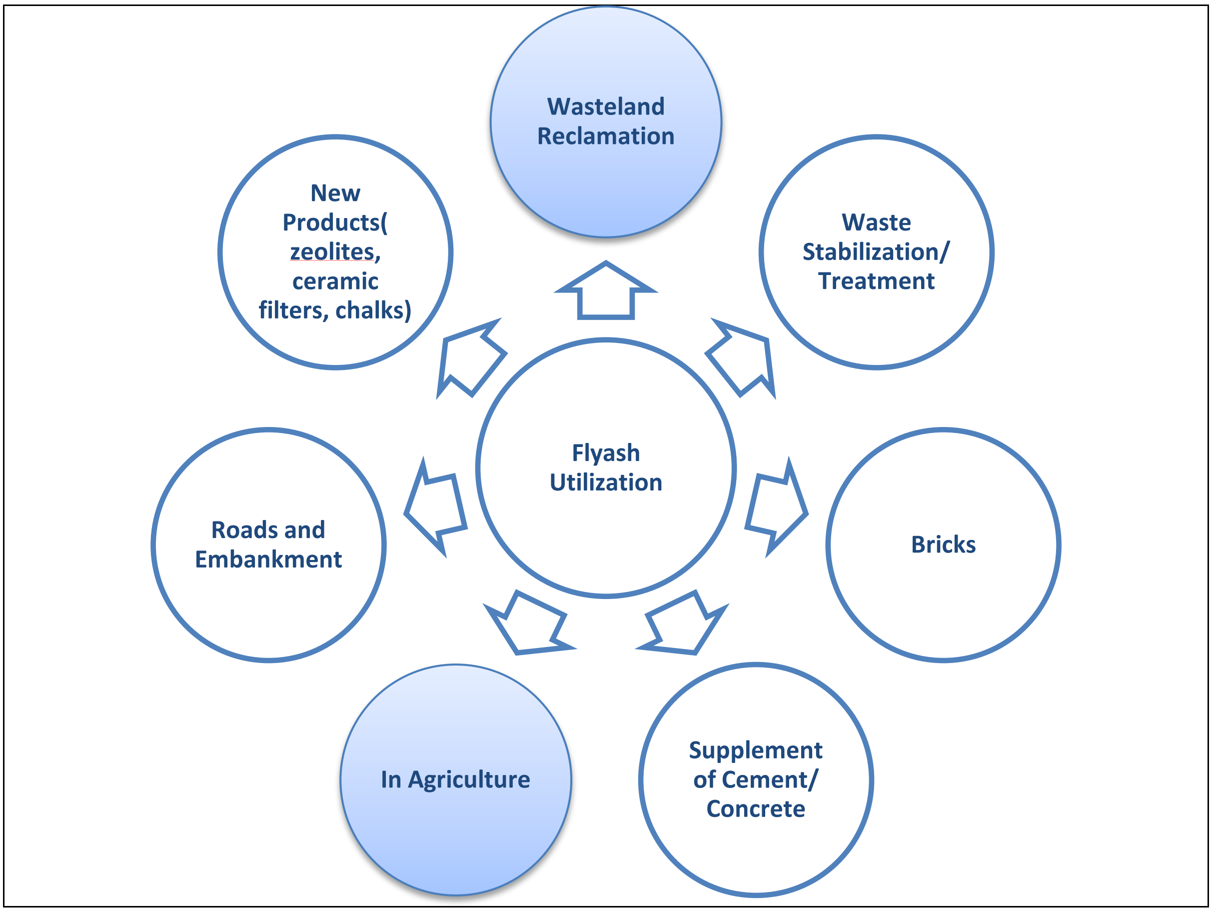


**Fig 1. Flyash Utilization options**

Flyash can be used as a soil ameliorate that may improve physical, chemical and biological properties of the degraded soils and is a source of readily available micro and macro nutrients. The high concentration of elements (Na, K, Zn, Ca, Fe and Mg) in flyash increases the yield of many agricultural crops.

Wasteland includes areas affected by water logging, ravine, sheet and gully erosion, riverine lands, shifting cultivation, salinity and alkalinity, shifting and sand dunes, wind erosion, extreme moisture deficiency, coastal sand dunes etc. The total area under degraded and wastelands in India stands at 114.01 M ha which is 34.68% as per the NRSA. And the Total degraded area in the Gujarat state is 3,129 thousand ha (about 16% of TGA) of country.

**Energy crop** is a plant grown as a low-cost and low-maintenance harvest used to make bio fuels, such as bio ethanol, or combusted for its energy content to generate electricity or heat. Energy crops are generally categorized as woody or herbaceous plants; many of the latter are grasses. Commercial energy crops are typically densely planted, high-yielding crop species where the energy crops will be burnt to generate power like miscanthus, willow, poplar, switchgrass, elephant grass, hemp, reed canary grass etc.

The idea to use dedicated plant biomass, the so called “energy crops” for methane production (bio-methanation) is not new. Although the digestion of crop material was demonstrated, the process was hardly applied in practice. With steadily increasing oil prices and improved legal framework conditions, “energy crop”-research and development was again stimulated in the 1990s. But in India there is still the technology is untouched.

## II. PHYSICO-CHEMICAL PROPERTIES OF INDIAN FLYASH

The mineralogical, physical and chemical properties of fly ash (Adriano *et at.*, 1980; Carlson and Adriano, 1993) depend on the nature of parent coal, conditions of combustion, types of emission control devices and storage and handling methods. There are basically four types, or ranks, of coal, each of which varies in terms of its heating value, its chemical composition, ash content, and geological origin. The four types, or ranks, of coal are anthracite, bituminous, sub-bituminous, and lignite. Therefore, ash produced by burning of anthracite, bituminous and lignite coal has different compositions.

**Physical Properties of Indian Flyash**

The Indian flyash particles are spherical in shape and colour is gray to black. Flyash have a size distribution with medium of around 4 µm and settle close to the plant site (Sadasivan et al, 1993). The mean particle density for non-magnetic and magnetic particles is 2.7 and 3.4 g/cm$^3$ respectively and the other physical parameters are shown in **table-1** given below (Natusch and Wallace, 1974). The flyash has usually high surface area and high texture due to presence of large, porous and carbonaceous particles.

Table-1 Physical properties of Indian flyash

| Parameters | Value |
|---|---|
| Bulk density | 1-18(g/cm$^3$) |
| Specific gravity | 2.1-2.6(g/cm$^3$) |
| Water holding capacity | 49-66% |
| Moisture content | 18-38% |
| Clay | 1-10 |
| Silt | 8-85 |
| Sand | 7-90 |
| Gravel | 0-10 |

**Chemical Properties of Indian Flyash**

The ash is mainly composed of silica, alumina, and smaller quantities of oxides of iron, magnesium, calcium and other elements. The ash also contains unburned carbon residue that gives it its dark colour. The **table-2** shows the chemical composition of Indian Flyash with values of constituents in % by weight (Patitapaban Sahu, 2010).

Table-2 Chemical Composition of Indian Flyash

| Constitutents | Percentage(%) |
|---|---|
| $SiO_2$ | 49-67 |
| $Al_2O_3$ | 16-29 |
| $Fe_2O_3$ | 4-10 |
| CaO | 1-4 |
| MgO | 0.2-2 |
| $SO_3$ | 0.1-2 |
| Loss on Ignition (LOI) | 0.5-3 |

## III. EFFECT OF FLYASH ON SOIL & CROP GROWTH AND PRODUVTIVITY

Several studies proposed that Flyash can be used as a soil ameliorate that may improve physical, chemical and biological properties of the degraded soils and is a source of readily available plant micro-and macro- nutrients. Practical value of Flyash in agriculture as an eco-friendly and economic fertilizer or soil amendments is to establish after repeated field experiments for each type of soil to confirm its quality and safety. Addition of Flyash at 70t/ha has been reported to alter soil texture of sandy and clayey soil to loamy (Capp, 1978). Flyash addition up to 40% also increased soil porosity by 10% and water holding capacity by 15% (Singh et al, 1997). Addition of 10% Flyash to sandy soil increases plant available water content by 52%. Addition of Flyash up to 20% increases the yield of grain and straw of rice (Sharma & Kalra). Mineralogical, fly Ash is broadly similar to soil but rich in macro and micro nutrients. Particle size distribution of fly ash improves physical conditions of soil. The large scale use of fly ash in agriculture holds a potential to increase on an average 10-15 % yield of crop plants (Patil Sujata et al, 2013). *Miscanthus giganteus* grass species growing on thermal plant of Utvin fly ash dumps resulting from burning lignite coal, after the first year from the planting. In order to stimulate the process of vegetative from the first year, have used three different fertilizing: with sewage sludge(V1), with cattle manure(V2) and mineral supplement such as N, P and K(V3), the best germination percentage was obtained in variants fertilized with sewage sludge and manure of cattle because ashes from deposit doesn't contain organic material (Lixandru B et al, 2013). The addition of flyash (10 - 200 tonne per ha) increased the yield of different crops from 10-40% (Vimal Kumar et al. 2005).

According to (Mittra et al, 2003), integrated use of fly-ash, organic and inorganic fertilizers saved N, P and K fertilizers to the range of 45.8%, 33.5% and 69.6%, respectively. One experimental study demonstrated that 1 ton of fly-ash could sequester up to 26 kg of $CO_2$, i.e., 38.18 ton of fly-ash per ton of $CO_2$ sequestered. This confirmed the possibility to use this alkaline residue for $CO_2$ mitigation (Montes et al, 2008). Use of fly-ash as soil ameliorant in place of lime could lead to reduction in CO2 emissions, thus contributing to minimize global warming (Ferreria et al, 2003).

## IV. ENERGY CROPS FOR PRODUCTION OF BIOGAS UNDER ANAEROBIC DIGESTION

Crop digestion was commonly not considered to be economically feasible. Crops, plants, plant by-products and -waste materials were just added occasionally to stabilise anaerobic waste digesters. With steadily increasing oil prices and improved legal framework conditions, "energy crop"-research and development was again stimulated in the 1990s. Numerous plants and plant materials have been tested for their methane formation potential. There are several energy crops from which the biogas can be produced like maize, wheat, oats, industrial hemp, sunflower, rapeseed, alfalfa, elephant grass, Napier grass, ryegrass, flax, triticale, turnip etc. The different energy crops have different methane yield as shown in **table-3** (Braun, 2007) given below.

Table-3 Methane potential of Indian energy crops

| Energy crops | Methane yield($m^3$/kg) |
|---|---|
| Maize | 0.20-0.45 |
| Wheat | 0.38-0.43 |
| Oats | 0.25-0.30 |
| Rapeseed | 0.24-0.34 |
| Alfalfa | 0.34-0.50 |
| Red Clover | 0.30-0.35 |

| | |
|---|---|
| Triticale | 0.34-0.55 |
| Ryegrass | 0.39-0.41 |
| Turnip | 0.31 |
| Industrial Hemp | 0.35-0.41 |
| Flax | 0.21 |
| Barley | 0.35-0.66 |
| Sorghum | 0.30-.37 |
| Potatoes | 0.28-0.40 |

(**Source:** Biogas from Energy Crop Digestion by the IEA)

## V. CONCLUSIONS

Flyash vary widely in its physical and chemical composition, therefore, the mode of use in agriculture is different and depends on the characteristics of soil or soil type. Flyash can be used as liming material on acid soils or acid mine soils or alkali soils for improving the pH of the soils depending on nature of soil and ash. The high concentration of elements like K, Na, Zn, Ca, Mg and Fe in flyash increases yield of agricultural crops. Due to fine nature of flyash, it improves the WHC of sandy soils removing the compaction of clay soils. Flyash improves the physical and chemical properties of problematic soils. Therefore flyash can be used as a soil ameliorant for wasteland reclamation.

Among farmers and researchers there is an increasing interest in alternative suitable crops for bioenergy production. As presented here, numerous crops are available for biogas production. The conversion of biomass to energy should be economically efficient and optimise the environmental benefits.

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