Utilization of fly ash: A review

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ABSTRACT

Fly ash is a waste by-product of coal combustion in coal-based thermal power plants and is liable for enormous environmental hazards. The core chemical components of fly ash are silicon dioxide (SiO2), aluminum oxide (Al2O3), ferric oxide (Fe2O3), and calcium oxide (CaO) and all these elements are noxious water and air pollutants. These elements can cause skin cancer, heart disease, and respiratory disorders in humans. Chhattisgarh is a comparatively new state with high industrial growth. Newly established plants of the state including Jindal Steel and Power Limited Raigarh, Chhattisgarh contribute maximum fly as pollutants. This study presents a brief review of the composition and utilization of fly ash in India and particularly in Chhattisgarh. As per the current estimates, Chhattisgarh produces over 20 million tonnes of ash and utilizes only 6-8 million tonnes per year.35% of the total production of fly ash is consumed by the construction industry, cement industries, Agriculture sector, and landfill management. Further research is needed on the toxicity of the variety of elements of fly ash as well as how it can be reused in a sustainable manner

Keywords - Fly ash, Composition, Utilization, Agriculture sector, Cement industries

Objective

The objective of this study is to explore the possibility of proper utilization and disposal of fly ash.

Introduction –

Coal-based thermal and steel power plants are the main source of fly ash in Chhattisgarh. Fly ash is the by-product of the biological source of energy retrieved after burning coal and lignite on a definite temperature. One of the reasons for the massive production of fly ash is the low quality of Indian coal that has high ash content (30-45%) as compared to imported coals (10-15%). As many as 217.04 million tons of fly as were produced in 2018-19. (Yousuf A., et al. 2020). Disposal, management, and reuse of this many by-products pose a problem for the related industries. Fly ash is the notorious waste product of coal-based electricity-generating thermal power plants, known for its ill effects on agricultural land, surface and sub-surface water pollution, and soil and air pollution. (Pati.S.L.2012) Chhattisgarh has a number of power plants that include SECL, NTPC, Jindal steel, and power limited Raigarh, Chhattisgarh. Jindal steel and power limited Raigarh is the largest coal-based sponge iron manufacturing plant of the world with up to 3.6 million tonnes per annum (MTPA) steel manufacture capacity. In order to cater to the energy needs Jindal has established a 299 MW captive power plant (CPP) at Raigarh, as well as a 540 MW CPP power plant at Dongamauha, district Raigarh, Chhattisgarh, India. These power plants produce an enormous number of pollutants fly ash.As per the 2021 NGT data the state produces over 20 million tonnes of fly ash and utilizes only 6-8 million tonnes a year. The data also corroborates that coal and lignite thermal power stations generate more than 106 million tons of fly ash. (statista.com). The disposal and proper utilization of this much pollutant fly ash is an uphill task for the nation. It also poses a health hazard as for humans as oral intake of certain components of fly ash is known to be carcinogenic. The six elements As, Hg, Cd, Cr, Pb, and Ni in fly ash increase the risk of environmental pollution. The ash contents like Cr and As need to be controlled because studies have ascertained that these components cause carcinogenic risks to the human body. (Wang, C Q., et al. 2022)Enormous Production, improper disposal, and disproportionate use of fly ash is liable to cause environmental problems. A measured amount of use of fly ash in brickmaking in the construction industry and agriculture sector is recommended and can help in fly ash management. Judicious use

of fly ash enhances soil quality such as water-holding capacity, soil porosity, organic nutrient, and microbial activities. (Pandey V.C et. al 2010) (Sheoran. H.S. et al.2014) (Panda R. B et al.2018). The present review evidence that fly ash has many important uses but requires more research and further coordinated effort by the stakeholders.

Methodology-

This study is based on primary as well as secondary sources. The primary source is the outcome of numerous surveys made around the Raigarh district C.G. During the survey, the researcher visited factories where fly ash is produced as a by-product and farmhouses where fly ash is used as fertilizer. These factories and farms are in the Raigarh district.

The secondary information has been sourced from a number of reports of national and international agencies dealing with the management and uses of fly ash available on different websites, research journals, and e-contents. The conclusion is based on the outcome of the analysis of the data retrieved from primary and secondary sources.

Composition of fly ash - SiO_2, Al_2O_3, Fe_2O_3, and rarely CaO is the substantial chemical components found in fly ash. (Yousuf A., et al. 2020, Alterary et al. 2021,) The combustion of coal and the concentration of trace material found in it are of different varieties. Apart from this, it contains very low concentrations of arsenic, beryllium, boron, cadmium, chromium, cobalt gallium, hexavalent chromium, cobalt, lead, manganese, mercury, molybdenum, selenium, strontium, thallium, and vanadium, and unburnt coal. There are mainly two varieties of ash -class C and class F. Class C ash is formed by the combustion of lignite and bituminous coal, in which the content of calcium oxide is higher than 10%. Class F ash is formed by the combustion of bituminous and anthracite coal, in which the content of calcium oxide is less than 10%. (Alterary et al. 2021). Fly ash contains Cr, Ni, Pb, As, Hg, Cd, and other heavy metal elements that are carcinogenic and harmful to the human body. The leaching behavior of these elements shows that in the external environment they are very harmful to the human body. The quality and nature of fly ash depend on its chemical composition. For example, ashes sourced from bituminous coals tend to be acidic and those from sub-bituminous tend to be alkaline. (Yousuf A., et al. 2020) Fly ash-treated in plots had marginally higher uptake of Zn, Cu, Fe, Mn, and Cd (Sarangi, P.K. et al 2001)

Discussion and result - Fly Ash as reusable material

The disposal of fly ash produced by coal thermal power plants and steel factories has been a major problem in India. About 35% of the total production of fly ash is consumed by the construction industry, cement industries, Agriculture sector, and landfill management.

1. **Fly Ash as Enhancer of soil fertility -** Fly ash, in certain cases, can be and has been used as fertilizer. Fly ash contains nutrients for soil the components like S, P, Cu, K, Ca, Zn, and Mg. are known to increase the fertility of the soil. studies show that proper use of Fly Ash in soil improves the soil texture. It also reduces soil density, and porosity and works as an insecticide due to the presence of Silica (Sarangi, P.K. et al.,2001, Basu et al., 2009, M. Ahmaruzzaman 2010 Ram and Masto, 2010, Shaheen et al., 2014). The use of fly ash in agriculture modifies the physical, and chemical properties of soils due to its high mineral content. It also improves crop quality and productivity. Sarangi, P.K. et al (2001) observed in a field experiment that Grain and straw yield increased by 21% and 18%, respectively, at 17.5 t ha-1 fly ash amendment when compared to the control.The grain yield of maize increases in fly ash-treated plots with the addition of ash up to a maximum addition of 10 t/ha. In most cases it has been observed that use of fly ash helps in the growth of shoots and roots of plants. The proper uses of Fly ash prove beneficial in crop raring and yield.Numerous physicochemical properties of FA including pH, low bulk density, electrical conductivity, porous particle, high water holding capacity, and source of essential nutrients make it an excellent soil ameliorant in agriculture, forestry, and wasteland recovery (Masto et al.2014). (Kalra, N.,2003 Panda et al.2018). The study highlights Increased yield of crops if fly ash is used under strict supervision with 70% soil, 20% fly ash & 10% compost. M Soil having Soil 70% + Fly ash 15% + Compost 15% produces a better yield of flowers. M Soil having Soil 70% + Fly ash 20% + Compost 10% better yield of a crop.Studies show that the use of ash improves the physicochemical and biological properties of the soil and provides micro and macronutrients to plants. Studies also show that a higher dosage of FA results in heavy metal pollution and hinders the microbial activity of soil. (Pandey V.C2010).The researcher surveyed the fields around Raigarh Chhattisgarh and noted that 10% of fly ash is used by farmers in radish ground nuts and Taro Root fields believing that it will increase the yield. The

physicochemicalcharacteristics of fly ash, particle size, porosity, water, and lime holding capacity, make it useful for soil in the agriculture sector.

2. Fly ash is used in brick making- Fly ash is used as a component in manufacturing brick due to its easy availability and strengthening capacity of the pozzolanic property.These bricks are lite in weight and stronger than the burnt clay common bricks. The construction of bricks from fly ash is environmentally friendly as it helps in protecting the topsoil of the earth that is used for brick making. The content of active components such as SiO2 and Al2O3 in fly ash contributes to the difference in its strength activity index. (Wang, C Q., et al. 2022). It has added benefits as bricks of varying strength can be produced by altering the component while bricks made of soil don't offer this freedom to the producer. These bricks can be utilized for various purposes including roads and pavements, dams, and bridges. (Attarde S.et. al. 2014)

3. Use of Fly ash as a road construction material

Fly ash has many beneficial uses in the field of civil engineering such as building construction, roads, and railways. The roads in rural areas of India, especially in the rainy season, remain in bad shape because they lack carrying capacity which causes pits impeding smooth transportation. The presence of calcium oxide iron oxide and silicate oxide in fly ash increase carrying capacity and bricks made of fly ash can be safely used for these kinds of roads. Researcher.(Vestin J.et al. 2012) studied Sweden's Gravel Road and found that the ash road can be best for Sweden's climate because it contains calcium oxide and silicate oxide. In India too such experiments have been done successfully. For example, Okhla fly-over bridge and Nizamuddin bridge in Delhi have used about 4,800 tonnes and about 150,000 tons of fly ash respectively. (Attarde S.et. al. 2014). The geotechnical properties of fly ash (e.g., specific gravity, permeability, internal angular friction, and consolidation characteristics) make it suitable for use in the construction of roads and embankments, structural fill, etc. (M. Ahmaruzzaman 2010).

.**4. Fly Ash as Land-filler** - The deep pits of used coal mines, empty chasms of mines, and other kinds of low-lying areas can be filled with fly ash, and thus fly ash consumption, as well as pollution caused by fly ash, can be systematically managed. As a matter of fact, the concept of fly ash application in landfill and forestry is a good suggestion to protect the environment.

Empty underground mines which are vulnerable can be filled up with fly ash, especially where sand availability is scarce. Likewise, open-cast mines can be reclaimed. Thus, fly ash can prove useful for reclaiming the land. Ahmaruzzaman (2010).

5. Use of fly ash as Cement mix - Fly ash, a by-product of coal combustion, a health hazard, and an environmental pollutant can be used in cement. This is echo nominally viable as well as sustainable. The utilization of fly ash to change cement results in economic and sustainable applications. Its lime binding capacity, especially the pozzolanic properties of the ash, makes it useful. Thus, fly ash has proven useful for the manufacture of cement, building materials concrete and concrete-admixed products. M. Ahmaruzzaman (2010). Researcher Kesharwani K.C. (2017) observed in his experiment that the fineness of fly ash was the most significant parameter influencing the suitability of fly ash for applications in concrete and chemicals SiO2, Al2O3, Fe2O3 and CaO are responsible for its pozzolanic activity. The use of pozzolanic components of fly ash material which requires no manufacturing process like cement can be a good replacement for cement. It is sustainable and decreases cement uses. Thus, it will reduce pollution and help in fly ash disposal management. (Krithika J.et al 2020),

6. **Use of fly ash in Roofing tiles and Interlocking pavers** – The physical properties of fly ash Physical properties of fly contain strength and durability. Its opaqueness ca be helpful in roofing tiles and Interlocking pavers. (Ammasi A. et al 2012).

Social Relevance of the research work- pollution caused by fly ash has huge social relevance. The human habitation around the ash-emitting plants is susceptible to carcinogenic and respiratory diseases caused by fly ash pollution. the living cast of the areas where these plants are situated is supposed to be higher as it necessitates better medical and health facilities. On the other hand, fly ash as a by-product can also be used in the agriculture sectorand construction that is likely to give a boost to the population residing around fly ash-producing plants

Conclusion

Increased industrial activities in recent decades have contributed to over production of hazardous materials and fly ash is one of them. Fly ash is an air, water, and soil pollutant but it can be reused and well-managed with new technologies and increased awareness. This study evidences that fly ash, which is a by-product and seemingly a waste material, can be reused in various industrial sectors like the cement industry, construction industry, and agriculture sector. Its uses is technically viable, economically beneficial as well as eco-friendly. Various components and characteristics of fly ash like physicochemical properties, water holding capacity, density, K, Ca, Si, Mg, S, Fe, and P, can be further researched to ascertain its uses in many new industries other than construction industries and the agriculture sector.

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• NGT asks Chhattisgarh to file a report on fly ash utilization
Link- https://www.downtoearth.org.in

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