International Journal of Management, IT & Engineering
Vol. 7 Issue 6, June 2017,
ISSN: 2249-0558 Impact Factor: 7.119
Journal Homepage: http://www.ijmra.us, Email: editorijmie@gmail.com
Double-Blind Peer Reviewed Refereed Open Access International Journal - Included in the International Serial Directories Indexed & Listed at: Ulrich's Periodicals Directory ©, U.S.A., Open J-Gage as well as in Cabell's Directories of Publishing Opportunities, U.S.A

POTENTIAL APPLICATION OF WASTE FLY ASH IN AGRICULTURE & CONSTRUCTION: PREVENTIVE MEASURES TO PROTECT HEALTH & ENVIRONMENT

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Abstract:

The present research paper deals with the problem associated with fly ash on health & environment & preventing measure to minimize pollution by promising application of fly ash in varied sector such as agriculture, development of bricks, use of fly ash for manufacturing of cement, development of ceramics, fertilizer, development of distemper and use of fly ash in road construction and road embankment. This article gives the direction for the beneficial use of fly ash generated from coal combustion power plants for greener environment.

Keywords: Fly ash, green environment, health, measures, pollution.

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Potential application of waste Fly Ash in Agriculture & Construction: preventive measures to protect Health & Environment

Introduction

Rapid industrialization has resulted in increased use of natural resources, which brought serious ecological and environmental imbalance. Poor quality, high ash content coal is being used in almost all these thermal power stations resulting into generation of not only electricity, but millions of tons of highly polluting fly ash too. Huge land and large amount of water required for disposal of fly ash have created ecological and eco-environmental problems. The disposal of the increasing amounts of fly ash is becoming a serious concern to the environmentalists. Environmentally, sound management of waste fly ash is a major concern in maintaining the quality of the Earth's environment and especially in achieving sound and sustainable ecological development. India ranks fourth in the world in the production of coal ash as by-product waste after USSR, USA and China.

Environmental hazards

The problem with fly ash lies in the fact that not only does its disposal require large quantities of land, water and energy, its fine particles, if not managed well, can become airborne. Currently 90 million tones of fly ash are being generated annually in India, with 65000 acres of land being occupied by ash ponds. Such a huge quantity dose poses challenging problems, in the form of land use, health hazards and environmental damages.

- It is a very difficult material to handle in dry state because it is very fine in nature and readily airborne even in mild wind.
- It disturbs the ecology of the region, being a source of soil, air and water pollution.
- Long inhalation of fly ash causes silicosis, fibrosis of lungs, bronchitis, pneumonitis etc.
- Flying fine particles of ash poses problems for people living near power stations, corrode structural surfaces and affect horticulture.
- Eventual settlement of fly ash particles over many hectares of land in the vicinity of power station brings about perceptible degeneration in soil characteristics.

Literature reviewed

Ahmad Shamshad, Fulekar M.H., Pathak Bhawana (2012)[1], Impact of Coal Based Thermal Power Plant on Environment Mitigation Measure, International Research Journal of Environment Sciences, Vol. 1(4), 60-64, expressed that Coal used widely as a thermal energy source in thermal power plant for production of electricity but available coal in India is of poor quality, with very high ash content and low calorific value. Utilization of huge amount of coal in thermal power plant has created several adverse effects on environment leading to global climate change and fly ash management problem. Coal based thermal power plants all over the world is cited to be one of the major sources of pollution affecting the general aesthetics of environment in terms of land use, health hazards and air, soil and water in particular and thus leads to environmental dangers. So, the disposable management of fly ash from thermal power plant is necessary to protect our environment.

Ansari, F. A., Gupta A. K., and Yunus M., (2011)[2] Fly ash from coal fired Thermal Power Plants: Bulk Utilization in Horticulture - A long Term Risk Management Option, International Journal of Environmental Research, Vol. 5, No. 1, pp. 101-108, strongly advocate in their research that management of solid waste (fly ash) has attained an apparent scenario for scientific & strategic concern in India due to large-scale dependence on coal-based thermal power plants. However, the large-scale and voluminous generation of fly ash averagely on regular basis calls for bulk utilization options in a productive purpose like horticulture and for production of two important vegetable crops, *viz*., Brinjal and Spinach, grown on fly ash substrate.

M. I. M. Loya and A. M. Rawani (2014)[3], a review: promising applications for utilization of fly ash, International Journal of Advanced Technology in Engineering and Science, Volume No.02, Issue No. 07, p.no. 143 advocate that to achieve utilization trend higher than the existing trend line; must be retained. Second, in addition to the first, underutilized large potential applications should be explored. The three key underutilized application groups identified are: (i) mine filling, (ii) bricks, blocks & tiles (iii) roads, embankments & ash dyke raising.

S.K.Chaudhary, (2014)[4], Fly Ash and Climate Change, Journal of Environmental Science and Sustainability (JESS) Vol. 2 (1) 31 – 35, expressed that Fly ash is one of the numerous

substances that cause air, water and soil pollution, disrupt ecological cycles and set off environmental hazards. Currently, more than 100 million tonnes of fly ash is being generated annually in India. 65,000 acres of land is being occupied by ash ponds. Such a huge quantity does pose challenging problems, in the form of land usage, health hazards and environmental dangers. Both in disposal as well as in utilization, utmost care has to be taken to safeguard the interest of human.

Vaishali Sahu & Gayathri. V (2014)[5], The use of stabilized fly ash as a green material in avement substructure: A review, international journal of civil and structural engineering Volume 4, No 3, page no. 306 – 314 expressed that Fly ash utilization is increasing in civil engineering applications; however the need is to increase the percentage utilization and to use the other potential industrial by-products along with fly ash. Fly ash having huge potential to replace the conventional concern. Even the use of cement can be avoided to large extent to save the environment from major greenhouse gas emission during its production. He further expressed that other available industrial wastes which can be used along with fly ash to manage their disposal and to save the environment from all types of pollution.

Mitigating Measures of fly ash

Fly ash is also a raw material for different industries. Some of major application areas of fly ash are: agriculture, Cement manufacturing, part replacement of cement in mortar and concrete, road & embankment construction, dyke raising, structural fill for reclaiming low lying areas, hydraulic structures, stowing material for mines, and other medium & high value added products like tiles, paints, light weight aggregate, extraction of alumina, bricks etc.

Application of fly ash in agriculture

Agriculture and waste land management have emerged as prime bulk utilization areas for fly ash in the country. It improves permeability status of soil; improves fertility status of soil (soil health) crop yield; improves soil texture; reduces bulk density of soil; improves water holding capacity porosity; optimizes pH value; improves soil aeration; reduces crust formation provides micro nutrients like Fe, Zn, Cu, Mo, B, Mn; provides macro nutrients like K, P, Ca, Mg, S etc; works as a part substitute of gypsum for reclamation of saline alkali soil and lime. For exclamation of acidic soils; ash ponds provides suitable conditions and essential nutrients for plant growth, helps improve the economic condition of local inhabitants; crops grown on fly ash amended soil are safe for human consumption & groundwater quality is not affected . Use of fly ash in agriculture has also proved to be economically rewarding. The improvement in yield has been recorded with fly ash doses varying from 20 tone/hectare to 100 tone/hectare. On an average 20-30% yield increase has been observed out of 150 million hectare of land under cultivation, 10 million hectares of land can safely be taken up for application of fly ash per year.

Application of fly ash in construction, roofing, road construction & mining




The use of fly ash in large quantities making the road base and surfacing can result in low value–high volume utilization technology demonstration projects at New Delhi, Dadri (U.P.) and Raichur (Karnataka) have been successfully completed for use of fly ash in road / flyover embankments. Guidelines have been prepared and approved by Indian Roads Congress (IRC) as national standard. More than 10 multiplier effects have taken place across the country. In the recent past CRRI offered advise/ consultancy services in the following road/embankment projects in which fly ash was utilized.

- Construction of plant roads at Budge-Budge thermal power plant using fly ash based pavement specifications (Collaboration with CESC Ltd, Kolkata).
- Construction of one km long rural road near Raichur in Karnataka with fly ash based flexible/semi-rigid pavement composition (Collaboration with Karnataka PWD and Raichur thermal power station – executed as Fly Ash Mission demonstration project).
- Construction of 1.9 km long, 6 to 9 m high road embankment forming eastern approach of the second Nizamuddin Bridge in Delhi using fly ash (Collaboration with Delhi PWD and Indraprastha thermal power station, Delhi)
- Construction of plant road and two rural roads using fly ash (collaboration with National Capital Power Station, NTPC, Dadri, U.P).

Application of fly ash in bricks and ceramic

The Central Fuel Research Institute, Dhanbad has developed a technology for the utilization of fly ash for the manufacturing of building bricks and ceramics. Fly ash bricks have a number of advantages over the conventional burnt clay bricks. Unglazed tiles for use on footpaths can also be made from it. Awareness among the public is required and the Government has to provide special incentives for this purpose. Six mechanized fly ash brick manufacturing units at Korba are producing about 60,000 bricks per day. In addition to this, two mechanized fly ash brick manufacturing units have been set up by private entrepreneurs also at Korba, the total production being about 30,000 bricks/day. Orissa Government in India has banned the use of soil for the manufacture of bricks up to 20 km. of a thermal power station. In the case of fly ash-clay fired

bricks, a mixture of clay and fly ash is fired. The un burnt carbon of the fly ash serves as fuel for burning. Approximately 20-30% energy can be reduced by adding25-40% fly ash.

Application of fly ash in detergent and cement

In the presence of moisture, fly ash reacts chemically with calcium hydroxide and CO2 present in the environment attack the free lime causing deterioration of the concrete. A cement technologist observed that the reactive elements present in fly ash convert the problematic free lime into durable concrete. Fly ash can substitute up to 66% of cement in the construction of dams. Fly ash in R.C.C. is used not only for saving cement cost but also for enhancing strength and durability. Fly ash can also be used in Portland cement concrete to enhance the performance of concrete. Portland cement is manufactured with Calcium oxide, some of which is released in a free state during hydration. Studies show that one ton of Portland cement production discharges 0.87 tons of carbon dioxide in the environment. Another Japanese study indicates that every year barren land approximately 1.5 times of the Indian Territory need to be afforested to compensate for the total global accumulation of carbon dioxide discharged into the atmosphere because of total global cement production. Utilization of fly ash in cement concrete minimizes the carbon dioxide emission problem to the extent of its proportion in cement.

Problem to be investigated

Energy requirements for the developing countries in particular are met from coal-based thermal Power plants. The disposal of the increasing amounts of solid waste from coal-fired thermal power plants is becoming a serious concern to the environmentalists. Current annual production of Fly ash, a by-product from coal based thermal power plant is about 112 million tons (MT) and

as reviled from literature, it is observed that foreign countries fly ash utilization is quite high as compared to Indian applications which is merely 38% only. Some of the major problems associated with Fly ash are large area of land required for disposal and toxicity associated with heavy metal leached to groundwater.

Harmful chemical contents in fly ash

Sr. No.	Constituent	(%)	Problems
01	Silica (SiO2)	**67**	silicosis
02	Alumina (Al2O3)	**26**	Vomiting sensation
03	Iron Oxide (Fe2O3)	**63**	fibrosis of lungs
04	Calcium Oxide (CaO)	**02**	Pneumonia
05	Magnesium Oxide (MgO)	**01**	Diarrhea
06	Sulphur (SO3)	**01**	Irritation
07	Potassium oxide K2O	**02**	Skin burning

(Source: Critical Review in Environmental Control CRC Press, 3, (1989)

Objectives of research

1. To make maximum application of fly ash in agriculture, construction & also in developing eco-friendly products.
2. To minimize effluents and disposals.
3. To protect health & environment from pollution.
4. To suggest some remedial measures to minimize pollution to protect and save environment.

Hypotheses

H_0 – Fly ash from thermal power plant is not properly used in Agriculture & Construction to protect Health & Environment.

H_1 – Fly ash from thermal power plant is properly used in Agriculture & Construction to protect Health & Environment.

Scope of study

The scope of the study revolves around two prime focuses i.e. one from environmental protection and other from organization point of view.

From environmental perspective: Eco-friendly product, pollutant free environment.

From organization Perspective: pollutant free environment, effective use of land, extra profit outlet from bi-product.

Research Methodology

In order to realize the aforementioned research objectives, following research methodology was adopted by the researcher.

Data Source

Primary Data

Questionnaire is a main tool for collecting the primary data. Questionnaire is pre tested & designed in such a systematized manners, so that it comprises all the aspects of the study. To make the study more practical in nature, primary data were collected through structured questionnaire and personal interviews of 200 farmer's respondent around the vicinity & six (06) thermal power plants in Vidarbha under observation to know about fly ash concern, awareness or its utilization.

Secondary Data

Secondary data were collected from related research works, published books, journals, reports of industries, government records, news papers, business magazines, and websites.

Sample technique

The research was carried out in Vidarbha of Maharashtra state. For the research study purpose convenient sampling method was used to select the sample (CSM).

Sample size

Sr. No.	T.P.P.	Area	Farmers
01	CTP	Chandrapur	
02	Adani T.P.P.	Tumsar	

03	NTPP	Nagpur	200
04	Lloyd T.P.P.	Wardha	
05	India Bulls T.P.P.	Amravati	
06	Paras T.P.P.	Buldhana	
Total	06		200

(Source: Primary Data)

Tools used for analysis

Statistical tools used for the study analysis area are

- Percentage Analysis

Limitations of the Study

- Sample Size has been restricted to 200 samples due to time constraints and to provide an in-depth analysis.
- The study is confined to the respondents at Vidarbha of Maharashtra state only.
- The study relies more heavily on primary as well as on secondary data.
- The details furnished by the respondents are considered as true and the study results are based on this assumption.
- The result arises from the research may or may not be applicable to other parts of the state or country.
- Duration of the study is confined to four month i.e. August 2016 to November 2016.

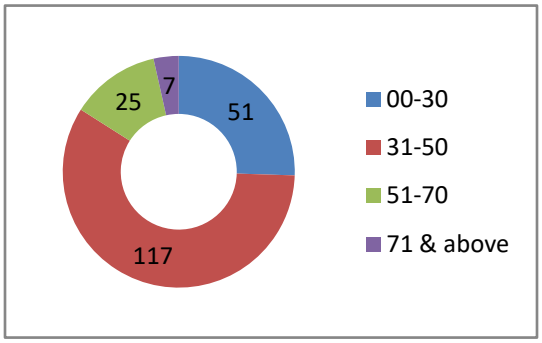
Data analysis & discussions

Table No. 1 Demographic Profile of farmers

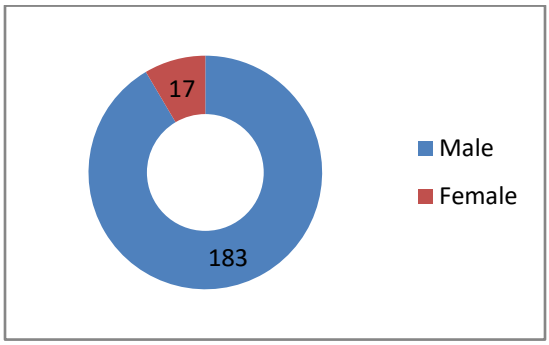
Sr. No.	**Age**	**F**	**%**	**Gender**	**F**	**%**
01	00-30	51	25.50	Male	183	91.50
02	31-50	117	58.50	Female	17	08.50
03	51-70	25	12.50			
04	71 & above	07	03.50			
Total		200	100		200	100

(Source: Primary Data)

While gathering the information from farmer respondents regarding fly ash it was observed that as high as 58.50% respondents observed to be in the age group of 31-50 years and the dominance of male respondents was mainly observed.



Age



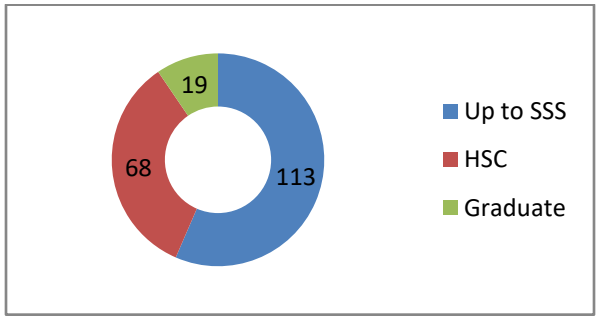
Gender

Table No. 2 Education

Sr. No.	Education	F	%
01	Up to SSS	113	56.50
02	HSC	68	34.00
03	Graduate	19	09.50
04	PG	-	-
Total		200	100

(Source: Primary Data)

From the information sought about farmer respondents it was noticed that maximum respondents was observed to below ssc and quite few were observed to be illiterate observed to be main cause of concern.



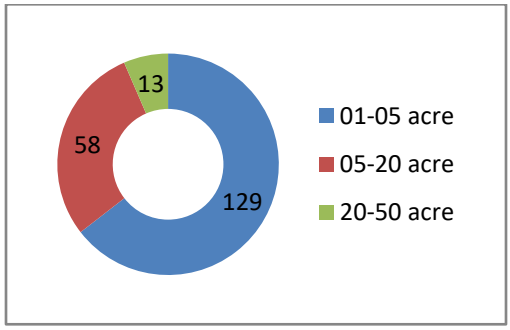
Education

Table No. 3 Land holding capacity

Sr. No.	Land holding in acre	F	%
01	01-05 acre	129	64.50
02	05-20 acre	58	29.00
03	20-50 acre	13	06.50
04	50 & above	-	-
Total		200	100

(Source: Primary Data)

As high as 64.50% respondents was observed to be holding 01 to 05 acres of land under cultivation.



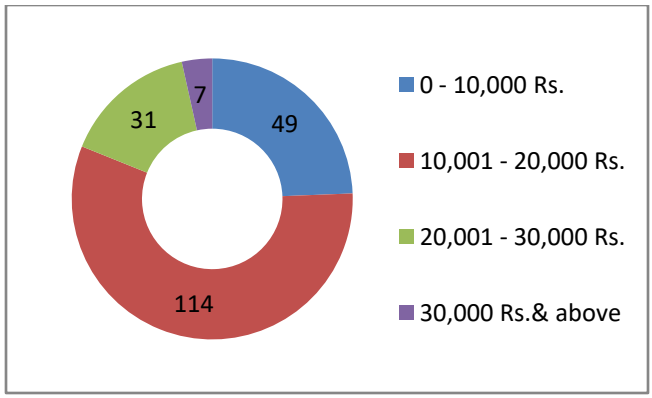
Land holding in acre

Table No. 4 Income

Sr. No.	Income Group monthly	F	%
01	0 - 10,000 Rs.	49	24.50
02	10,001 - 20,000 Rs.	114	57.00
03	20,001 - 30,000 Rs.	31	15.50
04	30,000 Rs.& above	07	03.50
Total		200	100

(Source: Primary Data)

Financial Poverty & poor educational level is the main cause of concern for the farmer's upliftment. As is revealed from data also 57% respondents observed to be in the mere income group of 10,001 - 20,000 Rs.



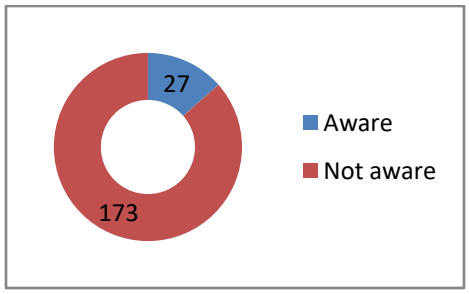
Income

Table No. 5 Awareness regarding Environmental concern

Sr. No.	**Awareness**	**F**	**%**
01	Aware	27	13.50
02	Not aware	173	86.50
Total	200	200	100

(Source: Primary Data)

During the course of survey it was noticed that mostly farmers were not aware regarding fly ash impact on agriculture and environment. They were stunned to know when discussed about ill effect of fly ash on environment. Further it was also noticed that awareness needs to be strengthen in this regard.



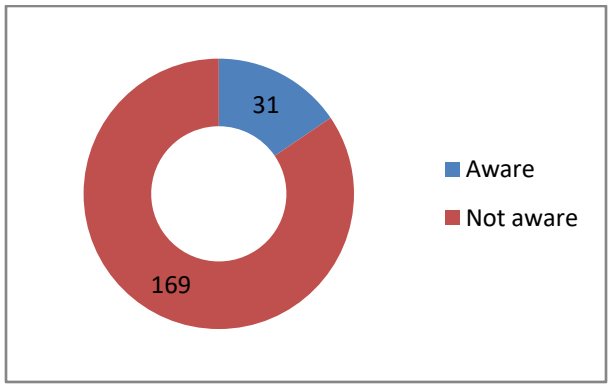
Environmental concern

Table No. 6 Awareness regarding Potential application of fly ash

Sr. No.	**Awareness**	**F**	**%**
01	Aware	31	15.50
02	Not aware	169	84.50
Total	200	200	100

(Source: Primary Data)

Awareness campaign by the government and the ministry of environment should be communicated to the farmers that fly ash is a source and not treated as a waste. Proper emphasis must be given to handle fly ash as well as to educate the farmers, industrialist for multiple uses of fly ash.



Potential application

Conclusions

To meet the growing energy demand and thereby increase power generating capacity, the dependency on coal for power generation and disposal of fly-ash will continue to increase along with various unavoidable problems. Hence, it is required to involve fly-ash more effectively in agriculture, construction & allied sources to exploit its various physical and chemical properties fully, which are beneficial for soil and crop health & environment. In view of the above research, the salient points from this extensive research could be summarized as:

Advantages of fly-ash use in agriculture

It could be noted that the potentiality of fly ash for its use in agriculture is popularizing day by day due to the fact that it contains almost all the essential plant nutrients i.e., macronutrients including P, K, Ca, Mg and S and micronutrients like Fe, Mn, Zn, Cu, Co, B and Mo etc. But still awareness regarding fly ash must be strengthen for better tomorrow.

It is now well proved that fly ash can be treated as a substitute for lime, chemical fertilizers and thereby reduces environment pollution. As agricultural lime application contributes very heavily to global warming extensive use of fly-ash as soil ameliorant can reduce CO2 emission and thereby lessen global warming.

Advantages of fly-ash use in construction

The use of fly ash in large quantities making the road base and surfacing can result in low value–high volume utilization have been successfully completed for use of fly ash in road / flyover embankments.

The Central Fuel Research Institute, Dhanbad has developed a technology for the utilization of fly ash for the manufacturing of building bricks and ceramics. Fly ash bricks have a number of advantages over the conventional burnt clay bricks. Unglazed tiles for use on footpaths can also be made from it. In the case of fly ash-clay fired bricks, a mixture of clay and fly ash is fired. The un-burnt carbon of the fly ash serves as fuel for burning. Approximately 20-30% energy can be reduced by adding25-40% fly ash. Awareness among the public is required and the Government has to provide special incentives for this purpose

In the presence of moisture, fly ash reacts chemically with calcium hydroxide and CO2 present in the environment attack the free lime causing deterioration of the concrete. A cement technologist observed that the reactive elements present in fly ash convert the problematic free lime into durable concrete. Fly ash can substitute up to 66% of cement in the construction of dams. Fly ash in R.C.C. is used not only for saving cement cost but also for enhancing strength and durability. Fly ash can also be used in Portland cement concrete to enhance the performance of concrete. Portland cement is manufactured with Calcium oxide, some of which is released in a free state during hydration. Utilization of fly ash in cement concrete minimizes the carbon dioxide emission problem to the extent of its proportion in cement.

Recommendations

A long-term perspective towards fly ash management needs to be drawn out. More importantly, greater participating role of thermal power plants, coal suppliers, industry, technologists & society are needed on a continued basis. Awareness campaign by the government and the ministry of environment should be communicated to the farmers that fly ash is a source and not treated as a waste. Proper emphasis must be given to handle fly ash as well as to educate the farmers, industrialist for multiple uses of fly ash. This is to ensure that the momentum is

maintained, more so, since environment issues shall be a prime concern during the coming century.

Scope for Future Research

As application of fly ash application in agriculture and construction gained its full momentum in coming future there is an ample scope for its application in near future in varied areas. As is revealed from literature reviewed fly ash can be extensively used in fertilizers, chemicals, paints, mines filling, partition material and value based fly ash product. In recent past fly ash is treated as a source of pollution but in fact if used properly may be observed as an economic resource.

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