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THE CURRENT SCENARIO OF THERMAL POWER PLANTS AND FLY ASH: PRODUCTION AND UTILIZATION WITH A FOCUS IN INDIA

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Abstract-*Coal fly ash is an industrial by-product produced from the burning of pulverized coal, during electricity generation in the thermal power plants. Fly ash is considered a major global pollutant due to the surplus amount of generation and hazardous nature. With the advancement in the techniques and various Government policies, it has acquired a status of value-added materials. Based on their mineralogical, elemental properties it can be used for the recovery of minerals like alumina, silica and ferrous. India is one of the major producers of coal and as well as fly ash. In India, around 70-75% electricity is generated by the coal-based thermal power plants. Every year nearly 40-50% fly ash remain unutilized in India. In the present work a current scenario and trend of coal-based thermal power plants, fly ash production and utilization with a focus in India has been considered. The government policies, initiatives towards fly ash handling, production, utilization and future prospects are also focused*.

Keywords: *Thermal power plants; fly ash; progressive utilization; River embankments; ash content*

I. Introduction

Energy is the backbone for any country and their industries for the sustainable development and growth [1]. Energy plays a vital role in the economic development of a nation [2]. A proverb is best fitted in this context "*Power is the key to the prosperity and development of a nation*". Today, energy is being required by each and every sectors- agriculture, industry, transport, domestic purposes and commercial. No matter the country is developed or developing both of them requires a continuous source of energy for their growth and development. India being a developing country, energy plays a very important role in its economy [3]. A developing country like India is still dependent on the natural reserves for the generation of energy [4]. India have sufficient reserves of both coal and nuclear. Even though India is rich in Thorium and Uranium resources but still we have very few nuclear power plants. Still, India is lacking in utilization, handling and of nuclear resources as a source of energy. Today even in the 21st century, coal is the first choice as a fuel, both in India and China for the electricity generation [5]. For about more than 100 years, coal is being used for the production of electricity at coal-fired thermal power plants worldwide [6]. For electricity generation, India depends mostly (70-75%) on coal-based thermal power plants which annually generates 235 MTs fly ash (2016) and is projected to exceed 1000 million ton by 2031-32.

II. Current Status of Thermal power plants in India

About 70-75% of total power generated in India is produced by coal-based thermal power plants [7]. Globally, among all the fuels coal is the largest single source of energy for electricity production and their share is rapidly growing [8]. Coal-based thermal power plants currently provide over 42% of global electricity supply [9]. Globally, coal is the world's most abundant and widely distributed fossil fuel. The coal reserves for all types of coal estimated to be about 990 billion tonnes in the whole world, which is sufficient for 150 years at current consumption (BGR, 2009) [10]. Coal-based energy generation is likely to remain a key component of the fuel mix for power generation to meet electricity demand, especially in the developing countries. From all the available, CEA reports India from 2010-11 to 2016-17 it has been found that, in the year 2011 there were about 88 Thermal power plants only whose total installed capacity was 80458 MW, which consumed about 407.61 MTs of coals. In the year 2011-2012, there were about 124 TPPs and installed capacity was 105925.3 MW which consumed about 437.41 MTs of coal. In the year 2012-2013 there were about 138 TPPs and installed capacity was 120312.30 MW which consumed 482.97 MTs of coal. In the year 2013-2014 there were about 143 TPPs and installed capacity was 133381.30 MW which consumed 523.52 MTs of coal. In the year 2014-2015 the total strength of TPPs increased to145 and installed capacity was 138915.80 MW which consumed 549.72 MT of coal. In the year 2015-2016 there were about 151 TPPs and installed capacity was 145044.80 MW which consumed 536.4 MT of coal. In the year 2016-17 there were about 155 TPPs and installed capacity was 157377.00 MW which consumed 509.46 MT of coal**.** This statistics shows that there is progressive growth in the installation of thermal power plants and coal consumption, due to the increase in demand of electricity by the increasing population. Table no.1 shows the year wise installed TPPs, newly installed TPPs, coal consumption and percentage ash content during 2010-11 to 2016-17 [11] [CEA Reports 2017 December]

Table no.1

Descriptions	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015	2015-16	2016-17
TPPs	88	124	138	143	145	151	155
Installed capacity (MW)	80458	105925.3	120312.30	133381.30	138915.80	145044.8	145044.8
Coal consumed (MTs)	407.61	437.41	482.97	523.52	549.72	536.4	536.4
Average ash content (%)	32.16	33.24	33.87	33.02	33.50	32.94	33.22

Thermal power plants, installed capacity, coal consumption & ash content during year 2010-11 to 2016-17

In India, National Thermal Power Corporation (NTPC), a public sector undertaking and several other state-level power generating companies are the major stakeholders, which are engaged in coal-based thermal power plants. In spite of these two there are several private companies also who are operating the power plants in India. The zone wise list of thermal power plants units, their installed capacity and energy production in MW is given below in the table no. 3. Here is some list of operating coal-based thermal power plants in India. [12] (CEA monthly reports, Power sectors January 2017).

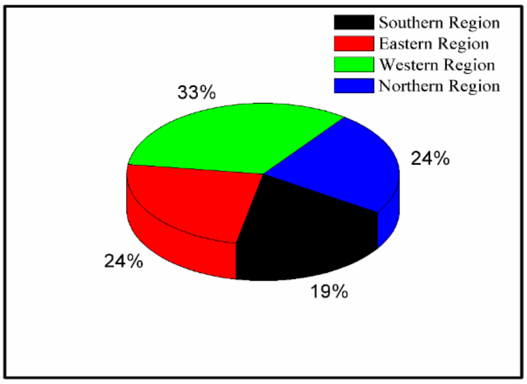

Fig.1 Power Generation in India by Thermal Power Stations Region-wise: Break –up

Table no.2

Thermal power plants distribution in India zone wise (31.01. 2018)

Region	Total TPPs	Units	Units MW
Western region	-	-	69508.62
Northern region	-	-	52489.20
Eastern region	-	-	26921.64
Southern region	-	-	44382.02
North-Eastern	-	-	520.02
Grand total	155	-	193821.50

III. FLY ASH AND THEIR PROPERTIES

Fly ash is the finest of coal ash particles produced as a byproduct during the production of electricity in the thermal power plants (TPPs). It is called “fly” ash because it is being transported from the combustion chamber by the exhaust gases [13]. Fly ash is a fine, spherical shape, glass-like particles, heterogeneous in nature whose size varies from 0.01-150 µm [14]. These micron-sized earth elements primarily consist of silica, alumina and iron along with the traces of oxides of Na, Mg, Ca, P, K, Ti and also the noncombustible matter in coal and a small amount of carbon that remains from incomplete combustion of coal. Fly ash is light in color and mostly consists of silt and clay-sized glassy spheres which provides fly ash a consistency somewhat like talcum powder [15]. The mineralogy and composition of fly ash vary from one sample to next depending on the source of the coal; design, type and operation of the power plant boiler unit

[16]. In comparison, bituminous coals fly ashes, lignite and sub-bituminous coal fly ashes have a higher calcium oxide content and a lower loss on ignition (LOI). Also, lignite and sub-bituminous coal fly ashes have a higher concentration of sulfate compounds than the bituminous coal fly ashes [17].

Fig. 2 Fly ash (Source: PYR fly ash suppliers)

As the origin of fly ash is coal whose major qualitative compositions are similar to the natural earthy materials. Generally, all other elements (except Al, Si, Ca, Ti, Na, Mg, C, O) occur in the parts per million range and collectively, seldom exceed 1% of the bulk composition. Fly ash is associated with various useful constituents, such as Ca, Mg, Mn, Fe, Cu, Zn, B, S, and P, along with appreciable amounts of toxic elements such as Cr, Pb, Hg, Ni, V, As, and Ba. The concentrations of trace elements in ash are extremely variable and depend upon the composition of the parent lignite, conditions during lignite combustion, an efficiency of emission control devices, etc [18]. Fly ash has gained much attention from the construction industry as a useful and increasingly important raw material. Once considered a nuisance waste product with a disposal problem, fly ash is now recognized as a valuable substance which confers certain desirable characteristics in its many applications. Fly ash is utilized in cement manufacturing, ceramics making, etc.; and more recently in wastewater treatment [19] [20] [21]. It has also a great potential to be used as a source of major and micro-nutrient elements required for healthy plant growth. In view of the potential of fly ash as a health hazard and as a useful industrial raw material, thereafter recovery of radioactive and valuable elements, studies of its elemental composition are highly desirable [22]**.** The applications of fly ash depends on the elemental and mineralogical properties which can be achieved by the characterization of fly ash by instrumental analysis. There are two classes of fly ash namely class F and class C which are primarily based on the amount of silica, alumina, iron and calcium, content in the ash. Besides these, the two types vary in their applications, mineralogy and content which has been summarized in the table no.3

Table no. 3

Summarized properties of Class F and class C types of fly Ash

S.No	**Class F- Fly Ash**	**Class C-Fly Ash**
1.	Produced from burning harder, older anthracite and bituminous coal	Produced by burning younger lignite and sub-bituminous coal
2.	Contains less than 20% lime	Contains more than 20% lime
3.	Calcium ranges from 1-12%, in the form of calcium hydroxide, calcium sulfate and glassy components	Calcium content: 30-40%
4.	Higher amount of alkali and sulfate	Less amount of alkali and sulfate
5.	Requires cementing agent like PC, quicklime, hydrated lime	Self-cementing properties
6.	Addition of air entrainer needed	Does not require activator & air entrainer
7.	Used in high sulfate exposure conditions	Can't be used in high sulfate conditions
8.	Useful in high fly ash content concrete mixes	Limited to low fly ash content concrete mixes
9.	Used for structural concretes, HP concretes, high sulfate exposure concretes	Primarily residential construction

3.1 Physical characteristics of fly ash

The color of fly ash can vary from tan to grey to black, depending on the amount of unburned carbon in the ash [23]. Lighter the color of fly ash, lesser the carbon content [24]. Fly ash produced from lignite or sub-bituminous coals have usually light tan to buff in color [25], indicating relatively low amounts of carbon as well as the presence of lime or calcium [26]. Bituminous coal gives rise to grey shades of fly ash, fly ashes are usually some shade of grey, and lighter shades of grey indicates generally a higher quality of ash [27]. Fly ash, which constitutes 85% - 90% of the overall ash, is a fine, a light grey powder made up of glassy spheres of size 0.01-150 microns (μ) in size. The specific gravity of fly ash varies from 1.9 to 2.4 [28] and the bulk density of about 0.8-1 ton per cubic meter and a maximal density of 1,000 - 1,400 kg/m^3. Fly ash specific surface area (measured by the Blaine air permeability method) falls in between 2,000 to 6,800 cm^2/gram [29]. The particle size of U.S. and Indian fly ash is given below in table 4.

Table no. 4

Size distribution in fly ash

Category based on grain size	Size (mm)	U.S. Fly ash (%)
Very coarse sand	2.00-1.00	0.2
Coarse sand	1.00-0.50	0.9
Medium sand	0.50-0.25	3.4
Fine sand	0.25-0.10	14.8
Very fine sand	0.10-0.05	13.1
Silt	0.05-0.002	63.2
Clay	< 0.002	4.3

The particle size distribution of most bituminous coal fly ashes is generally similar to that of silt (less than a 0.075 mm or No. 200 sieve). The fly ashes of sub-bituminous coals also have silt-sized, but they are slightly coarser than bituminous coal fly ashes in general. Eighty to 99% of a fly ash sample by weight passes a No. 200 sieve, which has a 0.074 mm (74 Arm) screen size.

3.2 Chemical properties

The pH of the fly ash varies depending on the source of the coal. Fly ash is known to be both acidic and alkaline in nature. Fly ashes with pH ranging from 4.5 to 12.0 have been identified due to differences in particle size and subsequent concentration of trace metals. Similarly, EC, which reflects the quantitative estimate of soluble cations and anions, varies between 0.177 to 14 mmhos/cm [30]. There exists a direct correlation between EC and total salt concentration in fly ash. Bituminous coal ashes are mostly acidic, whereas sub-bituminous coal gives rise to alkaline ash with a lower content of S, but a higher content of Ca and Mg than the bituminous coal. It must be noted that the Indian coal is lower in S, and the corresponding ash is alkaline in nature in contrast to most of the Europeans Coals [31]. Fly ash varies in its chemical composition depending on the parent coal and the operating conditions of the furnace. As fly ash is a by-product material, so chemical constituents may vary considerably but all fly ash commonly includes silicon dioxide (SiO_2), Iron (III) oxide (Fe_2O_3, Aluminum oxide (Al_2O_3) and calcium oxide (CaO) also known as lime. In general, approximately 95-99% of fly ash consists of oxides of Si, Al, Fe, Ca and Ti and about 0.5% to 3.5% consists of Na, P, K, Mg, Mn and S. The remainder of the fly ash is composed of trace elements (in alphabetical order): As, B, Ba, Br, Cd, Cl, Co, Cu, Cr, Fe, Ga, Hg, I, In, Mo, Ni, Pb, Po, Rb, Sb, Sc, Se, Sr, TI, W, V and Zn [32].

IV. FLY ASH: PRODUCTION AND UTILIZATION

India has a large amount of coal reserve and coal based thermal power plants for the electricity production. There are several government organizations which continuously keeps a track on the TPPs operations, Installations, their life, CO_2 emissions and fly ash production & utilization. Central Electrical Authority of India (CEA) collects the data from all the thermal powers plants and publishes the half-yearly and annually data in the month of June and December respectively. So based on the CEA reports during the period of 2010-11 to 2016-17 following information has collected, which is given below in the table no 5.

Table no. 5

Fly ash, production, utilization in India during the period of year 1998-99 to 2016-17 (CEA reports 2017)

Descriptions	2010- 11	2011-12	2012-2013	2013-2014	2014-2015	2015-16	2016-17
Fly ash production	131.09	145.42	163.56	172.87	184.14	176.74	169.25
Fly ash utilization	73.13	85.05	100.37	99.62	102.54	107.77	107.10
% Utilization	55.79	58.48	61.37	57.37	55.69	60.97	63.28

From the above table no.5, it is concluded that there is a progressive increase in the fly ash generation and utilization from the year 2010-11 to 2016-2017. The increased production of fly ash might be due to the installations of new super thermal power plants. While the increased utilization of fly ash might be due to the strict government directions, rules, awareness, government policies and by the technologies. The instruments help in the determination of the detailed properties of fly ash which also may play an important role in the increased utilization rate of fly ash. There is a continuous increase in the fly ash utilization from the year 1996-97 to the year 2016-17 from the above table no 6. (CEA report December 2017). In the year 1996-97, there was a utilization of only 9.63% after which there is a progressive increase in the utilization of various forms given (below) in the table no.6. While in the year 2016-17 the fly ash utilization percentage has increased up to 63.28% which is highest of all since 1996 to 2017. By looking at these figures it is expected that the future of fly ash utilization is better in India. In near future it will be no more a major pollution in the form of hazardous waste which is could be possible due to the advances in the techniques, Government initiatives & policies and awareness. Government have estimated that there will be production of approximately 240 and 300 MTs of fly ash by the year, 2020 and 2025 respectively.

Table no. 6

Progressive fly ash production & utilization during the period from 1996-97 to 2016-2017(CEA reports Dec, 2017)

S. No	Year	Fly ash production (Million Tonnes)	Fly ash utilization (Million Tonnes)	Percentage (%)
1	1996-97	68.88	6.64	9.63
2	1997-98	78.06	8.43	10.80
3	1998-99	78.99	9.22	11.68
4	1999-2000	74.03	8.91	12.03
5	2000-01	86.29	13.54	15.70
6	2001-02	82.81	15.57	18.80
7	2002-03	91.65	20.79	22.68
8	2003-04	96.28	28.29	29.39
9	2004-05	98.57	37.49	38.04
10	2005-06	98.97	45.22	45.69
11	2006-07	108.15	55.01	50.86
12	2007-08	116.94	61.98	53.00
13	2008-09	116.69	66.64	57.11
14	2009-10	123.54	77.33	62.60
15	2010-11	131.09	73.13	55.79
16	2011-12	145.41	85.05	58.48
17	2012-13	163.56	100.37	61.37
18	2013-14	172.87	99.62	57.63
19	2014-15	184.14	102.54	55.69
20	2015-16	176.74	107.77	60.97
21	2016-17	169.25	107.10	63.28

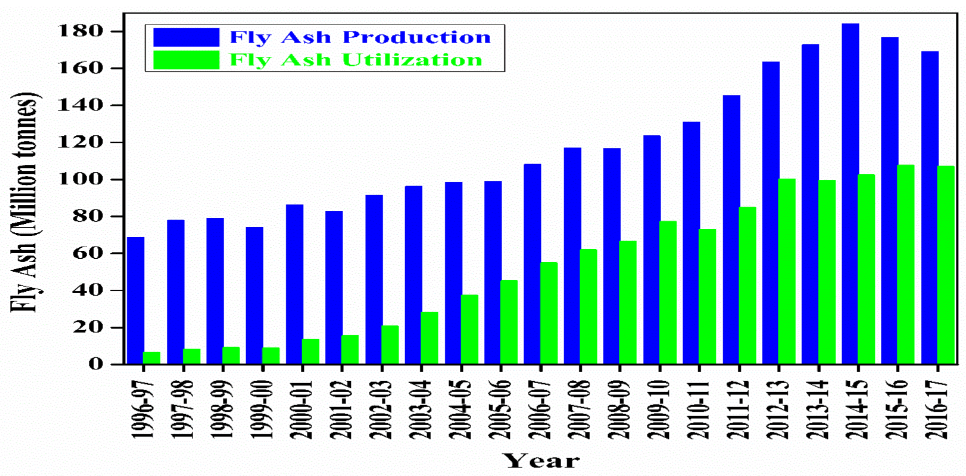

Fig. 3 Progressive production and utilization of fly ash from year 1996-97 to 2016-17

V. VARIOUS MODES OF UTILIZATION OF FLY ASH

Over a period of last twenty years, the image of fly ash has completely changed from a “hazardous waste” to “Resource Material”. This is achieved due to the focused thrust provided by Fly Ash Mission (FAM) & through Fly Ash Unit (FAU), Department of Science & Technology (DST) India. Fly ash is being used in all the fields whether as whole or in parts. It is being used in the form of cement, for road reclamation and low lying areas (RLLA), Road embankments, mine fillings, ash dyke raising, bricks and tiles, agriculture, concrete and others. The major portions of fly ash are being used mainly for the civil and constructions which include cement, mines fillings, concrete, bricks and tiles, Road embankments and reclamations. Still agriculture and metallurgical purposes it is being used in very less amount. Applications of fly ash in the field of agriculture is very less which might be due to unawareness by the farmers, or might be due to the presence of high content of toxic elements. But from the data, it is obvious that the utilization percentage in the field of agriculture has increased from the year 2010-11 to 2016-17 and about 2 MTs in the year 2016-17, which is highest among all the years.

Table no. 7

Major modes of fly ash utilization from the year 2010-11 to 2016-17

Mode of utilization	Cement	RLLA	Roads & Embank ments	Mine filling	Ash dyke raising	Brick s & tiles	Agriculture	Concrete	Others	Total
2010-11	35.47	9.31	8.52	6.04		4.61	1.27		7.91	73.13
2011-12	38.08	14.21	5.54	7.74	5.86	5.83	0.88		6.28	85.05
2013-14	19.56	5.20	2.20	5.37	4.27	5.03	1.47	0.68	3.32	47.10
2014-15	21.27	5.06	1.39	6.44	4.25	4.92	1.07	0.37	3.88	48.65
2016-17	40.586	11.03	6.194	11.78	11.88	14.91	1.92	0.76	7.98	169.2

5.1 In cements during 1996-97 to 2016-17

The compositions of fly ash are closely similar to the cements so, it is widely used by the cement industries as a pozzolanic material in manufacturing of Portland Pozzolan Cement (PPC). The manufacturing of PPC by fly ash saves both, precious limestone and coal. The application of fly ash for the manufacture of cement is highly value-added use. According to CEA report 2017, there is progressive utilization of fly ash by the cement Industries during the period from 1998-99 to 2016-17. As in the year 1988-99 only 2.45 MTs of fly ash were used for cements, whereas this value increased to 40.59 MTs during the year 2016-17 which alone constitutes 23.98 % of total fly ash utilization in the aforesaid year.

5.2 Reclamation of Low Lying Areas

Fly ash properties makes it a potential substitute of soil/sand and widely used for the reclamation of low lying areas thereby saving top layer of soil. CEA report 2017 reveals that during the year 1988-99 only 4.17 MTs were used for such purposes, which increased to 11.04 MTs in the year 2016-17 by constituting 6.52% of total fly ash utilized during the aforesaid year.

5.3 Construction of Roads/Embankments/Flyovers and raising of Ash Dykes

Fly ash is most widely used in the construction of civil works like roads/embankments/flyovers and the raising of ash dykes. It has a large potential for the utilization of fly ash. From the CEA report 2016-17, it was revealed that during the year 1998-99 only 1.055 MTs of fly ash was used for this applications while this value reached to 6.19 MTs in the year 2016-17 which alone constitutes 3.66% of the total fly ash utilized in the aforesaid year. However there is fall in the trend in the recent past noticed.

5.4 Back Filling/Stowing of Mines

Among mining fly ash is mostly used for backfilling of open cast mines and stowing of underground mines which saves the top fertile soil and precious river sand. It has large potential for fly ash utilization especially for pit head thermal power stations. The CEA report 2016-17 reveals that in the year 1988-99 only 0.65 MTs of fly ash was used for back filling/stowing of open cast and underground mines which increased to 11.79 MTs in the year 2016-17 which constitutes 6.96% of total fly ash used in the aforesaid year. The trend was on increasing side and increase in the latest year as compared to the previous year.

5.5 Building Materials like Bricks, Blocks and Tiles

Nowadays all the civil materials or building materials i.e. bricks, tiles, cements blocks, etc utilizes fly ash in variable compositions which indirectly helps in saving the fertile top soil. Fly ash amended materials are as good as clay-based conventional building materials. It has significant potential of fly ash utilization especially for thermal power stations positioned near load centers. CEA report 2016-17 reveals that in the year 1998-99 only 0.70 MTs fly ash was used for this purpose which increased to 14.91 MTs in the year 2016-17 and constitutes of about 8.81% of total fly ash used in the aforesaid year.

5.6 Agriculture

Due to the availability of numerous micronutrients in fly ash, it can be used as a manure in the agricultural sectors. It is also being used as in the form of herbicides, to maintain the pH of the agriculture soil, or to maintain the fertility of the soil. The progressive utilization of fly ash was observed in the agricultural sector during the period of year 1998-99 to 2016-17. As, during the year 1988-99 only 0.13 MT was used while it raised to 1.92 MTs in the year 2016-17 which constitutes 1.14% alone of total fly ash utilization in the aforesaid year.

In the last two decades, a large number of technologies has been adapted for the complete utilization and proper disposal of fly ash. The fly ash management would remain an important area of national concern. Due to the continuous efforts of the Government towards the utilization of fly ash now it has acquired a status of "useful and saleable commodity". While a few decades ago it was considered as a hazardous waste material of the industry. Earlier, the fly ash application was most predominantly restricted to road constructions, landfills and partly for bricks and cement. But nowadays, fly ash is being used for cement manufacturing, road embankments, bricks & tiles manufacturing, ash-dyke raising, mine-fills, landfills, and agriculture.

VI. DRAWBACKS OF COAL BASED THERMAL POWER PLANTS

The major drawbacks of these coal-based thermal power plants are their high maintenance and operating costs. Besides this, they require a very long time for the erection and putting into action. Moreover, a large quantity of water is required for its operation. During operation, there is a loss of most of the heat energy, the presence of trouble due to smoke and heat in the plant. Handling of coal also makes the whole process more cumbersome. The continuous production of ash as a byproduct is a one of the major problems.

VII. FLY ASH: DRAWBACKS AND DISADVANTAGES

Indian coals have high ash content about 30-50% in comparison to the coals of other countries. The quantum of fly ash production depends on the types of coal used and the operating parameters of the thermal power plants. By the year 2013-14, about 65000 acres of land has been already occupied by the ash ponds. While in the current year, 2016-17 the annual production of fly ash in India was about 169.25 MTs and utilization was 107.10 MTs, and about 63 MTs remained unutilized. This huge volume of fly ash requires large areas of lands in the form of ash ponds for dumping which may lead to encroachment on agricultural land. Such a huge volume possess a challenging threat, in the form of usage of land, health and environmental hazards. Other problems related to fly ash disposal includes high disposal costs and potential leaching of toxic heavy metals from the areas of dumped fly ash into surrounding soil or ground water [33], [34]. Utmost care has to be taken to safeguard the human life, wild life and environment from the fly ash disposal and utilization. When pulverized coal is burnt to generate heat, the residue contains 80% fly ash and 20% bottom ash [35]. A huge volume of fly ash generated from coal-based thermal power plants may create several threats from the environmental point of view. The ultrafine fly ash particles ranging in size from 0.5 to 300 micron in equivalent diameter, being lighter in weight, have potential to get airborne easily and pollute the environment [36]. If the fly ash management remained improper in sea/rivers/ponds then it could lead damage to the aquatic life also. Slurry disposal lagoons/settling tanks can become breeding grounds for mosquitoes and bacteria. The presence of traces of toxic heavy metals in fly ash may also contaminate the underground water resources. In order to get out the fly ash from the thermal power plants and to the dumping sites or ash ponds requires huge expenditures.

7.1 Water pollutant due to heavy metals

Fly ash is considered as a “hazardous pollutant” due to the high content of toxic heavy metals in them [37]. The heavy metals present in fly ash are Cd, Pb, As, Ni, Cu, Cr, Mo, Zn, Hg and Co which makes them severe toxic for the environment [38]. Heavy metals are considered to be the most important pollutant in the source and treated water. The heavy metals may leach out from the fly ash ponds or dumping sites to the nearby water bodies which may contaminate the potable water and ultimately lead to the water pollution. Earlier several outbreaks have been reported where there was spillage of fly ash from the ash ponds and contaminated the water reservoirs. Since water is a most crucial requirement for life as well as the existence of all the organisms, so water pollution is a major concern. Once heavy metals from fly ash are released into the water bodies or in the environment, there is bioaccumulation in the higher trophic levels of the food chain. Almost all the heavy metals are toxic to the living organisms and if ingested more than the prescribed levels then it could lead to both acute and chronic toxicity. The removal of such contaminants is considered to be a major problem in the environmental remediation [39]. Heavy metals in wastewater have emerged as the focus of environmental remedial efforts due to their toxicity and threat to human life [40] [41]. Water pollution is considered to be a major environmental problem worldwide, and among the various water pollutants, heavy metals require special attention because of their toxic effect on humans and the environment. Moreover, heavy metals form a very dangerous category due to their toxic carcinogenic nature, non-biodegradable and persistent nature, hence tends to accumulate in the environment for a very long time. Heavy metals thus can only be transformed from more toxic or carcinogenic to less toxic or non-carcinogenic form. Heavy metal remediation, detoxification and assay are of significant interest because exposure to metals like cadmium (Cd), lead (Pb), mercury (Hg), and arsenic (As) are known to cause a range of diseases that are detrimental to human health [42]. The presence of these toxic heavy metals limits the wider application of fly ash as a material and also challenges a potential threat to the surrounding areas of the dumping sites of the ash ponds. Moreover, metal mineralization is a very slow process in nature. So, for the wider applications of fly ash in the industries for different applications, it is required to minimize the heavy metals by processes like acidic leaching or treatment [43].

IX. INDIAN GOVERNMNET LATEST INITIATIVES FOR FLY ASH

The major steps were taken by the Indian government towards fly ash utilization and the real-time data availability in the year 2017, during which a web-based monitoring system and a mobile application were developed. By knowing the importance of fly ash utilization and slag for reducing the burden on the environment, NITI AAYOG has conducted several meetings regarding policies framework on fly ash utilization and slag. The meeting held on 17.03.2017, has decided that an online repository of the fly ash generated by thermal power plants highlighting the following measurements should be launched by Ministry of Power by 15th April 2017:

- Cumulative amount of fly ash availability in the ash ponds as on 31.3.2017
- Total amount of fly ash generated for the respective month (For instance, the month of April 2017)
- Total number of available ash ponds and their approved capacities in metric tonne
- Cumulative stock of fly ash available in the ponds for the month as on 30th April 2017
- Total amount of fly ash disposed or distributed to the consuming industries, which are in close vicinity of 100 Kms, 101-500 Kms, etc. with the details of the consumers.
- Amount of fly ash left (Balance stock) or available in the ash ponds for the month ending April, 2017 accordingly, a web based monitoring system and a mobile application (Ash Track) have been developed.

X. CONCLUSION

The fly ash particles size varies from 0.2 to 150 (µ) microns. Cenospheres particles are prominent in numbers in comparison to the ferrospheres in the fly ash particles. Indian fly ash has high ash content in comparison to other countries. Due to high physical, chemical, mineralogical and elemental properties it has progressively gained applications in the fields of recovery of metals, mining, road constructions and fillers. Among all one of the major application is in the form of cement, which constitutes 30-50% total utilization of fly ash every year. Some recent applications include bricks, tiles panels and composite materials. The government directives have also played an important role in the progressive increase in the utilization of fly ash. Present scenario of fly ash in India assures that fly ash utilization has better scope in future. It is possible to say that the chemical and physical properties of fly ash particles are a function of the mineral matter in the coal, the combustion conditions, and post-combustion cooling. Fly ash will be a source for revenue generation, reusing will conserve the natural raw materials and abridge the disposal cost. It will also generate revenues and business opportunities while protecting the environment at the same time. If understood and managed properly, fly ash could prove to be a valuable resource material.

REFERENCES

1. David L McCollum, Luis Gomez Echeverri, Sebastian Busch, Shonali Pachauri, Simon Parkinson, Joeri Rogelj, Volker Krey, Jan C Minx, Mans Nilsson, Anne-Sophie Stevance and Keywan Riahi, “Connecting the sustainable development goals by their energy inter-linkages”, Environ. Res. Lett. 13 (2018) 033006.
2. Science for Environment Policy": European Commission DG Environment News Alert Service, edited by SCU, The University of the West of England, Bristol.
3. Matleena Kniivilä, Industrial development and economic growth: Implications for poverty reduction and income inequality, Industrial Development for the 21st Century Pellervo Economic Research Institute, Helsinki, Finland, pp 295-332.
4. Haribandhu Panda, “Energy Scenario in India”, Conference Paper, January 2011.
5. Zmarak Shalizi, “Energy and Emissions: Local and Global Effects of the Rise of China and India”, Chapter 5, pp 117-56.
6. Professor Igor Pioro and Professor Pavel Kirillov, “Current status of electricity generation at thermal power plants”, Materials and processes for energy: communicating current research and technological developments (A. Méndez-Vilas, Ed.).
7. P.R. Shukla, Debashish Biswas, Tirthankar Nag, Amee Yajnik, Thomas Heller and David G. Victor, “Captive Power Plants: Case Study of Gujarat, India”, Working Paper #22 March 2004.
8. Mustafa Balat, “Usage of Energy Sources and Environmental Problems”, Energy Exploration and Exploitation · Volume 23 · Number 2 · 2005 pp. 141–168.
9. Igor Pioro, Sergey Buruchenko, “Nuclear Power as a Basis for Future Electricity Generation”, World Multidisciplinary Earth Sciences Symposium (WMESS 2017), IOP Conf. Series: Earth and Environmental Science 95 (2017) 042002.
10. https://www.energy.gov/sites/prod/files/Elem Coal_Studyguide.pdf.

11. www.cea.nic.in/reports/monthly/executivesummary/2017/exe_summary-12.pdf (CEA Reports 2017 December).
12. CEA monthly reports, Power sectors January 2017.
13. Rakesh Kumar Behera, "Characterization of fly ash for their effective management and utilization" B. Tech Thesis, NIT Rourkela, 2009-10.
14. http://shodhganga.inflibnet.ac.in/bitstream/10603/39791/7/07_chapter4.pdf.
15. Kamal Khetarpal, Bharat Bhushan Jindal, "Effect of Fly Ash on CBR Value of Sandy Soil", SSRG International Journal of Civil Engineering (SSRG-IJCE) – EFES April 2015.
16. Adriano, D.C., A. Page, A. Elseewi, A. Chang, and I. Straughan, "Utilization and Disposal of Fly Ash and Other Coal Residues in Terrestrial Ecosystems: A Review," Journal of Environmental Quality, v.9, n.3:333 (1980).
17. Jody K. Tishmack & Perre E. Burns, "The chemistry and mineralogy of coal and coal combustion products", Energy, Waste, and the Environment: a Geochemical Perspective. Geological Society, London, Special Publications, 236, 223-246, 2004.
18. O. Dogan, O. Simsek, M. Ertugrul, and M. Kobya, "X-ray fluorescence spectrometry analysis of trace elements in fly ash samples of Yenikoy thermal power plants", Instrumentation science and technology, 29 (5), 433-439 (2001).
19. Diamadopoulos, E.; Ioannidis, S.; Sakellaropoulos, G.P. As (V) Removal from Aqueous Solution by Fly Ash, Water Res. 1993, 27 (12), 1773-1777.
20. Pollard, S.J.T.; Fowler, G.D.; Sollars, C.J.; Perry, R. Low-Cost Adsorbents for Waste and Wastewater Treatment: A Review. Sci. Total Envir. 1992, 116, 31-52.
21. Panday, K.K.; Prasad, G.; Singh, V.N. Copper (II) Removal from Aqueous Solution by Fly Ash, Water Res. 1985, 19 (7), 869-873.
22. Adriano, D.C Trace Elements in the Terrestrial Environment, Ed.; Springer: New York, 1996.
23. Olushola S. Ayanda, Olaleken S. Fatoki, Folahan A. Adekola and Bhekumusa J. Ximba, "Characterization of Fly Ash Generated from Matla Power Station in Mpumalanga, South Africa", E-Journal of Chemistry, 2012, 9(4), 1788-1795.
24. Khairul Nizar Ismail, Kamarudin Hussin and Mohd Sobri Idris, "Physical, chemical & mineralogical properties of fly ash", Journal of Nuclear and Related Technology Vol. 4, Special Edition 2007, 47-51.
25. Ankita Naval, Ganesh Gajre, Seema Mishra, Amruta Diwan Dixit, "Fly ash: A Suitable Material for Solid Waste Management through Vermicomposting", Waste to resource material, Indian Institute of Environment management, 2014.
26. shodhganga.inflibnet.ac.in/jspui/bitstream/10603/121789/4/04_chapter_1.pdf.
27. A. A. Ramezanianpour, "Fly Ash" Cement Replacement Materials, Springer Geochemistry/Mineralogy pp 47-155, 2014.
28. G.G. Carette, V.M. Malhotra, Characterization of Canadian fly ashes and their relative performance in concrete, in Energy, Mines and Resources Canada, Ottawa, ON, CANMET Report 86-6E, 1986.
29. J.G. Cabrera, C.J. Hopkins, The effect of PFA on the rheology of cement pastes, in Proceedings of International Symposium on the Use of PFA in Concrete, University of Leeds, Leeds, UK, Apr 14–16, ed.by J.G. Cabrera, A.R. Cusens, Department of Civil Engineering, University of Leeds, Leeds, UK, 1982, pp. 323–343.
30. Fulekar MH, Naik DS, Dave JM. Heavy metals in Indian coals and corresponding fly ash and their relationship with particle size. Int J Environ Stud, 1983, 21: 179-182.
31. Sharma S, Fulekar MH, Jayalakshmi CP. Flyash dynamics in soil water systems. Critical Reviews in Environmental Control, 1989, 19: 251-275.
32. Roy, W.R., Thiery, R.G., Schuller, R.M., Suloway, J.J., 1981. Coal fly ash: a review of the literature and proposed classification system with emphasis on environmental impact. Environ. Geol. Notes 16, 1–43.
33. Mishra SB, Langwenya SP, Mamba BB, Balakrishnan M. Study on surface morphology and physicochemical properties of raw and activated South African coal and coal fly ash. Physics and Chemistry of the Earth 2010; 35: 811 – 814.
34. Temuujin J, Williams RP, Riessen A. Effect of mechanical activation of fly ash on the properties of geopolymer cured at ambient temperature. Journal of Materials Processing Technology 2009; 209: 5276 – 5280.
35. I. Nawaz, "Disposal and Utilization of Fly Ash to Protect the Environment", International Journal of Innovative Research in Science, Engineering and Technology, Vol. 2, Issue 10, October2013.
36. Himabindu Myadaraboina, "Development of high performance very high volume fly ash concrete with 80% replacement of cement by fly ash", Ph.D Thesis, RMIT, University, September 2016.
37. Lokeshappa B, Anil Kumar Dikshit, "Disposal and Management of Fly ash", 2011 International Conference on Life Science and Technology IPCBEE vol.3 (2011).
38. H.B.Bradl, "Chapter 1 Sources and origins of heavy metals", Interface Science and Technology, Volume 6, 2005, Pages 1-27.
39. Imtithal Sheeta, Ahmad Kabbanib, Hanafy Holail, "Removal of Heavy Metals Using Nanostructured Graphite Oxide, Silica Nanoparticles and Silica/Graphite Oxide Composite", Energy Procedia 50 (2014) 130 –138.
40. P. Solanki, V. Gupta, and R. Kulshrestha, "Synthesis of zeolite from fly ash and removal of heavy metals ions newly synthesised zeolite," Environ. J. Chemistry, 2010: 7 (4), pp.1200-1205).

41. X. Querol, X.Moreno, J.C Uman˜a, A. Alastuey, Herna´ndez, Lo´pez, E.A Soler, and P. Plana, "Synthesis of zeolites from coal fly ash: an overview," International J. of Coal Geology, 2002: 50, pp. 413– 423.

42. Wassana Yantasee, Ryan D. Rutledge, Wilaiwan Chouyyok, Vichaya Sukwarotwat, Galya Orr, Cynthia L. Warner, Marvin G. Warner, Glen E. Fryxell, Robert J. Wiacek, Charles Timchalk, and R. Shane Addleman, "Functionalized Nanoporous Silica for the Removal of Heavy Metals from Biological Systems: Adsorption and Application", ACS Appl Mater Interfaces. 2010 October; 2(10): 2749–2758.

43. R.C. Bansal and M. Goyal, Activated Carbon Adsorption. CRC Press, Taylor & Francis Group, Boca Raton, 2005.

