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Environmental Issues in Thermal Power Plants – Review in Chhattisgarh Context

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Abstract

Air and fly ash pollution is one of the major environmental concern by coal based thermal power plants (TPPs). In chhattisgarh about 15,000 MW installed capacity for electricity generation, which is coal-based, and 44483 million tonnes coal has been estimated for the same with annual fly ash generation of 8.7 million tons. Adverse impact of TPPs in Chhattisgarh are in the form of air pollution, linked with soil and water pollution due to fly ash and are severe in nature. Disposal problem of coal ash is associated with leachate generation, which contains heavy metals, is also an immense threat. Several adverse effects on the environment leading to worldwide climate change and fly ash management problem are associated with coal based power generation [1]. The thought of such issues is fundamental for all power plants and appropriate scientific preventive measures are required to beworked out.

1. Introduction

Coal has always been the backbone, as it is a main source of the power generation requirement for the entire developmental activities [2], however, it has harmful health consequences also [3, 4]. In India, the production capacity of coal raised about 300 percent and increases to 930 Mtce in 2040, making India next to China amongst the worldwide producers [5]. To meet the future power demand, total installed capacity is expected to enhance three times (from 159 GW in 2014 to 450 GW in 2030), and it is estimated that the total coal utilization will increase 2-3 times from 660 million tons/year to 1800 million tons/year; and subsequent CO_2 emissions from 1,590 million tons/year to 4,320 million tons/year [6] (Fig. 1).

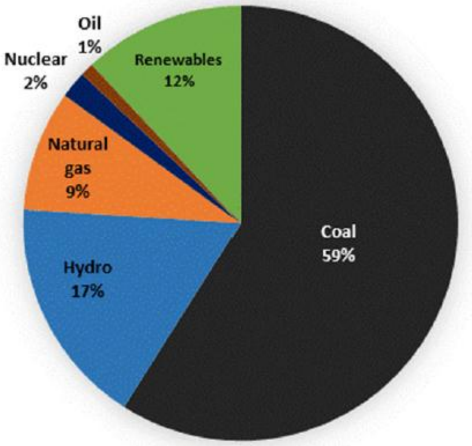

Figure 1: Sources of energy in India (*Source: Central Electrical Authority, 2013)*

The total premature mortality due to the emissions from coal-fired TPPs is expected to grow 2-3 times reaching 186,500 to 229,500 annually in 2030 [6]. Asthma cases are also associated with coal-fired TPP emissions will grow to 42.7 million by 2030 [7]. The coal based power plant areas with yearly SO_2 emissions greater than 50 Gg year–1 produce statistically considerable OMI signals, and has a highr correlation value (R = 0.93) is found between SO_2 emissions and OMI-observed SO_2 burdens. Contrary to the decreasing trend of national mean SO_2 concentrations reported by the Indian Government, both the total OMI-observed SO_2 and annual average SO_2 concentrations in coal-fired power plant regions increased by >60% for the period of 2005 to 2012, entail the air quality monitoring network needs to be optimized to reflect the true SO_2 situation in India [8] (Fig. 2).

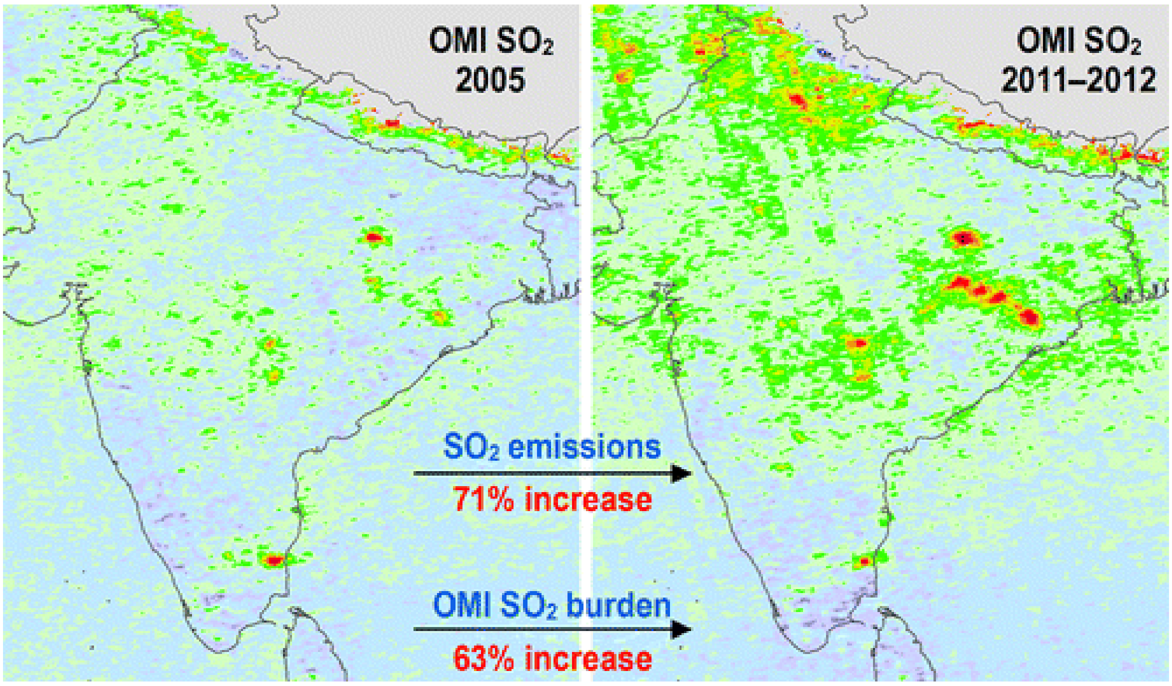

Figure 2: SO_2 emmission and OMI SO_2 burden increase (Zifeng Lu et al., 2013) [8]

A report shows that in 2011-2012, 80,000 to 1,15,000 premature deaths and more than 20 million asthma cases from exposure to air pollution emitted from Indian coal plants, resulted [6]. The pollution from the coal industry includes the consideration of issues such as land use, waste management, and water, air, noise, thermal, visual pollution caused by the coal mining, processing and the use of its products [1, 9]. In association to emissions pollution, the burning of coal produces a good total of coal ash, which may have various heavy metals. World Health Organization (WHO) reports in 2008 that, the coal particulates pollution is estimated to shorten approximately 1,000,000 lives annually worldwide [9]. Despite of various utilization modes of fly ash, a significant amount (at least 70%) is still being disposed in lagoons and landfill and its consequences – Air pollution – Water pollution [10]. Ash ponds may also contains some harmful heavy metals like As, B and Hg, have a fashion to leach out over a period of time and due to this the surrounding ground water gets polluted and becomes unsuitable for public uses [11, 12]. Large areas of land are also required for coal based thermal power plant as fly ash dumping sites, and consequently, there might be changes in soil quality and it becomes more alkaline due to the alkaline nature of fly ash [11].

2. Material and Methods

2.1 Problems associated with Coal based thermal power plants

Mostly, Indian coals are bituminous [13], with high ash content (35-40%), high PM emission [14], low calorific value (3820 kcal/kg in 2003-04 and 3603 kcal/kg in 2010-11) [6], and with a subsequent amount of inorganic impurities. As compared woth US coal (1.0-1.8%) and Chinese coals (0.5-1.0%) the sulfur content in Indian coals (0.5 – 1%) is less, as the burning of high sulphur coal produce SO_2 which is toxic and corrosive in nature and also, sulfur content in the Indian coal has a consumption-weighted average of 0.6% [15]. Indian coal ash has high silica and alumina content and is a another form of pollution, as it increases ash resistivity and decreases the collection efficiency at the electrostatic precipitators (ESPs) [16]. Emissions from coal based thermal power generation like, CO_2, SO_2, NOx; CFCs, other traces gases and airborne inorganic particulates, such as fly ash and suspended particulate matter (SPM) are considered as greenhouse gases (GHGs) resulted as a hazardous health concern to the society [17]. Stack emission and generationof coal ash are the major pollution arises by coal based thermal power plants [18]. Substantial sum of coal ash, rich in toxic trace elements and radioactive elements or radionuclides, are disposed off in large ash ponds and on the open grounds thus contaminate the surface soil and the subsurface aquifer [19]. People living near the ash ponds are subject to a high radiation dose from the ash ponds and the soil cover, which is ~ 2.6 times (approximately) higher than the world's average [20].

2.2. Air pollution

At present the carbon dioxide (CO_2) emitted by the coal combustion, is responsible for over 60% of the enhanced greenhouse effect. From buring of each tonne of as coal as fossil fuel, a minimum 1/3rd of a tonne of CO_2 is liberated into the atmosphare . It was reported that 0.8–0.9 kg/kW h CO_2 is emitted by Indian power plants [21]. A prediction was made by the International Energy Agency in World Energy Outlook 2000 have indicated that global CO_2 emissions would add to 29,575 and 36,102 million tonnes in 2010 and 2020, respectively [22].

The studies on coal based power plants in India are mainly focused on coal usage trends, resource management, GHG, and innovation related to renewable energy sources [23, 24, 25, 26, 27, 28] and total emissions inventories for base year 2005 or older [29, 30, 31, 32]. Of the estimated yearly anthropogenic emissions in India, the TPPs accounted w15% for PM2.5, w30% for NOx, and w50% of SO_2 [29]. Studies based on satellite measurements [33, 34] looked at the influence of power plant emissions on the column NOx concentration, include the influences of other significanmt causes, but there is an insufficient exploration on dispersion of emissions from the coal-fired power plants [16]. fly ash emissions and extremely reactive secondary particulate pollutants after the oxidation of sulphur and nitrogen oxides are also results in Coal based thermal power plants and are a major industrial emission source of ambient RSPM [35].

Based on the CEA data [36], specific coal usage at three plants is less than 0.6 kg/kWh, at 19 plants, usage is between 0.6-07 kg/kWh, thirty nine plants use coal between 0.7-0.8 kg/kWh, fifteen plants use between 0.8-0.9 kg/kWh, seven plants use between 0.9-1.0 kg/kWh, and at three plant coal usage exceeds 1.0 kg/kWh. Hence the efficiency of the plants and the coal usage per unit of electricity generation also differ at each plant [37]. According to new emission standards vide Notification No. S.O. 3305(E) dated 07.12.2015, many of the thermal power units, out of 163 thermal power units, in India [38] were lacking with air pollution standards however, when emissions standards in India is extremely lenient (The PM norms in India are 150-350 mg/Nm^3 compared to Chinese norms of 30 mg/Nm^3) [39]. In the year 2011-2012, emissions from Indian coal based thermal power plants resulted in 80,000 to 115,000 untimely deaths as well as more than 20 million asthma cases from exposure to total PM10 pollution [40]. In an analysis, it was reported that the respective increase of 13% and 31% for PM2.5 and SO_2 levels from 2009 to 2015 and due to air pollution from thermal power plants, the number of deaths increased from 1,300 in the year 2000 to 1,800 in 2013 [40].

2.3. Fly ash generation and its impact

Fly ash and some of the re-suspended ash from ash ponds deposited in the nearby environments (5-10 km) of coalfired power plants [2]. The impact of coal combustion residues (CCRs) is long-term, which influences contaminant accumulation and the health of aquatic life in the water associated with coal-fired power plants [41]. As per EPA, CCRs contain a broad range of metals, for example, As, Cd, Hg, Pb, and Se, but the concentrations of these are generally low. However, if not properly managed, (forexample, in linedunits), CCRs may cause a risk to human health and the environment [42]. Fly ash disposal remains a major problem. Presently, only about 50-60 percent of the 170 million tonnes of fly ash generated by the sector is "utilized"; the remaining is dumped into poorly designed and maintained ash ponds. Currently, about a billion tonne of the setoxicasheslie dumped in these ponds, polluting land, air and water. By 2031-32, the sector will produce 2000 million tonnes of fly ash every year in India [52].Coal ash may also be mixed with water and disposed in so-called "ponds" – some are more like small lakes – behind earthen walls. These wet "surface impoundments" account for about a fifth of coal ash disposal. That makes coal ash the second largest industrial waste stream in the state, second only to mine wastes. New Delhi/Raipur, February 21, 2015: A two-year long research study conducted by the Centre for Science and Environmenthas found many of Chhattisgarh's thermal power stations to be highly polluting with the reason that state has highest power generating capacity in the country of around 8.5 GW [43]. The major sources of heavy metal pollution in urban areas are anthropogenic, which also includes those associated with the fossil and coal combustion [2]. Fly ash is one of the incombustible mineral residues produced from the combustion of pulverized coal in the boilers. The particle size of the fly ash is varied between less than 1 to 100 μm[44]. The thermal power plants generate huge amount of fly ash as a solid waste material of coal combustion. This fly ash is usually collected in the ESPs and disposes off in the ash ponds or in the open lands and some of these enter into the atmosphere by passing through the stacks along with the flue gases. The atmosphere is an important transport medium for heavy metals from thermal power plants. A high proportion of the toxic metals in the fly ash deposition have been found around thermal power plants [2]. It is well-known that the by-product generated as coal ash (especially fly ash) and its unscientific management creates serious environmental issues [46] in the form of air, land and water pollution [45]. The average number of casualties per plant associated with each pollutant in 2008 was about 500 for SO_2, 120 for NO_x and 30 for PM2.5 [14]. Experts articulate that it is not only causing air pollution, but, also contaminating the valuable land, surface and ground water sources. The consequences could be disastrous as the whole ambience would be filled with black smoke, leading to several fatal diseases and water scarcity.However, its effective management not only reduces environmental pollution, but, also helps recover valuable resources, leading to sustainable development.

Coal ash toxics have leached from disposal sites in more than 100 communities, carrying toxic substances into above-ground waterways such as rivers, streams and wetlands, and into underground water supplies or aquifers that supply drinking wells, forcing families to find new drinking supplies. One community has even been designated as a superfund toxic cleanup site, due to coal ash leaching, which contaminated the drinking water [47]. Utilization of fly ash will not only minimize the disposal problem but will also help in utilizing precious land in a better way and give better results in almost every aspect such as better strength, economically feasible and environmentally friendly [1].

2.4. Leaching aspects of fly ash

Studies of trace elements and its presence in fly ash are distributed into the fractions of the fly ashes based on volatilization temperature [56]. The elements that are not volatilized and reported equally in both fly ash and bottom ash are included Al, Ba, Ca, Ce, Co, Cu, Fe, Hf, K, La, Mg, Mn, Rb, Se, Si, Sm, Sr, Th, Ta, and Ti. Elements that are volatilized on combustion and preferentially get adsorbed on the fly ash as flue gas cools down. These include As, Cd, Ga, Mo, Pb, Sb, Se and Zn. Elements that remain almost entirely in the volatilized state tend to escape to the atmosphere as vapours. These are Hg, Cl and Br [44]. It is accepted that the health hazards and environmental impacts of coal fired thermal power stations result of the mobilization of toxic elements from ash [57, 58]. Selenium is a naturally occurring element that is found in coal ash, which is stored in ponds at Sutton that drain into the lake. Eating too much selenium in food can cause health problems in people, such as brittle hair and deformed nails, but it can also cause deformities in young fish. As described by the various researchers coal fly ash contains a number of heavy metals and a host of other organic compounds that are reported for their prooxidant potential [24, 59, 60, 61, 62]. The concentration level of the Pb in the rainwater of Chhattisgarh region was considerably higher mainly due to the operation of several heavy metal industries, coal burning, combustion of leaded gasoline and dusty atmosphere etc. [63].
Fly ash from thermal power plants vary in chemical composition not only from plant to plant but also within the same plant [64, 65]. Chemically fly ash consists of Si, Al, Mg, Ca, K, Ti and Fe in greater proportion with many trace elements as V, Mn, Cr, Cu, Ni, As, Pb, Cd and smaller quantity of various potentially toxic elements. Chemical composition study shows mostly the presence of four major elements viz. aluminium, silicon, iron and calcium in the fly ash. Others, such as potassium, magnesium, barium, cobalt, cadmium, zinc, molybdenum, lead, etc. are present in traces [66]. Though in the traces, compared to the original coal, most of the elements are enriched in the fly ash, giving birth to the growing environmental concerns in the disposal and utilization environment due to release of trace/heavy elements metals [67]. The coal fly ash leach ate induced discernible oxidative stress in fish tissues as assessed by LPO measurement [24].

3. Scenario in Chhattasgarh

The Chhattisgarh state has 16% of the total coal deposits of India with 44483 million tonnes coal has been estimated in 12 coalfields located in Raigarh, Surguja, Koriya and Korba districts [48], and 10,300 MW of coal based power generation . The Central Electricity Authority reported that, it is about 12 per cent of India's current coal-based power capacity, and will append 56,000 MW (65% of the country's coal based power capacity). Just about two-thirds of this capacity are intended in Raigarh (37 per cent) andJanjgir- Champa (34 per cent) [49].
A two-year long research study conducted by the Centre for Science and Environment (CSE) has found many of Chhattisgarh's thermal power stations to be highly polluting (Fig. 3). The state has the highest power generating capacity in the country of around 8.5 GW. A capacity addition of 30 GW capacities is in the pipeline [43].

Figure 3: Coal based thermal power plants in Chhattisgarh

The detailed comprehensive monitoring data on air, water, land and noise collected by IIT Kharagpur team in the critically polluted area in Korba, Chhattisgarh during the year 2014. Based on the study and data collected in the critically polluted area of Korba ("With 6,000MW installed capacity, and seven power companies , Korba generates 48,000 metric tonnes of fly ash every day, and one lakh metric tonnes every year," says B S Thakur, government officer incharge of monitoring environmental compliance.) during May 2014 to December 2014, it has been found that the overall CEPI value in Critically Polluted Area, Korba has significantly improved and the present CEPI is 74.5 (earlier it was 83.00 in 2009) and place of Korba as one of the Critically Polluted Area was 5 in the list of CPCB Report (2009) and it is now much below in the list [50].

Table 1: Hourly Ambient air quality data (all in µg/m3)
(Sourcs:http://www.indiaenvironmentportal.org.in/files/file/Pollution%20effect%20of%20thermal%20power%20plants.pdf)

Name of Station	Parameters	PM10	SO_2	NOx	PM2.5
	National Ambient Air Quality Standards	100	80	80	60
	WHO Standards	50	20	40	25
Korba East		231	17	29	62
Korba STPS		71	13	15	50
LancoAmarkantak TPP		55	16	18	27
Hasdeo TPS		342	6	11	79

The Presence of large number of power plants & various other industries in Bilaspur, district gave a support for the existence of an environmental problem in this area [51]. Coal-based power plants emit carbon dioxide, which is the most preponderant greenhouse gas. In the Indian context because of high ash content, the combustion of 1 tonne of coal will result in an emission of around 1.5 tonnes of carbon dioxide (Public address delivered by Jairam Ramesh, 2014).Due to continuous & long lasting emission of SOx&NOx, which are the principal pollutants coal based plants, surrounding structures, buildings, monuments of historic importance & metallic structures too are affected very badly due to corrosive (Acid rain) reactions. It is also worth to note that very high amount of carbon dioxide (CO_2) emission (0.9-0.95 kg/kWh) from thermal power plants contribute to global warming leading to climate change [11]. Using the established dose-response functions from the GBD assessments, the estimated health impacts of Chhattisgarh state due to PM2.5 pollution from the coal-fired TPPs in the year 2017, 2020, 2025 and 2030 will be 3870, 4610, 5,600, and 6340 respectively [6].

About 40-50% of the generated coal fly ash in the whole Chhattisgarh is dumped unscientifically into poorly designed and maintained ash ponds. The study estimates about a billion tonnes of this toxic ash lies dumped in these ponds, severely contaminating land, air and water. The annual production of this residual ash is likely to go upto 300 milliontonnes per annum within 6-7 years, according to a study[53].

The public health of nearby villages in the region of the coal thermal power plants of Korba periphery is becoming hazardous due to huge emission of fly ash. Due to the unscientific management of fly ash, residents of Churri, Lotlota, Char Bhhatti, Churri Kordhand Jamini Palli, located very close to the power plants, are living a miserable life. People alleged that the ash causes skin problems, including itching. Besides, inhaling the ash causes lung problems and asthma. The livelihoods of the local people are badly affected due to activities of power plants. Their crops have been lost due to heavy toxic flyash esemitted by the plants. As the irrigated wateris also polluted due to fly ash, it badly affects the paddy field also [54].

Accordingto a study conducted by the CPCB (Central Pollution Control Board) in 2009, Korba ranks fifth in the 'critically polluted area' category amongst eighty eight industrial clusters. The Korba sky line is dotted with chimneys spewing dense smoke, which has made life of the living people of the area miserable. Local news dailies have reported several incidents related to health problems such as various skin diseases like rashes and itching and some respiratory diseases like chronic bronchitis, chest discomfort, asthma attacks and even cancer [55] 2.4 crore tonnes of fly ash are generated by the industries in Chhattisgarh every year, out of which only 26.97% of fly ash gets used up, whereas, according to the report of CEA in 2013 around 17.5 ton crore fly ash was generated in the nation, out ofwhich 55.6% was used. About 38 percent of coal ash isused in agricultural and engineering applications rather than being disposed, and in addition, a very less amount of its generation percentage is dumped in abandoned mines as fill.

4.**Mercury and Air Toxics Standards (MATS)**

Coal combustion industries are the largest sector for mercury emissions in India amounting to almost 140 tonnes per year. India is the third largest producer of hard coal after China and the USA and around 70% of the heat and electricity production in India is from indigenous coals [68]. Toxic air pollutants from fossil fuel-fired power plants cause serious health impacts and are the largest source of mercury emissions to the air. Once mercury from the air reaches water, microorganisms can change it into methylmercury, a highly toxic form that builds up in fish. People are primarily exposed to mercury by eating contaminated fish. Methylmercury exposure is a particular concern for women of childbearing age, unborn babies, and young children, because studies have linked high levels of methylmercury with, damage to the developing nervous system. This damage can impair children's ability to think and learn [69]. The Environmental Protection Agency (EPA) has found that living next to a coal ash disposal site can increase one's risk of cancer or other fatal or chronic diseases. If one live near an unlined wet ash pond (surface impoundment) and gets their supply of drinking water from a well, one may have a 1 in 50 chance of getting cancer from drinking arsenic-contaminated water. If eaten, drunk or inhaled, these toxicants can cause cancer and nervous system, impacts such as cognitive deficits, developmental delays and behavioural problems [69]. They can also cause heart damage, lung disease, respiratory distress, kidney disease, reproductive problems, gastrointestinal illness, birth defects, and impaired bone growth in children. The EPA estimated that 140 million tons of coal ash are generated annually. Arsenic is one of the most common, and most dangerous, pollutants from coal ash. The EPA also found that living near ash ponds increases the risk of damage from Cd, Pb, and other toxic metals. About one-third of producing coal ash is disposed in dry landfills, frequently at the power plant where the coal was burned [69].

In 2006-2008, power plants in India released 95 to 112 tonnes of mercury, states a study conducted by Toxics Link, a Delhi-based non-profit. This was based on the assumption that mercury content in Indian coal is between 0.18 and 0.61 grams per tonne. With huge investments being made within coal-based power plants, the impact of mercury raises grave concerns. By August 2011, the total capacity of power plants was 118.4 GW. Of this, 84 per cent was coal-based and 1 percent fuel oil-based. B Sengupta, former member secretary, Central Pollution Control Board, admits that the burning of coal is the largest source of mercury release in the country. Yet, India has made no effort to set emission levels for power plants [70].

Table 2: Widely-available control technologies that reduce mercury and other air toxics

(Source:http://www3.epa.gov/mats/powerplants.html#controls)

Pollutant Addressed	Existing Control Technologies to Address Toxic Pollutants
Mercury	Selective Catalytic Reduction (SCR) with Flue-gas Desulfurization (FGD), Activated Carbon Injection (ACI), ACI with Fabric Filter (FF) or Electrostatic Precipitators (ESP)
Non-mercury metals	FF, ESP
Dioxins & furans	Work Practice Standard (inspection, adjustment, and/or maintenance and repairs to ensure optimal combustion)
Acid gases	FGD, Dry Sorbent Injection (DSI), DSI with FF or ESP
Sulfur dioxide	FGD, DSI

The new mercury emission standards were announced by the United States Environmental Protection Agency (USEPA) in 2012, limiting emissions to 0.0017 micrograms per cubic metre.

5. Health risks assessment

Human health risks allied with exposure to particle bound traces (cancer risk and hazard quotient) and PM concentration (PM10 and PM2.5). By Use of Global Burden of Disease (GBD) methodology, the total health risk, as mortality, can be measure to estimate the impact of coal emmission. The GBD methodology accounts for the cases of ischemic heart disease (which can lead to heart attacks), cerebrovascular disease (which can lead to strokes), chronic obstructive pulmonary diseases, lower respiratory infections, and cancers (in trachea, lungs, and bronchitis) [73]. Figure 4 indicate the power plant clusters in Korba region to illustrate the movement of the emissions for three months, using the NOAA HYSPLIT trajectory model [74]. To find monthly, seasonal, and annual concentration maps, the dispersion modeling results for every month were averaged. The modeled annual average SO_2 and PM2.5 concentrations due to emissions by coal based TPPs are to be had in Figure 5 and 6. The total PM2.5 includes both primary and secondary contributions. The largest impact is felt over the largest part of central-east India including the Korba region of state Chhattisgarh, which is the largest clusters of coal-fired power plants. Total power generation capacity (in GW), annual coal consumption (in million tons) and annual emissions (in ktons for PM2.5, SO2, NOx, and CO; and in million tons for CO2) from the coal-fired TPPs in 2014 and 2030 in the study area Chhattisgarh is presented in Table 3.

Table 3: Various predicted parameters form coal emmission

2014							2030						
GW	Coal	PM2.5	SO_2	NO_x	CO	CO_2	GW	Coal	PM2.5	SO_2	NO_x	CO	CO_2
11.1	46	57	223	250	116	110	50.1	200	149	973	1008	726	479

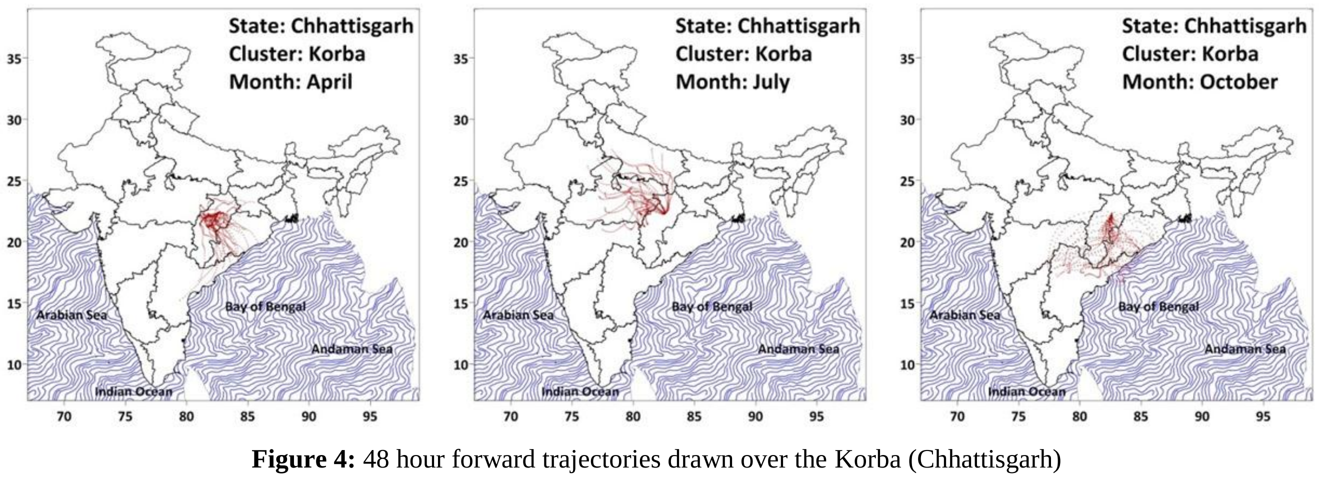

Figure 4: 48 hour forward trajectories drawn over the Korba (Chhattisgarh)

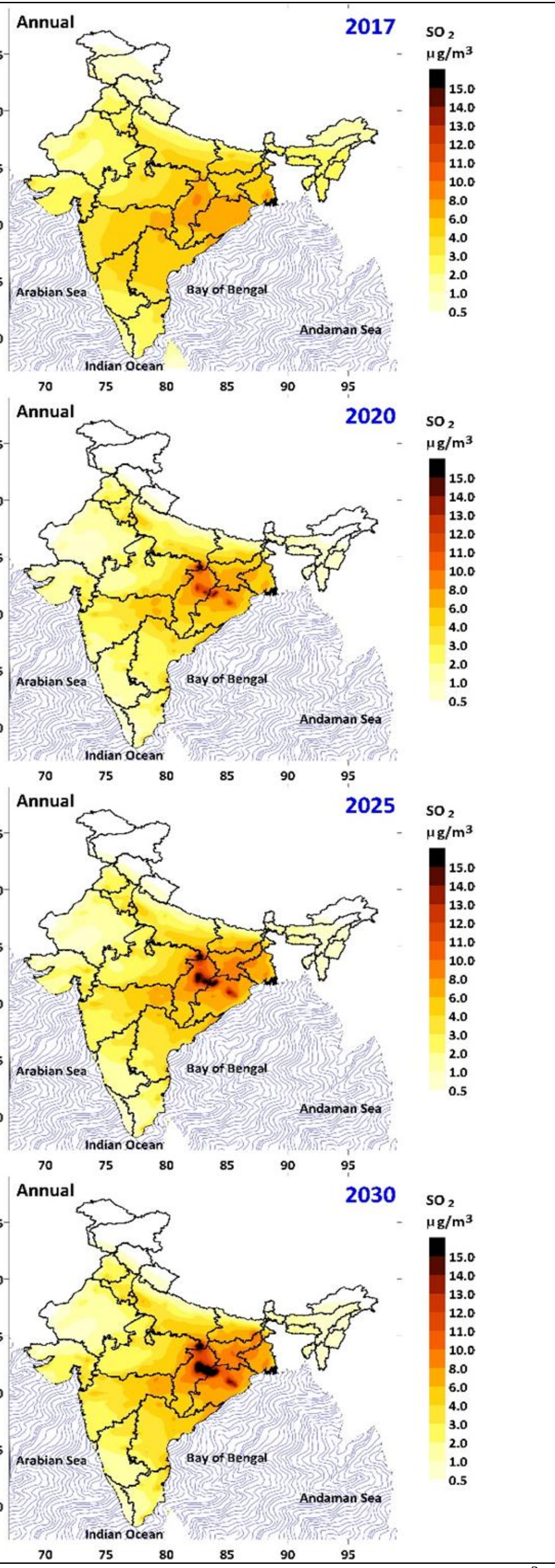

Figure 5. Modelled annual average SO_2 oncentrations ($\mu g.m^{-3}$) from the planned coal-fired TPPs in India through 2030. [74]

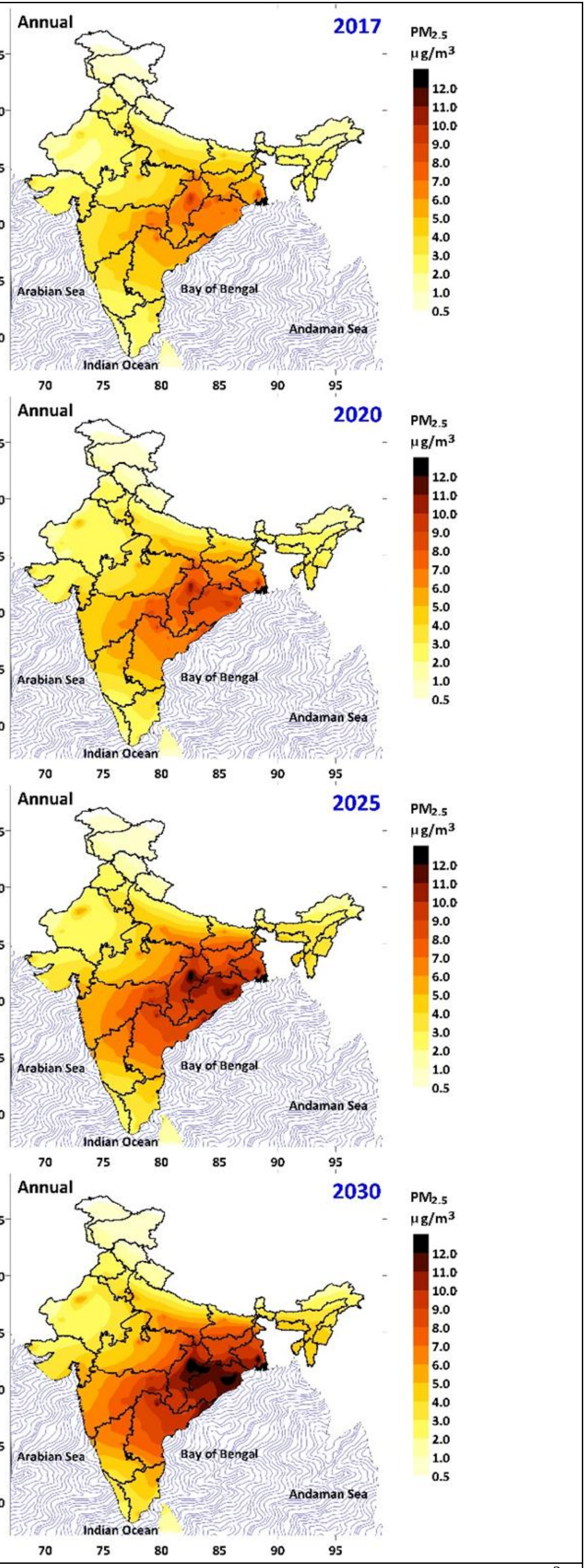

Figure 6. Modelled annual average PM2.5 oncentrations ($\mu g.m^{-3}$) from the planned coal-fired TPPs in India through 2030 [74]

The totality premature mortality in the region due to the emissions from TPPs is expected to at least double, reaching 2800 to about 6000 annually, associated with asthma cases reaching in 2030. For the future years, we assumed 1.1% net annual growth rate in the population (starting with the latest census projections), with the total population reaching 1.5 billion. In the year 2030 with a population growth rate of 1.3%, the total premature mortality due to the emissions from coal based power plants possibly will be as high as 6, 340-8, 680 annually.

6. Discussion and Conclusion

This review is an attempt to explore pollution challenges, due to; coal based thermal power plants, in the context of Chhattisgarh. The study indicated the poor status of the environment and the management commitment must be enhanced by the TPPs and society both, to overcome from today's critical situations. Chhattisgarh power industries have to evolve suitable strategies to address the air pollution challenges and huge generation of fly ash as by-product.

Two factors dramatically increase the risk from disposal units: the use of wet surface impoundments, instead of dry landfills, and provision of disposal units with composite liners to prevent leaking and leaching.

Surface impoundments have consistently shown higher risks than landfills. Some are mere pits in the earth, totally lacking of any protective liners. PSR concluded that coal ash is dangerously toxic and possesses a threat to human health. Its wet storage should be phased out, and its dry storage should be engineered for maximum control to prevent leaching, blowing or leakage of toxicants [71]. Need of Continuous monitoring and implementation of upgrading mitigation measures is required to reduce air pollutant levels in the vicinity of the power plant [72].

It has been observed in a survey of the study area that, the places where the electricity houses and/or coal plants were set up, governmental and non-governmental hospitals showed an increase in the patients of heart, TB and asthma. In the affected areas, the people can neither sleep on their terrace, nor can dry their clothes. The plantation along with the crops, is also getting destroyed, due to the less fertility of soil. The reports from Bhabha center are also frightening. During the γ(Gama) spectrometry experiments of fly ash, it was found that it contains a large quantity of V – rays.

Finally, we conclude that, the adverse impacts of coal based thermal power plants in Chhattisgarh are in the form of air pollution, associated with land and water pollution and are severe in nature, in major industrial regions like Korba, Raigarh, Bilaspur and parts of Durg-Bhilai, destroying the living environment for the human beings. Policies to control air pollution from Indian power plants have traditionally focused on reducing particulate emissions, due to the high ash content of Indian coal. The lower sulphur content of Indian coal has, perhaps, been responsible for the failure to directly control SO_2 emissions [23]. The installations of flue gas desulphurisation (FGD) equipment are anticipated with upgraded ESPs to increase on the back of strong enforcement of emission control norms.

Thus, a thorough analysis is required to ascertain, the presence of level of contamination of different forms of pollutants in air, land and leachate analysis for heavy metals concentration, in the vicinity of the thermal power plants situated in Chhattisgarh. Utilization of fly ash is, the best way to get rid of its ill effects, to prevent it being heaped up. Also, public awareness programmes are prominent preventive measures to these hazards.

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