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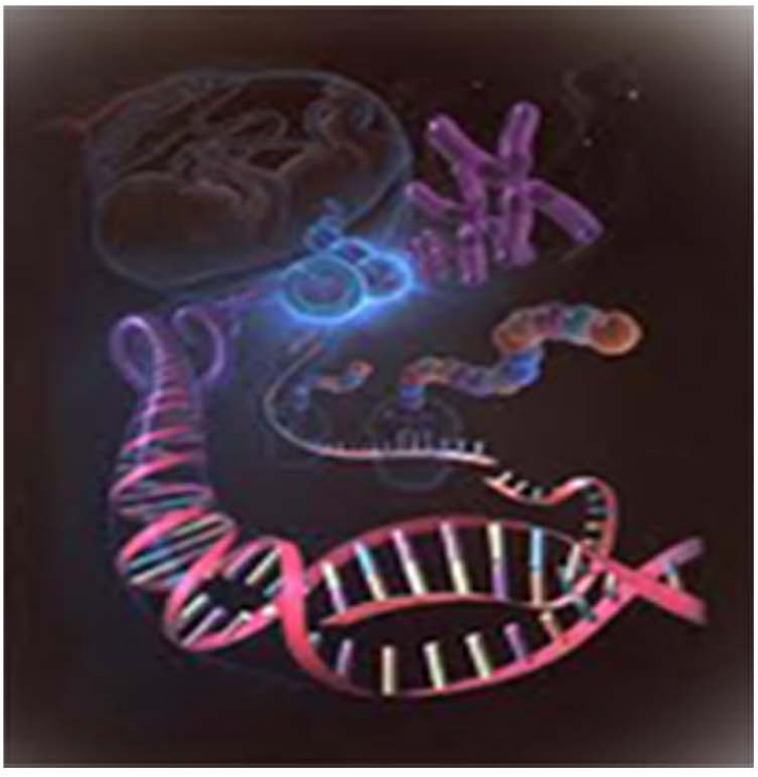

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Review Article

THERMAL POWER PLANT- TREATMENT EFFICIENCY FOR MERCURY

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Mercury is present as trace element in coal. When the coal is burnt in thermal power plants, the mercury available in coal is released. Once released, the mercury is either evaporated in the atmosphere; some part is trapped in pollution control instruments like electrostatic precipitator, bag, etc., and the rest goes with the bottom and fly ash. The small level of mercury can be tolerated without much harmful effects; however when there is concentration of industries at one place, the concentration level increases and the cumulative effect has a devastating effect on the humans. The irony is that the impact of today's emissions is visible after a very long time say 20-25 years. Thus, while selecting the location of thermal power plants, their clubbing at one place should be reviewed in light of pollution caused by mercury apart from other factors.

Keywords: Mercury, Coal, Thermal power plants

INTRODUCTION

India is a developing country and is targeting to be a developed nation by 2020. For development of the country, energy sufficiency and energy independence, both is a must. Our present installed capacity of electricity generation is 2, 10, 544 MW as of Dec 2012. Captive Power Plants generate an additional 31,500 MW making total installed capacity to 2, 42, 044 MW. This total installed capacity can be broadly bifurcated to two sources depending on the fuel used for electricity generation. Non-renewable power plants constitute 88.55% of the installed capacity and renewable constitute 12.45% of the installed capacity.In the 12th Plan period (2012-17), another 1, 00,000 MW is proposed to be added in the installed capacity.

The installed capacity of Thermal power plants, as of October 31, 2012 was 1, 40,206.18 MW, which is 66.99% of total installed capacity.

- Coal Based thermal power plants account for 1, 20,103.38 MW, i.e., 57.38% of installed capacity.
- Gas Based thermal power plants account for 18,903.05 MW, i.e., 9.03% of installed capacity.
- Oil Based thermal power plants account for 1,199.75 MW, i.e., 0.57 % of installed capacity.

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REQUIREMENT OF COAL

India has abundant reserve of coal, but the natural fuel value of coal is very poor. The Indian power plants using India' coal supply consumes about 0.7 kg of coal to generate 1 unit of electricity as compared to 0.45 kg of coal consumed in US for generation of 1 unit of electricity. This difference is basically because of difference in quality of coal as measured by the Gross Calorific Value (GCV). Indian coal is also containing very high ash content to the extent of 35-40%.

In terms of MW, the coal required to generate 1 MW of electricity is in the range of 4800 to 7600 MT/MW/year. And the ash generation is also to the extent of 3000 MT/MW/Year and the water required is 3,920 cu MT/MW/year.

MERCURY

A significant pollutant, mercury has been a subject for growing concern in recent years. According to the Technical EIA Guidance Manual for Thermal Power Plants prepared by Infrastructure Leasing and Financial Services Limited (IL&FS) for the MoEF in September 20, 2009 :

"A growing concern in India is the release of various toxic trace elements such as mercury (Hg), arsenic (As), lead (Pb), cadmium (Cd), etc., from power plants through the disposal and dispersal of coal ash. Among the various toxic elements mercury emissions from coal based TPP are of particular concern, mercury emitted in flue gases or in fly ash/bottom ash that is disposed off in ash ponds enters the hydrological system, wherein the mercury can be methylated. Then this methyl mercury can then enter the human food chain, mainly through consumption of fish (Shah *et al*., 2008). Thus this food chain exposure pathway to mercury at high levels can harm the brain, heart, kidneys, lungs, and immune system of people of all ages. "Mercury can be emitted in three different forms: elemental (Hg0), oxidized (Hg2+) and particle bound (HgP). Upon combustion, coal flyash tends to have a higher concentration of mercury, and estimates indicate that Indian coal ash has an average mercury concentration of 0.53 mg/kg, based on measurements from a few selected power plants.

"Besides, Indian coal is very high in mercury contents. The levels in Indian coal are high in comparison to other countries "Currently, there is no National Ambient Air Quality Standard (NAAQS) for mercury, although there are consent conditions necessitating monitoring of ambient and emission Hg for Greenfield TPP. Although there are no limits set at this stage for mercury emissions from power plants, there are some general guidelines available for mercury in power plant effluents. "Thus, while mercury emissions from plants are likely to have serious implications, there are neither standards nor limits set for power plants. This will be of particular concern where there are clusters of many power plants in a small area. Clearly, modeling mercury emissions in areas with a high concentration of TPPs, and mandating mercury control measures where appropriate is called for. In February 2009, the Governing Council of the United Nations Environment Program (UNEP) agreed on the need to develop a global, legally binding instrument on mercury. India is a party to these negotiations. However, the negotiations on this front are planned to be completed only by 2013. Therefore, the industries should not wait for this instrument to come into force to take up measures to control the impacts of mercury emissions.

Meanwhile, the UNEP Governing Council 25/5 has specified that the UNEP Global Mercury

Partnership will be one of the main mechanisms for the delivery of immediate actions on mercury during the negotiation of the global mercury convention. The overall goal of the UNEP Global Mercury Partnership is to protect human health and the global environment from the release of mercury and its compounds. However, India is not a Partner in this initiative. India's approach towards the negotiations for the globally binding instrument is not cause for optimism. India's submission to the 3rd Meeting of the Intergovernmental Negotiating Committee scheduled from October 31 to November 4, 2011 states the following:

"It is not feasible to adopt mandatory targets and rigid timelines. In India, thermal power sector is large and any change in technology or new measures will involve substantial financial implications. We are constantly trying to reduce our emissions intensity through technology up gradation. However, the technologies currently available for reducing mercury emissions are not cost effective and are not suited to our national circumstances. It would be difficult to retrofit the existing coal based thermal plants due to financial constraints. Further, the principle of common but differentiated responsibilities, including with natural resource endowments, energy infrastructure, population size and other issues need to be taken into consideration. India, therefore, is of the view that there should be a voluntary 'Reduction' of atmospheric emissions of mercury under conducive conditions and not the 'Elimination' of atmospheric emissions of mercury. "While India is justified in calling for the principle of common but differentiated responsibility at the international level, its stand that technologies currently available for reducing mercury emissions are not cost effective, and not suitable for our national circumstances, is a cause for concern as it can become an alibi to ignore the problem at the cost of severe domestic local impacts.

HEALTH HAZARDS DUE TO MERCURY

Mercury is a potent neurotoxin. Even at extremely low levels of exposure, it can cause permanent damage to the human central nervous system. The addition of even 0.9 g of mercury is enough to contaminate a 25-acre lake. At higher levels, mercury can damage vital organs such as lungs and kidneys. The nervous system is very sensitive to all forms of mercury. Methyl mercury and metallic mercury vapors are more harmful than other forms, because more mercury in these forms reaches the brain. Exposure to high levels of metallic, inorganic, or organic mercury can permanently damage the brain, kidneys, and developing fetus. Effects on brain functioning may result in irritability, shyness, tremors, changes in vision or hearing, and memory problems. Short-term exposure to high levels of metallic mercury vapors may cause effects including lung damage, nausea, vomiting, diarrhea, increases in blood pressure or heart rate, skin rashes, and eye irritation.

Mercuric chloride has caused increases in several types of tumors in rats and mice, and methyl mercury has caused kidney tumors in male mice. The Environmental Protection Agency (USEPA) has determined that mercuric chloride and methyl mercury are possible human carcinogens Health hazards of mercury to young children- Very young children are more sensitive to mercury than adults. Mercury in the mother's body passes to the fetus and may accumulate there. It can also pass to a nursing infant through

breast milk. However, the benefits of breast feeding may be greater than the possible adverse effects of mercury in breast milk. Mercury's harmful effects that may be passed from the mother to the fetus include brain damage, mental retardation, in-coordination, blindness, seizures, and inability to speak. Children poisoned by mercury may develop problems of their nervous and digestive systems, and kidney damage. Besides affecting human beings, it also increases morbidity and mortality among fish, wild animals and birds, causing ecological imbalance and economical loss. In several areas of the United States, concentrations of mercury in fish and wildlife are high enough to be a risk to wildlife.

ENVIRONMENTAL EXPOSURE OF MERCURY DUE TO COAL BASED TPPS

Mercury distribution in the environment has been a focus of scientific attention because of the potential health risks posed by mercury exposure. India is one among the world's most active mercury industrial centers. Coal fired thermal power plants are the second largest source of mercury emission in India

Mercury is released to atmosphere by burning fossil fuels (coal) in thermal power plants. In the process of combustion mercury is not used but gets released and is further accumulated, as mercury remains persistent in the environment. A typical 100 MW thermal power plant can emit over 10 kg of mercury in a single year. About 200 metric tons of toxic mercury escapes from industrial chimneys and effluents each year in India. Recent studies suggest that the total global atmospheric mercury burden has increased between 200 and 500%, since the beginning of the Industrial Age. Reports also indicate that the levels of mercury in rivers, coastal waters, and soil and food items are way above acceptable levels in India. Mercury's presence in air and water has increased dramatically in the past century owing to emission from thermal power plants. The total mercury pollution potential from coal in India is estimated to be 77.91 tons per annum, considering average concentration of mercury in coal as 0.272 ppm. About 59.29 tons per annum mercury is mobilized from coal-fired thermal power plants alone. The mercury emanating from the thermal power plants' stacks is 58.05% gaseous and 2.4% in particulate form. About 32.5% is retained in the ashes (fly ash and bottom ash). The remaining 7.05% could not be accounted for. Coal contains mercury as a natural component along with other elements in trace amounts (0.04- 0.7 mg/kg). As the coal is combusted in the utility boiler, (PrashantAgrawal *et al.*, 2008) mercury is vaporized and released as a gas. Pollution controls employed by utilities to curb other pollutants are not effective in removing mercury. At present, there are no commercially viable control technologies for mercury. As a consequence, this highly toxic form of air pollution continues to go largely unabated. Thus coal becomes a repository of toxic metals. For example, a super thermal power plant consuming 8 million tons of coal containing x grams per ton of any mercury will pump in to the surrounding eco system 8 x million grams of the mercury. Thus, mercury being persistent in the environment, its presence in the air in this amount could enter bodies through the nasal route and prove a great threat to people, especially those living in the vicinity of these thermal power plants. The 75 thermal power plants generates about 65-75 million tons of fly ash. In India, mercury is concentrated as 0.1 ppm as a trace element in

the fly ash. Therefore, the generated fly ash is a matter of huge concern because of its environmental impacts. This fly ash is transported to the ash ponds near the thermal Power Plants by wet deposition method. These ash ponds affect the local environment. The impact can be described as Leaching of mercury into surface water and ground water· Accumulation of mercury in soil and plants around ash ponds Mercury in the Indian Environment Fewer studies have been done to estimate the presence of mercury in the environment surrounding thermal power plants.

CASE STUDY OF SINGRAULI

A study on mercury contamination in the Singrauli area was done by the Industrial Toxicology Research Centre to assess the environmental risk to human population related to mercury contamination in the Singrauli area. It is an epidemiological study, tracing impact of mercury emissions from thermal power plants and fly ash on the environment and mercury levels in the local people's bodies. The probable source of mercury contamination has mostly been food items. The study shows that the proportion of mercury in the blood samples was high in the population of Singrauli region. The five giant super thermal power plants in Singrauli area, which supply 10% of India's power, stand responsible for 16.85%, that is, 10 tons per annum, of the total mercury pollution resulting from power generation.

Another study by researchers concludes that serious mercury pollution is occurring in GBP reservoir and other surface waters of Singrauli, posing a grave threat to the health and livelihood of the population. The major cause of pollution, which appears in the study, is the deposition of mercury transported via the air route from the emissions of large thermal power plants. (Pervez and Pandey, 1994) found presence of Hg in Hasdeo River water samples. This river is being contaminated by the ash pond discharges of Thermal power plant located in Korba. Permissible limits for mercury, Mercury emission from massive coal consumptions enhances the level of mercury more than 1 ppm in soil and (Prashant Agrawal *et al.,* 2008) more than 10 ppm in ground water and ponds, Govt. of India is reviewing the occupational exposure standards of 0.1 mg/m^3 of air, set up by Occupational Safety and Health Administration, USA for its implementation in our country. There is a need to reduce mercury air emissions from coal-fired power plants. Bureau of Indian Standards (BIS) and World Health Organization (WHO) limits the concentration of Mercury only up to 0.001 ppm in drinking water and 0.05 mg/kg in soil. The maximum allowed concentration of total mercury in fish is 0.50 ppm in India. The WHO guideline set for mercury intake by fish is 0.47 mg/kg/day, while the limit set by EPA is 0.1 mg/kg /day, which is one fifth to that of WHO. Mercury free alternatives to generate electricity-Alternatives to fossil fuel power plants include nuclear power or solar power and other renewable energies. Renewable energy technologies include solar power, wind power, hydroelectricity, micro hydro, and biomass and bio fuels.

CLUSTERS OF THERMAL POWER PLANTS IN INDIA

Central Pollution Control Board (CPCB) in association with Indian Institute of Technology, New Delhi carried out an environmental assessment of industrial clusters across the India. Based on this, comprehensive environmental pollution index was calculated to identify polluted industrial clusters in the country. This was done

to priorities planning needs to improve quality of environment in these industrial clusters. Total 88 industrial areas have been selected for this study.

Comprehensive Environmental Pollution Index (CEPI) is calculated considering four prominent factors like Pollutants, Pathway, Receptor and additional high risk element. Each of these factors comprises Sub-factors as detailed:

Pollutant

This is evaluated as

$A = A1 \times A2$

where A1 is Presence of toxins and

A2 is Scale of industrial activities.

Maximum Score for this factor is considered as 30.

Pathway

This may be is calculated as

$B = B1 + B2 + B3$

where B1 is Pollutant concentration,

B2 is Impact on people; and

B3 is Impact on Eco-geological feature.

Maximum Score for this factor is considered as 20.

Receptor

This is calculated as

$C = C1 \times C2 + C3$

where C1 is Potentially affected population,

C2 is Level of exposure and;

C3 is Risk of sensitive receptors.

Maximum Score for this factor is considered as 30.

ADDITIONAL HIGH RISK ELEMENT

This depends on inadequacy of pollution control measures for large scale, medium and small scale industries. It is cumulative of ETPs, CETPs, Air pollution control devices and unorganized waste disposal.

Maximum Score for this factor is considered as 20.

On the above basis score for these factors calculated as

Score = A + B + C +D = 30 + 20 + 30 + 20 = 100

CEPI based on above mentioned score is calculated for air, water and land.

The clusters having CEPI above 70 are termed critically polluted. It is seen from the above table that 8 clusters out of 9 clusters, which are hub of coal mines or power plants are having CEPI above 70.

S. No.	Ranking	Industrial Cluster / Area	Air	Water	Land	CEPI	
1	4	Chandrapur (Maharashtra)	70.75	67.50	66.50	83.88	Ac_Wc_Lc
2	5	Korba (Chhatisgarh)	67.00	57.00	72.50	83.00	Ac_Ws_Lc
3	7	AngulTalcher (Orissa)	64.00	69.00	65.75	82.09	Ac_Wc_Lc
4	9	Singrauli (Uttar Pradesh)	70.50	64.00	59.50	81.73	Ac_Wc_LS
5	13	Dhanbad (Jharkand)	64.50	59.00	65.50	78.63	Ac_Ws_Lc
6	28	Ib Valley (Orissa)	61.00	56.50	59.00	74.00	Ac_Ws_Ls
7	33	Jharsuguda (Orissa)	61.00	56.50	56.00	73.34	Ac_Ws_Ls
8	42	Asansole (West Bengal)	58.38	56.25	50.50	70.20	As_Ws_Ls
9	52	Durgapur (West Bengal)	49.50	58.50	47.50	68.26	An_Ws_Ln

The Singrauli, which holds ninth rank based on CEPI have been widely studied both by Industrial Toxicology Research Centre as well as by Center for Environment for the ill effects being caused by mercury pollution. No such study has been reported for other clusters and hence the ill effects and the prevalence of pollution due to mercury is not known

STANDARDS

Govt. of India is reviewing the occupational exposure standards of 0.1 mg/m^3 of air, set up by Occupational Safety and Health Administration, USA for its implementation in our country. There is a need to reduce mercury air emissions from coal-fired power plants. Bureau of Indian Standards (BIS) and World Health Organization (WHO) limits the concentration of Mercury only up to 0.001 ppm in drinking water and 0.05 mg/kg in soil. The maximum allowed concentration of total mercury in fish is 0.50 ppm in India. The WHO guideline set for mercury intake by fish is 0.47 mg/kg/day, while the limit set by EPA is 0.1 mg/kg /day, which is one fifth to that of WHO.

There are standards for measuring mercury level in air, soil and water. These measurements may be within acceptable level at one place or for one industry but when there are clusters of Industries, their cumulative effect is likely to be more and even at acceptable level bordering to the max on persistent basis may do harm to the humans which can be recognized after 20 to 25 years of their actual exposure. Moreover as fish, which can have as much as 1,00,000 times more mercury content as compared to surrounding water should be tested on a regular basis in the vicinity of Power plants and coal mines industrial clusters and suitable advisory be issued for the public at large so that public in general and women of child bearing age are protected.

It is pertinent to note that the level of mercury in fish is up to the extent of more than 1,00,000 times than in the surrounding water as such the measurement of mercury level in water only may not be true representative of mercury. Even in the fishes, the level of mercury varies from fish to fish.

CONCLUSION

Thermal power plant emissions have added a new dimension to the ecosystem management. Coal fly ash disposal on land affects soil, vegetation surrounding thermal power plants and ground water around disposal pond. Toxic mercury present in coal fly ash poses potential risks to soil and water ecosystems. Thus its solubility, mobility and bioavailability have become a matter of concern in recent years. A regular monitoring and clinical surveying of subjects residing in the power plant areas is a must. There is also a need for further and in-depth studies for accurate appraisal of the situation. As coal is used in Thermal Power Plant, mercury pollution is bound to happen till the existence of TPP, even if strict pollution control measures are taken and needs very careful treatment.

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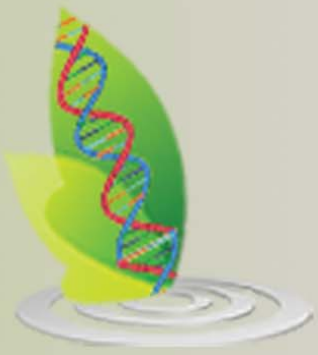

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