

Mercury Exposure in Indian Environment due to Coal Fired Thermal Power Plants and Existing Legislations- A Review

*Prashant Agrawal, **Anugya Mittal, ***Manoj Kumar, ****S K Tripathi

*Senior Research Fellow, **Junior Research Fellow, ***Lecturer

**** Professor and Head

Department of Forensic Medicine, Institute of Medical Sciences
Banaras Hindu University, Varanasi, U.P.

Abstract

Coal fired thermal power plants (TPPs) are the second largest source of mercury emission in India. Almost 73% of energy is obtained from TPP which uses about 220 millions tonnes coal/year. Coal contains mercury (Hg) naturally and its combustion in the boilers to generate electricity causes release of mercury in to the environment. A typical 100 mw TPP can emit over 10kg of mercury in a single year. Once Hg reaches to the environment it never breaks down and persists in the environment, cycling through land, air and water. Low level exposure of Hg may cause permanent damage to the central nervous system (CNS). At higher levels, Hg can damage vital organs such as lungs and kidneys.

Mercury has been the focus of regulatory activity because of its documented toxic and carcinogenic effects, as well as its persistent prevalence in the environment. Since mercury is volatile and readily mobilized, and often travels great distances before being deposited, regulatory concern about the

Reprint requests: Prashant Agrawal

Senior Research Fellow, Department of Forensic Medicine, Institute of Medical Sciences, Banaras Hindu University, Varanasi, U.P.
Phone-09451984349,
Email: prashantimsbhu@yahoo.co.in

environmental impacts of mercury appear to be quite justified.

Keywords

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Introduction

Mercury (Hg) is a naturally occurring, highly volatile heavy metal. It is found in trace quantities throughout the environment – rocks, soils and the oceans. Being an element, mercury never breaks down but persists in the environment, cycling through land, air and water. Mercury can exist in the environment in elemental, organic or inorganic forms. According to the International Chemical Safety Council of United Nations, an organic form of mercury (methyl mercury) is one of the six most serious pollution threats to the earth. While most of the mercury released into the environment by human activity is in either elemental or inorganic form, biological processes convert inorganic mercury into highly dangerous forms of organic mercury, such as methyl mercury. This form is the most harmful to people and wildlife because of its ability to take part in biochemical reactions and accumulate in the food chain.¹

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 grams 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. Methylmercury 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.²

Mercuric chloride has caused increases in several types of tumors in rats and mice, and methylmercury has caused kidney tumors in male mice. The Environmental Protection Agency³ (US EPA) has determined that mercuric chloride and methylmercury 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.²

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.

Mercury in coal

The mercury content of coal produced by different mines varies widely according to the location. A study by K.C. Sahu⁴ shows mercury content in a coal sample as 0.11 ppm. According to Mishra et al,⁵ the conc. of Mercury in coal ranges from 0.01 to 1.1 ppm in Indian coals against up to 20 ppm in Russian coals, 0.2 to 2.0 ppm in Belgium coals, 0.03 to 1.3 ppm in Canadian coals and 0.01 to 2.0 ppm in American coals.

A World Bank document in the year 2000 on the National Thermal Power Corporation (NTPC) showed results for mercury concentrations in coal analysis done by NTPC in the range of 0.11 to 0.14 ppm while another study of coal analysis, done by the Roorkee University, India, showed mercury to be in the range of 0.8 to 11.4 ppm. The Central Pollution Control Board⁶ (CPCB) conducted a study on 'Mercury balance in thermal power plants'. The CPCB analyzed 11

coal samples and found the average mercury concentration to be of 0.272 ppm (ranges between 0.09 to 0.487 ppm).

Coal Fired Thermal Power Plants

Coal fired thermal power plants are the largest source of electricity generation in India. More than two-thirds of India's power supply (73%) is provided by all the 75 coal-fired power stations. Thermal power plants are currently using about 220 million tonnes of coal per year, which account for about 75 per cent of the total coal production.

India is the third-largest producer of coal in the world. Coal is the most abundant fossil fuel resource and is the primary fuel for energy in India. The installed capacity of coal-based electricity generation has increased from 800 MW in 1973 to 50,000 MW in 1994-95 and is expected to go up by another 50,000 MW in the next 15 years. The demand of coal for thermal power stations will increase year after year.⁷

Most of India's coal is characterized by low trace element concentration. The quality of coal depends upon its rank and grade. Indian coal is of mostly sub-bituminous rank, followed by bituminous and lignite (brown coal). The ash content in Indian coal is approximately 35 to 55 per cent.⁴

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 India⁸. Mercury is released into the air 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 megawatt thermal power plant can emit over 10 kg of mercury in a single year⁷. About 200 metric tonnes 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 per cent 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 tones per annum, considering average concentration of mercury in coal as 0.272 ppm. About 59.29 tones per annum mercury is mobilized from coal-fired thermal power plants alone. The mercury emanating from the thermal power plants' stacks is 58.05 per cent gaseous and 2.4 per cent in particulate form. About 32.5 per cent is retained in the ashes (fly ash and bottom ash). The remaining 7.05 per cent 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)⁹. As the coal is combusted in the utility boiler,

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 tones of coal containing x grams per tone of any mercury will pump into the surrounding eco system $8x$ 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 tonnes of fly ash. In India, mercury is concentrated as 0.1 ppm as a trace element in the fly ash¹⁰. 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. 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 per cent of India's power, stand responsible for 16.85 per cent, that is, 10 tones 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.¹¹

Pervez and Pandey¹², 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 1ppm in soil and

more than 10 ppm in ground water and ponds ¹². Govt. of India is reviewing the occupational exposure standards of 0.1 mg/m³ 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 India¹³. 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, biomass and biofuels. According to the National Thermal Power Corporation, coal is used for approximately 62.3% of India's

electric power generation; oil and gas account for 10.2%; hydropower contribute 24.1%; nuclear, wind, and other power generation methods contribute to the remaining 3.4% of the power generated.

Environmental Legislations in India

In 1976 Parliament passed the 42nd Amendment to the Constitution and India became the first country in the world to provide protection and improvement of the environment in the Constitution itself. The Ministry for Environment and Forests is the focal point in the Government of India for all matters relating to the environment

Legislative control of environmental pollution caused by toxic mercury and the protection of workers engaged in the related industries involves:

- * Laying down a set of rules on the expert recommendations to control environmental pollution.
- * Adopting international conventions and recommendations concerning the prevention of occupational risks.
- * Observing the codes of practice and guides on prevention.

S No	Acts and Rules	Brief description
1	The Water (Prevention and Control of Pollution) Act, 1974.	To provide for the prevention, control and abatement of water pollution; and the establishment of central and state boards to implement that objective.
2	The Environment Protection Act, 1986.	Provides for the protection and improvement of environment
3	The Workmen's Compensation Act, 1923.	Provides for compensation payment by certain classes of employers to their workmen- Diseases caused by mercury or its toxic compounds are included
4	The Factories Act [Act No. 63 of 1948] as amended by the Factories (Amendment) Act, 1987.	Covers all the aspects of health and safety of workers. Permissible limits of exposure to mercury in the work environment.
5	The Public Liability Insurance Act, 1991.	Provides for public liability insurance for the purpose of providing immediate relief to the person affected by accident.
6	The Municipal Solid Wastes (Management and Handling) Rules, 2000.	Regulates municipal solid waste- mercury in ground water, composts and leachate.

Conclusion

Thermal power plant emissions have added new dimensions to the nature. 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 required. 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. Therefore, all other non-polluting methods of power generation should be encouraged against TPP

The main problem of our legislations lies in the poor level of implementation by the various implementing agencies. If the legislation and standards were properly implemented, half of India's environmental problems would be solved.

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