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Heavy metal pollution and health hazards around singrauli region India

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Abstract
Pollution has both acute and chronic effects on human health, affecting a number of different body systems and organs ranging from respiratory infections, heart diseases, lung cancer, aggravation of pre-existing heart and lung diseases, asthmatic attacks as well as premature mortality and reduced life expectancy. One of the major environmental problems resulting due to the use of coal as fuel in Thermal Power Plants (TPPs) is the production of ash. Coal fly ash disposal on land affects soil, vegetation surrounding TPPs and ground water, through the process of leaching in residential area and around disposal ponds. The toxic metals in coal fly ash pose potential risks to human health and soil and water ecosystems. Thus, their solubility, mobility and bioavailability have become a matter of concern in recent years. In the present article authors have mainly highlighted the heavy metals pollution due to fly ash produced during burning of coal from thermal power plant around Singrauli region and toxicity which is produced by these toxic metals among local residents on that area after reviewing the previous researches of Singrauli region.

Keywords: Singrauli, Heavy Metals, Thermal Power Plants, Health hazards, Toxic Gases etc.

1. Introduction
One of the major environmental problems resulting due to the use of coal as fuel in Thermal Power Plants (TPPs) is the production of ash which is particularly important for Indian power stations because most of the power stations in India use poor quality coal yielding about 100 million tons of ash per year [1]. Coal fly ash disposal on land affects soil, vegetation surrounding TPPs and ground water, through the process of leaching in residential area and around disposal ponds. The toxic metals in coal fly ash pose potential risks to human health and soil and water ecosystems. Thus, their solubility, mobility and bioavailability have become a matter of concern in recent years. The wastes produced from the coal-fired TPPs are bottom ash and fly ash the latter of which consists of finer sized particles, ranging from 0.5 to 200 micron [2]; is released during burning of coal in TPPs; disperses in air and affects the health of human and livestock causing cancer, respiratory problems and skin diseases.
Pollution has both acute and chronic effects on human health, affecting a number of different body systems and organs ranging from respiratory infections, heart diseases, lung cancer, aggravation of pre-existing heart and lung diseases, asthmatic attacks as well as premature mortality and reduced life expectancy [3]. Coal combustion is a significant source of emission of heavy metals some of which are potentially toxic, and transferred to the surrounding environment through different pathways [4-7]. The heavy metal pollution is highest in Asia, which is adversely affecting the health of people as well as wild life [7].

2. Heavy Metal Toxicity
Heavy metals have been used by humans for thousands of years. Although several adverse health effects of heavy metals have been known for a long time, exposure to heavy metals continues, and is even increasing in some parts of the world, in particular in less developed countries [8]. The main threats to human health from heavy metals are associated with the exposure to *Pb, Cd, Hg, As* and *Ni*. These metals have been extensively studied and their effects on human health regularly reviewed by international bodies such as the WHO.

The heavy metal pollution contributes, to a large extent, to the contamination of food and water, which makes ingestion in several cases the major route of pollutant intake [9] via the gastrointestinal and respiratory tract, absorption of pollutants may occur, while a number of toxic substances can be found in the general circulation and deposit to different tissues. Elimination occurs to a certain degree by excretion [10]. Ingesion is the most common route of exposure in children [11] Children may develop toxic levels from the normal hand-to-mouth activity of small children who come in contact with contaminated soil or by actually eating objects that are not food (dirt or paint chips) [12].

Symptoms of chronic toxicity are often similar to many common conditions and may not be readily recognized [11-16]. Common symptoms are cramping, nausea and vomiting; pain; sweating; headache; difficult breathing; impaired cognitive, motor and language skills; mania; and convulsions. Symptoms of chronic exposure are very similar to symptoms of other health conditions and often develop slowly over months or even years. Moreover, there exist several susceptibility factors such as age, nutritional status and predisposing conditions [16].

3. Some Important Health Related Researches of Singrauli Region

Agrawal (2009) [17] studied a large number of water and soil samples with epidemiological aspects of Singrauli area and found significantly higher levels of heavy metals including *As*. A few studies have been carried out during the last decade on the presence of heavy metals in blood and urine samples of human population residing nearby areas of coal based TPPs including Singrauli region. The present study was undertaken to investigate *As* load in human beings with disease profile of inhabitants around TPPs of Singrauli region, comprising of 238 blood samples of hospital based subjects collected from the surroundings of four TPPs spread over a period September 2005 - December 2009. To estimate the concentration of *As* samples were analyzed by Atomic Absorption Spectrophotometer (AAS).

4. Overview of Singrauli

The Singrauli region is fast emerging as an energy hub of India for electric power and coal and therefore, it is also known as *urjanchal* (a Hindi word which means land of energy).The total installed capacity of all five coal based TPPs in the Singrauli region is around 10% of total installed capacity of India. Singrauli area is a part of Singrauli District (MP), and the adjoining southern part of Sonebhadra District (UP) in India and is popularly known as "Energy Capital of India". It is one of the most polluted industrial sites of Asia. ; encompasses 11 open cast coal-mines and 5 coal based TPPs which generate about 9000 MW electricity (about 10% of India's installed generation capacity). TPPs represent the main source of pollution in Singrauli region, emitting 6 million tonnes of fly-ash per year, which is produced through high-temperature combustion of fossil fuel rich in ferromagnetic minerals in TPPs [18].

Poor hygiene, poverty, malnutrition, and lack of resources seem to be the root causes of most of the chronic diseases of Singrauli residents. A 1990 survey indicated the poor state of health in the region. Over half of the respondents suffered from chronic ailments, the most common being gastrointestinal infections, recurrent fevers including malaria and respiratory diseases. The principal serious illnesses that compel people to go to these hospitals all have an environmental health dimension: tetanus, tuberculosis, cholera, and acute dysentery [19]. The most common ailments at the parastatal NCL Singrauli hospital are broncho-pulmonary problems such as tuberculosis and asthma that are partly related to inhalation of fly ash; these illnesses have affected at least half of the population residing near the Bina mining area [20].

According to a published report, in parts of Singrauli the fly ash lies in piles five feet thick. It consists of fine particles (including calcium, sulphate, silicon and magnesium); along with toxic trace elements such as Hg, Pb, As, Se, and Cd. These heavy metals can leach into ground water and soil, cause acid rain, and affect human health through inhalation. The health effects ranges from permanent respiratory disorders, aggravation of ailments like asthma, bronchitis, and even lung cancer due to prolonged inhalation of fly ash [21]. Srivastava, (2005) [7] assessed exposure to mercury by monitoring mercury level in 1200, Singrauli Resident's Blood and hair samples and reported that the mean mercury levels in blood and hair was 21.39 ± 2.11 ng/ml and 1.90 ± 0.10 ug/g) respectively among exposed subjects. Prevalence of tremors in the study populations was 8.0% and tremors were predominantly of fine type. Sensory disturbances were present in 2.3%. Clinical findings in 120 children attending the pediatric clinics at the hospital revealed respiratory problems (n=46), diarrhea and abdominal pain in (n=50), worm infestation (n=80) and pica (n=5) cases. Hyper pigmentation of lower limbs, blue gum lining, lower IQ was also found in some of the examined cases. Women (n=100) attending the gynecology clinic revealed headache and still births, menstrual irregularities, sterility, numbness and tingling of the lower extremities. Hyper-pigmentation, anaemia, black line over gums, high B.P. and the fine tremors were also seen in some of the cases.

5. Types of Pollution around Singrauli region

5.1. Air: *As* is released into the atmosphere primarily as arsenic trioxide or, less frequently, in one of several volatile organic compounds, mainly arsines [22]. Trivalent arsenic and methyl arsines in the atmosphere undergo oxidation to the pentavalent state [23] and *As* in the atmosphere is usually a mixture of the trivalent and pentavalent forms [23, 24].

5.2. Water : Populations exposed to *As* via drinking water show excess risk of mortality from lung, bladder and kidney cancer, and the risk increasing with increasing exposure. There is also an increased risk of skin cancer and other skin lesions, such as hyperkeratosis and pigmentation changes [25]. Arsenic (*As*) in water can undergo a complex series of transformations, including oxidation-reduction reactions, legand exchange, precipitation, and biotransformation [26, 27]. Rate constants for these various reactions are not readily available, but the factors most strongly influencing fate processes in water include Eh, pH, metal sulfide and sulfide ion concentrations, iron concentrations, temperature, salinity, distribution and composition of the biota, season, and the nature and concentration of natural organic matter [28, 29].

As contamination of groundwater has led to a massive epidemic of *As* poisoning in Bangladesh and neighboring countries. In India *As* contamination in ground water has been observed in some parts of the States of West Bengal,

Bihar, Uttar Pradesh, Assam and Chhattisgarh. Presently 42 major incidents around the world have been reported on groundwater *As* contamination. It is estimated that approximately 57 million people are drinking groundwater with *As* concentrations elevated above the World Health Organization's standard of 10 parts per billion. However, a study of cancer rates in Taiwan [30] suggested that significant increases in cancer mortality appear only at levels above 150 parts per billion. The northern United States, including parts of Michigan, Wisconsin, Minnesota and the Dakotas are known to have significant concentrations of *As* in ground water. Increased levels of skin cancer have been associated with *As* exposure in Wisconsin, even at levels below the 10 part per billion drinking water standard [31].
Analyzing multiple epidemiological studies on inorganic *As* exposure suggests a small but measurable risk increase for bladder cancer at 10 parts per billion [32]. According to Peter Ravenscroft of the Department of Geography at the University of Cambridge (usatoday.com) roughly 80 million people worldwide consume between 10-50 PPb *As* in their drinking water. If they all consumed exactly 10 parts per billion *As* in their drinking water, the previously cited multiple epidemiological study analysis would predict an additional 2,000 cases of bladder cancer alone.

5.3. Soil: In soil, *As* is found as a complex mixture of mineral phases, such as co-precipitated and absorbed species, as well as dissolved species [11] The degree of arsenic solubility in soil depends on the amount of *As* distributed between these different mineral phases. The dissolution of *As* is also affected by particle size. The distribution between these phases may reflect the arsenic source (e.g., pesticide application, wood treatment, tanning, or mining operations), and may change with weathering and associations with iron and manganese oxides and phosphate minerals in the soil [11, 33].

5.4. Food: Food is the largest source of *As* exposure (about 25 to 50 micrograms per day). Among foods (meat, fish, and poultry), some of the highest levels are found in fish and shelfish; however, this *As* exists primarily as organic compounds, which are essentially non-toxic [25].

6. Conclusion

Overall from the above mentioned previous health related researches on singrauli region it is clearly indicated that, the presence of the higher concentration of heavy metals i.e. As, Hg Pb, Cd and Ni subjects indicating alarming situation for Singrauli residents. Therefore, the following steps are needed to minimize pollution effects in coal-fired TPPs areas at Singrauli region:

(1) Among the measures that can be thought of to control the health hazards from metallic pollutants derived from fly ash emitted from coal fired TPPs, the following may be noteworthy:
(2) Control measure at source and (ii) Surveillance by regulatory authorities ought to be regular to ensure appropriate pretreatment and condensation of fly ash with downstream neutralization in making of bricks etc.
(3) Campaign for special and regular health education awareness programme to the population living in risky region to adopt healthy habits e.g. disciplined hygiene, practices of self, food and beverages. The source of drinking water must be protected and the drinking water sources preferably be off hand-pumps, drill deep to draw, less polluted, unpolluted.
(4) A forestation of the area preferably with *Metallophytes* like Neem etc. and supplemented with Dhatura in the waste land because they have capacity to reduce the heavy metal loads from environment.
(5) Creation of specialized pollution information centers for monitoring water, Air and soil levels of pollutants and issuing active alarms. The center should arrange for awareness building among health care givers to look for diagnose, to know epidemiologic links of the pollutants with diseases and appropriate deliver preventive and curative services for the people suffering intoxication with the chronic exposure of metallic pollutants.
(6) NGOs and other voluntary organizations should be promoted as public participations at all about above discussed levels.
(7) A national registry *"on zone wise occurrences of striking high prevalence of specific disease"* to be made to guide necessary researches on various aspects of health hazards and its controls.

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