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# Assessment of ground water contamination for heavy metals in the proximity of ash ponds

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**ABSTRACT**

Heavy metals on fly ash surface has tendency to leach and contaminate the ground water, which will affect the human by entering food chain. Present study has been carried out to assess the ground water contamination in the surrounding villages closer to two thermal power plants in Delhi, India. Ground water samples from different location within the 2 Km radius of both thermal power plants were collected and analyzed for heavy metals (Cd, Cr, Cu, Fe, Ni and Pb). This study indicates that the bore well and pond water within the study area is contaminated with higher concentration level of these heavy metals. The concentrations of these selected heavy metals are crossing the prescribed standard of drinking water quality in India. Supernatant of ash ponds contain heavy metals, needs remediation before discharging into the environment.



## Introduction

The power generation in India was about 2,00,000 x $10^6$ Watt in 2012 and expected to increase up to 3,00,000 x $10^6$ Watt by 2017 [1]. About 54.09 percent of electricity is generated from coal based thermal power plants. The present fly ash generation rate is about 131.09 x $10^6$ tonnes per annum and utilization rate is 73.13 x $10^6$ tonnes per annum [1].

The unmanaged disposal of such huge quantity of fly ash is major problem, probably the leaching of pollutants into surface and ground water. Groundwater and soil contamination is a common issue at ash ponds and landfill sites. Contaminants such as iron, chromium, nickel, lead, and cadmium can dissolve from soil and waste material into groundwater in a process known as leaching.

The impact of coal ash leachates on receiving waters, cause changes in water pH with implications for trace element mobility [2]. In wet disposal system the fly ash is mixed with water and the slurry is discharged into ash ponds or lagoons. The supernatants of ash ponds are then discharged into a receiving system like a river/canal.

The present methods of fly ash disposal cause metal contamination of surface and groundwater resources [3]. The major portion of fly ash is disposed off in unmanaged landfills or ash ponds, which leads to environmental pollution in the area through fly ash erosion and leachate generation [4]. Heavy metals like Cd, Pb, Ni, Cu and Cr found in fly ash are toxic for living organisms. In most of the ash ponds, leaching of heavy metals is possible due to unlined construction of the ash ponds [5].

The poorly managed disposal of fly ash brings ecological and health associated risks to the environment [6,7,8,9]. The presence of potentially hazardous high concentrations of heavy metals in leachates has been reported by several researchers [10,11,12,13]. Mobile metals in soil or fly ash have potential to cause contamination issues. The mobility of metals in soil and water is also dictated by the oxygen availability of the subsurface [14]. Several heavy metals that may be present in landfill leachates are considered as priority pollutants for ground water resources like Cd [15]. The composition of landfill leachates is dependent on many factors such as the origin, waste composition, climate condition, site hydrology, bacterial activities and duration of generation of wastes [16,17,18,19,20].

The objective of the study is to assess the contamination of selected heavy metals like Fe, Cu, Cd, Ni, Pb and Cd in ground water samples of the surrounding area of two thermal power plants in Delhi. The above mentioned metals have been selected for the study because these metals are of common environmental concern vis-a vis their ecotoxicology and health hazards to the human beings as well as to aquatic biota.

## Materials and Methods

Two coal based power plants are operational in Delhi, India, namely Rajghat Power House (RPH) and Badarpur Thermal Power Station (BTPS). The RPH was commissioned in 1967 and is a 135 x $10^6$ Watt coal fired thermal power plant, consisting of two units of 67.5 x $10^6$ Watt and uses 0.73x $10^6$ tonnes of coal per year and produces about 0.23x $10^6$ tonnes of fly ash annually [3].

The BTPS was commissioned in 1973 and is a 705 x $10^6$ Watt coal fired thermal power plant. It uses 3.68 x $10^6$ tonnes coal per year and produces about 1.10 x $10^6$ tonnes fly ash annually.

Four ground water samples were collected from the proximate of ash ponds of each thermal power plant. After preservation, the samples were placed in an insulated ice box for transportation to laboratory for the analysis of respective heavy metals.

The depth of the bore well varies from 15 ft to 60 ft. The location map of sampling point and study area of RPH and BTPS is given as fig. 1 and fig. 2 respectively. The concentration of selected elements i.e. Iron, Copper, Chromium, Cadmium, Nickel and Lead were analysed using Atomic Absorption Spectrophotometer (Perkin Elmers, Model- AAnalyst 700).

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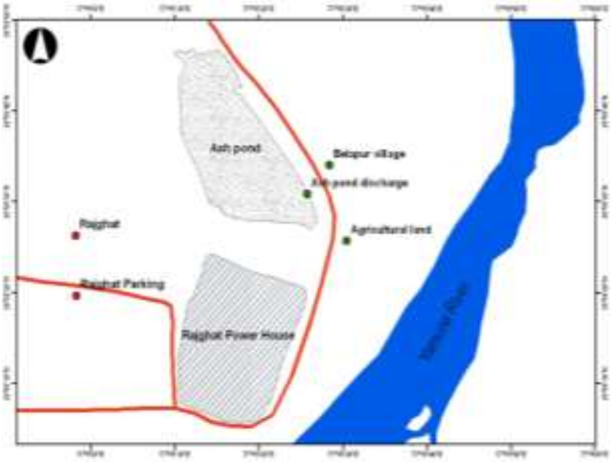


**Figure. 1. Location of study area of Rajghat Power House**

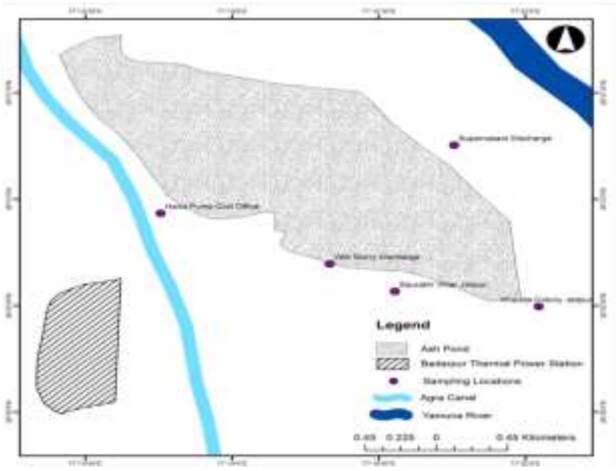


**Figure. 2. Location of study area of Badarpur Thermal Power Station**

**Results and Discussions**

The analytical results of ground water samples collected from the nearby area of ash ponds of thermal power plants and discharge point of the ash ponds shows that the total concentrations of the heavy metals vary seasonally in small variation. The concentration of heavy metals in ground water near the ash ponds of RPH during pre-monsoon, monsoon and post monsoon is presented in fig. 3, 4 and 5 respectively and the concentration of heavy metals in ground water near the ash ponds of BTPS during pre-monsoon, monsoon and post monsoon is presented in fig. 6, 7 and 8 respectively.

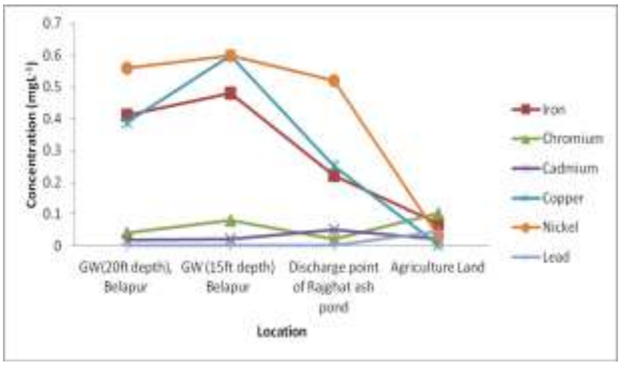


**Figure. 3. Metals concentration in ground water samples near ash pond of RPH (Pre-Monsoon)**

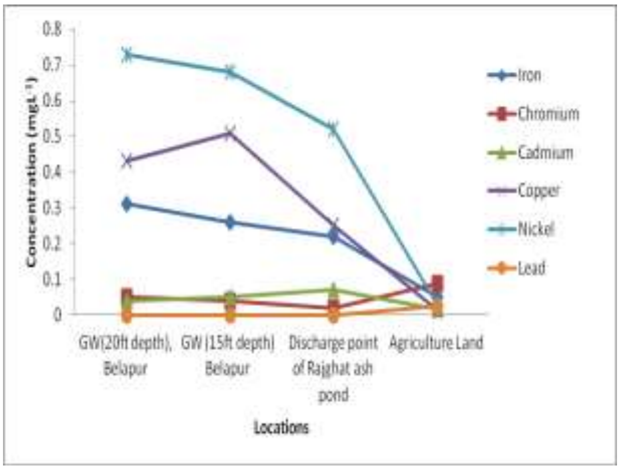


**Figure. 4. Metals concentration in ground water samples near ash pond of RPH (Monsoon)**

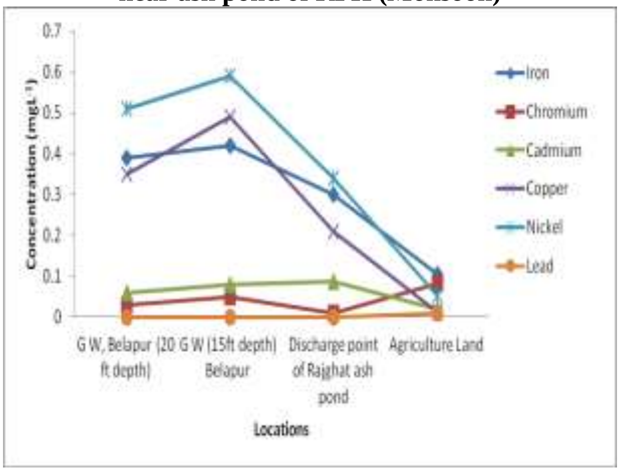


**Figure. 5. Metals concentration in ground water samples near ash pond of RPH (Post-Monsoon)**

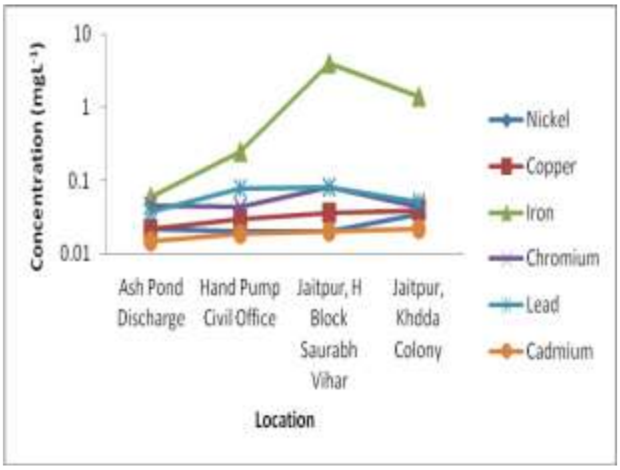


**Figure 6. Metals concentration in ground water samples near ash pond of BTPS (Pre-Monsoon)**

At RPH, ash pond discharge point and at BTPS, Saurabh vihar showed the maximum amount of Cadmium. High cadmium level in ground water samples near the thermal power plants was previously reported [21,22]. Cadmium affects calcium metabolism and can result in bone mineral loss and associated bone pain, osteoporosis and bone fractures. The concentration of Chromium, Iron and Lead exceeding the permissible limits at all sampling locations. The high concentration of these metals in ground water has adverse impact on human being, if it consumed. It is reported that, frequent ingestion of Cr contaminated water can cause anemia and stomach cancer. Fe ingestion in large quantities results in a condition known as heamochromatosis, where in tissue damage results from iron accumulation [23]. High concentrations of lead in the body can cause failure of central nervous system, which results in hyperactivity, memory and concentration problems, high blood pressure, hearing problems, headaches, slowed growth, muscles and joint pain, digestive problems and reproductive problems in men and women.

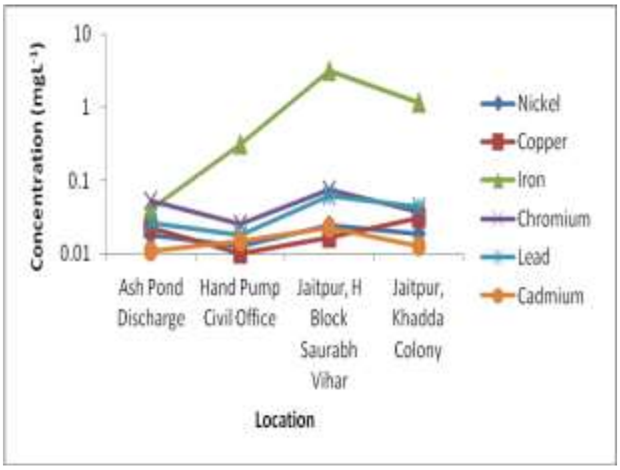


**Figure 7. Metals concentration in ground water samples near ash pond of BTPS (Monsoon)**

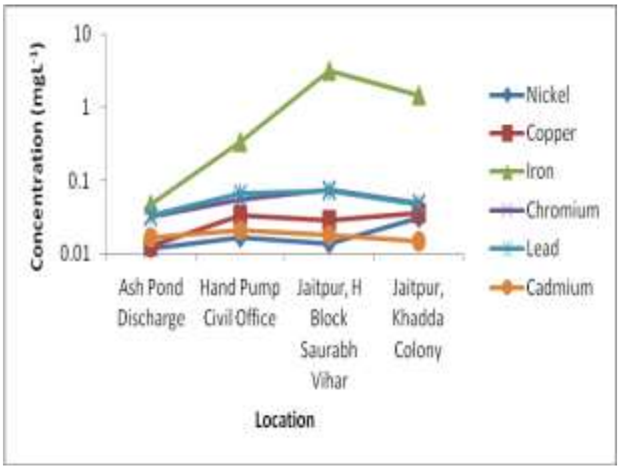


**Figure 8. Metals concentration in ground water samples near ash pond of BTPS (Post-Monsoon)**

The results of water samples collected from the proximity of ash ponds illustrate the contamination of water resources in the surrounding villages Belapur, Saurabh Vihar, Khadda colony due to unmanaged way of disposal of fly ash in ash ponds. These ash ponds are in the flood plain area of river Yamuna, and in permeable soil with shallow water tables, enhancing the potential of leachate to contaminate ground water. It was seen that, as the depth of bore well increases, the metal concentration decreases, same was reported by Liang [24]. Vega et al. [25] reported that the seasonal variation in precipitation, surface runoff, interflow, groundwater flow have a strong impact on heavy metal concentration. The concentration of most of the heavy metals in pre-monsoon are higher than those of monsoon and post-monsoon, mainly due to rainfall and flood that would cause the heavy metal concentration to be diluted. Rajani et al. [26] found the high concentration of some metals in water of Tributaries River in Pahang, Malaysia in post monsoon to compare pre-monsoon they were concluded the river runoff and suspended sediments can be effect on increase of heavy metals concentration in water. Shivakumar and Srikantaswamy [27] reported the main reason behind the seasonal variation of heavy metals is dilution of metal ions during rainy season and accumulation due to free movement of the metal ion in the remaining seasons. Since, the source of coal, coal combustion technology at RPH and BTPS is different, the fly ash hydration properties and the leaching characteristics of heavy metals can vary significantly [28]. The concentrations of Fe, Pb and Cr have higher than the other selected metals around RPH, whereas Fe, Pb and Cr have higher concentration than the other selected metals around BTPS, mainly because the bioavailability of different metals at different places is variable. Prasad and Mondal reported that the percentage amount of heavy metals from fly ash surface follow the trend as Fe > Cu > Cr > Ni > Pb > Cd [29]. The concentration of Fe at Jaitpur (H Block, Saurabh Vihar) was observed too high; this may be due to the development of new landfill site near the Jaitpur village [30]. It is seen that the leaching of heavy metals in ground water is very high near thermal power plants [22,31,32].

**Conclusions**

Unmanaged and improper handling of wet ash disposal in ash ponds is evident from the water drainage to the nearby stream, which has enhanced the ionic concentrations. Heavy metals being leached out from the ash ponds and contaminated the water resources nearby and will affect the health and livelihood of local people. The technology for coal ash disposal should be implemented to control the migration of leachate from fly ash to ground water. Technology includes many methods like liner system in the leachate collection system, waste cover, etc. Fly ash landfill can be designed with multiple liner system, a double composite liner. The abandoned open cast mine located in barren area can be used for disposal of fly ash.

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