

# Bioaccumulation of Heavy Metals by Dominant Grassy Species around Mejia Thermal Power Station

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**ABSTRACT:** A field study was conducted in the fly ash dominated swamp, at Mejia Thermal Power Station (MTPS) located in West Bengal (India) to find out biologically accumulated metals in root and shoot portions of the naturally growing vegetation. Two dominant grassy vegetation namely *Typha elephantia* and *Phragmites karka* were collected in the winter months (November and December), 2015. Bioaccumulation of metals in root and shoot portions were found to vary significantly among the species. The field study revealed that *Typha elephantia* and *Phragmites karka* could be used for bioremediation of fly ash lagoon.

**KEYWORDS:** heavy metals, thermal power plant, fly ash lagoon, grass species, bioaccumulation, translocation, Mejia Thermal Power Station.

## I. INTRODUCTION

Mejia Thermal Power Station (MTPS) (23°26'39.6"N and 87°07'48.2"E), commissioned during 1996, is the largest thermal power plant, in terms of generating capacity in the state of West Bengal as well as among other DVC power plants and is located adjacent to the Damodar barrage, Durgapur, West Bengal. During the production process of the Thermal Power Plants (TPPs) a huge quantum of fly ash is generated. Fly ash is a source of heavy metals like Zn, Cu, Mn, Fe, Co, Ni, Pb etc., which has several adverse effects on the ecosystem<sup>1-8</sup>. The fly ash generated also poses detrimental effects on the surrounding water bodies as the generated suspended particulate matter inhibits the penetration of solar radiation in the aquatic system and affects the primary production. Furthermore, the natural vegetation by virtue of their bioaccumulation capacity concentrates these heavy metals when they grow on these dumped fly ash sites. On this background, the MTPS authority initiated an afforestation program during 2001 with the basic aim to upgrade the ambient environment. The major vegetation constituted of trees and naturally regenerated grass species. The present research programme is an attempt to quantify the bio-amplification potential of the pioneer grass species growing in the fly ash dump sites. The programme has considerable implications in the sense that these grass species are mostly grazed by herbivores, whose milk and meat are consumed by the local inhabitants. Thus, there is a high probability of transference of these metals to human tissue through the food chain existing in the fly ash based ecosystem.

## II. RELATED WORK

Fly ash is the end residue from combustion of pulverized bituminous or sub-bituminous coal (lignite) in the furnace of thermal power plants and consists of mineral constituents of coal which is not fully burnt. Use of high

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ash containing (30–50%) bituminous or sub-bituminous coal in thermal power stations, in addition to several captive power plants, contributes to indiscriminate disposal of this industrial waste every year<sup>9,10</sup>. However, in many countries this industrial by product has not been properly utilized rather it has been neglected like a waste substance. In China, about 100 MT (million tons) of coal combustion products are produced each year (<http://www.tifac.org.in>). In India, presently, the figure is around 112 MT and is likely to exceed 170 MT by 2012<sup>11</sup>. Many experiments and studies on the effect and potentiality of fly ash as an amendment in agricultural application have been conducted by various agencies, research institutes at dispersed locations all over the world. In this paper, the utilization of fly ash as a value added product of agriculture is reviewed with the aim to open up the usage of fly ash and to reduce the environmental and economic impacts of disposal. In most thermal power plants, fly ash contains considerable levels of heavy metals. The total contents of the trace elements in the fly ash samples are related to the differences in coal composition and combustion technology. Turiel - Fernandez et al., (1994) studied the mobility of Cd, Co, Cu, Ni, Pb, Sb and Zn metals from six different coal-fired power plant fly ashes by using sequential extraction process and showed that there is a wide variation in mobility for different metals. Phytoremediation is the technology being adopted in the modern era, based on the use of plants to clean up polluted sites<sup>13,14</sup>. Through this we can remove the metals (or other pollutants) from contaminated soils whereby the metal is taken up from the soil, and is then translocated to and stored in the harvestable parts of the cultivated plant<sup>15,16,17</sup>. These technologies are being considered as the most cost-effective and bio-safe techniques as they help remediating toxic metal in contaminated sites at a fraction of the cost of conventional technologies, such as soil replacement, solidification and washing techniques<sup>15,18</sup>. Hyperaccumulating plants are those that accumulate very high levels of metals but unfortunately grow slowly and eventually have a low biomass. Apart from this, some heavy metals are not easily available for plants due to their insolubility and interactions with soil particles. One suitable example is that of metal lead (Pb) that is present in huge amounts in exposed areas, but due to its high interactions with soil particles and low solubility it becomes almost unavailable to plants<sup>19</sup>. The introduction of metal-binding proteins and peptides into plants to enhance metal tolerance and/or accumulation is a compelling strategy. These metal binding peptides or proteins should be preferentially metal specific such that only the toxic metals are sequestered (for example Cd, Hg and Pb) and not essential trace metals such as Zn. Apart from crop plants, fly ash amended soil bed (90% fly ash with respect to soil and humus), are reported to encourage the growth of forestry tree species, flowering and non-flowering alike (namely – *Acacia auriculiformis*, *Acacia nilotika*, *Dalbergia sissoo*, *Alstonia scholaris*, *Neolamarckia kadamba*, *Leucaena leucocephala*, *Delonix regia* etc.); thus aiding eco-restoration by converting an environmental dump site to a budding agro-forest zone<sup>20</sup>. However, the naturally growing pioneer species or colonizer species of plants that are found growing in a metal infested land are of primary concern, due to their natural emergence and adaptability to a toxic environment.. Such grassland species found growing luxuriously on the fly ash bed are of prime focus in this study.

### III. SCOPE OF RESEARCH

The present study is immensely important from two perspectives namely costing and technology. Methods, which are presently available to reduce the content of toxic elements in the fly ashes, through conventional water based leaching and more recently using, artificial CO<sub>2</sub> involve a high cost. Moreover these methods do not eliminate the toxic elements yet simply create an additional contaminated waste stream<sup>21</sup>.

The present study is therefore extremely important, as in this case, floral community reduce the level of toxic elements on fly ash, through the process of bioaccumulation.

The study is also important, as these vegetation are often used as fodder by the cattle, and thereby, the elements in the vegetation may be transferred to human system through the food-chain (by means of milk and meat products of the cattle).

# International Journal of Innovative Research in Science, Engineering and Technology

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## IV. PROPOSED METHODOLOGY

### MATERIALS AND METHODS

#### Analysis of Heavy metals in grassy vegetation

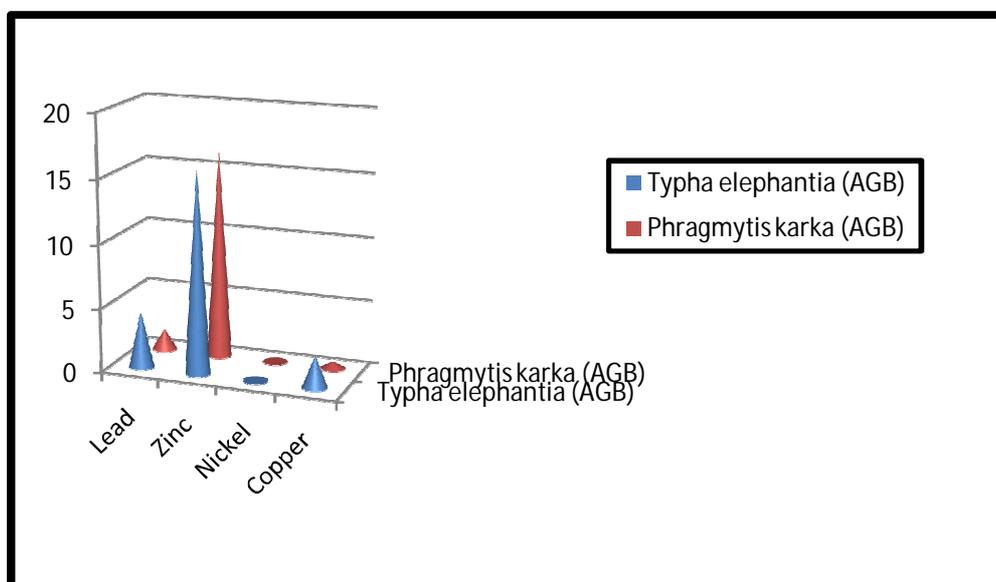
10 gm of the collected grass samples of each species (from Mejia Thermal Power Station) were dried separately at 105°C overnight. Each dried sample (1 gm on dry weight basis) was digested with a mixture of nitric acid and hydrogen peroxide followed by addition of hydrochloric acid<sup>22</sup>. The digested samples were analysed for Zn, Cu, Pb and Ni against standard concentration of each metal on a Perkin Elmer Atomic Absorption Spectrophotometer (Model 3030) equipped with an HGA-500 graphite furnace atomizer and a deuterium background corrector. Blank corrections were carried out to bring accuracy to the results.

#### Evaluation of Translocation Factor (TF)

It is the ratio of the concentration of a particular metal in the shoot region, to that of the root region as outlined in details by<sup>23</sup>.

## V. EXPERIMENTAL RESULTS

The levels of heavy metals in the Above Ground Biomass (AGB) and Below Ground Biomass (BGB) of the selected species namely *Typha elephantia* and *Phragmites karka* are represented in **Fig. 1**, **Fig. 2** and **Fig. 3**.



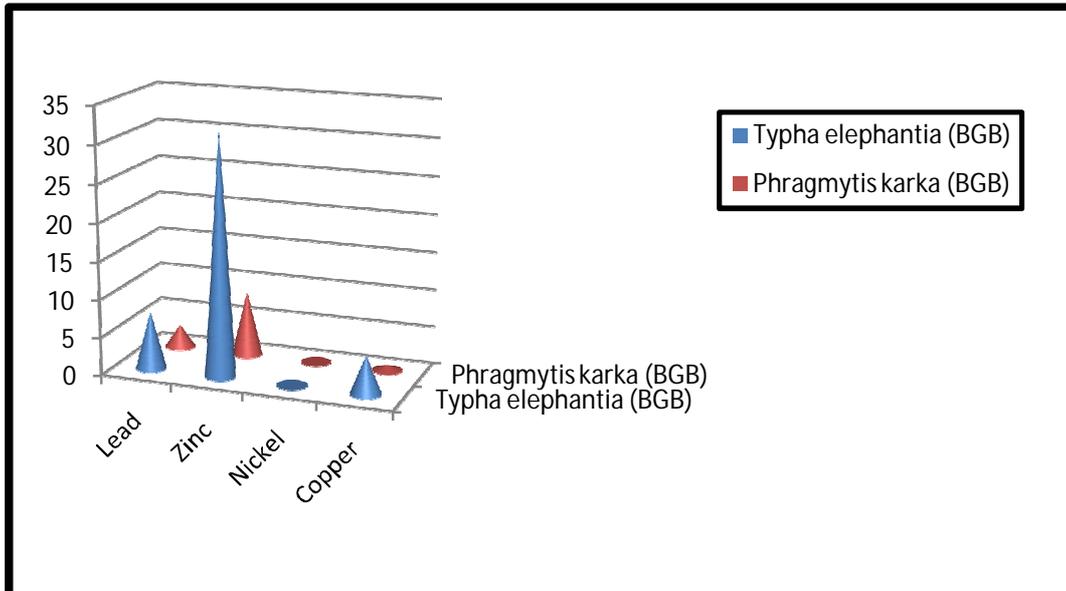
**Fig. 1** The concentration of selected heavy metals in the AGB of the two grass species.

In Fig. 1, the concentrations of the concerned heavy metals in the AGB show that zinc is the most accumulated heavy metal in both the grassy species (*Phragmites karka*, *Typha elephantia*). Also, *Typha elephantia* shows better metal accumulation tendency over *Phragmites karka*.

## International Journal of Innovative Research in Science, Engineering and Technology

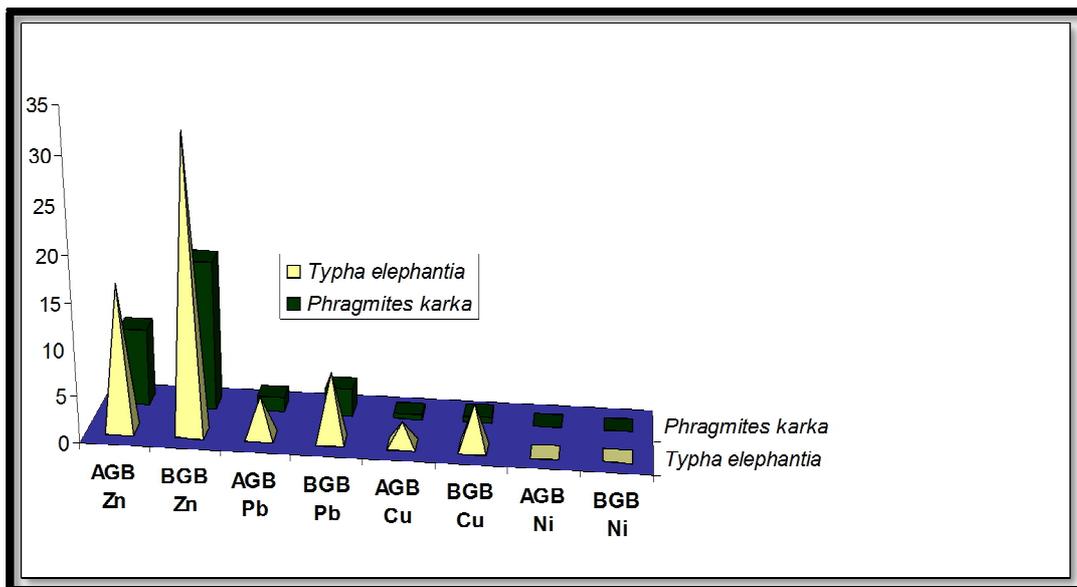
(A High Impact Factor, Monthly Peer Reviewed Journal)

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**Fig. 2** The concentration of selected heavy metals in the BGB of the two grass species.

Fig. 2 shows similarity with Fig. 1, in the context of zinc being the most accumulated heavy metal in the BGB of both the grassy species in consideration. Also, nickel is not accumulated and its concentration was negligible (BDL).



**Fig. 3** Comparison of the AGB and BGB of the selected grass species, and the metal concentrations in each.

All the Figures (Fig. 1, Fig. 2, Fig. 3) showed that Zinc being an essential element for the normal growth of organisms exhibited highest accumulation in both the species namely *Typha elephantia* and *Phragmites karka*. In both the species the metal accumulated more in the Below Ground Biomass (root) than in the Above Ground

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Vol. 5, Issue 2, February 2016

Biomass (leaf and stem). The level of lead was also considerable in both the species of the study area. The same sequence of accumulation with greater value in the BGB compared to AGB is also observed in this metal. Levels of copper, in the selected species also exhibited similar order of accumulation with highest concentration in the BGB compared to that of AGB. In both the species, the heavy metal nickel was below the detectable level (BDL), when the detection limit for nickel is 0.1ppm (by default).

## VI. DISCUSSION AND CONCLUSION

Trace elements contamination in the environment has been occurring for centuries but its extent has increased markedly in the last 50 years due to technological developments and increased consumer use of materials containing these elements<sup>24</sup>. The concentration of metal in plants serves to indicate the metal status and also the abilities of various plant species to take up and accumulate the metals from fly ash<sup>25</sup>.

It is interesting to note that metals in the BGB is always greater compared to the AGB. This is because of the direct exposure of the root system to the ambient media consisting of fly ash. Our results are in accordance with the work of Maity and Jaiswal, (2008) who conducted similar experiments on four grassy species sampled from fly ash lagoon namely *Typha latifolia*, *Fimbristylis dichotoma*, *Amaranthus defluxes* and *Saccharum spontaneum*.

Phytoavailability of metals from root to shoot can be assessed by simple index known as Translocation Factor (TF). This term is defined as the ratio of the metal level in shoot to that of the metal level in root<sup>23</sup>. Based on our findings, the TF for zinc is 0.4976 (~0.50) for *Typha elephantia* and for *Phragmites karka* the value is 0.5181 (~0.52). The TF for lead is 0.5819 (~0.60) for *Typha elephantia* and for *Phragmites karka* the value is 0.5317 (~0.53). In case of copper the TF is 0.4898 (~0.49) and 0.7727 (~0.77) for *Typha Elephantia* and for *Phragmites karka* respectively. We cannot give the TF data for nickel due to absence of the heavy metal in both the species.

It is observed that in all cases the TF values are less than 1 which suggests the retention of the metals in the BGB. The rate and extent of the translocation depends on the plant species and also on the metal. TF values vary with the metal content in the fly ash. The more abundant the metal in fly ash, the lower the TF of the metal, because root exhibits higher values of that metal. However, we cannot come to any definite conclusion in this pointin context to the specific reason behind the variation of the TF values between metals, asin present study the concentrations of metals have not been detected in fly ash. It can be advocated at the end that both the selective species *Typha elephantia* and *Phragmites karka* have bioremediation potential with BGB as the major compartment.

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Vol. 5, Issue 2, February 2016

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