Bioaccumulation of heavy metals in *Brassica juncea*: an indicator species for phytoremediation

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Abstract: *Zn, Cu, and Pb were analysed in the leaf, stem and root of Brassica juncea (Indian mustard) from Changdana, near Baduria, Deganga (North 24 paraganas),during January 2017. Selected heavy metals were also analysed for the sediment samples collected from the study site. The order of metal accumulation in the vegetative parts is as per the order leaf> root> stem. In the soil sample the heavy metal concentration was found to be Zn> Cu> Pb.*

Key Words: *Heavy metal, vegetative parts, concentration, accumulation.*

1. INTRODUCTION

Heavy metals are considered major pollutants of the environments [1] causing pollution of air, water and soil. Different anthropological factors contribute towards heavy metal toxicity and its increased level [2]. Heavy metal pollution in the environment is a result of release by natural processes and a long history of anthropogenic use of heavy metals. Mainly mining and smelting, automotive emissions, Pb-based paints and industrial activity are Sources of Pb contaminated soil [3-6].

Lead (Pb), a potentially toxic heavy metal with no known biological function, has attracted more and more considerable attention for its widespread distribution and potential risk to the environment. Zn and Cu comprise of essential micronutrients for plant growth, but at higher levels may prove to be toxic. Indian mustard (*Brassica juncea*) typically a native herb of the Indian continent is commonly found growing in soil having high metal concentration and is effective in extracting heavy metals such as lead from the soil in toxic dumping grounds as well as acts as an indicator species as it has a higher tolerance for these metals which gets stored in its cells [7].

Mustard belongs to the family Brassicacea and is a household spice in form of seed. It is also cultivated for oil production and thus serves as a specific oil crop. Certain plant species have effective bioaccumulation capability and contribute towards heavy metal accumulation of various heavy metals.

Some potential green plants have been screened for phytoremediation of heavy metals both from aquatic and terrestrial environment [8] and interestingly Indian mustard *(Brassica juncea)* has been observed to serve as an efficient phytoremediator of some heavy metals. *B. juncea* (figure 1) has been used earlier for remediation of some heavy metals like Cd, Pb and Zn at different concentrations. Particularly, *Brassica juncea* has been studied for its potential to remove cadmium from soil [9]. Thus, the process of removal of heavy metals from soil is called phytoremediation can prove to be cheaper and easier method for heavy metal reduction in soils, and also effective in reducing soil erosion. The present study is a snap shot of its bioaccumulation potential of selective heavy metals (Zn, Cu and Pb).

Figure 1. ***B. juncea*** **(Indian mustard**

Figure 2. Field photograph of sampling site

2. MATERIALS AND METHODS

2.1 Sampling:

The samples for this study were collected from Changdana village near Deganga bordered by Baduria, Taki and Bongaon (Figure 2 &3). Samples were collected during winter in the month of January 2017. The coordinates of the sampling site were 22˚41'54"N, 88˚38"47"E. Figure 2 depicts the location map. Changdana and Chowrashi are remote villages in the Deganga block of North 24 Paraganas, and are major areas were agricultural land availability facilitates growing of food or oil crops like mustard.

Figure 3. Sampling site (22˚41'54"N, 88˚38"47"E) Source: Google maps

2.2 Heavy metal analysis*:*

10 gm of the collected samples each of leaves, roots and stems, were dried at 60˚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. The digested samples were analysed for Zn, Cu and Pb 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. Metal concentration in soil was determined using the aqua-regia extraction method. Blank correction was carried out to bring accuracy to the results [10].

3. RESULTS & DISCUSSION:

The concentration of selected heavy metals accumulated in the vegetative parts of *B.juncea* is is quite low in comparison to the heavy metal concentration in the rhizosphere soil of the selected sampling station (represented in Figure 4). The order of accumulation of heavy metal is Zn>Pb>Cu irrespective of vegetative parts. The maximum amount of heavy metal concentration is found in the leaves of *B. juncea*.

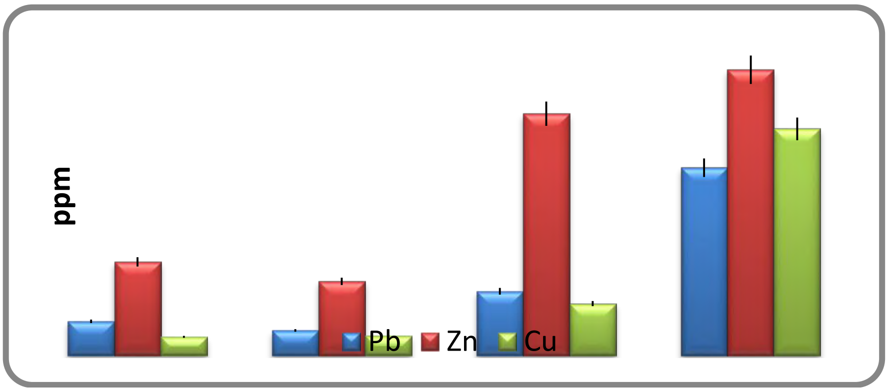

Figure 4. Zn, Cu and Pb accumulation in vegetative parts of *B.juncea* and soil sample

Plant species termed as metal accumulators can gather metal in their aerial parts, to far exceeding levels than present in the soil. However hyperaccumulators are plants that can absorb very high levels of contaminants (heavy metals) in their roots, stems and/or leaves [11-13]. More than (1000 mg/g) of copper, cadmium, chromium, lead, nickel cobalt and 1% (>10,000 mg/g) of zinc or manganese in the dry matter of certain plants has been reported as metal hyperaccumulators by Baker and Brooks. Such hyperaccumulators plants have been identified, collected and studied, belong to areas were heavy metal concentration in soil is comparatively more than normal or are geographically rich in certain metals [14]. The family Brassicacea contains a large number of hyper accumulating species with widest range of metals; these include 87 species from 11 genera [14].

For the proper accumulation of metals by plants the metals must mobilise into the soil. The bioavailability of these metals is increased by various means. Secretion of phytosidophores into the rhizosphere to chelate and solubilise metals that are soil bound is one of the way that [15] helps plants achieve these metals. Metals entering the root are either stored in the root or translocated to the shoots. This indicates that the heavy metals uptaken by the roots are translocated *via* stems to the leaves which accumulate the maximum concentration of the selected metals for our present study. The present study area is under the influence of a large number of small and large-scale industries. Industries like cotton handloom, leather tanning, manufacturing of cutlery, brass and bell-metal industries, pottery, embroidery and lace works (chikan) etc. flourished in the district during the last century. Later large scale industries like jute manufacturing, engineering, rubber, textile, paper, chemical, etc. have been established. Cotton handloom textile industries and jute manufacturing industries plays an important role in the district's economy [18]. This ascertains the availability of heavy metals in the rhizosphere soil of the present study area and its consequent bioaccumulation in the selected plant species.

Commonly called Indian mustard, *Brassica juncea*, has been found having good ability to transport lead from the roots to the shoots. The phytoextraction coefficient for *Brassica juncea* studied earlier was found to be 1.7 and also it is observed that a lead concentration of 500 mg/l is not phytotoxic to Brassica species [16]. Phytoextraction coefficient is the ratio of the metal concentration found within the surface biomass of the plant over the metal concentration found in the soil. *Brassica juncea* is reported to be capable of removing 1, 1550 kg of lead per acre [16-17]. Figure 5 shows a representative image of the process of phytoextraction.

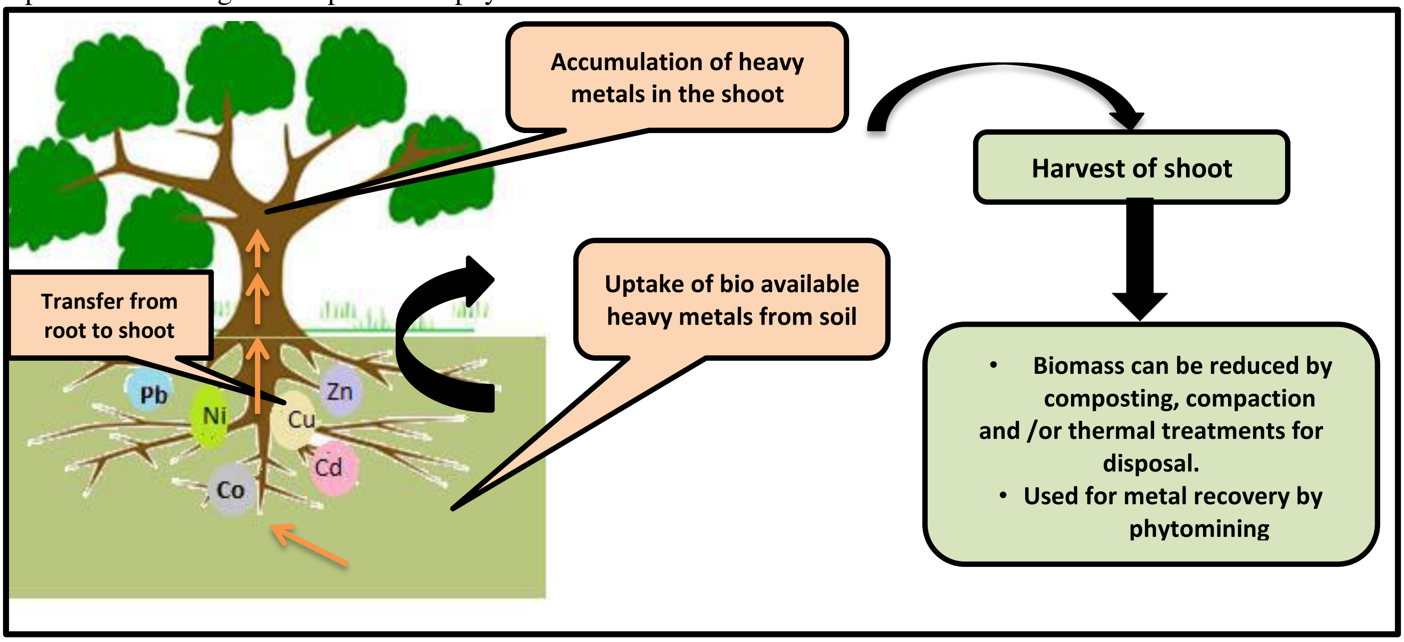

Figure 5. Phytoextraction of heavy metals by plants

4. CONCLUSION:

The present study indicates the level of heavy metal pollution in the soil from and around the sampling site of Deganga area. Heavy metal analysis shows bioaccumulation of Zn, Cu and Pb in the root, stem and leaves of the experimental plant sample of *B. juncea*. Being an indicator species, Indian mustard can bioaccumulate heavy metal in its vegetative parts, thus, reducing heavy metal contamination of the soil by the process of phytoremediation. Repeated cropping of plants in contaminated soil is involved in the process of phytoextraction, until the metal concentration drops to acceptable level. The ability of the plants to comprise of the decrease in soil metal concentrations as a function of metal uptake and biomass production plays an important role in achieving regulatory acceptance. Phytoremediation is a flourishing field, including initiated field application of phytoremediation of organic and inorganic wastes and radionuclides globally over the last ten years. This process is fast emerging as a sustainable, inexpensive and feasible alternative comparable to conventional remediation methods, and may prove to be most suitable for developing nations. Studies have been conducted in developed countries and the knowledge of suitable plants is often limited. In our country commercial application of phytoremediation of soil heavy metal or organic compounds is in its preliminary phase. Perception and optimization of the process of plant heavy metal uptake and the proper disposal of it biomass produced is required to implement it skilfully worldwide.

5. ACKNOWLEDGEMENT:

We acknowledge Techno India University for providing the lab facilities.

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