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Phytoremediation potential of *Lantana camara* and *Polygonum glabrum* for Arsenic and Nickel contaminated Soil

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Abstract

This study was carried out to investigate the potential of Lantana camara and Polygonum glabrum for the accumulation and distribution of arsenic (As) and nickel (Ni) in the different plant organs. The plants and soil samples used in this study were obtained from the places nearby Koradi Lake which is situated to the northern side of Nagpur and then analyzed for arsenic (As) and nickel (Ni) content. The metals accumulated were investigated using inductively coupled plasma atomic emission spectrometer (ICPAES). The arsenic content in soil was 2.29 ppm and that of nickel was 58.344 ppm. The ability of plants to absorb metal from the soil was calculated by bioconcentration factor (BCF) whereas their ability to translocate metal from root to aboveground plant part was calculated by translocation factor (TF). On the basis of bioconcentration factor (BCF) and translocation factor (TF) values, Lantana camara and Polygonum glabrum were identified as potential plants for phytoextraction of nickel and arsenic contaminated soil respectively.

Keywords: Phytoextraction, bioconcentration factor, translocation factor.

Introduction

Heavy metals are well known to cause harmful health effects due to their negative influence on living organisms. According to Lasat, metals are natural components in soil[1]. Heavy metals cannot be degraded or destroyed biologically but can be converted from one oxidation state to other[2,3]. Accumulation of toxic heavy metals such as chromium (Cr), mercury (Hg) and lead (Pb) is a matter of serious concern due to their long term persistence in the environment and carcinogenicity to human beings[4].

Some elements are useful for human metabolism in small quantities. This includes metals like Fe, Zn, Cu, Co, Cr, Mn, Ni but after exceeding certain level they may be toxic whereas other elements like lead, mercury, cadmium, and arsenic etc. are harmful and toxic. Heavy metals that have been identified as environmental pollutants are arsenic, cadmium, copper, lead, chromium, zinc and nickel. Heavy metal contamination can arise from geological and anthropogenic sources[5]. Anthropogenic sources include emission, effluents and solid discharge from industries, metals from mining and smelting, fuel production, use of agricultural chemicals and coal combustion. These metal contaminants are usually removed by physicochemical methods[6]. Disposal of municipal wastage also contributes to increased load of soil contamination. Other sources can include excessive use of pesticides, fungicides and fertilizers[7-10].

Plants are considered as a good source for bioaccumulation of heavy metals. Phytoremediation also called as botanical bioremediation[11], is an emerging cheaper technology, ecofriendly and safe alternative to conventional cleanup techniques. Phytoremediation involves the use of green plants to remove or detoxify the environmental contaminants. Phytoremediation is composed of various categories. These are phytoextraction, phytovolatilisation, phytostabilization, phytodegradation and rhizofiltration.

Baker classified the plants into three categories i.e. accumulators, excluders and indicators depending upon the strategies used by plants growing on metal contaminated soils[12]. In accumulators, the concentration ratio of the metal in the plant to that in the soil is greater than one. In excluders, metal concentration in above ground plant parts are maintained low (<<1) and constant across a wide range of soil concentrations. In indicators, there is proportional relationship between metal levels in the plant parts and soil.

Heavy metal pollution such as arsenic (As), chromium (Cr), Nickel (Ni), etc in the environment has aroused a considerable attention due to its toxic nature, persistence and nondegradability. The continuously growing population, industrialization and methods of waste disposal increase the pollution load of the pond as well as soil[13]. The rate of contamination of water is much faster as compared to its purification methods, so there is a need to analyze the physicochemical properties of water[13,14]. Any damage to the reservoir will affect the environment in its vicinity.

So, there is a need to search or identify the plants that will help to remove pollutants from contaminated soils. According to Ma et al., contaminated soils should be phytoremediated by using green plants that accumulates and translocates maximum concentration of metals in their aboveground parts as compared to soil[15]. The present study aims to assess the potential of *Lantana camara* and *Polygonum glabrum as* a possible bioremediating plant.

Material and Methods

Study area: The plants used in this study were obtained from the places nearby Koradi Lake (Latitude 21° 14′ 55″ N., Longitude 79° 5' 55" E.) It is a man made reservoir situated in a low lying area to the northern side of Nagpur receiving water from Navegaon Khairi dam. Moreover, Koradi is also a popular Tourist attraction for its scenic beauty and the famous koradi devi temple.

Sampling: The plant *Lantana camara* belongs to family Verbanaceae. It is a low, erect perennial shrub. It grows to 2 - 4 meters in height. The plant Polygonum glabrum (willd.) belonging to the family Polygonaceae are sub shrubs growing up to 2.5 cm. The plant mostly found as dense clumps in river banks and marshy areas. These plants were selected since these are common/dominant plant species found abundantly.

To investigate the extent of heavy metals uptake by plants, the plants were collected in clean plastic bags. At the same time, the soil samples around the plants collected randomly and brought to laboratory.

Plant analysis**:** Plants were carefully washed using tap water to clear dust and sediment particles. The plant samples were separated into two parts i.e. shoot and root. These samples were sun dried in separate containers for 15 days. Thereafter, the dried samples were ground till fine powder was formed using mortar and pestle.

For analysis, 1.0 g of plant sample was taken in a beaker and 50ml aquaregia along with 5% HNO_3 was added and then digested for 3-4 hours on hot plate. After digestion, the samples were left to cool and then filtered with Whatman Ashless filter paper (no. 40). The samples were then transferred to 100ml volumetric flasks and the rinsing water was added to the volumetric flask to make the volume upto 100ml, followed by AAS analysis of arsenic and nickel [Thermofischer model no. IRIS Intrepid II].

Soil analysis**:** The soil sample was sun dried for 8-10 days, followed by oven drying at 110^0C for 24 hours. The dry sample was ground using mortar and pestle and sieved through a nylon sieve to obtain homogenized fine particles and stored in plastic bags.

For analysis, 1.0 g of plant sample was taken in a beaker and 50ml aquaregia was added and then digested for 3-4 hours on hot plate. After digestion, the samples were left to cool and then filtered with Whatman Ashless filter paper (no. 40). The samples were then transferred to 100ml volumetric flasks and the rinsing water was added to the volumetric flask to make the volume upto 100ml, followed by AAS analysis of arsenic and nickel.

Plant ability to take up heavy metals from soil was evaluated by bioconcentration factor (BCF). BCF is the ratio of metal concentration in aerial plant part to the soil metal concentration. Plants with high BCF value (generally > 1) are suitable for phytoextraction.

The translocation factor (TF) indicates the potential of the plant to absorb and translocate the metal contaminants by plant roots into the above ground parts of the plants[16].

Lesser TF values (generally < 1) indicates that plants stores accumulated metals in the roots and with values greater indicating metal are transferred to the above ground parts of the plant[17].

Results and Discussion

The metals chosen for the study were arsenic (As) and nickel (Ni). Of these metals, Ni is essential, in trace concentrations, for plant growth. Arsenic is a non-essential element for plants.

The plants were obtained from the places nearby koradi lake. The area nearby water body consists of variety of weeds such as ipomoea, typha, camara, nelumbo, glabrum, etc. The species Lantana camara and Polygonum glabrum were selected since these are local plant species found abundantly. So, the study was carried out to check the potential ability of these plants to accumulate these metals. For this, the heavy metal concentration in the soil as well as in the plant species were determined and their bioconcentration factor as well as translocation factor were calculated.

Heavy metal concentration in soil and plants: The arsenic and nickel concentration in the soil follows the order Ni (58.344 ppm) > As (2.29 ppm). The concentration of nickel exceeded the tolerable limits prescribed by WHO[18] and FEPA[19] implying that the inhabitants are liable to heavy metal pollution[20, 21]. Similarly, Yusuf et. al. investigated some heavy metal concentration in soil sample from Illela Garage in Sokoto state, Nigeria and found that concentration level exceeded the tolerable limits prescribed by WHO and FEPA implying that the inhabitants are vulnerable to heavy metal toxicity[22].

The arsenic and nickel concentration in the organs of *Lantana camara* and *Polygonum glabrum* are shown in figure-1 and 2. The decreasing trend for both the species was shoot > root. The concentrations of arsenic (As) in the aerial part of *Polygonum glabrum* (2.508 ppm) was higher than *Lantana camara* (1.03 ppm) whereas the concentration of nickel was higher in the aerial part of *Lantana camara* (103.51 ppm) as compared to

Polygonum glabrum (54.282 ppm). Between the two plant species, *Lantana camara* showed the higher capacity in Ni accumulation whereas *Polygonum glabrum* showed higher capacity in As accumulation. The relative higher concentration of As in *Polygonum glabrum* shoot and that of Ni in *Lantana camara* shoot than in soil suggests that the plants have a potential to absorb these metals from soil. Determinations of the metals i.e. As and Ni in plant organs (i.e. shoots and roots) showed that these plants may be considered as metal accumulators.

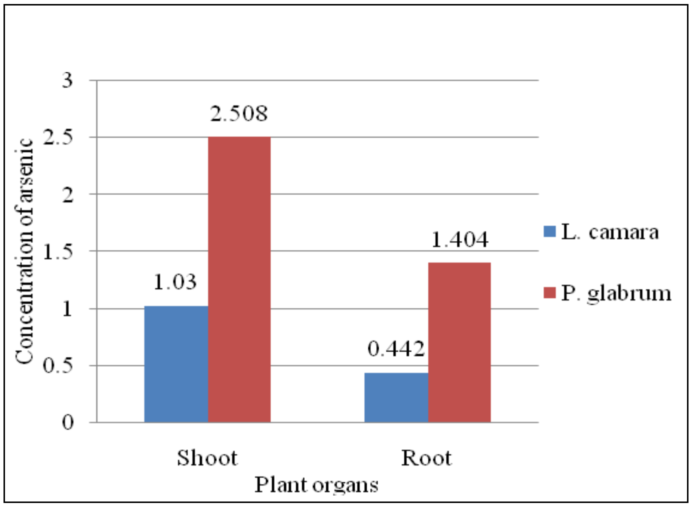

Figure-1
Showing concentration of arsenic (As) in plants in ppm

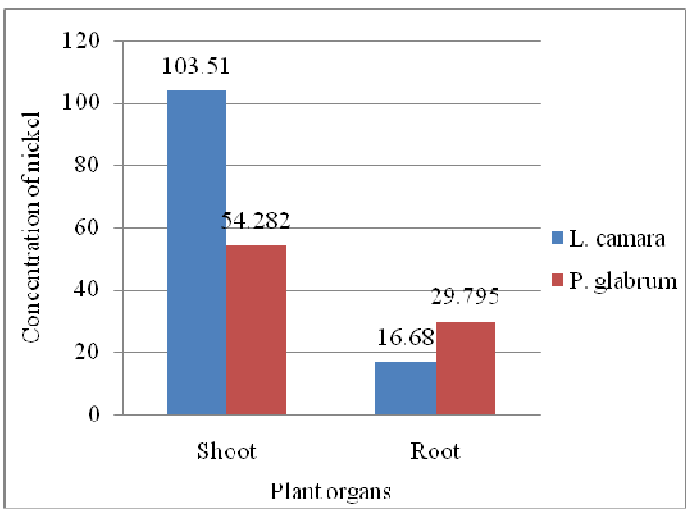

Figure-2
Showing concentration of nickel (Ni) in plants in ppm

Bioconcentration Factor and Translocation Factor: The bioconcentration factor (BCF) is the capacity of the plant to take up heavy metals with reference to its concentration in the soil. and used to determine the amount of heavy metals consumed by the plant from the soil[23]. The translocation factor (TF) is the capacity of the plant to transfer metals to the shoot from the roots.

Bioconcentration factor and Translocation factor were evaluated for both the studied species as shown in figure 3 and 4. The BCF value for arsenic in *Polygonum glabrum* is more than one whereas it is lesser than one in *Lantana camara*. For nickel the BCF value is higher in *Lantana camara* as compared to *Polygonum glabrum*. According to Blaylock et al. the plant is more suitable for phytoextraction when the BCF value is higher[24].

Lantana camara had high BCF (1.77) and TF (6.2) for nickel whereas *Polygonum glabrum* had high BCF (1.09) and TF (1.78) for arsenic. Heavy metal tolerant species with high BCF and TF can be used for phytoextraction of contaminated soil. *Lantana camara* had low BCF (0.45) for arsenic indicating not suitable for phytoextraction of arsenic contaminated soil. *Polygonum glabrum* had considerable BCF (0.93) and TF (1.82) value for nickel.

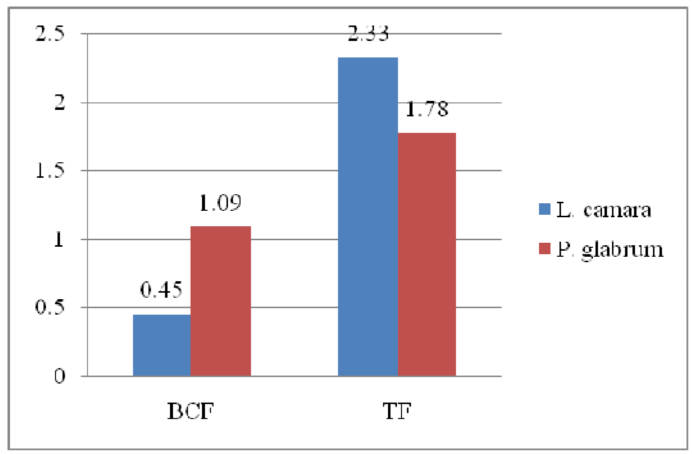

Figure-3
Bioconcentration factor (BCF) and Translocation factor (TF) of Lantana camara and Polygonum glabrum for arsenic (As)

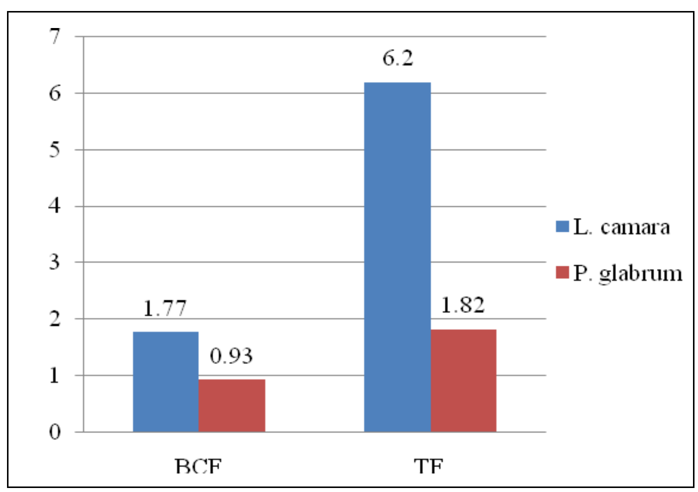

Figure-4
Bioconcentration factor (BCF) and Translocation factor (TF) of Lantana camara and Polygonum glabrum for nickel (Ni)

Conclusion

The contamination of heavy metals to the environment is of great environmental concern due to their negative impact on human and animal health. From the study, it was found that both *Lantana camara* and *Polygonum glabrum* had the ability to accumulate arsenic and nickel in their tissues. *Polygonum glabrum* accumulates higher As concentration whereas *Lantana camara* accumulates higher Ni concentration. Shoot accumulates more concentration of metals than root in both plants. In the present study, *Lantana camara* and *Polygonum glabrum* had the potential to accumulate nickel and arsenic respectively from contaminated soils to shoot since the bioaccumulation factor was greater than one. Therefore, *Lantana camara* may be considered as nickel accumulator whereas Polygonum glabrum as arsenic accumulator and promising plants for phytoremediation.

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