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Phytoremediation of Heavy Metals from Contaminated Soil by *Catharanthus roseus*

Talad Khan[*1], Harihar[1], Samuel Gorden Singh[1], Mukul Baghel[1], Humrah Iqbal[1] and Priya Yadav[2]
[1]Department of Botany, St. John's College, Dr. Bhimro Ambedkar University, Agra, Uttar Pradesh, India
[2]Department of Environmental Studies, School of Life Sciences, Khandari Campus, Agra Uttar Pradesh, India
Email[*]: taladkhan9557@gmail.com

ABSTRACT

Heavy metals are contaminated that poses great environmental burden as they are hazardous to human, animal, plant health and the environment at large. In this study, *Catharanthus roseus* herbaceous ornamental plant was used for the phytoremediation of lead, nickel, zinc and chromium. Sample of soil was collected and analyzed for certain pollutants Pb, Ni, Zn and Cr. Also evidence of accumulation of these metals in the various plant parts studied was established using the Atomic Absorption Spectrophotometer (AAS). From the results, it was clear that the root of *Catharanthus roseus* were found to contain higher concentration of Pb, Ni, and Cr than the stem. After 60 days of experiment, the concentration of heavy metals in soil sample in decreasing order was found to be as Pb>Cr>Zn>Ni respectively where as the accumulation of heavy metals in plant parts include Pb>Cr>Zn>Ni. Finally, this study shows that the plant species was good accumulator of these heavy metals.

Keywords: Heavy metals, contaminated soil, Accumulation, *Catharanthus roseus*

INTRODUCTION

The global problem concerning contamination of the environment as an aftermath of anthropogenic activities is on the increase which has resulted in environmental buildup waste product of which heavy metals are of particular concern (Yashim et al, 2015). Heavy metals that are hazardous viz. Lead, mercury, cadmium, nickel, arsenic, copper, zinc and chromium. Such metals are found naturally in soil in trace amount. Metals like Cd (cadmium), Pb (lead), Zn (zinc), Cr (chromium) when present in high concentration in soil exert potential toxic effect on overall growth and metabolism of plants (Agarwal Sharma, 2006)

and bioaccumulation of such toxic metals in the plants poses a risk to human and animal health. This poses significant danger to human, animals and plants.

With the rapid urbanization, industrialization and agricultural intensification, a large amount of pollutants are being discharged in to soil ecosystem. Many industries in India discharge their untreated waste water on land or natural stream (Liu *et al*, 2015). This causes lot of physical, chemical and biological hazards of land and water. Due to discharge of effluents directly or after treatment soil of nearby industrial area get contaminated. Heavy metal constitutes a main group of soil pollutants around Yamuna River. Phytoremediation is a green technology that uses hyperaccumulator plants and their rhizospheric microorganisms to stabilize, transfer or degrade pollutants in soil, water and environment (Liu *et al*. 2020). This technology is considered as well efficient cheep and adaptable with the environment (Ashraf *et al*., 2010; Nedjim 2020).

According to soil conditions pollutants and the species of plants used, five types of phytoremedition have been applied.

Phytodegradation - organic contaminants are absorbed inside the plants and metabolized to non toxic molecules by natural chemical process with in plants.

Phytoextraction or accumulation – plant roots can remove metals from contaminated sites and transport them to leaves and stems for harvesting and disposal or metal recovery through smelting processes.

Phytostabilizartion- plants immobilize metals by adsorption to root surface.

Phytovolatilization- plat take organic contaminants through the roots transport them to the leaves and release the contaminants as a reduced or detoxified vapor in to the atmosphere.

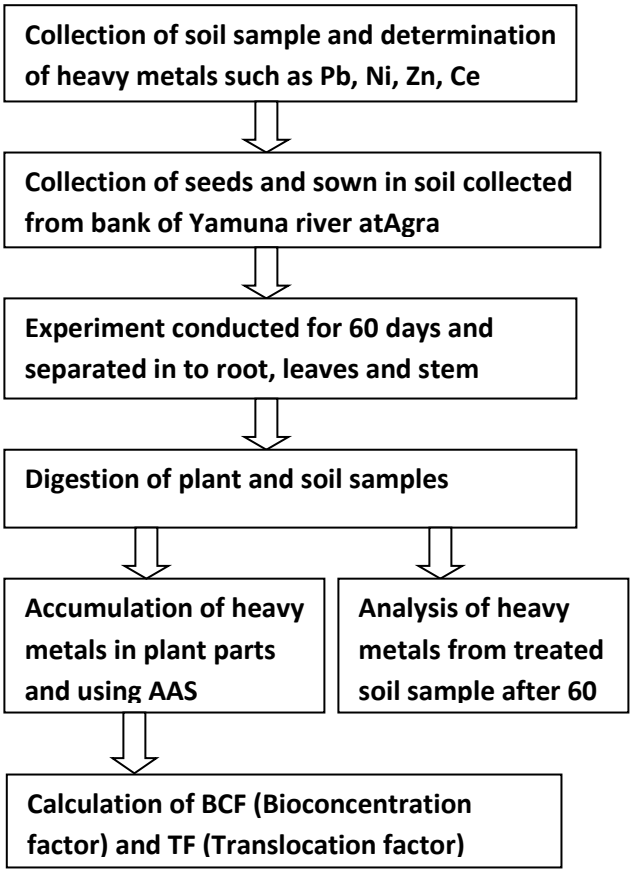
Phytorestoration- it is referred as the revegetation of uninhabited soil thus avoiding the dispersion of contaminated soil particles.

The plants used for phytoremediation must be fast growing and have the ability to accumulate large quantity of metal contaminants in their shoot tissues. Barley (*Hordeum valgare* L.) and oat (*Avena sativa* L.) are the highly tolerant species of metals such as Cu, Cd, Zn and accumulate moderate to high amount of these metals in their tissue. Many herbaceous species also accumulate moderate amount of various metals in their shoot. Several studies were available on many fast growing Brassicasfor their ability to tolerate and accumulate metals including *Brassica juncea* L. (Indian mustard), *Brassica napus* L. (rape), *Brassica campestris* L. (turnip), *Brassica oleracea* L. (kale). The aquatic and semiaquatic vascular plants such as *Echhornia crassipes* (water hyacinth), *Hydrocotyle umbeliata* (pennyworth), *Lemna minor* (duckweed), *Azolla pinnata* (water velvet) can take up lead, copper, cadmium, iron and mercury form contaminated solution existed for long tme (Prasad et al, 2001).

Catharanthus roseus, plant species has been selected for the present study to examine the potential to absorb the heavy metals from the soil and accumulate them in the above ground and below ground biomass. *catharanthus roseus* commonly known as pink periwinkle or Madagascar periwinkle is a perinnial species of flowering plant in the family apocynaceae. It is native and endemic to Madagascar but grown elsewhere as an ornamental and medicinal plant.

Figure 1 Site of sample collection

MATERIALS AND METHODS



Sample collection and analysis - soil samples were collected from bank of Yamuna River at Agra in June 2022. The collected river bank soil samples were first air dried at room temperature, then sieved for further analysis of heavy metals viz. Nickel, lead, cadmium and zinc using AAS (Atomic Absorption Spectrophotometer).

Experimental procedure- The seeds of *Catharanthus roseus* were obtained from St.John's College, Agra and rinsed with distilled water. Seed were sown in pot containing soil collected from bank of river Yamuna. The plants were grown for a period of two months (60 days). After 60 days the plant samples

from pots were collected and washed thoroughly under running tap water and distilled water removes dust particles. The samples were then cut to separate the roots, stems and leaves. The different parts (root, stems, and leaves) were air dried and then placed in a dehydrator for 2-3 days and then dried in an oven at 100°C. The dried plant samples were powdered and stored in polyethylene bags.

1 gm of powdered plant material were weighed in separate digestion flasks and digested with HNO_3 and HCl in the ration of 3:1 after cooling the solution was filtered. Filtrate was analyzed for heavy metals in AAS.

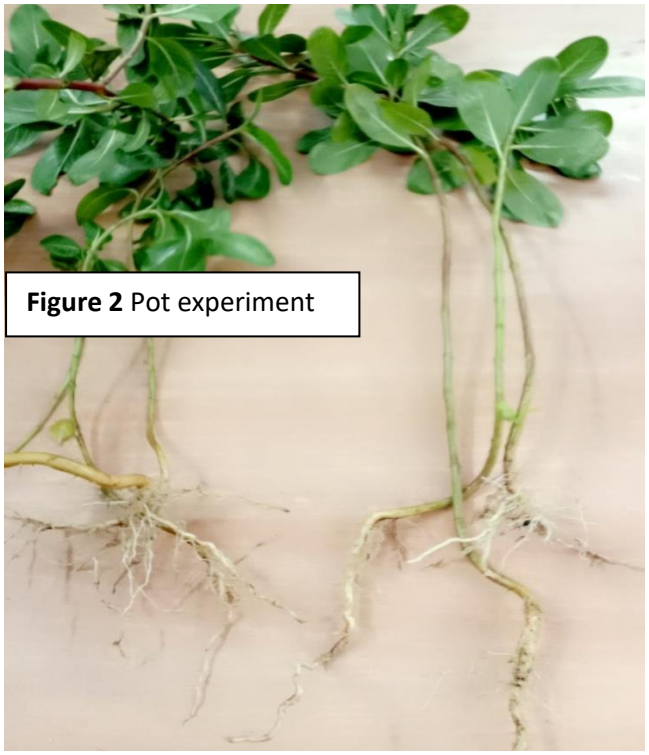


Figure 2 Pot experiment

Figure 3 *Catharanthus roseus* plant

Calculation of Bioconcentration factor (BCF) and Translocation factor (TF)

The concentration, transfer and accumulation of metals from soil to root and shoots were evaluated in term of Bioconcentration factor and translocation factor.

Bioconcentration factor was calculated as metal concentration ratio of plant roots to soil (Yoon et al., 2006).

$$\text{TF} = \frac{\text{Metal comtent in plant shoot}}{\text{Metalcontent in root}}$$

$$\text{BCF} = \frac{\text{Metal content in plant tissue}}{\text{Initial metal content in soil}}$$

The translocation factor indicates the transfer of accumulated metals from root to shoot of the plants. It was calculated by the formulae (Cui et al., 2007; Li et al., 2007).

RESULT AND DISCUSSION

Accumulation of metals in *Catharanthus roseus*

Catharanthus roseus absorbed Pd through root system in high quantities (71.49 mg/kg) by 60 days and Pb was translocated in slow manner throughout the period of experimentation. There was lowest accumulation in leaves 1.39 mg/kg with total accumulation of Pb (82.86 mg/kg) in the whole plant. The result revealed that *Catharanthus roseus* is a good accumulator of lead. Similarly accumulation of nickel was also high in root. Out of 56.76 mg/kg of nickel accumulated in plant 25.63 mg/kg was retained in the root, 18.6 mg/kg of nickel was accumulated in stem and 12.53 mg/kg in leaves. Zn was accumulated 12.3 mg/kg in root, 11.85 mg/kg in stem and 39.13 mg/kg in leaves. On the whole, leaves recorded highest accumulation of Zn followed by roots and stem. The highest accumulation of Zn in leaves leaving low quantities of zinc in stem and roots revealed that maximum quantity of zinc is translocated up to leaves. Out of the total 63.28 mg/kg of zinc absorbed 12.3 mg/kg was translocated to root and 11.85 mg/kg to stem and 39.13 mg/kg to leaves.

The accumulation of chromium (Cr) was highest in root (32.89 mg/kg) followed by leaves (25.75 mg/kg) and lowest in stem (8.74 mg/kg). Finally resulting highest accumulation of chromium in roots followed by leaves and stem.

Metals	Root	Stem	Leaves	Total accumulation	BCF	TF
Pb	71.49	9.98	1.39	82.86	0.520	0.159
Ni	25.63	18.6	12.53	56.76	0.764	1.214
Zn	12.3	11.85	39.13	63.28	0.724	4.14
Cr	32.89	8.74	25.72	67.35	1.064	1.048

Table: 1 Metal accumulation (mg/kg) in *Catharanthus roseus* during the experimental Period

Catharanthus roseus showed (fig. 1) a differential tendency of accumulation of different metals. The leaves have accumulated lowest quantities of lead and nickel while zinc accumulated in highest quantities (39.13 mg/kg) in leaves. The leaves showed vide variation in affinity of accumulation i.e. from 1.39

mg/kg of lead to 39.13 mg/kg of zinc. Among the three plant parts, roots showed highest accumulation of lead, nickel and chromium, while leaves accumulated lowest quantities of lead and nickel and no metals accumulated in highest quantities in stem except nickel compared with leaves and roots.

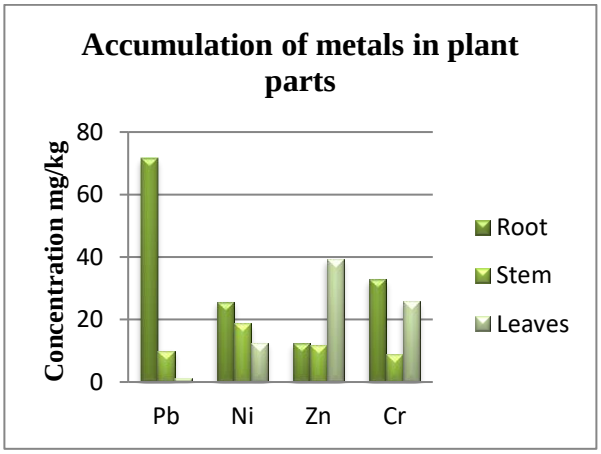


Figure 3.1: Accumulation of Pb, Ni, Zn and Cr in Catharanthus roseus

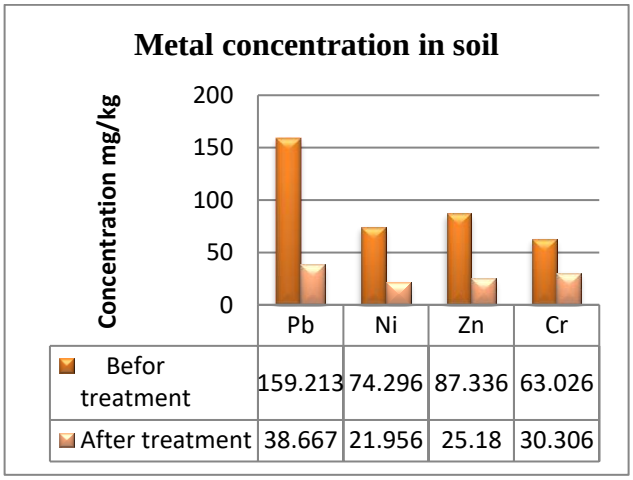


Figure 3.2: Metal concentration in soil

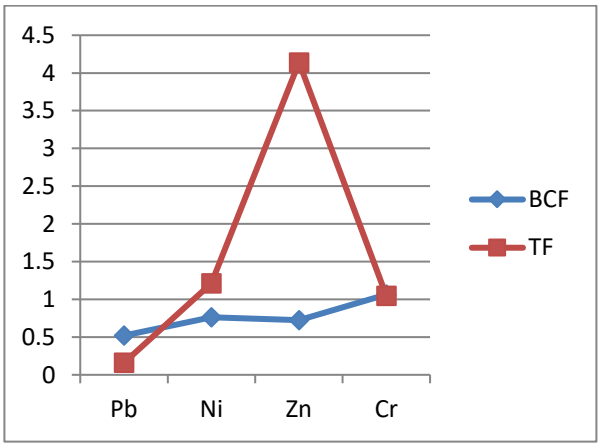


Figure 3.3: Bioconcentration factor and Translocation factor

CONCLUSION

Phytoremediation is method which green plants for clean up contaminated hazardous waste sites. For this study,it was concluded that this plant *Catharanthus roseus* can remediate contaminated soil and therefore a reasonable choice for remediation of the contaminated site of Yamuna river. Therefore, this provided valuable data supporting the use of *Catharanthus roseus* plant in phytoremediation. In the present study, the result shows that the experimental plant species *Catharanthus roseus* was good accumulator of lead, nickel, zinc and chromium from contaminated bank soil of river Yamuna.

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