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Phytoremediation of chromium contaminated soils by using *Catharanthus roseus*

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Abstract

Phytoremediation is a developing technique that used plant to remediate, degrade, remove or extract organic and inorganic pollutant from soil, water and air. In the present study *Catharanthus roseus* was used for chromium phytoremediation, this plant was seeded in polyethylene pots that contain 8kg of soil. The plant was irrigated with wastewater for four months (May, June, July and August) and the accumulation of heavy metal were analyzed after every month for leaf, stem and root by using Atomic Absorption Spectrophotometer (AAS). The result of translocation factor showed that the accumulation of chromium was high in root than stem. This plant had been Hyperaccumulation depending on the result of Bioconcentration factor (11.45) for August months. The result express that the order of chromium removal was August (93%), July (33%), June (12%) and May (7%). This plant has been effective for removing this metal from soil irrigated by wastewater.

Keyword: Phytoremediation, Bioconcentration factor, *Catharanthus roseus*, Heavy metal, Translocation factor

Introduction

The grey waste water is considered not only a rich source of organic matter and other nutrients but also harbor heavy metals like Fe, Mn, Cu, Zn, Pb, Cr, Ni, Cd and Co at high concentrations in receiving soils [1].Metals are natural components in soil. Some of these metals are micronutrients necessary for plant growth, such as Zn, Cu, Mn and Co, while others have unknown biological function, such as Cd, Pb, Ni,Cr, As and Hg [2, 3].

The heavy metals may come from natural sources, leached from rocks and soils according to their geochemical mobility or come from anthropogenic sources, as a result of human land occupation and industrial pollution [4]. Heavy metals are found soluble in water, so that, it can inter in ecosystems by water pathways [5]

Chromium has strong carcinogenic implication on livestock as well as human. Trivalent form of chromium is necessary to livestock and human because it plays an important role in insulin metabolism. Chromium toxicity includes liver necrosis, gastrointestinal irritation, nephrites, ulcers (coetaneous, nasal and mucus membrane) [6]. Each source of pollutant has its hold damaging effects to plants, animals and finally to human health, and heavy metals that add to soils and waters are of serious concern due to their perseverance in the environment and carcinogenicity to human beings. They cannot be damaged biologically but are only transformed from organic complex to another [7]. There are numerous remediation methods such as soil dressing, soil washing and replacement of polluted soils, but most of these method are too expensive and time consuming and also needed huge amount of water and unpolluted soil therefore, phytoremediation has attracted great attention as a new and inexpensive technology [8], So that, there are need to develop a process to remove heavy metals from water and soil and this method should be effective cost, friendly to environment and easily to remove heavy metals[9].

Phytoremediation was cost effective and environmentally sound technologies for removing of heavy metals from contamenated soils and wastewaters, and it was a topic of global interest [10]. Several types of phytoremediation are being used to-day

Phytoextraction,Phytostabilazation, Phytovolatilization, rhizofiltrationand phytodegradation.

The objective of this research is to determine the ability of Catharanthus roseus plants to remove Chromium metal from soil that irrigated by wastewater and to determine the effectiveness of this plant in removal.

Material and Method

Samples Collection and Analysis :

Catharanthus roseus plants were grown in pots filled with (8 kg) of the sandy soil that bring from Tigris river Figure 1. Chromium was selected for this study, the uptake was estimated in root, stem and leaves for every 30 days for a total period of 120 days. The metal uptake was estimated once in every 30 days for four month. The sample plants were removed from the pots and washed" under a stream of water and then washed with distilled water. The collected plants were air dried, and the placed in a dehydrator for 2-3 days and then dried by oven dried for four hours at 100℃. The dried samples of the plant were powdered and stored inpolyethylene bags. 1gm of the powdered plant sample were weighed in separate digestion flasks and digested by adding HNO_3 and H_2O_2 in the ratio of 6:2, respectively [11]. The digestion on hot plate at 120℃ for 2 hours or continued till a clean solution was obtained. After filtering with (Whatman No. 42 filter paper), these sample was analyzed for the metal contents in AAS (Shimadzu 6300).

Figure 1: Show the experimental work for *Catharanthus roseus*

Calculation of Bioaccumulation Factor and Translocation Factor

Bioconcentration factor refer to the efficiency of a plant species for accumulating a metal into the tissues of plants from the round environment [12].It was calculated by using the below formula [11, 13]

$$\textit{Bio-concentration Factor (BCF)} = \frac{C_{root}}{C_{soil}} \quad \textbf{(1)}$$

Translocation factor (TF) can be define as the ratio of shoot to root of plants metals indicates internal metal transportation [13]. Translocation factor can calculate from the below formula [12, 14].

$$\textit{Translocation Factor (TF)} = \frac{C_{stem}}{C_{root}} \quad \textbf{(2)}$$

Where: C_{root} is the concentration of heavy metals in plant root, C_{soil} are the concentration of heavy metals in soil and C_{stem} is the concentration of heavy metals in plant root.

Results and Discussion

In the present research, *Catharanthus roseus* plant accumulated Chromium metals. In May 20…, Chromium concentration was low in leaves and high in roots of plant. While in stem it was 6.15mg/kg. There was a change in Chromium content in leaf, stem and there was a little change in the concentration in root of plant for June.

Chromium concentration in stem increased to 13.79 mg/kg and leaf concentration was increased to 15.89 mg/kg biomass much change observed in the leaf for July (Table1). In August, 20… the concentration of Chromium was increase in all parts of plant; leaf, stem and root. Finally, after four month of experimental period it was concluded that Chromium accumulation in leaf was higher compared to that in stem and leaves. The accumulation of chromium metal were 12.51 and 12.653 mg/kg for stem and root, respectively.

Table 1: Accumulation of chromium metal in Catharanthus roseus (mg/kg)

Plant part	Control	May	June	July	August	Total Accumulation
Leaf	5.86	7.35	10.13	15.89	20.34	14.48
Stem	5.94	6.15	9.23	13.79	18.45	12.51
Root	6.697	9.24	10.98	13.99	19.35	12.653
Total Accumulation	18.497	22.74	30.34	43.67	58.14	39.643

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Figure 2 showed that August have high accumulation for chromium metal in leaf, stem and root and May are less accumulation.

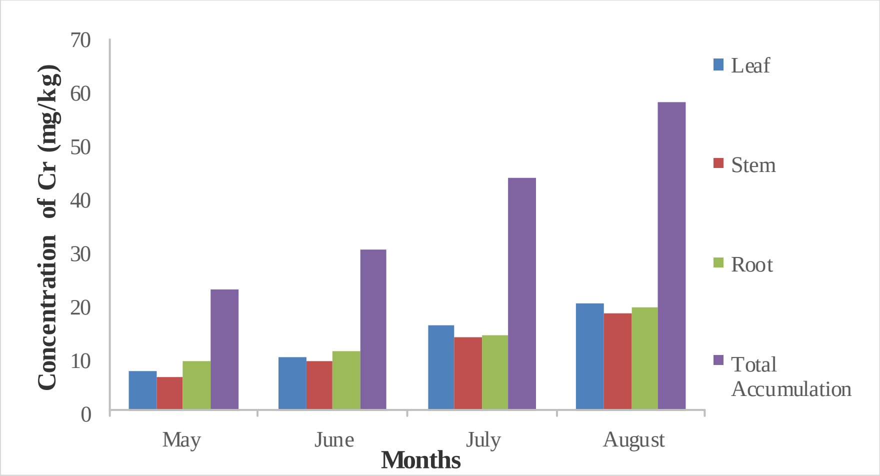

Figure 2: Accumulation of Cr through the experimental work

BCF is a more importance measured than shoot metal concentration when considering the potential of a given applicant species.Translocation factor value greater than 1 indicates that the translocation of the heavy metals from root to above-ground part was good [11].

According to Baker and Walker (1990) an indicator plant species is the one of which the levels of heavy metals in the tissues are similar to those in the surrounding environment and soil.

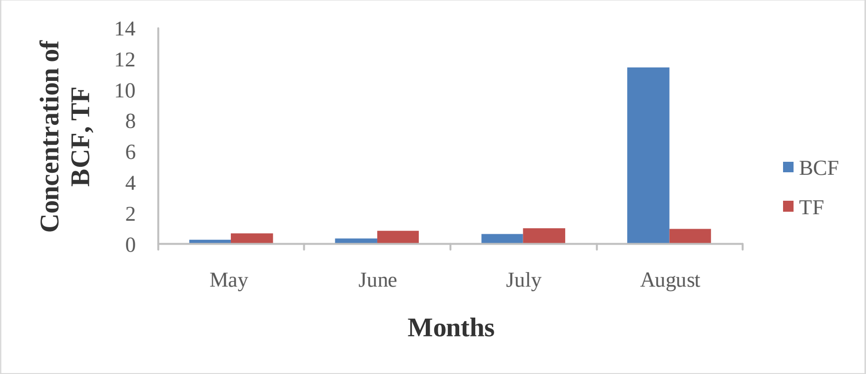

Figure 3: Translocation factor and Bioconcentration factor for *Catharanthus roseus* during the experimental work.

Based on the results Bioconcentration factor and translocation factor values were calculated as shown in Table 2. Bioconcentration factor was calculated using soil chromium. The concentration of chromium that residual in soil where 29.7, 39. 09, 34.38, 23.05 and 1.69 mg/kg for control, May, June, July and August month respectively. Chromium Bioconcentration factor was 11.45 and translocation factor was 0.95 for August as shown in Figure 3. Based on the results of translocation factor the plant species was highly accumulating chromium metal in the root part.

Table 2: Bioconcentration Factor and Translocation Factor during experimental period

Plant	Bioaccumulation Factor (BCF)	Translocation Factor (TF)
May	0.24	0.67
June	0.32	0.84
July	0.61	0.99
August	11.45	0.95

Removal Efficiency (RF %)

Removal Efficiency of *Catharanthus roseus* based the concentration of heavy metal that residual in soil after the plant uptake the metal from soil to the initial concentration of chromium metal in the soil that filled the pots.

Table 3: values of Removal Efficiency for *Catharanthus roseus* plant

Plant species	Removal Efficiency (%)
May20…	6.79
June20..	18.07
July20…	41.53
August20..	94.36

Figure 4 and Table 3 clearly shown that *Catharanthus roseus*have ability to remove chromium metal from the soil that irrigation with wastewater. However, removal efficiency was increased gradually with month. The order of chromium removal ability was: August 94.36%> July 41.53%> June 18.07%> May 6.79%.

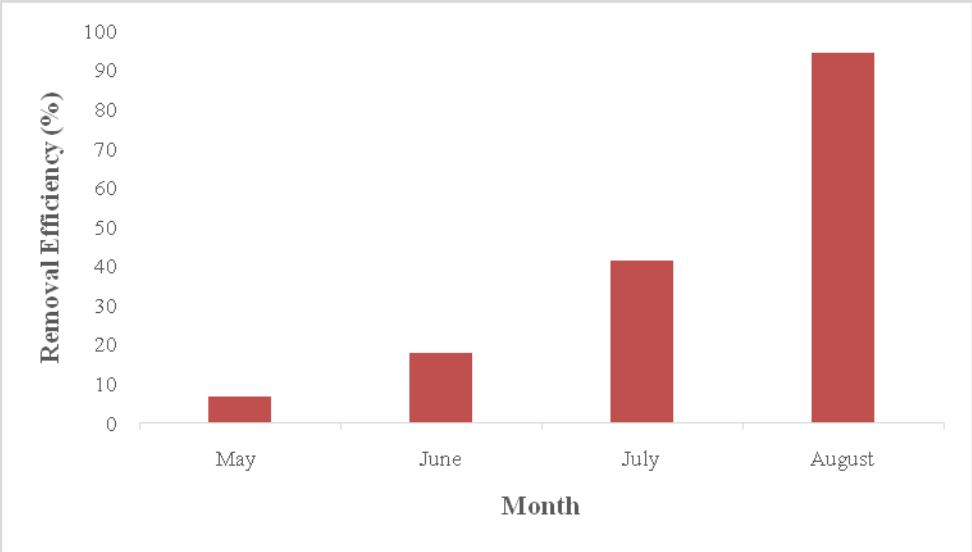

Figure 4: Removal Efficiency of removing Chromium metal from soil.

Conclusion

In the present research,*Catharanthus roseus*, a non-edibleplant could grow in the soil that irrigated by wastewater that contain high concentration of this metal. This study was concluded that this plant highly accumulated chromium metal based on the Bioconcentration factor and based on the result of translocation factor the plant species was highly accumulated of this metal in the root of part. This plant was very effective in removing this metal depending on time, so that, when the time increase the removal efficiency was increased.

Finally, Phytoremediation process is become a commercially available technology in the world.

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