Removal of Heavy Metals from Contaminated Soil Using Phytoremediation

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Abstract

Industrial waste is one of the most important sources of contamination in the surface environment. The impact of heavy metals in soils, plants, animals and humans is due to the unabated expansion of toxic effects. Human activities all over the earth have increased environmental pollution by heavy metals in agricultural soil. Pollution of the biosphere with toxic metals has to accelerate dramatically since the beginning of the industrial revolution. Phytoremediation uses plants to remove pollutants from the environment. The use of metal accumulating plants clean - up soil and water contaminated with toxic metals. It is the most rapidly developing component of this environmentally friendly and cost - effective technology. The leather tanning effluent soil was collected and analyzed. The results also showed that the isolated Eclipta alba has the capacity to remove heavy metals (Cd, Cr, Cu, Pb & Zn) in the effluent soil. The metal removing capacity increased with increase in concentration of the metals.

Keywords: Phytoremediation; Vermicompost; Effluent soil; Heavy metals; Eclipta alba;

Introduction

Heavy metal pollution of soil and water is a major environmental problem facing the modern world. The global heavy metal concentration in various environments is increasing in the environment due to increase in number of industries. Most of the industrial waste water contains heavy metals like Cadmium, Chromium, Copper, Lead and Zinc. Among heavy metals Chromium is the major pollutant of the leather tanning industry and is toxic to plants and animals around the environment [1]. But it is widely used in steel production, as metal corrosion inhibitor, alloy formation, in paints as pigments and various other applications [2].

The major contribution of Cr contamination is the leather tanning, electroplating and stainless steel industries [3]. Conventional chrome tanning results in waste water containing as high as 1500 – 3000ppm of Chromium; however, the present day high – exhaust chrome tanning methods lead to a waste water containing 500 – 1000ppm of Chromium [4]. Trivalent Chromium – Cr (III) and hexavalent Chromium – Cr (VI) are the two species of Chromium which are found naturally in the environment. Cr (VI) appears to be more toxic than Cr (III) [5].

Many technologies, physico – chemical and biological techniques, precipitation, oxidation reduction, microbial absorption and phytoremediation have been used for Chromium removal. A number of plants have the inherent capacity to absorb and hyperaccumulate heavy metals in their tissues, a characteristic that can be harnessed to remove toxic heavy metals from contaminated soils [6]. Bioremediation of contaminated soils is a widely accepted technology in which native introduced microorganisms and/or biological wastes, such as compost, animal manure and plant residues are used to detoxify or transform toxic Chromium to less toxic forms. Although bioremediation has several limitations, this technology holds antiquing interest because of its cost – effectiveness [7]. In this regard, bioremediation, typically referring to microbe based clean – up and phytoremediation or plant based clean – up, have generated much interest as effective low – cost and environmentally – friendly technique for the clean – up of a broad spectrum of hazardous organic and inorganic pollutants [8]. Plant based environmental remediation has been widely pursued by academic and industrial scientists as a favourable low – impact uncontaminated technology applicable in both developed and developing nations [9, 10]. The objective of the study was to examine the potential of Eclipta alba and various composition of soil - vermicompost for the remediation of Chromium contaminated soil.

Materials and methods

Collection of materials

The garden soils are gathered from nearest places. The effluent is collected from tannery industry located at Sempattu, Tiruchirappalli, Tamilnadu. Karisalankanni (Eclipta Alba) seeds are collected from this plant (Edavakkudi, Poondi, Thanjavur, Tamil nadu). Vermicompost was prepared with cow dung using earthworm species Eurdius euginae. Seeds were germinated in experimental pots and watered. On fifteenth, thirtieth, forty fifth and sixtieth days the plants were harvested from pots and the concentration of heavy metals Cadmium (Cd), Chromium (Cr), Copper (Cu), Lead (Pb) and Zinc (Zn) of the samples were noted.

Experimental setup

The seedlings were exposed to different concentrations of heavy metal chromium to find the toxicity. Chromium at high concentrations of 200 and 300 mg/kg showed high toxicity that the plants died. (Revathi et al., 2011)

Heavy metal analysis of soil samples

Soil samples of each pot were air dried, crushed and pass through 0.2mm sieve and stored in Zip lock covers for analysis. Heavy metals present in all the samples were analyzed by AAS (Atomic Absorption Spectroscopy).

Table 1 Experimental setup

S.No.	Pot No.	GS (kg)	KK Seeds (g)	VC (kg)	TE (ml)	Plant harvested (days)
1	A1	1	2	-	50	15
2	A2	1	2	-	50	30
3	A3	1	2	-	50	45
4	A4	1	2	-	50	60
5	B1	1/2	2	1/2	50	15
6	B2	1/2	2	1/2	50	30
7	B3	1/2	2	1/2	50	45
8	B4	1/2	2	1/2	50	60
9	C1	1	2	-	100	15
10	C2	1	2	-	100	30
11	C3	1	2	-	100	45
12	C4	1	2	-	100	60
13	D1	1/2	2	1/2	100	15
14	D2	1/2	2	1/2	100	30
15	D3	1/2	2	1/2	100	45
16	D4	1/2	2	1/2	100	60
17	E1	1	2	-	200	15
18	E2	1	2	-	200	30
19	E3	1	2	-	200	45
20	E4	1	2	-	200	60
21	F1	1/2	2	1/2	200	15
22	F2	1/2	2	1/2	200	30
23	F3	1/2	2	1/2	200	45
24	F4	1/2	2	1/2	200	60

GS – Garden Soil, KK – KarisalanKanni, VC – VermiCompost, TE – Tannery Effluent

Results and discussion

Within 60 days all the plants in A, B, C, D, E and F type pots have been harvested. The concentration of heavy metals in untreated tannery effluent contaminated soil decreases in the following categorize (Cr>Zn>Pb>Cu>Cd). During that period, accumulation of heavy metals and the plants growth is maximum in soil – vermicompost combination (B, D and F type pots). Whereas in other pots there is a

minimum accumulation of heavy metals and the plants growth is suppressed (A, C and E type pots). After 60 days there is an incredibly small increase in heavy metals and there is no change in plants growth.

Table 2 Physico – chemical characteristics of the effluent collected from the tannery industry

S.No	Name of the parameter	Sample details
Physical parameter		
1	Colour	>1hue
2	Odour	Unpleasant
3	Turbidity	400NTU
4	Total dissolved solids	2746
5	pH	8.19
6	Electrical conductivity (dsm^{-1})	4.29
7	BOD (mg/l)	1450
8	COD (mg/l)	850
Heavy metals		
9	Zinc (mg/l)	32.05
10	Chromium (mg/l)	38.06
11	Lead (mg/l)	25.09
12	Cadmium (mg/l)	12.00
13	Copper	27.04

Table 3 Heavy metal concentrations in various soil samples

S.No.	Pot No.	Cd (ppm)	Cr (ppm)	Cu (ppm)	Pb (ppm)	Zn (ppm)	Plant harvested (days)
1	A1	11.09	37.56	25.60	28.79	31.06	15
2	A2	10.03	30.29	24.72	26.82	27.48	30
3	A3	7.89	19.69	20.03	21.65	19.23	45
4	A4	7.01	17.29	18.81	19.45	17.41	60
5	B1	10.72	36.09	25.06	28.05	29.75	15
6	B2	9.06	28.25	23.04	22.61	26.08	30
7	B3	6.76	14.62	13.57	12.81	18.62	45
8	B4	5.86	11.09	10.48	09.28	15.19	60
9	C1	11.12	37.80	25.81	29.15	30.82	15
10	C2	10.85	32.46	24.06	27.08	26.92	30
11	C3	08.09	21.65	21.09	21.82	20.68	45
12	C4	07.46	19.21	18.42	18.09	17.08	60
13	D1	10.08	36.51	25.19	28.75	29.68	15
14	D2	08.94	30.61	24.09	25.42	27.45	30
15	D3	06.02	15.52	14.25	13.48	19.61	45
16	D4	05.92	12.61	11.65	10.66	14.08	60
17	E1	11.82	37.07	25.92	29.06	30.12	15
18	E2	10.47	32.69	24.38	28.65	25.34	30
19	E3	07.64	22.02	21.88	22.08	19.82	45
20	E4	07.02	18.72	9.08	18.37	16.43	60
21	F1	11.00	35.69	25.23	28.65	28.09	15
22	F2	09.25	29.47	24.76	26.08	25.45	30
23	F3	06.89	16.03	15.08	14.15	18.61	45
24	F4	05.92	12.79	12.43	10.08	14.76	60

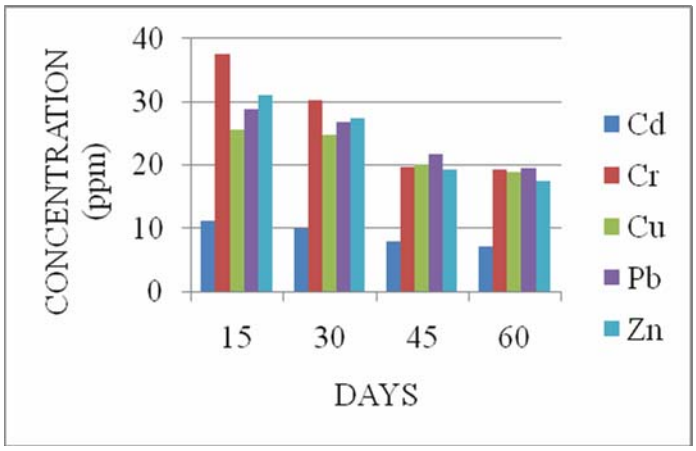

Figure 1 Reduction of Cd, Cr, Cu, Pb and Zn in Pot No. A1 to A4

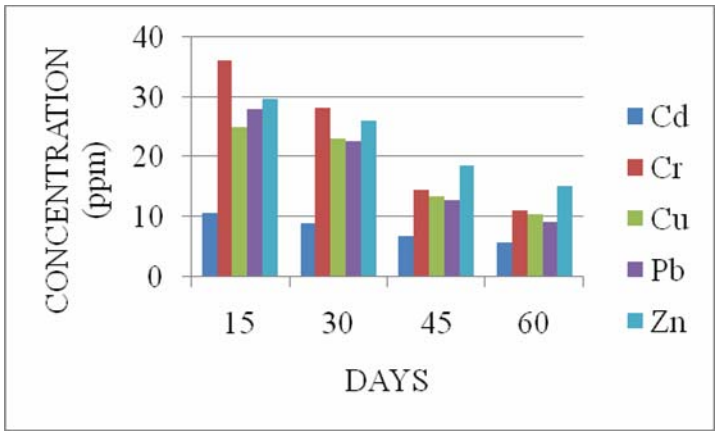

Figure 2 Reduction of Cd, Cr, Cu, Pb and Zn in Pot No. B1 to B4

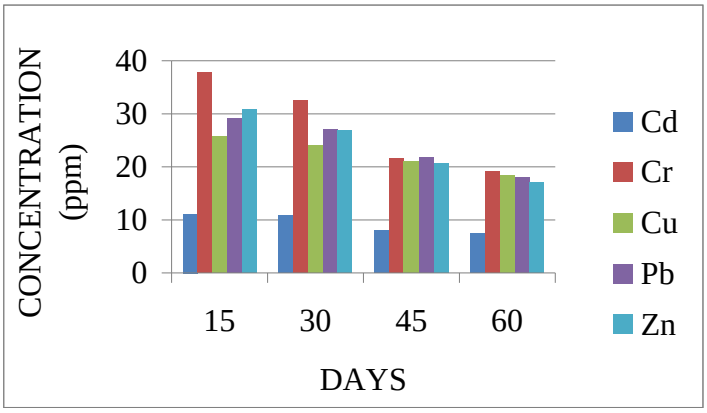

Figure 3 Reduction of Cd, Cr, Cu, Pb and Zn in Pot No. C1 to C4

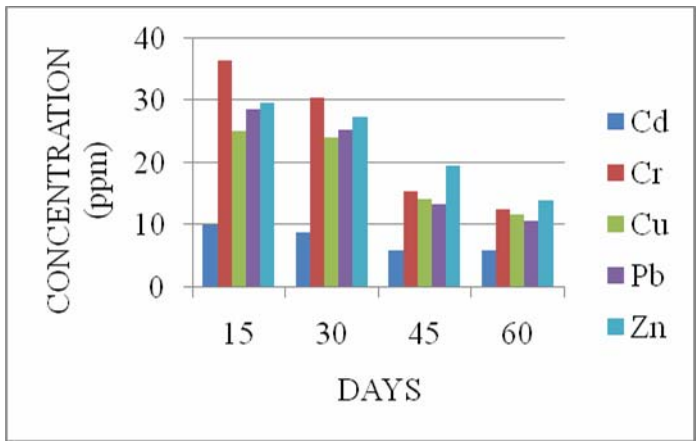

Figure 4 Reduction of Cd, Cr, Cu, Pb and Zn in Pot No. D1 to D4

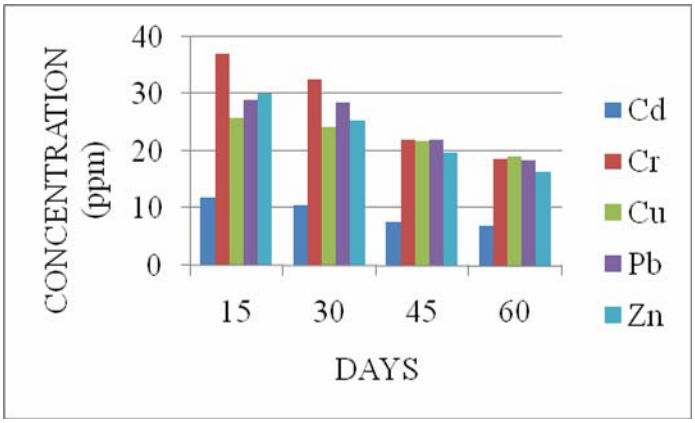

Figure 5 Reduction of Cd, Cr, Cu, Pb and Zn in Pot No. E1 to E4

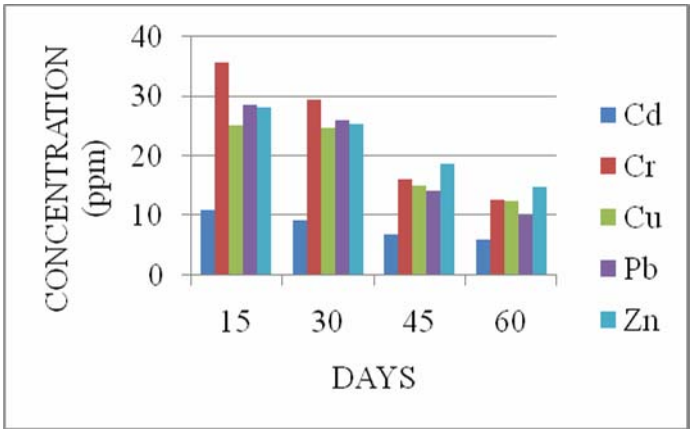

Figure 6 Reduction of Cd, Cr, Cu, Pb and Zn in Pot No. F1 to F4

Conclusion

This research work deals with the analysis of heavy metals by Phytoremediation method using Eclipta alba in the soil – vermicompost media. Another advantage of Phytoremediation is that it leaves the soil fertile and has less adverse environmental effects as compared with the conventional methods. The results indicate that the concentrations of heavy metals gradually decrease in vermicompost with garden soil combination (B, D and F type pots). So, it is suitable for well growing plant and heavy metals accumulation. The other pots are not suitable for the removal of heavy metals in a rapid manner from the tannery effluent contaminated soil (A, C and E type pots). Thus the study shows that **Eclipta alba** has a good potential to uptake and accumulate the toxic heavy metals from tannery polluted soil. It is also recommended for the development of an economically cheap technology and suitable for a good phytoremediation method.

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