ISSN: 2321-3132

Research Article

International Journal of Chemistry and Pharmaceutical Sciences

www.pharmaresearchlibrary.com/ijcps

A Study on Phytoremediation of Heavy Metals from Paper Mill Effluent Soil Using *Croton Sparsiflorus*

B.Ashokkumar[1G], S.Jothiramalingam[2], S.K.Thiyagarajan[3], T.Hidhayathullakhan[4] and R. Nalini[5]

[1]*Research scholar, Khadir Mohideen College, Adirampattinam – 614701, Thanjavur (Dt), Tamilnadu, India.*
[2 & 3] *P.G and Research Department of Chemistry, A. V. V. M. Sri Pushpam College (Autonomous), Poondi-613 503, Thanjavur (Dt), Tamilnadu, India.*
[4]*Department of chemistry, Khadir Mohideen College, Adirampattinam - 614 701, Thanjavur (Dt), Tamilnadu, India.*
[5]*Department of Chemistry, Periyar Maniammai University, Vallam, Thanjavur (Dt), Tamilnadu, India.*

Received: 4 June 2014, Accepted: 29 August 2014, Published Online: 27 September 2014

Abstract

Today indiscriminate and uncontrolled discharge of metal contaminated industrial effluents into the environment has become an issue of major concern. Release of heavy metal without proper treatment poses a significant threat to public health. Pollution of the biosphere with toxic metals has accelerated dramatically since the beginning of the industrial revolution. In many ways living plants can be compared to solar driven pumps, which can extract and concentrate certain elements from their environment. Certain plants have the ability to accumulate heavy metals such as Cd, Cr, Pb and Zn etc., The present study deals with phytoremediation of heavy metals in paper mill effluent contaminated soil. The effects of addition of biosolids like vermicompost on the bioaccumulation efficiency of the plant were investigated. The results indicated that there is significant reduction of biomass of the plant with increased dosage of heavy metals.It is also observed that addition of vermicompost to the contaminated soil improves the biomass of the plants thus making room for more bioaccumulation. Phytoremediation is found to be the cost-effective and highly efficient in remediating the heavy metal polluted sites.

Keywords: Phytoremediation, Bioaccumulation, *Croton Sparsiflorus*, Vermicompost

Contents

***Corresponding author**
B. Ashokkumar
Research scholar, Khadir Mohideen College, Adirampattinam–614701, Thanjavur (Dt), Tamilnadu, India.
Manuscript ID: IJCPS2154

PAPER-QR CODE

1. Introduction

Industrial waste is one of the most important sources of contamination in the surface environment. Numerous studies of environment contamination due to industrial wastage activities have been undertaken to further the understanding of the impacts of heavy metals [Pb, Zn, Cr, Cu & Cd] and metalloids in soils, plants, animals and humans. The treatment process produced sludge, making heavy metals contracted waste. Measures to metals polluted soil were emphasized towards the physico chemical processes such as soil removal and land filling, stabilization or solidification, physico-chemical extraction, soil washing and flushing [1]. In amendment, adsorption using low-cost adsorbents is one of the effective and economic methods [2].

Pulp and paper mill, categorized as one of the 12 most polluting industries in India releases environmentally hazards liquid effluent containing heavy metals and other organic toxicants [3]. To remove toxic metals, industries employ several physico-chemical processes, which often require high capital and recurring expenditure [4]. Irrigation of crops with effluents is a very common practice in India due to scarcity of irrigation water [5, 6]. The effect of irrigation with effluents is also studied in many crops to observe the concentration of accumulated metals to which human beings are exposed [7, 8, 9]. Various low-cost adsorbents have been used for the removal of metals using abiotic adsorbents such as ash particles [10, 11]. Biotic adsorbent using plant was become a major concern in developing countries [12] as well as phyto process [13].

The phytoremediation method was simple, efficient, cost effective and environmental friendly [14]. The phytoremediation of metal-contaminated soils offers a low cost method for soil remediation, and some extracted metals may be recycled for value. Plants that accumulate metals to high concentrations are sometimes referred to as "hyperaccumulators" [15]. It is an integrated multidisciplinary approach to the cleanup of contaminated soils, which combines the disciplines of plant physiology, soil chemistry and soil microbiology [16]. Certain species of higher plants can accumulate very high concentrations of metals in their tissues without-showing toxicity [17, 18]. Such plants can be used successfully to cleanup heavy metals polluted soil if their biomass and metal content are large enough to complete remediation within a reasonable period [19]. The heavy metals accumulation efficiency of the *Croton Sparsiflorus* and also effect of addition of biosolids like vermicompost on the bioaccumulation plants were subjected to phytoextraction and the concentration of metals extracted from the plants were also evaluated.

2. Materials and Methods

Collection of materials

The garden soils are gathered from nearest places. The effluent is collected from paper mill located at Solagampatti, Thanjavur, Tamilnadu. *Croton sparsiflorus* 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 lead to find the toxicity. Lead at high concentrations of 200 and 300 mg/kg showed high toxicity that the plants died. (Revathi et al., 2011). The various experimental setup used for the present study are listed below:

Table 1: Experimental setup

S.No	Pot. No	GS (kg)	CS Seeds (g)	VC (kg)	PME (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, CS–*Croton Sparsiflorus*,
VC – Vermi Compost, PME–Paper Mill Effluent

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).

3. Result and Discussion

The concentration of heavy metals are varies in paper mill effluent (Pb>Cu>Zn>Cr>Cd). Heavy metals concentration are decreases largely in B, D and F type (15–60 days) pots, because it consists of vermicompost which is used to growing plant and accumulation of heavy metals. So, the well growing plants which accumulate heavy metals easily than other pots (A, C and E type). Phytoremediation is applicable to sites that contain low to moderate levels of metal pollution, because plant growth is not sustained in heavily polluted soil. Soil metals should also be bioavailable or subject to absorption by plant roots. Finally, excess amount of heavy metals in soil are remediated by combination of vermicompost with garden soil.

Table 2: Heavy metal concentrations in various soil samples

S.No	Pot No.	Cd (ppm)	Cr (ppm)	Cu (ppm)	Pb (ppm)	Zn (ppm)	Reduction of concentration (Days)
1	A1	12.5	28.65	35.65	39.72	34.09	15
2	A2	11.6	22.5	30.08	32.65	29.75	30
3	A3	9.52	12.35	24.82	20.76	19.61	45
4	A4	8.41	7.92	20.07	16.84	15.09	60
5	B1	12.25	26.46	33.26	36.54	31.08	15
6	B2	11.02	18.74	27.41	28.64	22.64	30
7	B3	8.5	8.25	16.53	11.61	9.61	45
8	B4	7.92	6.51	12.20	6.52	5.85	60
9	C1	12.56	27.41	34.89	38.65	35.04	15
10	C2	11.85	23.05	31.09	33.81	30.09	30
11	C3	10.05	14.42	25.92	21.62	21.51	45
12	C4	9.89	9.25	21.65	17.81	16.75	60
13	D1	12.54	26.95	34.06	37.06	32.07	15
14	D2	11.49	19.07	28.45	29.4	23.19	30
15	D3	9.06	9.21	17.96	12.81	10.67	45
16	D4	8.45	6.26	13.49	7.61	6.76	60
17	E1	12.6	28.72	35.25	38.02	34.92	15
18	E2	11.85	23.06	31.08	32.08	29.69	30
19	E3	10.45	16.48	25.46	21.05	20.48	45
20	E4	9.8	9.65	20.01	16.51	15.84	60
21	F1	12.65	26.59	34.08	38.09	31.60	15
22	F2	11.46	19.26	28.09	30.48	22.96	30
23	F3	9.09	9.76	17.65	13.09	10.08	45
24	F4	8.75	6.84	13.81	7.96	6.39	60

Physico – chemical characteristics of the effluent collected from the paper industry is given below:

Table 3: Physico – chemical characteristics of the effluent collected from the paper industry

S.No	Name of the parameter	Sample details
Physical parameter		
1	Colour	>1hue
2	Odour	Unpleasant
3	Turbidity	105NTU
4	Total dissolved solids	1453
5	pH	7.89
6	Electrical conductivity (dsm^{-1})	2.27
7	BOD (mg/l)	525
8	COD (mg/l)	705
Heavy metals		
9	Zinc (mg/l)	36.03
10	Chromium (mg/l)	29.45
11	Lead (mg/l)	42.05
12	Cadmium (mg/l)	13.67
13	Copper (mg/l)	37.13

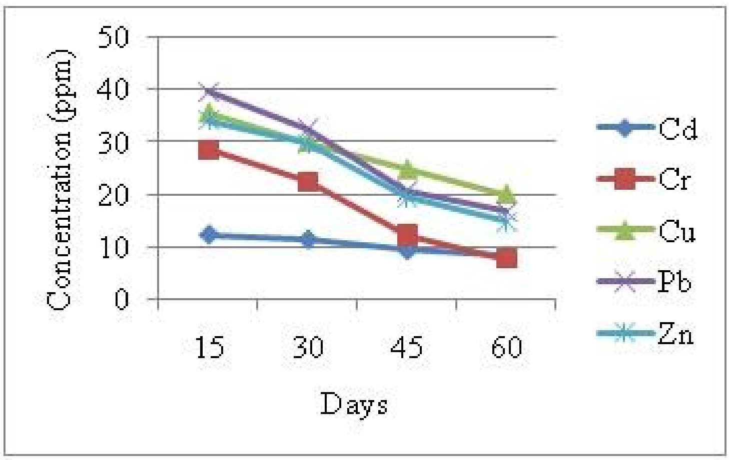

Figure 1: Reduction of Cd, Cr, Cu, Pb and Zn in Pot No. A1 to A4

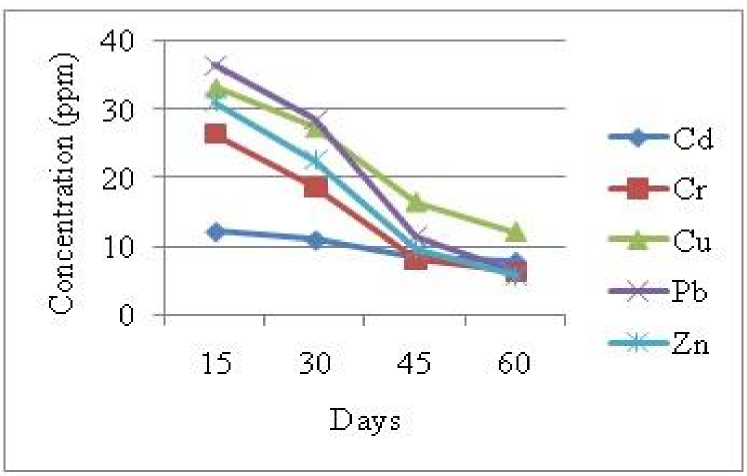

Figure 2: Reduction of Cd, Cr, Cu, Pb and Zn in Pot No. B1 to B4

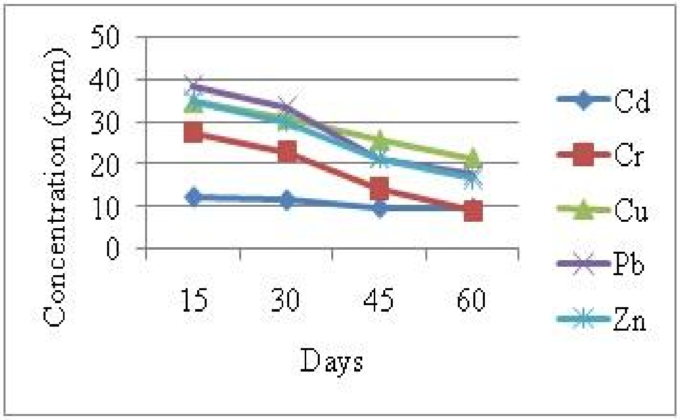

Figure 3: Reduction of Cd, Cr, Cu, Pb and Zn in Pot No. C1 to C4

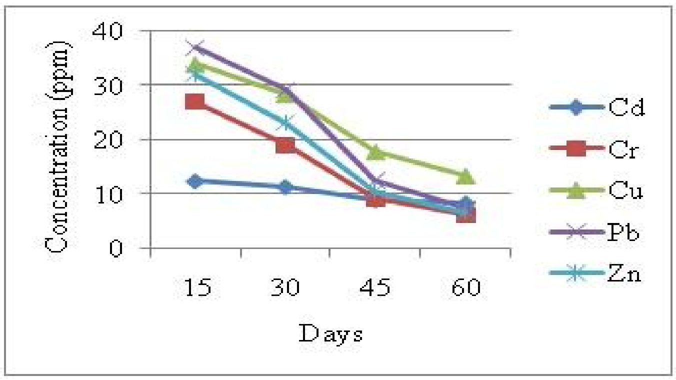

Figure 4: Reduction of Cd, Cr, Cu, Pb and Zn in Pot No. D1 to D4

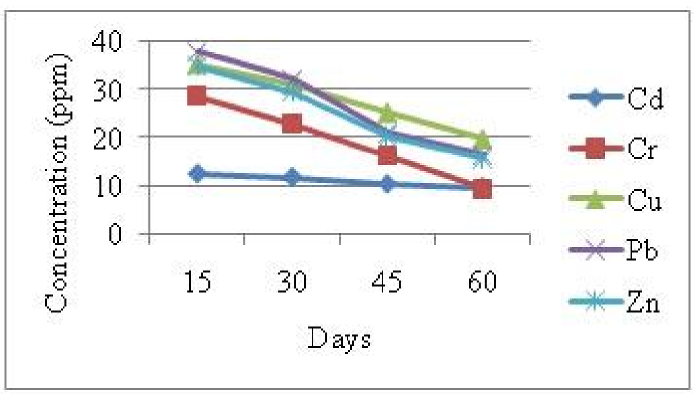

Figure 5: Reduction of Cd, Cr, Cu, Pb and Zn in Pot No. E1 to E4

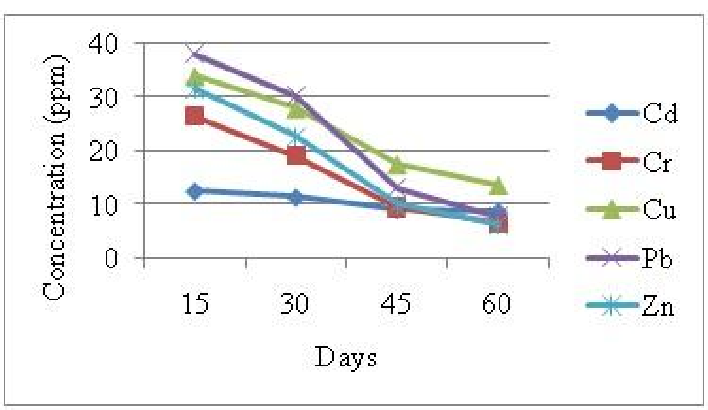

Figure 6: Reduction of Cd, Cr, Cu, Pb and Zn in Pot No. F1 to F4

4. Conclusion

The results indicated that the concentration of heavy metals is gradually decreases in vermicompost with garden soil combination. So, it is suitable for well growing plant and heavy metals accumulation (15-60 days). Other pots (A, C and E type) are not suitable for the removal of heavy metals in contaminated soil, because it decreases heavy metals slowly than above type of combination. This study shows that *Croton sparsiflorus* has a good potential to uptake and accumulate the toxic heavy metals from paper mill polluted soil. It also pares away for the development of an economically cheap technology and suitable for a good phytoremediation method. These technologies will prove useful in environmental cleanup procedures and subsequent restoration of soil fertility. Hence, attempts on remediation of polluted soil by phytoremediation methods fulfills the National Policy of 'Eco–friendly' development and create socio–economic, scientific developments among the Environmentalists, Agriculturalists and scientists who involve in the application of this technique. Above all, this low cost technique will help the poor farmers to reuse the lands for agricultural purposes.

5. References

1. H A Hossain, M Kumita, Y Michigami and S Mori, Optimization of parameters for Cr-VI adsorption on used black tea leaves, *Adsorption,* **2005,** *II (5-6)*: 561-568.
2. K Nikhel, Ecological management of polluted waters due to mining and allied industries, *Journal of Industrial Pollution and Contamination.* **2005,** *12(2)*: 225-271.
3. P Singh and I S Thakur, Removal of colour and detoxification of pulp and paper mill effluent by micro organisms in two step bioreactor, *J.Sc.Ind.Res*. *63* **2004**: 944 – 948.
4. A Kapoor, T Viraraghavan and D R Cullimore, Removal of heavy metals using the fungas *Aspergillus niger, Biores Technol.* **1999,** *70*: 95-99.
5. M Arora, B Kiran, A Rani, B Kaur and M Mittal, Heavy Metal Accumulation in Vegetables Irrigated with water from Difference Sources, *Food Chemistry,* **2008,** *111(4)***:** 811-815.
6. R K Sharma, M Agarwal and F M Marshall, Heavy Metals Contamination of Soil and Vegetables in Suburban Areas of Varanasi, India, *Ecotoxicology & Environmental Safety,* **2007,** *66(2)***:** 258 – 266.
7. W H Liu, J Z Zhao, Z Y Ouyang, L Soderland and G H Liu, Impacts of Sewage Irrigation on Heavy Metals Distribution and Contamination, *Environment International,* **2005,** *31(6)*: 805-812.
8. B S Ismail, K Farihah and J Khairiah, Bioaccumulation of Heavy Metals in Vegetables from selected Agricultural Areas, *Bulletin of Environmental Contamination and Toxicology,* **2005,** *7(2)***:** 320-327.
9. S Singh and M Kumar, Heavy Metal Load of Soil, Water and Vegetables in PeriUrban Delhi, *Environmental Monitoring and Assessment,* **2006,** *120(1-3)*: 71-79.
10. A K Rai and K Surendra, Removal of Cr-VI by using Brick Kiln and Fly ash, *Indian Journal of Environmental Health,* **1999,** *41(1)* : 65-73.
11. Y C Sharma, Adsorption of Cr –VI on to Wallastonite: Effect of $_P$H. *Indian Journal of Chemical Technology,* **2001,** *8*: 191-194.
12. P M Devaprasath, J S Solomon and B V Thomas, Removal of Cr-VI from aqueous solution using natural plant material, *Journal of Applied science in Environmental Sanitation.* **2007,** *2 (3)*: 77-83.
13. D Claus, H Dietz, A Gerth, W Grosser and A Hedner, Application of agronomic practice improves phytoextraction on a multipolluted site, *Journal of Environmental Engineering & Landscape Management,* **2007,** *15(4)*: 208-212.
14. S Mangkoedihardjo and Suramaida, *Jatropha curcas L*. for Phytoremediation of Lead and Cadmium polluted soil, *World Applied Sciences*, **2008,** *4(4)*: 519-522.
15. A Majiri, The potential of Corn (*Zea mays)* for Phytoremediation of soil contaminated with Cadmium and Lead, *Journal of Biological & Environmental science,* **2011,** *5(13)*: 17-22.
16. S D Cunningham and D W OW, Promises and prospects of root zone of crops Phytoremediation, *Plant physiology,* **1996,** *110*: 715-719.
17. S P Klassen, J E Mclean, P R Gressel and R C Sims, Fate and behavior of Lead in soils planted with metal-resistant species, (River birch and small wing sedge), *J. Envinn.Qual.* **2000,** *29*: 1826-1834.
18. L E Bennet, J L Burkhead, K L. Hale, N Terry, M Pilon, and E A H. Pilon-Smits, Analysis of transgenic Indian Mustard plants for phytoremediation of metals-contaminated mine tailings, *J.Environ. Qual.* **2003,** *32*: 432-440.
19. S D Ebbs and L V Kochian, Phytoextraction of Zinc by Oat *(Avina Sattiva)* Barley (*Hordeum Vulgare)* and Indian Mustard (*Brassica juncea), Envinn. Sci. Technol.***1998,** *32***:** 802-806.