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THE STUDY OF ACCUMULATION OF CADMIUM IN THE BIOMASS OF DIFFERENT PLANT SPECIES

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Declaration

The Declaration of the authors for publication of Research Paper in The Indian Journal of Research Anvikshiki ISSN 0973-9777 Bi-monthly International Journal of all Research: We, *Darpan Singh and Vishrut Chaudhary* the authors of the research paper entitled THE STUDY OF ACCUMULATION OF CADMIUM IN THE BIOMASS OF DIFFERENT PLANT SPECIES declare that, We take the responsibility of the content and material of our paper as We ourself have written it and also have read the manuscript of our paper carefully. Also, We hereby give our consent to publish our paper in Anvikshiki journal, This research paper is our original work and no part of it or it's similar version is published or has been sent for publication anywhere else. We authorise the Editorial Board of the Journal to modify and edit the manuscript. We also give our consent to the Editor of Anvikshiki Journal to own the copyright of our research paper.

Abstract

Plants can be used to remove, transfer, stabilize and degrade contaminants. The technique was first adapted to constructed wetlands, reef beds and floating plant systems for the treatment of contaminated ground and waste waters. Current efforts now focus on expanding the phytoremediation strategy to address contaminated soils and air pollutants in an attempt to preserve the biodiversity of soil and its biota. Phytoremediation is an emerging and environment friendly 'green' technology that uses plants to clean up the organic and inorganic pollutants. In recent years, phytoremediation, i.e., the use of plants to cleanup-contaminated soils is showing promises as a new method.

Introduction

Different auxiliary agents for metal uptake including the chelating agent ethylene diamine tetraacetic acid (EDTA) have been studied over the past decade (Piechalak et al., 2003 and Lopez et al.., 2005). Synthetic chelators facilitate the uptake of heavy metals, and their translocation to the above ground parts. (Piechalak *et al.*, 2003) Metal extraction can be achieved with organic or inorganic acids. EDTA is the most popular reagent because it is a strong, recoverable and biostable chelating agent (Wu *et al.*, 2003).

Romkens *et al.* (2002) reported that EDTA, which has a high specific affinity for Cd, enhanced metal solubility, but plant metal uptake did not increase accordingly and shoot and root biomass production was depressed (Wu *et al.*, 2004). Synthetic chelating agents like EDTA are perhaps the most

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widely studied extractants for soils and sediments. It is generally believed that EDTA extraction is also effective in displacing organically bound metals present in soils. It is explained that greater proportion of Cd than Zn was released by the EDTA treatment.

Probably several 100,000 ha in Europe and the US are contaminated by heavy metals (Lewandowski *et al.*, 2006). The quantification of the benefits of multiple land use (MLU) systems requires the quantification of land use functions in biophysical and economic terms. That means in a first step the bio-physical performance, for example tones of soil prevented from erosion, number and kind of species being supported and in a second step the economic value are assessed (Lewandowski *et al.*, 2011).

Salt *et al.* (1998) estimated that the cost of conventionally remediating heavy metal-contaminated sites in the USA alone would exceed $7 billion. They further estimated that due to the cost effectiveness and ecofriendly non-disturbing nature of phytoremediation technique, market for phytoremediation of heavy metal contaminated sites in North America and Europe could reach $ 400 million per year. Glass (2000) estimated that the market for the phytoextraction of metals from soils in the USA alone was approximately $ 1-2 million in 1997, with a potential to increase to $ 15-25 million by 2000 and $ 70-105 million by 2010. Soil pollution is a very important environmental problem (Cunningham et al., 2000, Ali et al., 2004, Maiti et al., 2004).

Increasing international concern about the risks associated with long-term consumption of crops contaminated with Cd has led the international food standards organization, Codex Alimentarius Commission, to propose a 0.1 mg $Cd.kg^{-1}$ dry weight limit for cereals, pulses and legumes (Yanai *et al.*, 2006 and Vassilev *et al.*, 2002).

Since the discovery of "itai-itai disease" in Japan in 1950s, adverse effect of cadmium (Cd) on human health through the consumption of Cd contaminated rice have received much attention (Yanai *et al.*, 2006). A total of 2.2×10^4 tons of Cd has been discharged into the environment during the past half-century (Singh *et al.*, 2003). Cadmium has no essential biological function and is highly toxic to plants and animals. Keeping the above things in mind the present study has been planned to achieve the following objectives:

To study the phytoextraction potential of the Raya (*Brassica juncea*), Toria *(B. compastris)*, Oat *(Avena sativa)*, Barley *(Hordeum vulgare)*, Bathua *(Chenopodiun murale)* and Rijhka *(Medicago sativa)* in the Cd contaminated soil.

Experimentation

Experiment I: Phytoextractablity of different plant species from cadmium spiked sandy loam soil

To evaluate the relative efficiency of different plant species for their ability to decontaminate Cd enriched sandy loam soil. The experiment was conducted using 5 kg capacity earthen pots. The physico-chemical properties of soil are given in table 1.

TABLE 1 *Physicio-Chemical Characteristic of the sandy loam soil*

Characteristics	Contents
*pH	7.67
*EC (dSm^{-1})	0.39
Mechanical Composition (%)	
i) Sand	76.3
ii) Silt	12.3
iii) Clay	1.4
Organic carbon (%)	0.36

Olsen's P (mg kg^{-1})	12.0
CEC (m.e/100 g)	7.2
Metal contents (mg kg^{-1})	
i) Lead	2.78
ii) Cadmium	0.80
iii) Nickel	0.25
iv) Zinc	3.1
v) Iron	14.4
vi) Manganese	5.1
vii) Copper	3.4

* 1:2 Soil: water suspension

Treatments

(a) Cd levels: Five (0, 20, 40, 60 and 80 mg Cd Kg^{-1} soil)

(b) EDTA levels: The 1 g kg^{-1}soil EDTA was added in each pot at preflowering (Rossett stage)

(c) Plant Species: Raya (Brassica juncea, Var raya), *Toriya* (Brassica compastris, var Toria), *Rijhka* (Alfalfa Medicago sativa L., var Ramagonal), *Bathua* (Chenopodium murrale), *Oat* (Avena sativa) *and Barley* (Hordium vulgare L.)

(d) Replications: Three

Sampling; All the plants species were harvested at the maturity. The root, stem leaf and seeds were separated and weighed. All the samples were ground and stored in polythene bags for the heavy metal analysis.

Analysis of root for Cadmium concentration

The plant samples taken at harvest were chemically analyzed to estimate Cd concentration in different plant parts. Each sample was ground in grinder after drying and then in oven at 65±2°C till a constant weight was achieved. A known amount of ground sample was digested by diacid mixture. The Cd concentration was obtained by atomic absorption spectrophotometer (AAS).

In order to determine Cd in seed, stem, leaf and root, 1 g of ground and well mixed plant material was digested in a diacid mixture of nitric and perchloric acid (4:1). After digestion the volume was made to 50 ml with double distilled water, filtered and stored in well washed plastic bottles. Cd was estimated using the Atomic Absorption Spectrophometer (GBC 932 Plus) Standard solutions were prepared by diluting 1000ppm standard of heavy metal, purchased from 'Merck'. Analytical grade (AR) chemical were used throughout the study.

Results and Discussion

The experiment with the different plant species in Cd contaminated soil was carried out to meet the objectives of the present study. The results of the present study are shown in the table 2. Before starting the experiment, the soils were characterized. It was necessary to observe the amount of cadmium initially in the soil. Visual toxicity symptoms of Cd were recorded of all six-plant species. In the controlled (Cd) treatment there were no distinct Cd toxicity symptoms throughout the growing period of crops. At 40 mg Cd kg^{-1}, some light chlorotic symptoms, resembling to Fe-chlorosis, appeared after about 2 weeks of germination.

The chlorotic symptoms became more conspicuous with the increasing levels of Cd, and Chlorosis was most conspicuous in oat followed by Barley, Toria, Bathua, Rijhka and Raya. At 60 and 80 mg Cd kg^{-1} soil treatments, the leaves were considerably narrow and small as compared to Cd control in all the species tested. The toxicity symptoms appeared in the form of burning of margins of older leaves and acquired a light/dark-brown/yellow colour after 4 to 5 weeks of germination. White patches on leaves were also noticed.

Cd concentration in plants grown in sandy loam soil

The relative concentration of Cd in different plant parts varied markedly with plant species and increased with increasing rates of Cd application. The data presented in Table 4.5 showed that Cd concentration in different plant parts increased than the control with the application of EDTA in all the species. EDTA is the most effective and popular reagent because it is a strong chelating agent, which has potential for soil remediation applications. EDTA elevates the extractability of metals from the contaminated soil. EDTA mobilizes metals rapidly. With application of EDTA the concentration of Cd increased mainly because the EDTA had solubilize the Cd and boost the uptake by the plant system.

The lowest Cd concentration was observed at Cd_0 level and the highest was observed at 80 mg Cd kg^{-1} soil, with the application of EDTA in all the species. The Cd concentration in root increased about 3, 8, 13 and 18 times more as compared to control at 20, 40, 60 and 80 mg Cd kg^{-1} soil, respectively. However, the magnitude of increase in Cd concentration varied with the species. Raya accumulate higher Cd concentration than the other species. This indicates that Raya has higher potential to decontaminate Cd polluted soil as compared to other species. Due to the application of EDTA the increase in stem cadmium concentration was about 5, 10, 14 and 18 times more then the control, at 20, 40, 60 and 80 mg Cd kg^{-1} soil, respectively. However, the Cd concentration varied between species and Cd concentration.

The maximum mean Cd concentration was observed at 80 mg Cd kg^{-1} soil, with application of EDTA in species.

TABLE 2 *Cd concentration (mg g^{-1}) in root, stem, leaf and seed of different species as influenced by Cd and EDTA application in sandy loam soil*

Cd levels (mg kg^{-1})	Different species: Raya	Toriya	Rijhk	Bathua	Oat	Barley	Mean
			Root				
0	4.92	5.14	10.71	7.04	8.88	10.70	7.90
20	18.62	26.30	30.89	21.04	27.10	30.86	25.80
40	48.64	59.80	78.22	61.12	72.39	78.20	66.40
60	55.39	64.29	137.41	90.24	128.63	137.50	102.24
80	61.21	69.79	207.51	128.59	196.40	207.50	145.17
Mean	37.76	45.06	92.95	61.61	86.68	92.95	
C.D.(0.05)	Cd levels= 18.31		Species = 20.06		Cd x spp.=NS		

Conclusion

The dry matter yield and accumulation of Cd by six plant species commonly grown in North India in sandy loam soil and sewage water irrigated soil have been determined in the present study. Plant species showed reduced biomass when grown in Cd contaminated soil. The accumulation increased with the increase in Cd concentration when increased in soil. The maximum Cd accumulation was found in Raya.

The present study aimed to develop a technique for remediation of the contaminated soil with heavy metals by plants. Raya, Toriya, Rijhka, Bathua, Oat and Barley carried out the experiments to determine the efficiency for the removal of Cd. The soils were characterized for background concentration of Cd and different chemical parameters and they are shown in Table 1. The Raya is widely used for the removal of the contamination from soil and showed better results in the remediation of contaminated soil.

Experiments, in which soils used rather than solution, approximately are more closely to the natural conditions, where the effect of soil buffering capacity influences nutrient availability to plants. The goal was to assess to develop the heavy metal removal technique in natural conditions of the soil with and without chelators. It was observed that Cd affects all the growth parameters. In present experiment biomass was greatly reduced with external cadmium levels. The Cd concentration was lower in shoots than in roots indicating that a higher proportion of the Cd taken up by plants remained in the roots.

Thus, the success of phytoextraction is an environmental clean up effort depends to a large degree on the identification of suitable plants that not only concentrate metals to levels that would not inhibit growth of plants, demonstrate prolific growth with established agronomic practices. The efficacy of phytoextraction as a viable remediation technology is still being explored, though the results are positive. This study provides a promising start for biomass-based phytoextraction as it includes high biomass producing species and growing these species is practically easier than producing hyper accumulators. Phytoextraction as well as agronomic practices for sustaining high shoot biomass production should be further explored.

Summary

The salient findings and conclusions drawn from the study "Phytoextraction of cadmium using different plant species from metal contaminated soil" are being summarized. The Cd concentration increased significantly in various plant parts in all the six species tested due to increased level of cadmium. Increase in Cd concentration in root, stem, leaf and seed was noted with an application of Cd than control. Root had higher concentration of Cd than stem; leaves and seed of all the species tested at all the Cd levels demonstrating that there is limited transport of this element from the root system to the above ground plant parts. Raya had significant higher Cd concentration than those of Toriya, Rijhka, Bathua, oat and Barley indicating that it has better absorbing ability than others and has higher potential for removing Cd from moderately contaminated soils.

Irrespective of tolerance of different species there was an increase in Cd concentration in different plant parts. Strategy for managing heavy metal contaminated sites definitely does have a great deal of potential in crop and cultivar selection. Different species show substantial differences in uptake of metals from the soil and in their ability to cope with higher metal accumulation.

Further research in identifying hyperaccumulator species and selecting improved genotypes with high biomass and high metal accumulating characteristic using conventional agronomic practices is needed for efficiently and economically managing metal contaminated soil environment.

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