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A GREEN TECHNOLOGY FOR CONTROL OF POLLUTION AND RECOVERY OF METAL

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Declaration

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Abstract

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

Introduction

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. 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).

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

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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.

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.

Soil pollution is a very important environmental problem (Cunningham et al., 2000, Ali et al., 2004, Maiti et al., 2004). It has been attracting considerable public attention over the last decades (Alkorta *et al.*, 2001). Unfortunately, the enormous costs associated with the removal of pollutants from soils by means of traditional physicochemical methods have been encouraging to ignore the problem. Chaoui *et al.* (2005) observed the effects of cadmium and copper on antoxdant capacities, vivification and auxin degradation in leaves of pea. Bovet *et al.* (2005) made a study on possible involvement of plant ABC transporters in cadmium detoxification.

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.*, 2006). Probably several 100,000 ha in Europe and the US are contaminated by heavy metals (Lewandowski *et al.*, 2006).

Keeping the above things in mind the present study has been planned to achieve the following objectives:

To study the biomass yield 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

To evaluate the relative efficiency of different plant species for their growth in 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.

Treatments:

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

(b)Plant Species

1. Raya *(Brassica juncea, Var raya)*
2. Toriya *(Brassica compastris, var Toria)*
3. Rijhka *(Alfalfa Medicago sativa L., var Ramagonal)*
4. Bathua *(Chenopodium murrale)*
5. Oat *(Avena sativa)*
6. Barley *(Hordium vulgare L.)*

(d)Replications: Three

Sampling and Dry biomass yield

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.

The plant samples taken at harvest were analyzed to estimate weight of different plant parts. Each plant was separated in to different plant parts. The readings were taken after drying in oven at 65±2°C till a constant weight was achieved.

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 1. 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.

TABLE 1 *Biomass yield (g $plant^{-1}$) of root, stem, leaf and seed of different species as influenced by Cd application in sandy loam soil*

Cd levels (mg kg^{-1})	Different species						Mean
	Raya	Toriya	Rijhka	Bathua	Oat	Barley	
				Root			
0	1.33	1.26	0.92	1.39	1.02	1.09	1.17
20	1.29	1.24	0.93	1.2	1.01	1.08	1.11
40	1.19	1.15	0.79	1.1	0.88	0.9	1.02
60	1.06	0.99	0.55	1.03	0.65	0.79	0.85
80	0.92	0.86	0.4	0.79	0.56	0.53	0.68
Mean	1.16	1.1	0.72	1.1	0.82	0.88	
C.D.(0.05)		Cd levels= 0.15		Species = 0.16		Cd x spp.= NS	
				Stem			
0	5.31	5.06	1.25	2.09	1.67	1.43	2.8
20	5.24	4.99	1.23	2.07	1.65	1.41	2.77
40	5.03	4.87	1.17	2.03	1.61	1.33	2.67
60	4.94	4.66	1.03	1.96	1.52	1.19	2.55
80	4.75	4.09	0.95	1.75	1.34	0.92	2.3
Mean	5.05	4.73	1.13	1.98	1.56	1.26	
C.D.(0.05)		Cd levels= 0.15		Species = 0.0.16		Cd x spp.= NS	

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.

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 2. The Raya is widely used for the removal of the contamination from soil and showed better results in the remediation of contaminated soil.

TABLE 2 *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

The dry matter yield of 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.

Summary

The salient findings and conclusions drawn from the study "Phytoextraction of cadmium using different plant species from metal contaminated soil" are being summarized. 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 hyper accumulator 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. The biomass produced during the cropping must be avoided from the entry in food chain. The biomass must be use for the production of energy, heat through burning in industries and metal may be recovered from the ash.

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