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Phytoremedation of soil by naturally grown plants, contaminated with potentially toxic elements (Fe, Pb, Cu, Zn & Cr) near by Yash Paper Mill, Faizabad, U.P.

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Abstract
The present study deals to determine the heavy metal accumulation potential of three naturally grown plants viz. Metals Fe, Pb, Zn, Cu, and Cr have been detected in soil and plants species of contaminated (Site-Yash paper mill) and non contaminated (near by 20 km of the site) area, 3 naturally grown plant species have been taken for the study. It is revealed that *Argemone Mexicana, Calotropis procera and Cannabis sativa* growing naturally in the field at Faizabad, U.P. in effluent contaminated area. We suggest the plantation of these plants species in contaminated field because heterogeneous accumulation of metals was found in these plants species at contaminated and uncontaminated area. Higher accumulation of metals was found in the plants leaves which is naturally growing. Elevated accumulation of metals in species *Argemone Mexicana, Calotropis Procera, and Cannabis sativa sp.* growing along the effluent channel has been identified as a potential source of bio-monitoring of metals particularly for Fe, Pb,Cu, Zn and Cr are as well as utilised for the removal of heavy metal from contaminated soil.

Keywords: Heavy metals, Accumulation, Translocation, Fe, Pb, Cu, Zn & Cr

Introduction

The problem of environmental pollution on account of essential industrial growth is, in practical terms, the problem of disposal of industrial water, whether solid, liquid or gaseous. All three types of wastes have the potentiality of ultimately polluting water. Polluted water, in addition to other effects, directly effects soil not only in industrial areas but in also agricultural fields, as well as the beds of rivers, creating secondary sources of pollution (1988; Barman and Lal 1994; Barman and Ray, 1999; Kisku *et al*., 2000; Barman *et al*., 2000) [2]. The effect of industrial pollution on water, soil and plants, near by Yash Paper Mill Faizabad in Uttar Pradesh is studied. The source of water is effluent water, supplied from an overhead tank. Wastewater is discharged by the electroplating unit. The mill has its own effluent treatment plant and oxidation pond. Treated effluent is stored in the pond/reservoir which is also used by local farmers. Some cultivators use the treated effluent for irrigating fields and grow vegetables and crop plants.

Materials and Methods

Water samples were collected from the Yash Paper Mill discharged treated effluent (nearby agricultural field), Selected physico-chemical parameters of the samples were determined by standard methods (APHA, 2000). Soil samples approx. depth of 0-15, were collected from the Yash Paper Mill (nearby agricultural field) with the help of soil augar, at 1 km distance from the confluence point (control site). At each location, three soil samples were taken, within metre radius, mixed, air dried and sieved for analysis. 3 plant samples each consisting of different plant species, were collected. Of these, 3 plants were collected which are naturally grown near by effluent pond. The soil and plant samples weighing 1g each, were digested in a mixture of concentrated nitric and perchloric acid (5:1) until a clear solution was obtained (APHA 2000). The solution was filtered, reconstituted to the desired volume and metal content determined in atomic absorption spectrophotometer (LABINDIA AA 7000). Plant samples were analysed in triplicate.

Results and Discussion

Soil

The physico-mechanical parameter of soil near the confluence point were not changed by irrigation with treated effluent as compared to control soil. The concentration of metals Fe, and Cu in the field near confluence point were 1137.77 and 450 higher than in control soil. The heavy metal content in soil samples near the effluent holding tanks was much higher than in the control/background sample. Higher level of metals was found in the soil alongside the effluent channel as well as around the treatment plant. Metals were also washed out during the rainy season from polluted areas to unpolluted areas as well as air pollution.

Table 1: Assessment of Soil Samples

Parameters	Unit	Contaminated	Control site
pH	Mol/l	6.26± 0.10	07.47
EC	(dS/m)	00.15±0.1	00.17
Total Organic Carbon	%	2.34±0.2	0.71
Fe	μg g^{-1}	1137.77	367.77
Pb	μg g^{-1}	BDL	BDL
Cu	μg g^{-1}	450	117
Cr	μg g^{-1}	BDL	BDL
Zn	μg g^{-1}	BDL	BDL

* BDL- Below Detection Line (AAS)

Plants

Aquatic plants have the ability to accumulate nutrients and accelerate nutrient cycling in the environment A number of workers have reported the uptake of metals from the polluted water by the aquatic macrophytes resulting in purification of such water (Ray *et al*., 1990, Generally, in an aquatic environment, the uptake of a metal by living organisms depend on the concentration and chemical form of the metal (Bordin *et al*., 1992). The rate of uptake depends on several factors such as salinity, temperature, pH, alkilinity, oxygen concentration of the water (Hakason, 1984). Two wild species of plants were found to be growing vigorously in the effluent channel; their appreance was normal with no any phenotypic symptoms. The accumulation pattern of 5 metals is given below in descending order of magnitude.

The accumulation pattern of these metals is the same in the above samples. Lower concentration of metals was found in *Argemone Mexicana* than in *Cannabis Sativa* except for Cu, Pb, and Cr. Thus the accumulation of metals in the plants is very specific. In *Calotropis Procera* the results indicate that the mobilities of Fe, Zn and Cu are high. Fe, Zn, and Cu are easily translocated/absorbed by this plant. Thus, accumulation of Fe, Zn, and Cu was exceptionally high in plant parts. It has been reported that the accumulator plant *Calotropis Procera* can reduce the contaminated field to some extent. Thus, *Calotropis Procera* can be used for removal of heavy metals from the contaminated field.

Futher, in the samples of naturally grown plants namely *Argemone Mexicana, Calotropis Procera* and *Cannabis Sativa*, and the concentration of each metal varied over a wide range.

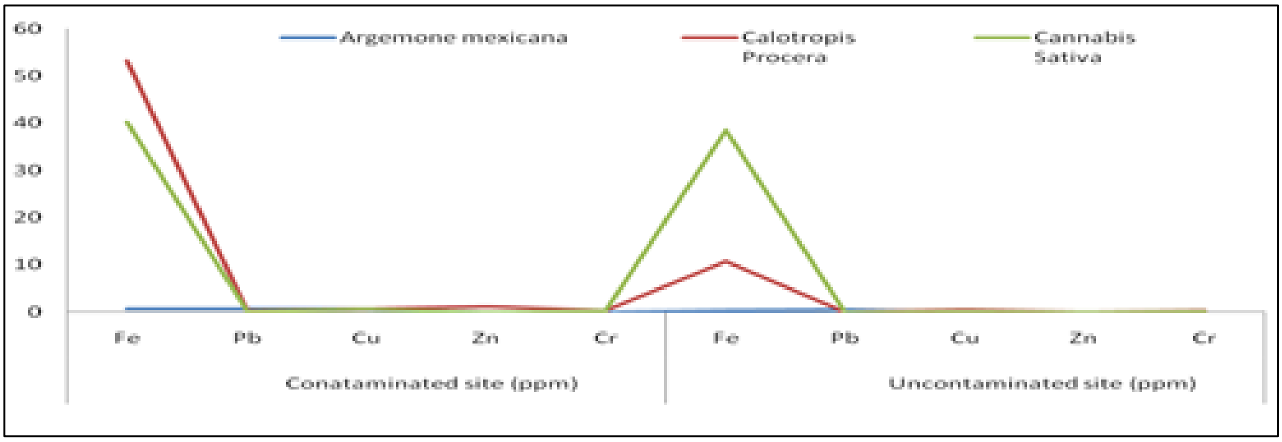
(1) Argemone Mexicana: Pb < Fe < Cu < Zn<Cr
(2) Calotropis Procera: Fe < Zn < Cu < Pb < Cr
(3) Cannabis Sativa: Fe < Cu < Cr < Pb < Zn

Heavy metal content of naturally grown plants grown in industrially polluted area.

It may be concluded that inspite of high concentration of metal in plant leaves, the plants do not show any phenotypic symptoms. Competition among metals at the binding site in plant tissues may reduce the effectiveness of individual metals. Khan and Frankland (1983) showed that the mobility of Fe was higher than that of Pb and there was very little movement of Pb through the sub-soil. (Meraj *et al*., 2019) Further, Pb is not easily translocated into plants. In this study plant, water and soil have studied and the values are shown within standard limits. It can be concluded that there may be apparently synergistic effects of wide variety of metals and some other unknown modified chemicals/pollutants play an important role in increasing metal accumulation in plants.

Table 2: Uptake of heavy metals in naturaaly grown plants near by contaminated site and Control site

Name of Plant	Part Analysed	Contaminated site (ppm)					Control site (ppm)				
		Fe	Pb	Cu	Zn	Cr	Fe	Pb	Cu	Zn	Cr
Argemone Mexicana	Leaves	0.60	0.60	0.56	0.07	BDL	0.37	0.40	BDL	BDL	BDL
Calotropis Procera	Leaves	53.09	0.26	0.68	1.19	0.26	10.78	BDL	0.46	0.07	0.26
Cannabis Sativa	Leaves	40.13	0.13	0.64	0.07	0.30	38.41	BDL	0.19	BDL	0.10



It was found that accumulation of Fe, Cu, Zn and Pb was extremely high in some species which can be considered as best accumulator or resistance species and which can be used for phytoremediation. Resistance to the effect of industrial pollution, specially heavy metals, a characteristic of plant life. Our present studies shows, that this characteristic of resistance to changed/polluted environment is present in plants in all regions of the world. It would appear that resistance is a function of the cytogenetical makeup of the species/variety of plant. Plants get adopted to the adverse environment and shows improvement in the growth and yield parameters from generation to generation, carrying more and more of toxic/hazardous metals into the food chain, thus maiming, blinding, or even killing, usually in epidemic form, more and more people silently.

Distribition of Metal and Impact on Plants

We observed that there was high absorbtion of metals like Fe, Pb, Zn, Cu and Cr in plants, near by Yash Paper Mill area. Therefore, the mobilization ratio for Fe is ~1. This is in agreement with Gestring and Jarnell (1982) [12], who reported significant differences in Fe concentration in plant and soil. There is no uniform distribution of PTE in the root adjacent soils as well as in the different plant species. Soil-plant bio-accumulation relationships are variable from metal to metal and plant to plant. The highest accumulation of Fe, Pb, Cu, Zn and Cr were found in *argemone mexicana, calotropis procera and cannabis sativa* respectively, in the naturally grown plants near by Yash Paper Mill site. The results reflect that *Calotropis Procera* having more affinity to Fe and Cu where as *Argemone mexicana* showed higher affinity to Fe, Pb and Cu while *Cannabis sativa* to Fe and Cu. The naturally grown plants species of Yash Paper Mill area are higher in PTE concentrations than the cultivars for all the five metals. Such a difference was also observed between legumes and grass by Mitchell *et al.* (1957) [16] for copper concentrations.

Interestingly, luxurious growth (in terms of vegetative growth, root length, and number of rootless, number and color of leaves, etc.) of plants was observed at Yash Paper Mill Faizabad area. The crops and vegetables on the other hand showed reduce growth. The growth of plants at Yash Paper Mill Faizabad area was similar to growth of plants at uncontaminated area, Faizabad. This indicates that plant species differ in their ability to absorb, accumulate, and tolerate PTE.

Recommendations to Reduce Pte Load in the Environment

Some of the precautionary measures to be adopted to check the daily intake of potentially toxic metals through foodstuff are as follows:

Increasing the efficiency of effluent treatment plants of individual industry will reduce the metal load in the environment. Agricultural land should not be irrigated with industrial or mixed effluent of industrial effluent. Liming to contaminated soil elevates pH which decreases the availability of these metals in plants. These metal accumulator/tolerant plant species (i.e. hyper accumulator plants) can be alternatively grown with crops and vegetables to eliminate or to reduce some extent the metal concentration. Organic matter (humus) cab also be added to the soil which will restrict metal transport to the plants by providing binding sites (ligands). Instead of cultivating in the heavily contaminated area, social forestry may be taken up as remedial measure to avoid soil erosion and health hazard in the future. There has been recent interest in the concept of cropping and removing the above ground biomass for decontamination of polluted surface soils. Cultivators should also be discouraged to cultivate the root/tuber and leafy vegetables.

Conclusion

The information generated is highly significant for selecting plant species that would be appropriate for cultivating in land/field irrigated with industrial effluent. The mobilization ratio revealed that *calotropis procera* and *cannabis sativa* are the best metal accumulator plants species which can efficiently restrict the passage of PTE from the contaminated soil. So, these plant species can be used for phytoremediation and this restriction could be due to the cumulative effect of genetically controlled features, morphological and anatomical differences, or due to the physiology of the ion transport mechanism (Cataldo and Wildung 1978) [4].

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