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ASSESSMENT OF HEAVY METAL AND PESTICIDE CONTAMINATION IN PADDY FIELDS AND DEVELOPMENT OF PHYTOREMEDIATION SYSTEM IN KOZHIKODE DISTRICT, KERALA, INDIA

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ABSTRACT

Analysis of soil samples collected from various paddy fields in Kozhikode district was carried out to identify extent of heavy metal and pesticide contamination. Analysis by atomic absorption spectrometry revealed cadmium contamination in some of the paddy fields (Kuytheri and Balussery) in the district. GC analysis revealed that both organo chloride and organophosphate pesticide contamination was absent in paddy fields of Kozhikode district. Among the several ornamental plants evaluated for assessing cadmium phytoremediation potential, *Impatiens walleriana* Hook.f. showed highest phytoaccumulation potential. Thus the study revealed that, *I.walleriana* have the innate capacity for accumulation of appreciable quantity of cadmium from polluted soils and the plants could be used for removing the cadmium from cadmium contaminated soil.

KEY WORDS : Heavy metals, Soil, Ornamental plants

INTRODUCTION

Agriculture production relies on resources like land and water. Unfortunately, these valuable resources have been rigorously ruined or polluted. Sources of pollution includes effluents and discharge from industries, vehicle exhaustion and metals from smelting and mining, and soluble salts (natural and artificial), use of insecticides/pesticides, dumping of industrial and municipal wastes and excessive use of fertilizers (McGrath *et al*., 2001; Nriagu and Pacyna, 1988; Schalscha and Ahumada, 1998). Each source of contamination has its own damaging effects to plants, animals and ultimately to human health, but those that add heavy metals and non biodegradable pesticides are of serious concern due to their persistence in the environment and carcinogenicity (Garbisu and Alkorta, 2001; Gisbert *et al*., 2003).

Heavy metals that cause serious environmental problems are As, Cu, Cd, Pb, Cr, Ni, Hg and Zn. Excessive uptake of metals by plants may produce toxicity and cause acute and chronic diseases in humans. For instance, Cd toxicity can lead to acute gastrointestinal and respiratory damages and heart, brain and kidney damages(Garbisu and Alkorta, 2001; Schmidt, 2003; Schwartz *et al*., 2003). Soil contamination with heavy metals and pesticides may also cause changes in the composition of soil microbial communities (Giller *et al*., 1998; Kozdrój and van Elsas, 2001; Kurek and Bollag, 2004). Mercury, and cadmium are two common toxic heavy metals in the environment (*Yurdako˜k*, 2015) The use of agro chemicals, such as chemical fertilizers and pesticides, is integral in the current agriculture production system around the globe. The applied pesticide can be transported from the sprayed area to non target areas away from the crop, which thus affects not only the pest species but potentially the non target species also. Thus it has become imperative to develop methods to remove such pollutants from the environment.

Phytoremediation is an economical, long-lasting, and aesthetic solution for remediation of hazardous pollutants from contaminated sites (Kramer, 2005; Suresh and Ravishankar, 2004).

Rice is the most important staple crop in Kozhikode district, Kerala. Therefore, it was important to identify and remove heavy metal and pesticide contamination from paddy fields in Kozhikode district. Unfortunately no such studies were conducted earlier. Present study was conducted to evaluate heavy metal and pesticide contamination in paddy fields of Kozhikode district and to develop phytoremediation system to remove contaminants from soil.

MATERIALS AND METHODS

Study area

Kozhikkode is one of the districts in Kerala. Agriculture is one of the occupations for majority of population and rice is the most important food crop under cultivation in the district.

Soil samples

Soil samples collected from different paddy fields of ten typical locations viz. Kuttyadi, Vanimel, Nanmanda, Mukkam, Ramanattukara, Balussery, Thiruvambadi, Puduppadi, Koyilandi and Feroke of Kozhikode district were used for the study. The samples were collected from a depth of 0-5 cm.
Experimental protocol and Procedure

Test for Heavy Metals

Soil samples collected from 10 different paddy fields of Kozhikode district were used for the study. One gram of each soil sample were digested with repeated addition of 10ml nitric acid and (HNO3) and Hydrogen peroxide (H2O2).The solutions were heated to boiling and filtered. 20ml of Hydrochloric acid (HCl) was added to the initial digestate and the sample was refluxed. After filtration the digestate was made upto 100 ml. The heavy metal concentration in all the samples were analysed by Flame Atomic Absorption Spectrophotometer at CWRDM (Centre for Water Resources Development and Management), Kozhikode, Kerala.

Test for Pesticides

5g of each soil sample collected from different places of Kozhikode district were taken. It was then shaken with 20ml of hexane for one hour. After filtration, the volume of the solution thus obtained was made up to 50ml. The Pesticide concentration in all the samples were tested by A Varian-make CP-3800 gas chromatograph equipped with Ni63 ECD electron-capture detector at CWRDM (Centre for Water Resources Development and Management), Kozhikode, Kerala.

Phytoremediation studies

Ten common ornamental plants were selected study for the present phytoremediation study. They were *Angelonia angustifolia* Benth, *Asystasia gangetica* (L.)T. Anderson, *Clerodendrum thomsoniae* Balf.f., *Gomphrena globosa* L., *Heterotis rotundifolia* (Sm) Jacq. Fel., *Impatiens walleriana* Hook.f., *Nerium oleander* L., *Plumbago auriculata* Lam. *Tagetes erecta* L. and *Zinnia elegans* L. The plants were collected from Kozhikode district and acclimatized in the Botanical Garden of St. Joseph's college, Devagiri.

Twenty plants of each species were collected and acclimatized in the college garden for two weeks. These plants were divided into two sets. First set of ten plants of each species was kept as the control plants. The second set of ten plants of each species was used for heavy metal treatment. The heavy metal treatment was carried out for 10 days after the acclimatization period. Each plant of the control set was given 100 mL of water regularly for 10 days. Each plant of the second set was treated with 100 mL of cadmium chloride solution regularly for 10 days. The cadmium chloride solution was prepared by dissolving 1g of cadmium chloride in 1L of water.

After the treatment period, the plants were taken out of the soil, washed with distilled water to remove the soil particles, dried in an oven for 48 hours at 80 ^{0}C and were ground into powder.0.5g ground powder of plants of each set were weighed accurately and digested with 40ml mixture of nitric acid (HNO_3) and perchloric acid ($HClO_4$) taken in the ratio 4:1. The resulting mixtures were evaporated to dryness and were extracted with distilled water. The solutions were heated to boiling and filtered. The volume of the solutions thus obtained was made to 50ml each. The metal ion concentrations in all the samples were analyzed by Flame Atomic Absorption Spectrophotometer.

RESULTS AND DISCUSSION

Continuous use of soil for various purposes leads to an increase in its heavy metal and pesticide content in soil. Rise in the percentage of heavy metals and

pesticides, above the level at which it naturally occurs, is a possible threat to living organisms. It also interrupts the food chain due to the accumulation of these non degradable heavy metals. Results obtained in the present study by the analysis of soil samples collected from paddy fields in Kozhikode district were summarised in Tables 1, 2 & 3.

Table 1. Amount of Cd and Hg present in soil collected from different paddy fields of Kozhikode District.

Sl. No.	Fields	Cd Present in Soil (mg/kg)	Hg present in soil (mg/kg)
1	Ramanattukara	BDL	BDL
2	Thiruvambadi	BDL	BDL
3	Kuytheri	0.05	BDL
4	Nanmanda	BDL	BDL
5	Feroke	BDL	BDL
6	Puduppadi	BDL	BDL
7	Koyilandy	BDL	BDL
8	Balussery	0.02	BDL
9	Mukkam	BDL	BDL
10	Kuttyadi	BDL	BDL

BDL: Below Detection Level

Soil analysis for identifying heavy metal contamination revealed that soil in paddy fields of Kuytheri and Balussery regions in Kozhikode district were contaminated with cadmium. The amount of cadmium present in soil in paddy fields of Kuytheri and Balussery regions were 0.05 mg/kg and 0.02 mg/kg respectively. In the remaining places like Ramanattukara, Thiruvambadi, Nanmanda, Feroke, Puduppadi, Koyilandy, Mukkam and Kuttiadi soil in paddy fields were not polluted with cadmium. Mercury contamination was not at all observed in soil in paddy fields of Kozhikode District.

Analysis of pesticide contamination of soil revealed that synthetic pesticides of both Organochlorine and Organophosphorus types were absent in soil in paddy fields of Kozhikode district. This might be due to increased awareness among farmers about the harmful effects of synthetic pesticides and also due to legal restrictions imposed by the Government over their use.Phytoremediation studies

Soil analysis revealed cadmium contamination in some of the paddy fields in Kozhikode district. Among heavy metals Cadmium is one of the most dangerous heavy metal. It causes severe risk to human health even in trace amounts. Hence phytoremediation studies were conducted to identify suitable ornamental plants that can be used for removing Cadmium from soil. Results observed in comparative analysis of accumulation of Cadmium in control and experimental plants during phytoremediation studies were summarised in Fig. 1 and Table 4.

In the present studies cadmium accumulation was found to be below detectable level in control plants. This clearly showed that the level of cadmium in the soil used for growing control plants was very low or the soil used for growing control plants was not contaminated with cadmium.

All the plants treated with cadmium, except *Nerium oleander* L. (0.62 mg/kg), showed significant levels cadmium accumulation. *Impatiens walleriana* Hook.f. showed highest level of cadmium

Table 2. Amount of Organophosphorus and Organochlorine pesticides present in soil collected from different paddy Fields of Kozhikode District.

Organophosphorus Pesticides		Organochlorine Pesticides	
Name of the pesticide	Concentration in soil	Name of the pesticide	Concentration in soil
Mevinphos	BDL	Lindane	BDL
Phorate	BDL	Aldrin	BDL
Disulfoton	BDL	Daldrin	BDL
Methyl parathion	BDL	α–Endosulfan	BDL
Thionazin	BDL	β–Endosulfan	BDL
Parathion	BDL	DDE	BDL
Triazophos	BDL	DDT	BDL
Piperonyl butoxide	BDL		
Dimethoate	BDL		
Famphur	BDL		

O,O,O Triethyphosphorothioacetal BDL
Sulfotep BDL
BDL: Below Detection Level

Table 3. Absorption levels of cadmium in control and cadmium treated plants.

S. No.	Plants	Cadmium accumulated in control plant (mg/kg)	Cadmium accumulated in treated plant (mg/kg)
1	*Angelonia angustifolia* Benth.	BDL	2.91
2	*Asystasia gangetica* (L.)T. Anderson	BDL	10.0
3	*Clerodendrum thomsoniae* Balf.f.	BDL	4.56
4	*Gomphrena globosa* L.	BDL	1.08
5	*Heterotis rotundifolia* (Sm.) Jacq.Fel.	BDL	6.55
6	*Impatiens walleriana* Hook.f.	BDL	14.77
7	*Nerium oleander* L.	BDL	0.62
9	*Tagetes erecta* L.	BDL	6.16
8	*Plumbago auriculata* Lam.	BDL	2.31
10	*Zinnia elegans* L.	BDL	10.66

BDL: Below Detection Level

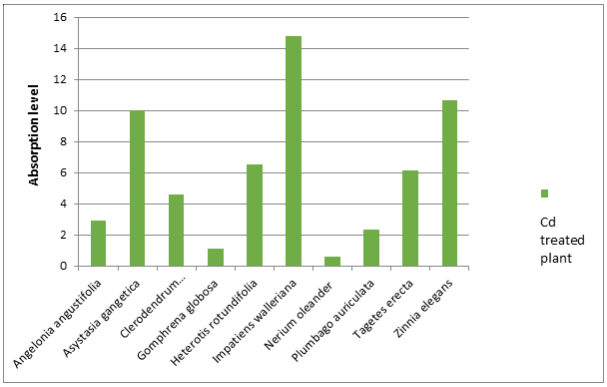

Fig. 1. Graph showing levels of Cadmium accumulated in control and Cadmium treated plants.

accumulation (14.77mg/kg). *Zinnia elegans* L. and *Asystasia gangetica* (L.) T. Anderson. also showed a high level of cadmium accumulation (10.66 mg/kg and 10.0 mg/kg, respectively). The potential of *Impatiens walleriana* for the phytoremediation of Cd contaminated soil was reported earlier by Lai & Cai (2016). In the present study, *Tagetes erecta* L. plants were found to be less efficient in removing cadmium from contaminated soil when compared to many other plants used in the study.

CONCLUSION

In the present study, it was found that several paddy fields (Kuytheri and Balussery) of Kozhikode District were polluted with cadmium. Phytoremediation studies showed that among all the ten plants used for the study, *Impatiens walleriana* Hook.f. showed the highest amount of cadmium accumulation. It was also found that, Zinnia *elegans* L. and *Asystasia gangetica* (L.) T. Anderson also accumulate appreciable quantities of cadmium. These results revealed that, *I.walleriana* have the innate capacity for accumulation of appreciable quantity of cadmium from polluted soils and *I.walleriana* plants could be used for removing cadmium from contaminated soil.

The present study also revealed that each plant absorbs a specific metal best at a specific concentration of that metal in the soil. Further studies are required to identify specific tissues and organs of the plant body where toxic heavy metals are accumulated in the plant body.

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