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CONCENTRATIONS OF HEAVY METALS IN *CLEOME GYNANDRA* FROM THE TAMIL NADU COAST, SOUTHERN INDIA

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ABSTRACT

The aim of this work was determination of trace metals (Pb, Zn, Ni, Cu and Fe) in different parts (Leaves, stem and root) of the plant (*Cleome gynandra*), ground water and surface soil samples collected in the vicinity of Manamedu village which is situated along the banks of river Cauvery in Tiruchirappalli district, Tamil Nadu state during summer and monsoon seasons of 2014. The concentrations of trace metals cadmium (Cd), chromium (Cr), copper (Cu), iron (Fe), nickel (Ni), lead (Pb) and zinc (Zn) were determined by AAS (atomic absorption spectrometry). Enhanced levels of iron were observed in all the analyzed samples. In order to compare with and assess the metal-accumulating ability of the different parts of the plant and to find the interaction of trace metals between the three different samples (plant, surface soil and ground water). The metal contents of water and soil such as Cd, Cr, Cu, Fe, Ne Pb and Zn concentrations were between 0.06 – 0.10, BDL – BDL, 0.15 – 0.22, 378 – 554, BDL – 0.06, 0.08 – 0.12 and 0.24 – 0.29 mg L^{-1}, and 0.52 – 0.76, 0.06 – 0.08, 0.98 – 1.06, 1346 – 1568, 0.06 – 0.10, 0.20 – 0.28 and 4.56 – 7.72 mg kg^{-1}, respectively. The elevated level of trace metals concentrations were proved that the study site were contaminated by the trace metals due to the sewage waste and the waste from massive industrial and improper agricultural practices. The orders of decreasing trace metal values were: Surface soil > *Cleome gynandra* > Ground water. The metal contents of *Cleome gynandra* such as Cd, Cr, Cu, Fe, Ne Pb and Zn concentrations were between BDL – 0.08, BDL – 0.04, 0.04 – 0.18, 0.10 – 0.32, BDL – 0.04, BDL – 0.10 and 0.12 – 0.28 mg kg^{-1}, respectively. Monitoring the content of mineral elements in *Cleome*

gynandra, ground water and soil is of high importance because some heavy metals in large quantities in the body may have a toxic effect.

KEYWORDS: *Cleome gynandra*, Heavy metal, Plant root, Tiruchirappalli

INTRODUCTION

Trace metals analysis are an important part of environmental pollution studies. Trace metals in the environment are the result of natural geochemical processes, as well as of numerous anthropogenic sources. To the natural geochemical processes belong: weathering of rocks, evaporation of the oceans, volcanic eruptions, forest fires and soil processes. The anthropogenic sources include mining and smelting of metal ores, agricultural materials (fertilizers and waste used for fertilizing, food preservatives, waste from intensive farming); energy based on burning coal and lignite, metallurgy, electronics, waste disposal and chemical industry (Vignesh et al., 2012a). Some trace metals are essential in plant nutrition, but plants growing in a polluted environment can accumulate trace elements at high concentrations, causing a serious risk to human health (Vousta et al., 1996; Sharma et al., 2004). Content excess of heavy metals in plants can be negative on their development.

The main sources of trace metals to plants are the air and soil from which metals are taken up by the root or foliage. The uptake of metal concentration by roots depends on speciation of metal and soil characteristics and type of plant species etc. In contaminated areas bodies of plants produced adaptation and defense mechanisms which involves precipitation of excess metal in crystalline forms or salt deposition on the tips of the leaves. Consequently, metal mobility and plant availability are very important when assessing the effect of soil contamination on plant metal uptake, as well as translocation and toxicity or ultra-structural alterations (Chandra Sekhar et al., 2001). This effect can explain improper size and form of plants in comparison with those grown on uncontaminated areas. Atmospheric metals are deposited on plant surfaces by rain and dust. The consequence of trace metals in foods such as vegetables and tubers have been a considerable interest because of their toxicity effect which are important in human beings (Asaolu, 1995).

The metals i.e. As, Se, Cd, Hg, Pb, etc. are very toxic to humans and environment and plants are suggested as potential biosorbents for trace metals removal from the soil. In plants, several groups (i.e. hydroxyl, carboxyl, carbonyl, sulfhydryl, thioether, sulfonate, amine, amide, imine, imidiazole, phosphonate, phosphodiester groups, etc.) are suggested the

complexation of metal ions. The World Health Organization (WHO, 1997) recommends that medicinal plants which form the raw materials for the finished products may be checked for the presence of heavy metals, pesticides, bacterial or fungal contamination. The medicinal herbs are a potential source of toxic metal exposure for man and animals (Pethkar et al., 2001).

Cleome belongs to the Capparaceae family and is indigenous to South Africa. The tender leaves or young shoots, and often the flowers, are boiled and consumed as a potherb, tasty relish, stew or side dish. Fresh leaves are used as ingredients in other mashed foods, and dried leaves are ground and incorporated in weaning foods. The leaves are rather bitter, and for this reason are cooked with other leafy vegetables such as cowpea (Vigna sp.), amaranth (Amaranthus sp.) and blackjack (Solanum nigrum L.). The *Cleome gynandra* are an important herb and widely distributed throughout the tropical areas. In India various species of the genus *Cleome* are found in everywhere. The most commonly available species are the *Cleome viscosa* with yellow flower, *Cleome chelidonii* with blue flower (Mishra et al., 2011). The objective of this study was to estimate the certain trace metal levels in the plant and the biosorption pattern of trace metals in the various plant parts (i.e. leaves, stem and root) which were collected from Manamedu village of Tiruchirappalli district, Tamil Nadu. The results obtained from this study will provide information for the background levels of metals in the water, soil and plants and at the same time, to find the source of metal pollutions and interaction between the environmental things.

MATERIALS AND METHODS

Sampling and processing

The ground water, surface soil and plant (*Cleome gynandra*) samples were collected from Manamedu village of Tiruchirappalli district, Tamil Nadu during summer and monsoon 2014. The 2000 ml of water samples were collected with a 2500 ml sterile container and 250 g of surface soil samples were collected with a sterile spatula. All samples were kept in iceboxes and processed within 12 h of collection. For heavy metal analysis, the one liter of sea water was acidified immediately with concentrated nitric acid (HNO_3).

Trace metal analysis

For trace metal study, acidified the water samples were filtered by Whatman No.1 filter paper and processed (APDC + MIBK) for metal analysis. The soil samples were air-dried and smaller than (>) 63 µm in size were retained in pre-cleaned properly. Simultaneously, the

three different parts (root, stem and leaves) of *Cleome gynandra* plant sample was collected from the Tiruchirappalli, Tamil Nadu district, Tamil Nadu. The plant leaves were carefully removed and washed with sterile distilled water, separately. Thereafter, the dried soil and plant samples were crushed by agate mortar and pestle. The samples were treated with aqua-regia mixture (i.e. HCl:HNO_3= 3:1) in Teflon bomb and were incubated at 140 °C for 2-3 days after dried and sieved samples. After incubation, the reaction mixture was filtered with nitrocellulose (0.45 µm) filter paper by Millipore vacuum filtration unit. Then the extraction was test for trace metals (Fe, Cu, Zn, Pd, Cd, Cr and Ni) analysis. The trace metals in the water and soil samples were determined by the atomic absorption spectrophotometry (GBC SensAA - AAS, Australia) in flame mode.

RESULT AND DISCUSSION

The obtained results of trace metals in *Cleome gynandra* plant, ground water and water samples are given in Tables 1–2. The uptake of metals concentrations by roots depends on speciation of metals and soil characteristic and type of plants species. Atmospheric metals are deposited on plant surfaces by rain and dust, too (Srinivas et al., 2009). The chemical leaching of bedrocks, water drainage basins and runoff from banks are the lithogenic contribution of heavy metals (Vignesh et al., 2012b and 2014). Discharge of urban/ rural waste water, industrial waste, combustion of fossil fuels, mining and smelting operations, processing and manufacturing industries and waste disposal including dumping are anthropogenic sources of metal and microbial pollution (Vignesh et al., 2013).

Trace metal contamination is of concern due to its effects as a carcinogen. Understanding the distribution of some trace metals in some common plant leaves and the surrounding environment (ground water and soil) are important for establishing baseline concentrations from which anthropogenic effects can be measured. The Fe concentrations of water and soil ranged from 378 – 554 mg L^{-1} and 1346 – 1568 mg kg^{-1}, respectively. The Cu levels in water and sediment samples ranged from 0.15 – 0.22 and 0.98 – 1.06 mg kg^{-1}, respectively. In monsoon, the average Cd concentration in water and soil was 0.06 mg L^{-1} and 0.52 mg kg^{-1}, respectively. In summer, the average Cr concentration in water and soil was BDL mg L^{-1} and 0.08 mg kg^{-1}, respectively. In soil, the average Pb concentrations were in the range of 0.20 – 0.28 mg L^{-1} with an average of 0.24 mg kg^{-1} while in water average was 0.10 mg L^{-1}. The concentration of Ni in ground water and surface soil ranged from BDL – 0.06 mg L^{-1}, and 0.06 – 0.10 mg kg^{-1}, respectively. In soil, concentration of Zn was found in the range from

4.56 – 7.72 mg kg^{-1}. For ground water, Zn concentration ranged from 0.24 – 0.29 mg L^{-1}. Some of the values of heavy metals in ground waters were crossing the BIS prescribed level (BIS, 1991). All the trace metals analyzed were found present in the water, soil and plant sample with iron and zinc having the highest concentration. This indicates that, despite the close proximity of the cultivated land to high pollution sources, agricultural soils does not seem to have been contaminated by atmospheric deposition. This may be due to low deposition rate resulting from the dispersion of atmospheric pollutants and variations in soil physicochemical characteristics (Sharma et al., 2004).

In plant sample, metal contents of leaf part such as Cd, Cr, Cu, Fe, Ne Pb and Zn concentrations were between 0.04 – 0.05, BDL – BDL, 0.06 – 0.12, 0.14 – 0.24, BDL – BDL, BDL – 0.06 and 0.16 – 0.20 mg kg^{-1}, respectively while in stem part, Cd, Cr, Cu, Fe, Ne Pb and Zn concentrations were between BDL – 0.02, BDL – BDL, 0.04 – 0.08, 0.10 – 0.18, BDL – BDL, BDL – 0.05 and 0.12 – 0.15 mg kg^{-1}, respectively. But in root part, Cd, Cr, Cu, Fe, Ne Pb and Zn concentrations were between 0.06 – 0.08, 0.02 – 0.04, 0.12 – 0.18, 0.21 – 0.32, 0.04 – 0.04, 0.08 – 0.10 and 0.24 – 0.28 mg kg^{-1}, respectively. While the essential elements iron and zinc are desirable in the nutrition of man, animals and plants, their presence could reduce the bioavailability of lead; their undue presence in food could be harmful (Udosen et al., 1990). The high storage of iron and zinc in the leafy part of some of the vegetables might be advantageous for their useful biochemical functions in human nutrition (Asaolu and Asaolu, 2010). Studies have shown that the excessive intake of zinc and iron results to vomiting, dehydration, electrolyte imbalance and lack of muscular co-ordination (WHO, 1984). The distribution order for the trace metals in different parts of plant have similar trend, and found to be in increasing order: Cr < Ni < Pb < Cd < Cu < Zn < Fe. Similar trend was also observed in the ground water and surface soil samples. Large number of factors control metal accumulation and bioavailability associated with soil and climatic conditions, plant genotype and agronomic management, including: active/passive transfer processes, sequestration and speciation, redox states, the type of plant root system and the response of plants to elements in relation to seasonal cycles (Kabata-Pendias and Pendias, 1984). Furthermore, studies are needed to determine the growth performance, biomass production and metal accumulation of plants in metal contaminated areas for their better management and conservation.

CONCLUSION

This study was conducted to screen different parts of plant growing on a contaminated site to determine their potential for metal accumulation. The higher metals content was found to be soil samples than different parts of plant and water samples. In this study, the orders of decreasing trace metal values were: Soil > Ground water > Root > Leaves > Stem. The concentration of the some trace metals in various parts of the *Cleome gynandra* exceeded the permissible levels. The contaminated soil, ground water and dust are expected to be major significant sources for their sorption in the *Cleome gynandra*. They can accumulate in the *Cleome gynandra* through the foliage and root system. The use of medicinal plants grown in the polluted site may be one of the dangerous potential entry pathways in humans and other animals.

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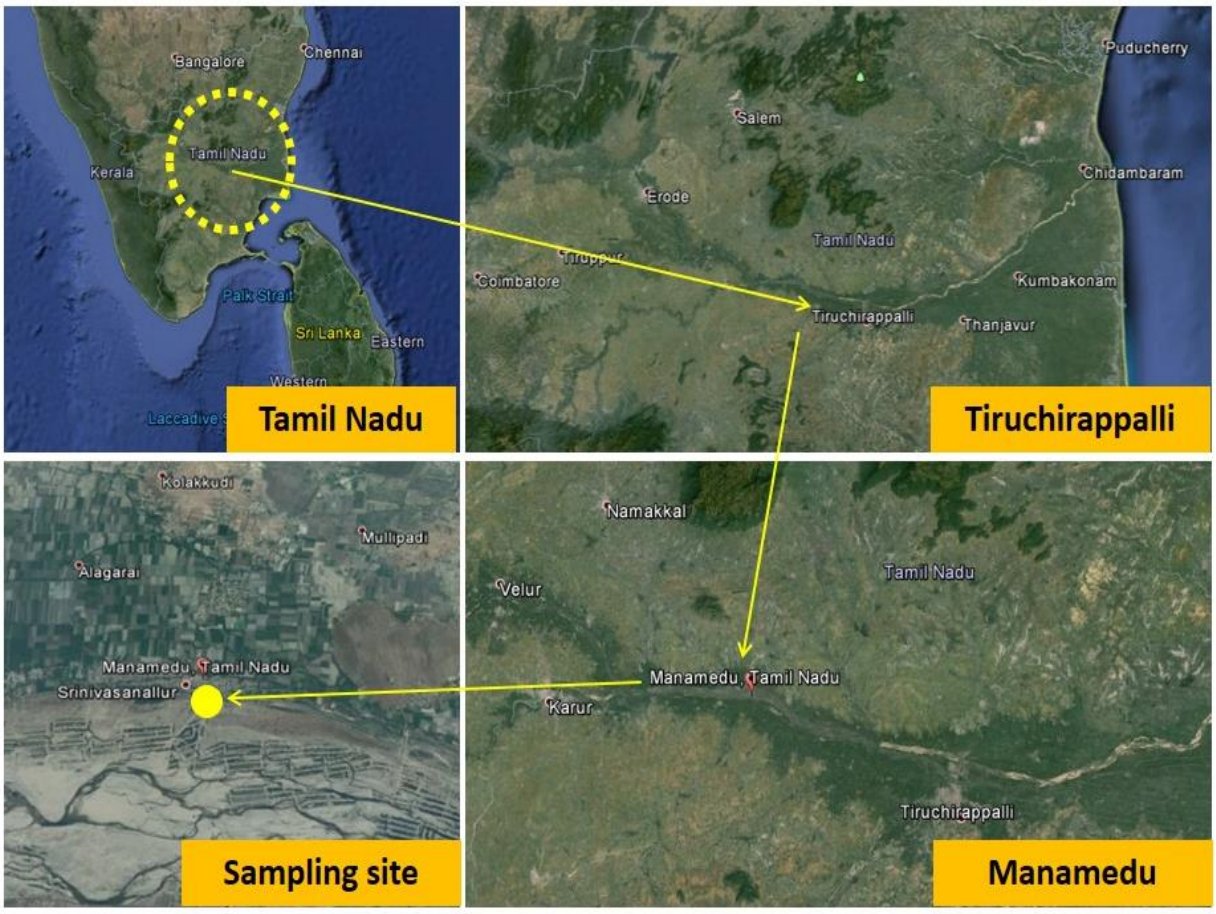

Figure 1. Sampling site of the study area.

Table 1. Concentration of trace metals in ground water and surface soil samples during summer and monsoon season.

Season	Sampling Locations	Latitude & Longitude	Sample Type	Cd	Cr	Cu	Fe	Ni	Pb	Zn
Summer	Manamedu, Tiruchirappalli	10°58'22.77" N 78°23'09.78" E	Water *(mg/l)*	0.10	BDL	0.22	554	0.06	0.12	0.29
			Sediment *(mg/kg)*	0.76	0.08	1.06	1568	0.10	0.28	7.72
Monsoon	Manamedu, Tiruchirappalli		Water *(mg/l)*	0.06	BDL	0.15	378	BDL	0.08	0.24
			Sediment *(mg/kg)*	0.52	0.06	0.98	1346	0.06	0.20	4.56

BDL – Below detectable limit.

Table 2. Concentration of trace metals in different parts of *Cleome gynandra* during summer and monsoon season.

Season	Sampling Locations	Latitude & Longitude	Sample Type	Cd	Cr	Cu	Fe	Ni	Pb	Zn
Summer	Manamedu, Tiruchirappalli	10°58'22.77" N 78°23'09.78" E	Leaves *(mg/kg)*	0.05	BDL	0.12	0.24	BDL	0.06	0.20
			Stem *(mg/kg)*	0.02	BDL	0.08	0.18	BDL	0.05	0.15
			Root *(mg/kg)*	0.08	0.04	0.18	0.32	0.04	0.10	0.28
Monsoon	Manamedu, Tiruchirappalli		Leaves *(mg/kg)*	0.04	BDL	0.06	0.14	BDL	BDL	0.16
			Stem *(mg/kg)*	BDL	BDL	0.04	0.10	BDL	BDL	0.12
			Root *(mg/kg)*	0.06	0.02	0.12	0.21	0.04	0.08	0.24

BDL – Below detectable limit.

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