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Trace Metal Analysis in Soil and Plant Samples of Tirupati Region, Andhra Pradesh

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ABSTRACT: *Rapid economic and industrial development across Tirupati region in recent decades has necessitated massive construction and building works and resulted in the contamination of environmental compartments. In addition to the disposal of untreated domestic wastes from the nearby villages industrial activities are also increasing in this region. In the present context there is a dire need to know the level of environmental contaminants in the environmental compartments such as soil and plants. The present study investigated the concentrations of trace metals in soil and plants around Tirupati region. Our results indicate that the sites are moderately polluted and potential negative biological effects may occur in the vicinity.*
Keywords*: Trace metal, Soil, Plants, Tirupati region, Cadmium, Chromium, Lead.*

I. Introduction

For the past few decades the concern over the studies on different pollutants such as trace metals, pesticides, oil and fertilizers and their impacts on environmental compartments such as soil, plants and water have attained a great importance. In the soil the presence of trace metals is due to lithogenic origin and sometimes increases by anthropogenic factors such as agricultural practices and industrial activities. [1]. Industrialization and Urbanization are the main activities which contribute a lot for the Ground water contamination and leads to environmental consequences. Industrial waste, leaking waste containment facilities, leakage of underground storage tanks, the intersection of surface and groundwater are sources of pollution and relatively comes under Point sources. Even though industrialization contributes a lot for the economical development in the developing countries, on other hand most of the very important natural resources like water and soil are commonly polluted with waste material which in-turn effect the agriculture production and food security. Polluted soil and water also act as secondary source of pollution [2].

Soil pollution by wastewater discharged from various point and nonpoint sources has become a major subject of concern in all industrialized areas of different countries and as well as within the country. The developing countries in particular have a common practice of disposing the effluents produced by various industries on the nearby land area or in big lagoons without any treatment of wastewater or any prescribed procedure of its disposal. The deleterious substances from these effluents penetrate into the soil, leaving it unfit for agriculture. The constant seepage of these effluents into the soil also leads to the pollution of groundwater reservoirs [3]. The presence of high levels of metals in soils exerts a pressure on plant species leading to the selection of a specific flora [4]. Plants growing on metal-loaded soils respond by exclusion, indication or accumulation of metals [5]. Plants growing in polluted environment can accumulate trace elements at higher concentrations, causing a serious risk to human health when plant based food stuffs are consumed [6-9]. Soil formation is a long-term process, and due to diversity of the soil-forming factors over the landscape, diverse soils are formed in different localities. They will have differences in their physical, chemical and biological properties. These properties determine the capabilities and limitations of a soil for plant growth. And once formed, the properties are relatively stable unless catastrophically disturbed by nature or man [10]

Table 1. Range of concentration in soils and plants of some inorganic elements that occur as environmental contaminants (Brady, 1984).

Metal	Metal		Sources of soil contamination
	Soils ($\mu g\ g^{-1}$)	Plants ($\mu g\ g^{-1}$)	
Arsenic	0.1-40	0.1-5	Pesticides, industrial air pollution
Cadmium	0.1-7	0.2-08	Smelting, sewage sludge roasting and plating, mineral fertilizer impurities.
Lead	2-200	0.1-10	Combustion of leaded gasoline smelting, fertilizers, pesticides.
Manganese	100-4000	15-100	Mine seepage, flyash, fertilizer
Nickel	10-1000	-	Fertilizers, gasoline combustion
Zinc	10-300	15-200	Sewage effluents, industrial waste, fertilizers, pesticides

Plants, animals and man can be seriously affected by metal contamination. The major pathway is from polluted soil. Lead, cadmium, can readily accumulate in soils, particularly in surface soil and become accessible to plant roots [11]. There are various sources of contamination of these metals in food grains especially the use of contaminated water in rice fields may enhance the level of cadmium contents in rice grains. A number of cases have been reported the accumulation of these metals in rice which is a major food of different countries. In humans the cadmium intake might be due to the consumption of the metal accumulated rice. The 50% cadmium intake in Indonesia has been reported due to the consumption of the contaminated rice and this amount is ranged from 40 to 60% in Japan [12]. The contaminated soil may also an important factor for higher intake of Cadmium in rice grains. In Taiwan the highest cadmium contents (5.9 mg/kg with mean level 2.5 mg / kg) were found in brown rice when it was grown in contaminated soil [13]. The maximum permissible limit for cadmium contents in rice grain is only 0.5 mg / kg set by department of health / republic of China (1988) in Taiwan.
There are about 100 industries surrounding Tirupati region dealing with battery manufacturing, dyeing, Fertilizers, pesticides and pharmaceutical production, electroplating, tannery, mining and metallurgy, paint, paper and pulp production. Most of these industries discharge their untreated effluents either open land or into ditches. According to previous survey reports, cadmium (Cd), chromium (Cr) and lead (Pb) are the major heavy metal pollutants in this area. The environmental impact of metallic contaminants in soils is dependent both on the chemical speciation of the metal and the response of the matrix to biological and physiochemical conditions. These factors are responsible for the mobilization of the metal from solid into the aquatic phase and transport within the immediate vicinity, influencing the rate of dispersal, dilution, uptake and transfer into living systems like plants. There are several reports in literature about the deleterious effects of harmful pollutants on nature of the soil. Discharge of Industrial waste waters are the main sources of all the pollutants whether organic or inorganic [3]. The goal of the present study is to evaluate the level of metal concentrations in soil and plant samples in the study area.

II. Materials And Methods

Collection of Soil Samples
Twenty sites located in industrial and non industrial areas, subject to varying degrees of pollution, were selected for soil sampling at Tirupati, India. Inside a square of about 25m x 25m, 16 samples (500 gm each) were systematically collected from the surface to a depth of 30 cm at intervals of about 6 min.

Collection of Plant Samples
Leaf, stem and root of plant samples were collected as (described by Gregorauskienne) from individual plants from the same surroundings of industrial and non industrial sites where soil sampling has been done [15, 16].

Sampling of Soil Samples
The soil samples were kept in polythene bags and labeled to avoid a mix-up of the different soil samples. Unwanted materials such as stones and debris were removed from the soil samples by hand-picking. The soil sample was further broken down into finer particles using a laboratory mortar and pestle. The soil samples were dried for 8 hours at 800 ^{0}C in oven and kept for digestion.

Sampling of Plant Samples
The different plant samples were kept in different polythene bags and properly labeled. Each plant sample was separated into leaves, roots, and stems and then dried at 500 ^{0}C for 8 hours in oven. The dried plant samples were milled using a laboratory blender and kept for digestion.

Digestion of Soil and Plant Samples
Plant and Soil samples were digested following the method of Allen et al. 0.5 g of the milled plant sample were weighed into a conical flask using a digital weighing balance. 3 ml of 60% hydrochloric acid and 10 ml of 70% nitric acid were added to the weighed milled soil and plant sample. The conical flask was then placed on a laboratory hot plate for digestion until the white fume evolving from the conical flask turned brown. The digest was allowed to cool and then filtered through a Whatman's filter paper, leaving a whitish residue. The filtrate was then made up to 50 ml using distilled water and kept for further analysis. The digested plant and soil sample were analyzed for lead (Pb), cadmium (Cd) and chromium (Cr) using Atomic Absorption Spectrometer (AAS).

III. Results And Discussion

The samples collected in industrial and non-industrial sites were based on the main characteristics of industrial effluents, land use, agricultural activities and intensification of human activities. Details of the soil samples collected are shown in Table 1.

Table 1. Details of Soil samples in Industrial and Non-Industrial sites

S. No	Sample Identification	Nature of Sample	Sources
1	S-1	Industrial Site-1	Leather Products (Cr)
2	S-2	Industrial Site-2	Batteries & Pharmaceuticals Products (Pb)
3	S-3	Industrial Site-3	Mining & Metallurgy Products (Cd)
4	S-4	Non-Industrial Site-1	Agricultural Land-1
5	S-5	Non-Industrial Site-2	Forest land

Priority has been given for the determination of three metals namely cadmium (Cd), Chromium (Cr) and Lead (Pb) in soil and plant (leaf) samples collected from the Industrial and non-industrial sites. Metal concentrations of plant (leaf) samples were compared with soil sample's metal concentrations to know the bioavailability of the metals Cd, Cr and Pb in different plant samples which are accumulated from soils of both industrial and non-industrial sites of Tirupati, India. The plant samples collected are grown in almost all places where soil sampling has been done and the details of plant samples collected is shown in Table 2.

Table 2. Details of collected Plant samples

S. No	**Sample Identification**	**Local Name**	**Scientific Name**
1	P-1	Tulasi	*Oscimum Sanctum*
2	P-2	Nela uciri	*Phyllanthus Niruri*
3	P-3	Ummettha	*Datura Stramonium*

The digested plant and soil samples were analyzed for lead (Pb), cadmium (Cd) and chromium (Cr) using Flame Atomic Absorption Spectrometer (FAAS). Each soil sample results were compared to the respective plant samples (P1, P2 and P3) collected from the same location. The obtained results are shown in the following Tables 3(a), 3(b), 3(c), 3(d) and 3(e).

3(a) Concentration of metals in S1 in comparison with P1, P2 and P3

Soil Sample	Cadmium (µg/g)	Chromium (µg/g)	Lead (µg/g)
S-1	1.26±0.89	12.32±1.16	9.14±1.48
Plant Samples	Cadmium (µg/g)	Chromium (µg/g)	Lead (µg/g)
P-1	0.68±0.62	6.52±1.64	0.76±0.25
P-2	0.24±0.16	4.83±1.02	0.51±0.17
P-3	0.46±0.23	7.29±2.13	0.86±038

3(b) Concentration of metals in S2 in comparison with P1, P2 and P3

Soil Sample	Cadmium (µg/g)	Chromium (µg/g)	Lead (µg/g)
S-2	3.24±2.12	2.34±1.29	11.36±2.01
Plant Samples	Cadmium (µg/g)	Chromium (µg/g)	Lead (µg/g)
P-1	1.56±0.67	0.92±0.72	0.94±0.59
P-2	1.18±0.49	0.81±0.64	0.78±0.43
P-3	1.79±0.92	1.26±0.97	0.97±0.61

3(c) Concentration of metals in S3 in comparison with P1, P2 and P3

Soil Sample	Cadmium (µg/g)	Chromium(µg/g)	Lead (µg/g)
S-3	10.32±1.41	2.83±0.84	5.84±2.14
Plant Samples	Cadmium (µg/g)	Chromium (µg/g)	Lead (µg/g)
P-1	5.94±1.28	0.81±0.09	1.59±0.83
P-2	4.57±1.19	0.54±0.07	1.17±0.46
P-3	6.29±1.34	0.97±0.16	1.77±0.94

3(d) Concentration of metals in S4 in comparison with P1, P2 and P3

Soil Sample	Cadmium (µg/g)	Chromium (µg/g)	Lead (µg/g)
S-4	0.93±0.38	0.59±0.06	0.69+0.20
Plant Samples	Cadmium (µg/g)	Chromium (µg/g)	Lead (µg/g)
P-1	0.32±0.16	ND	0.14±0.08
P-2	0.14±0.07	ND	ND
P-3	0.36±0.18	ND	0.21±0.06

3(e) Concentration of metals in S5 in comparison with P1, P2 and P3

Soil Sample	Cadmium (μg/g)	Chromium (μg/g)	Lead (μg/g)
S-5	ND	ND	0.49±0.19
Plant Samples	Cadmium (μg/g)	Chromium (μg/g)	Lead (μg/g)
P-1	ND	ND	ND
P-2	ND	ND	ND
P-3	ND	ND	0.16±0.08

The above table's shows that the concentrations of cadmium, chromium and lead are higher in soil samples obtained from the industrial areas when compared with those obtained from the non-industrial areas. The concentrations of the trace heavy metals in the plant samples were higher in the industrial area than the non-industrial area. However, chromium was not detected in the plants from non-industrial areas. There is no doubt that heavy metals present in soil naturally and non-degradable, and can be accumulated in the plants. There are concentrations of trace heavy metals in the plant samples of Industrial areas. Chemicals such as dyes and other finishes of industrial activities lead to an increase in the concentration of heavy metals in the soils. Moreover, direct and indirect discharges of industrial effluents, dumping of metallic products and atmospheric deposit can lead to high levels of heavy metals in soils.

IV. Conclusions

The quantitative analysis shows the presence of trace heavy metal concentrations in the analyzed soil and plant samples. Heavy metals are known to be biomagnified in the tissues of the consumers along the food chain. Moreover, the short food chain between plant and man as an herbivore makes the efficiency of transfer from plant to man very high. Hence the level of heavy metals in man can easily increase. From these results it may be concluded that cultivation around industrial areas should be minimized and discouraged as much as possible.

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