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Study of Levels of Heavy Metal in Soil under Amravati Municipal Juridiction, Maharashtra (India)

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Abstract : The study involves the atomic absorption analysis of six selected heavy metals lead, cadmium, zinc, copper and chromium pollution in the soil sample of Amravati municipality, Maharashtra. A total of 160 surface soil samples (0-5 cm.) and 160 sub-surface soil sample (10-15 cm.) were collected from industrial, agricultural, road side and residential area. The result shows that the level of cadmium and copper exceeded the recommended level. Lead and zinc pollution was found only in the industrial area cobalt pollution was found in the industrial and road side area. There was no chromium pollution in the soil samples analyzed.

Key Words : Atomic Absorption Spectroscopy, Heavy metals, pH, Organic content

Introduction

As far as the impact of the environmental pollution is concerned, heavy metals are known to be most harmful like most organic pollutants. The metals are not biodegradable or perishable. When heavy metals are carried into the soil, they will accumulate there with time and enter into the biosphere or the food chain causing harm to human health (Xing and Ching, 2004).

The high density, heavily populated areas with activities, such as sewage and sludge disposal, with high concentration of traffic and automobile combustion are prone to danger of soil contamination with heavy metals especially Mn, Cu, Ni, Fe and Zn (Maharaju, 2010).

The Index of geo-accumulation, enrichment and contamination factor invariable shows that the soil from residential area is moderately contaminated with Cr, Ni and Pb (Cu to some extent). The agricultural soil indicated relatively less contamination indices and it is presumed that plant/crop uptake of these elements along with other macro and micro nutrients during its growth has effectively removed the toxic metals from the soil (Dasaram *et al*., 2011)

The numbers of factor are responsible for the type of pollution *viz.*, geo-climatic conditions, rate of urbanization, improper waste management, other anthropogenic causes etc. almost all these elements that contaminated the system get readily absorbed by plants and then to animal and are relatively toxic at levels slightly above than required for maintaining normal metabolic activities of the body (Chakraborthy *et al*., 2004). This work aimed to increase the awareness of effect of heavy metal pollution on human being. Heavy metal pollution is a major environmental problem threatening to biological system that is least studied in fast growing Amravati municipal area of Amravati District.

Materials and Method

The study was conducted in Amravati municipality which covers 36.26 square kilometer of Amravati District. Amravati is divided into 41 wards. Cotton is the main cultivation of this area. A total of 160 surface soil samples (0-5 cm) and 160 sub-surface soil sample (10-15 cm) were collected from industrial, agricultural, road side and residential area. The metal content were analyzed by Flame Atomic Absorption Spectrometry (FAAS) in the Environmental Impact And Risk Assessment (EIRA) Division, National Environmental Engineering Research Institute (NEERI), Nagpur.

Results and Discussion

For convenience of study Amravati Municipality was divided into industrial area, agricultural area, road side and residential area. In this

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municipality there was no major industries but a number of small scale industries are functioning in south-east side of city. The major part of municipality comprises residential area and agricultural area and main cultivation is cotton (*Gossypium hirsutum*), wheat (*Triticum astivum*), jowar (*Foeinocular valgure*), tur (*Cajanus cajun*), soyabeen (*Glycin max*), orange (*Citrus sp.*) garden and vegetable garden are common. The discussion here will be limited to six selected heavy metals namely lead (Pb), cadmium (Cd), zinc (Zn), chromium (Cr), copper (Cu) and cobalt (Co) (Table 1, 2, 3).

Table 1. Minimum, Maximum and Mean Levels (µg/g) of Metals of Various Study Areas:

Study Areas ?		**Industrial Area**		**Agricultural Area**		**Road Side Area**		**Residential Area**	
		Top Soil	Sub-Soil	Top Soil	Sub-Soil	Top Soil	Sub-Soil	Top Soil	Sub-Soil
Pb	Min.	7.9	0.5	0.8	1.5	11.3	11.8	6.1	5.1
	Max.	190.7	135.9	23.8	21.1	83.0	36.4	19.4	16.7
	Mean	99.0	68.2	12.3	11.3	47.0	24.0	13.0	11.0
Cd	Min.	6.2	6.5	3.7	5.2	6.8	6.4	0.4	0.4
	Max.	8.6	8.5	7.1	6.7	8.7	8.6	8.4	9.2
	Mean	7.4	7.5	5.4	5.9	7.75	8.5	4.5	4.8
Zn	Min.	94.6	40.0	85.2	85.7	100.7	113.8	89.4	98.4
	Max.	539.6	621.9	183.9	208.3	187.9	201.6	178.8	164.5
	Mean	317.0	331.0	135.0	147.0	144.0	158.0	94.1	132.0
Cr	Min.	44.6	47.4	16.5	31.4	53.9	53.3	4.1	50.0
	Max.	109.3	122.1	105.0	100.3	87.0	111.1	115.0	87.9
	Mean	77.0	85.0	61.0	66.0	71.0	82.0	60.0	69.0
Cu	Min.	53.9	34.3	46.2	49.0	123.0	145.1	112.9	119.0
	Max.	144.4	181.4	161.9	159.5	163.0	215.4	137.9	199.1
	Mean	99.0	108.0	104.0	119.0	144.0	167.0	126.0	160.0
Co	Min.	35.9	40.9	6.7	2.7	30.6	30.6	3.2	11.0
	Max.	44.5	47.6	7.8	29.5	45.1	48.0	31.7	39.3
	Mean	40.0	44.0	08.0	16.0	38.0	39.0	17.45	25.0

Table 2: Metal variation in surface and subsurface soil in different study area:

	Industrial Area		Agricultural Area		Road Side Area		Residential Area	
	Surface	Sub-Surface	Surface	Sub- Surface	Surface	Sub- Surface	Surface	Sub- Surface
Pb	99.0±0.02	68.2±0.14	12.3±0.05	11.3±0.4	47.0±0.13	24.0±0.22	13.0±0.35	11.0±0.22
Cd	7.4±.050	7.5±0.13	5.4±0.09	5.9±0.25	7.75±1.25	8.5±0.42	4.5±1.3	4.8±1.9
Zn	317.0±12	331.0±14.4	135.0±10.2	147.0±16.5	144.0±14.9	158.0±12.6	94.1±5.6	132.0±8.9
Cr	77.0±2.3	85.0±1.3	61.0±5.2	66.0±8.5	71.0±1.5	82.0±6.5	60.0±4.2	69.0±5.3
Cu	99. 0±4.2	108.0±8.4	104.0±5.2	119.0±9.4	144.0±4.2	167.0±9.1	126.0±12.0	160.0±9.4
Co	40.0±1.2	44.0±4.6	08.0±3.2	16.0±8.7	38.0±5.2	39.0±10.9	17.45±1.5	25.0±0.9

Table 3: Surface/Subsurface soil ratio in different study area:

	Lead	Cadmium	Zinc	Cromium	Copper	Cobalt
Industrial Area	1.451613	0.986667	0.957704	0.905882	0.916667	0.909091
Agricultural Area	1.088456	0.915255	0.918367	0.924242	0.873950	0500000
Road-Side Area	1.958333	0.911765	0.911392	0.865854	0.852071	0.974359
Residential Area	1.181818	0.937500	0.712879	0.869565	0.787500	0.698000

Lead: More than 95% of lead now cycling in the biosphere is anthropogenic in origin. As lead has less mobility and persistence for long time, it enters in the biological system and will cause harm to living beings including humans (Fig.1).

The motor vehicles, paints and dyes, batteries, pesticides, fertilizers, explosives and metallurgical industries mainly release the lead to the soil. The highest level of lead was recorded (190.7µg/g) in soil sample from Agro-chemical and Engineering work Industries. Mechanical works with metals, unscientific measures or approach to motor vehicles, use of petrol, diesel and their release resulted serious lead pollution here.

Agricultural areas near major cities receive some

Pb

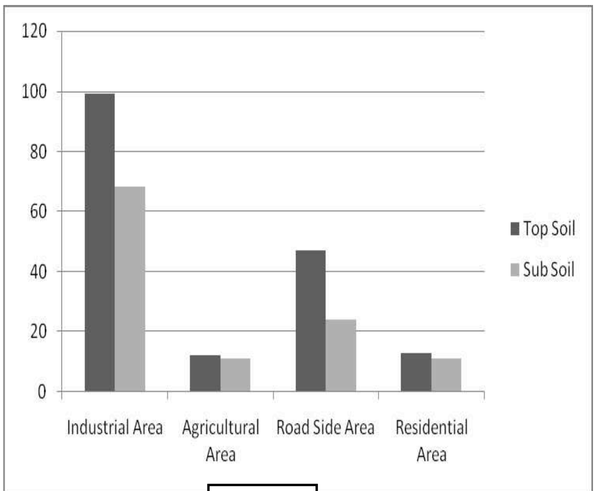

Fig. 1

Cd

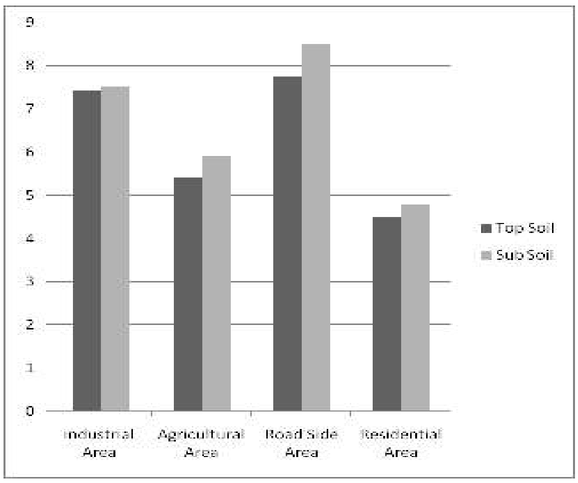

Fig. 2

lead from automotive emissions and metal industries emitting lead into the atmosphere.

Studies of a pastoral agro ecosystem near Adelaide showed that lead concentrations in surface soils had measurably increased up to about 50 km from the city boundary (Tiller *et al.*, 1987).

The roadside ecosystems are the natural targets of lead pollution. The roadside soils generally contain higher levels of heavy metals than other soils. The amount of Pb is higher in samples collected from the main roads and nearby soils of oil refinery (Smith and Flegal, 1995).

In the residential area though the value showed is little high most of the area is not polluted.

Cadmium: From the Fig. 2, it is clear that cadmium concentration is higher in subsurface soil samples, which indicates mobility and leakage of this metal. The study revealed that higher levels are strongly associated with human activities and automobile emissions. The levels of cadmium in both surface and sub-surface soil samples are higher than the permissible level. The wide use of metals paints and dyes in the industrial sites is the main reason for cadmium pollution in these soil samples.

Agricultural management practices that directly affect cadmium concentration and availability in the soil may influence the cadmium accumulation by crops. Specifically the addition of sludge or fertilizer having high cadmium concentration to agricultural land may cause significant increase in the uptake of cadmium by crops (Grant *et al.*, 1999). Soils treated with phosphate fertilizers showed an increase in concentration of cadmium.

High density traffic is pollutant for soil, water and environment (Koc *et al.*, 2004). The increasing concentration of heavy metals coincided with the increasing population and as a result increasing number of private and public vehicles in the city (Talebi and Bedi, 2004). The high value of cadmium in the subsurface of residential area has been noticed.

Zinc: The zinc content in surface soil samples varies from 85.2mg/g to 539.6mg/g with an average value of 172.53mg/g, whereas subsurface soil samples range from 40.0mg/g to 621.9mg/g with an average value of 192.0mg/g. High concentration of zinc was found to be associated more in the industrial locations than in residential areas (Claramma and Joseph, 2008). Even though, there was no sample showing zinc pollution, some subsurface and a few surface samples show higher levels, but never exceeded the lower limit or minimum level recommended for zinc concentration in soil shows a higher concentration of zinc in subsurface soil samples indicates continuous leaking of this metal (Fig. 3).

The higher concentration of zinc is present in Industrial area. In agriculture and farming there is extensive use of pesticides, fungicides and bio-solids along with fertilizers. These materials are good sources of heavy metals like zinc, lead, chromium, cobalt, cadmium and copper. The heavy metal concentration in soil is a result of soil forming processes, as well as agricultural and human activities.

Zn

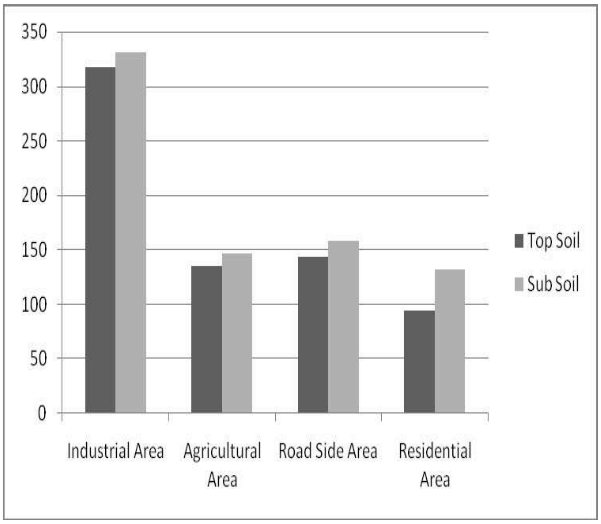

Fig. 3

Cr

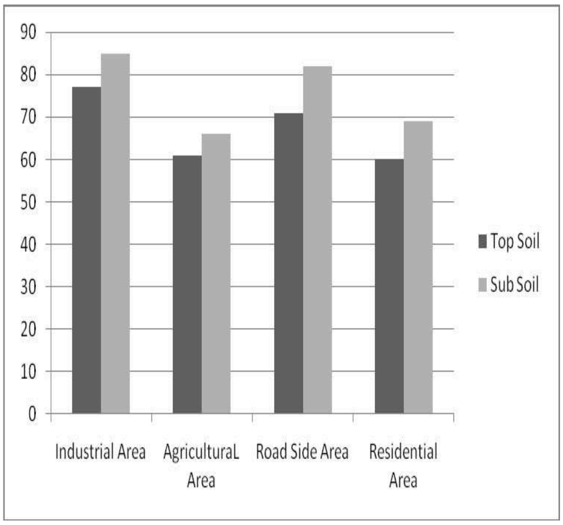

Fig. 4

Chromium: The chromium concentration is higher in subsurface soil samples, which indicates mobility and leakage of this metal. The chromium content in subsurface soil samples varies from 31.4mg/g to 121.1mg/g with an average value of 75.5mg/g, whereas surface soil samples range from 4.1mg/g to 115.0mg/g with an average value of 59.55mg/g. High concentration of chromium was found to be of subsurface soil sample in the industrial area. Chromium concentration in the agricultural area and residential area is near about same (Fig. 4).

Copper: The Fig. 5 shows a close average level in the roadside area and residential area but a higher accumulation of copper in the subsurface soil of roadside area probably continuous deposition and leaching. Roadside area is more-dry. The moisture content of the soil was important for Cu retention. Dry soil had higher Cu concentration than humid soil. One important peculiarity noted in Cu distribution is that when agricultural land is classified into different plantations/the mean concentration of Cu in the surface and subsurface soils are near about same or the ratio of cu in the surface to subsurface soil is unity. Extensive use of pesticides, fungicides and bio-solids along with certain fertilizers in agriculture and farming resulted in higher concentration of Cu in the soil. Application of animal manure and urban wastes on farmland and repeated application of copper containing pesticides concentrates copper in the soil (Van der Watt *et al.*, 1994).

Cobalt: The cobalt content in surface soil samples varies from 3.2g/g to 45.1mg/g with an average value of 24.15mg/g, whereas subsurface soil samples range from 2.7mg/g to 47.6mg/g with an average value of 25.15mg/g (Fig. 6). High concentration of cobalt was found to be of subsurface soil sample in the industrial area. The average concentration of cobalt in soils throughout the world is 8 parts per million (ppm) (MOEE 1993). The cobalt concentration is higher in subsurface soil samples, which indicates mobility and leakage of this metal. The cobalt concentration is found like above increasing order-

Residential Area > Road Side Area > Residential Area > Agricultural Area.

The concentration of heavy metals, lead, cadmium, copper, chromium, zinc and cobalt increases with increase in organic content in the soil (Wesley, 2004). The samples showing high levels of heavy metals had high organic content. A complication process occurs between heavy metals and organic carbon and results in the retention of heavy metals in the soil. The samples that showed highest levels of the heavy metals are collected from the soils of Industrial area. The organic carbon of this soil was 2.6 % and it was the highest value among other areas samples.

Increase in pH in the soil results in increase heavy metal concentration in the soil i.e. alkaline pH favors heavy metal accumulation in the soil (Claramma and Joseph, 2008). All the samples exhibited a positive correlation with pH (Table 4).

The highest value of pH 9.2 was noted in the sample from Industries. This sample had the highest concentration of heavy metals. Even though the higher pH favors heavy metal retention in soil it limits the heavy metal uptake by plants. The heavy metal uptake by plants decreases at higher pHvalued. But the acidic pH favors the uptake and causes harm to the living beings via, food chain.

Most of the samples analyzed had pH below 7, i.e., acidic in nature. This indicates that the uptake by plants was high and the biological system was already contaminated by the heavy metals. Soil pH and high organic content have a higher retention capacity of heavy metal in soil. The present study agrees with the findings of William and David (1976).

Cu

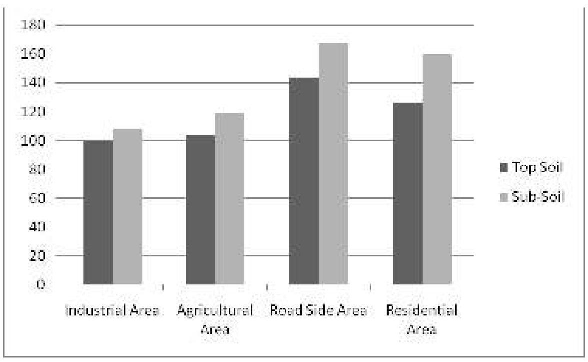

Fig. 5

Co

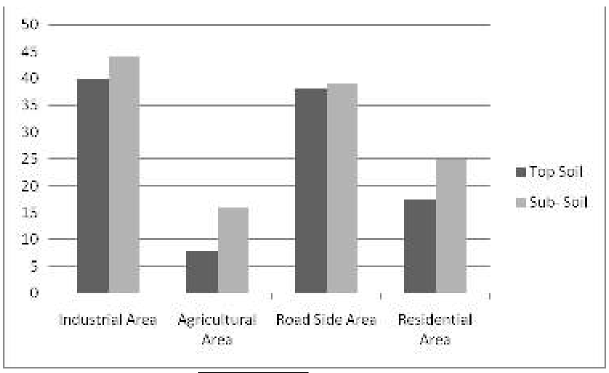

Fig. 6

Table 4: pH and OM variation in surface and subsurface soil in different study area:

	Industrial Area		Agricultural Area		Road Side Area		Residential Area	
	Surface	SubSurface	Surface	Sub- Surface	Surface	Sub- Surface	Surface	Sub- Surface
pH	9.22±0.4	8.25±0.3	7.10±0.2	7.21±0.3	5.91±0.5	5.84±0.4	8.42±0.2	8.11±0.5
OM(%)	1.53	1.68	10.31	11.10	3.46	3.59	5.20	5.68

Surface/subsurface ratios:

Table 3 records the ratios of surface mean metal content to mean subsoil content in the studied areas. Lead is markedly enriched in surface soil samples, general environmental contamination and arid conditions, particularly in the industrial area and along roadsides where the ratios 1.5 and 1.96 respectively. Al-Shayeb *et al*. (1995) reported that the lead content of Riyadh roadside was as much as 123.28μg g^{-1} in the top 5 cm layer and decreased to 39.56 μg g^{-1} at 10-15 cm. The most important reason for difference in these concentrations that lead is not very mobile, mostly accumulating in the top 5 cm of the soil profile. The ratio grades from lower value in the residential area to higher values in agricultural, roadside and industrial areas, with the highest values in the industrial areas.

Similarly copper enrichment was very obvious in industrial area soils. Soil samples show that all different metals were largely concentrated in the topsoil of industrial area soil. Cadmium, zinc and chromium have greater mobility and no significant difference between the top and sub soil levels. Cobalt enrichment was very obvious in roadside soils. Soil samples show that all-different metals were largely concentrated in the topsoil of roadside, confirming the automobile origin of these metals.

In the soils of Amravati the sources of large-scale pollution are not so much individual emitters as group of emission sources. Traffic volume, age of the road, prevailing wind etc. can affect roadside metal levels. Temperature is likely to influence the pattern of distribution of pollutants through its effects upon air movements.

Other major factors that affect heavy metal level in the soil are $CaCO_3$, cation exchange capacity (CEC) and clay content. Bansal (1997) reported that $CaCO_3$, acts as a strong adsorbent of cadmium, thereby affecting their availability. CEC has a negative co-relation with heavy metals. Increase in CEC of soil shows a decrease in heavy metal concentration (Bansal, 1997). Krishna Swami (2003) studied the cadmium adsorption capacity of Tamil Nadu soils and concluded that the cky present in it influenced Cd adsorption capacities of soil.

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