Environmental Effect on Heavy Metals in Roadside Plants of *Eucalyptus* and *Guaiacum officinale*

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Summary: Roadside plants (*Eucalyptus and Guaiacum officinale*) from controlled and polluted areas of Karachi city were analyzed for heavy metals. Leaves of these plants were taken for the study. Atomic Absorption technique was employed for the analysis. Levels of Pb and Cu were found to be elevated in leaves of industrial and high traffic density areas. Rain was found to influence the metal concentration. Pb and Co levels increased while Cu, Ni and Cd levels got decreased following rain. The collected data manifests that automobile exhaust and industrial wastes in urban areas of Karachi are causing pollution.

Introduction

It has been reported that plants are more sensitive to pollution than animals or man. Injury to vegetation caused by heavy metals has been well documented as a result of many botanical and chemical investigations during the past hundred years [1, 2].

The weather of Karachi is mostly dry and average numbers of rainy days are not more than 10 days per year. The total average annual rainfall is 6-8 inches (150-200 mm) [3]. Since it seldom rains here, the dry movement of major and trace elements to the ground would be largely, follow the sink mechanism [4].

Particulate type air pollutants such as ash, dirt and grit land on the top of leaves don't enter the leaf but may damage it by mechanical abrasion of the surface. Particulate matter can also block the sunlight and thereby reduce the food processing ability of the plants. Deposition of lead on leaves mainly depends upon the characteristics of the leaf surface and the wind speed, and to lesser extent on the other environment conditions like temperature, humidity, etc [5]. The plant growing near highways are usually exposed to more automobile lead discharge than any other location [2, 6]. Small amount of lead and other heavy metals can penetrate the cuticle probably through stomata and other openings. The stomata of plant growing on the roadside in central district of Karachi are blocked to the extent of 20-50 % depending on the location [7]. This shows that a serious problem has arisen now in the congested parts of the city. Tarry deposits have already started damaging plants and various sensitive species to the extent that they are dwarfed and color of leaves has changed from green to gray at some locations. The deterioration in quality of macro environment has thus exceeded the critical limit of adaptation of plants to stress situation.

Heavy metals along with other pollutants are discharged into the atmosphere through industrial activities (dye stuffs, pigments, drugs, agrochemical, plastics, batteries, zinc recovery operations, electroplating and metal surface cleaning agents and discharge of untreated effluents from these Industries), automobile exhaust, man made activities, pesticides use in agriculture etc. It has now been well established that people residing in urban areas are exposed to larger amounts of potentially hazardous elements like Ni, Co, Cr, Fe, Cu, Pb, Cd, etc than their counterparts [8].

The aim of this study was to estimate the concentration of Pb, Cu, Co, Cd, Ni in the leaves of plant growing along the road side in polluted, industrial, and relatively unpolluted areas of the city and to check the effect of rain on their concentrations.

Results and Discussion

Karachi has been declared as a mega city among the 20-mega cities of the world by global environmental monitoring system (GEMS) [9]. The soil of Karachi is partly residual, calcareous, derived from limestone, sandstone and dolomite, which are

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the dominant rock formations. It is partly alluvial being drifted from the high land deposition of the region [10]. There are more than 6,50,000 registered motor vehicles playing in Karachi, emitting exhaust laden with lead and carbon [1]. A mean concentration of 2989-ppm lead was found in street dust of Karachi. It has been calculated that about 28,447 kg of lead is being spread in to the environment of Karachi every year [3]. Lead levels of 100-300μg /g have commonly been reported both in soil and in ash of plants taken from the vicinity of the roads carrying a volume of traffic e.g. more than 10,000 vehicles/ day [11]. The air borne lead is usually present in the form of insoluble particulate matter and bulk of it is retained in the soil and sediments with very little present in water in the soluble form [12].

Lead in leaves

In Pakistan, lead (Pb) additives are still used as anti-Knock agents. The Pakistan standard specification for lead in ordinary petrol is 0.4 g/L and 0.84 g/L for super petrol [13].

The levels of lead in leaves of *Guaiacum officinale* (Table-1) and *Eucalyptus* (Table-2) were found to be the highest at Korangi Industrial area. This pattern has been the same for both dry and wet seasons. It may be due to the facts that along with high traffic density, a large number of various Industries are also present in this area. The levels of Pb in leaves of both species at Liaqatabad No. 10 were found higher than Orangi S.I.T.E and Gulshan-e-Maymar but less than Korangi Industrial area, although the traffic density is highest at Liaqatabad No. 10. This is because the accumulation of the metal at the surface of leaves may also depend upon "tunnel effect" [14] i.e. accumulation of metals is facilitated as a result of construction of multi-storeyed building along the busy roads of the city. The location of Liaqatabad No. 10 is a relatively open place and situated on the intersection of very wide road so that the Pb emitted from vehicles gets rapidly dispersed to a large area. It may also be due to presence of an overhead bridge so that a large number of vehicles that pass through the bridge emit smoke above tree levels (height).

Copper in leaves

The levels of Copper (Cu) in leaves of *Guaiacum officinale* (Table-1) and *Eucalyptus* (Table-2) at Liaqatabad No. 10 were found higher than at Orangi S.I.T.E and Gulshan-e-Maymar. This pattern is same for both dry and wet seasons. This is

Table-1: Levels (μg/g) of trace metals in leaves of *Guaiacum Officinale.*

	Location	Pb (μg/g)	Cu (μg/g)	Ni (μg/g)	Cd (μg/g)	Co (μg/g)
MARCH	L	49.33	18.83	40.08	1.56	2.87
2003	O	44.64	27.08	39.72	1.79	3.92
	K	79.72	47.01	48.78	1.41	4.128
	G	32.59	9.51	55.62	1.90	4.06
*JULY	L	64.43	15.91	10.67	0.071	6.25
2003	O	62.95	9.26	10.72	0.37	4.68
	K	95.07	21.76	6.40	0.44	4.18
	G	53.64	2.11	7.16	0.49	4.95

L = Liaqatabad No. 10; O = Orangi Industrial Area; K = Korangi Industrial Area; G = Gulshan-e-Maymar. *After Rains

Table-2: Levels (μg/g) of trace metals in leaves of *Eucalyptus.*

	Location	Pb (μg/g)	Cu (μg/g)	Ni (μg/g)	Cd (μg/g)	Co (μg/g)
MARCH	L	35.56	16.97	45.45	1.48	1.96
2003	O	16.11	13.85	12.21	1.18	3.83
	K	49.56	10.88	37.89	1.33	4.40
	G	19.15	6.68	9.55	0.84	3.84
*J ULY	L	57.84	4.37	9.37	0.59	3.97
2003	O	50.87	6.51	9.45	0.55	4.30
	K	61.10	5.46	8.29	0.35	9.44
	G	54.42	1.57	5.96	0.48	3.59

L = Liaqatabad No. 10; O = Orangi Industrial Area; K = Korangi Industrial Area; G = Gulshan-e-Maymar. *After Rains

because Cu mainly comes from automobile radiator, component of engine, thrust bearings and bearing metals [15] i.e concentration of Cu in leaves is directly related to the number of vehicles. Copper levels are found highest at Korangi Industrial area. This may be due to reason that $CuSO_4$ is also used in huge quantities in textile industries.

Nickel in leaves

Nickel (Ni) in leaves of *Guaiacum officinale* is found highest at Gulshan-e-Maymar (Table-1). It may because (a) Ni occurs naturally higher in vegetables and plants [2] (b) Ni is also found higher in soil of Gulshan-e-Maymar. (c) We may consider the domestic use of oil as a fuel in addition to coal, gas and wood. No significant difference is found in concentrations of Ni in leaves of *Guaiacum officinale* at polluted and non-polluted areas.

Ni in leaves of *Eucalyptus* (Table-2) is found highest at Liaqatabad No. 10 and lowest at Gulshan-e-Maymar. It is because Ni also comes from oil combustion, Ni alloy pipes and wear and tear of cars.

Cadmium in leaves

Cadmium (Cd) levels were found lowest in leaves amongst all the metals (Table-1). The level of

Cd in *Guaiacum officinale* were found highest at Gulshan-e-Maymar (Table-1). But in leaves of *Eucalyptus* it is found highest at Liaqatabad No. 10 and lowest at Gulshan-e-Maymar (Table-2). This is because Cd is used as an additive in tyres in the range of 20-90 μg/g [15], lubricating oil, metals plating. It also means that *Eucalyptus* is better indicator than *Guaiacum officinale* for checking Cd levels.

Effect of rain on metal concentrations

*Statistical significant effect of rain for a particular metal at different locations was determined by one tail paired t-test ($p = 0.05$, $\nu = 3$, $t_{tab} = 2.35$) [16].

Accumulation of Pb increases significantly in leaves of *Guaiacum officinale* ($t_{cal} = 12.46$) and *Eucalyptus* ($t_{cal} = 4.58$) at each location. This is because that the air dust contains mostly insoluble Pb compound [4] and a wet surface of leaves might absorb more metals than dry surface. Therefore rainwater enhances the Pb level in the leaves instead of diminishing it. It means that rain can act as an important agent for removing Pb from atmosphere.

Cu, Ni, and Cd levels decrease significantly ($t_{cal} > t_{tab}$) in leaves of *Guaiacum officinale* and *Eucalyptus* at each location. This is because most of the Cu, Ni, and Cd in air dust are soluble in water [4]. So rainwater removes these metals from the surface of leaves. There is an exception for Ni in leaves of *Eucalyptus* (($t_{cal} > t_{tab}$), it means that Ni is strongly adsorbed on surface of *Eucalyptus*.

Cobalt in leaves and effect of rain

No significant change in level of Cobalt (Co) in leaves of *Guaiacum officinale* (Table-1) and *Eucalyptus* (Table-2) due to rain is observed at Gulshan-e-Maymar but it increases at Liaqatabad No. 10, Orangi, and Korangi Industrial area. It means that Co in leaves mainly comes from air dust and wet surfaces of leaves absorb more Co than dry leaves.

Experimental

Sampling Sites

The sampling sites were divided into three main groups.

1. Industrial Area (Orangi and Korangi)

These have been chosen due to the fact that these are expected to be heavily affected by either or both of the vehicular traffic and Industrial waste.

2. Polluted Residential Area (Liaqatabad No. 10)

The area of Liaqatabad is heavily populated and also a large number of automobiles play through this area.

3. Controlled Residential Area (Gulshan-e-Maymar)

The area of Gulshan-e-Maymar is devoid of pollution causing agents.

Sampling procedure

Samples were collected in March 2003 (dry season) and July 2003 (during rainy season). The plant samples (*Eucalyptus* and *Guaiacum officinale*) were collected and transported to the laboratory in polyethylene bags. The plants were washed with distilled and de-ionized water and the green shoots were dried at 90 ^{0}C for 24 hours. Sample filters were kept in polyethylene bags to minimize sample loss until the time of analysis

Sample preparation and analysis

Plant samples were gently ground using electrical grinder. About 3 g of dried leaves was accurately weighed and treated with 20 ml of HNO_3:$HClO_4$ 2:1. The mixture was heated in a beaker until all matter dissolved and then cooled. The digested plant samples were then re-dissolved in 10 % $HClO_4$ to avoid precipitate formation. Here we did introduce $HClO_4$ but we had blanks prepared in the same medium. So the presence of $HClO_4$ could be minimized. Extracts were filtered through Whatman filter paper No.40, and the volume was adjusted to 50 mL with 10 % $HClO_4$ in polyethylene volumetric flask.

Reagent blanks for soil and plant filters were also prepared in the same way as those of samples. Metal analysis was carried out with a Flame Atomic Absorption Spectrometer (PERKIN ELMER-2380) [16]. The optimum conditions for the analyses of trace metals by F.A.A.S. are

Cd in *Guaiacum officinale* were found highest at Gulshan-e-Maymar (Table-1). But in leaves of *Eucalyptus* it is found highest at Liaqatabad No. 10 and lowest at Gulshan-e-Maymar (Table-2). This is because Cd is used as an additive in tyres in the range of 20-90 μg/g [15], lubricating oil, metals plating. It also means that *Eucalyptus* is better indicator than *Guaiacum officinale* for checking Cd levels.

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Metal	Wave Length (nm)	Lamp Current (mA)	Slit Width (nm)	Standard Concentration Range (ppm)
Co	240.70	30	0.2	0.04---10.00
Ni	232.00	30	0.7	0.09---8.00
Cu	324.80	10	0.7	0.01---4.00
Pb	217.00	15	0.7	0.10---12.00
Cd	228.80	8	0.7	0.004---1.80

Oxidant = Air, Fuel = Acetylene, Flow rate of fuel and oxidant = 10-14 ml/min, Air pressure = 60-80psi, Air flow = 40-45ml/min, Acetylenepressure=12psi.

Conclusions

The study has revealed that trees absorb particulate matters, soot and smoke and decrease the level of air pollution. The data collected shows that automobile exhaust and industrial wastes in urban areas of Karachi are generating almost all pollutants. Plants can act as an important sink for pollutants released through automobile exhaust, industrial discharges and other human activities in the absence of rain by dry deposition. The weather of Karachi is mostly dry so we must need to increase the number of trees for removing particulate matter from atmosphere [17].

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