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Heavy Metal Accumulation in Road Side Vegetation of Urban Areas of Karachi

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Lead and heavy metal accumulation in the tarry deposits on the leaves of trees and shrubs grown along road side of urban area has been determined. Samples of leaves were collected in summer and winter. Pb, Cu, Mn and Zn were analysed from the tarry deposit. The range of average concentration of lead was around 250 to 1155 ppm, copper around 845 to 100 ppm, manganese 171 to 650 ppm and zinc 103 to 706 ppm. The gravitational sedimentation and impact on vegetation of coarse fraction is responsible for high lead contamination. Areas of greater traffic density have vegetation with higher lead levels. The data collected shows that almost all the pollutants are being generated by automobile exhaust in the urban area of Karachi.

Key words: Tarry deposit, Heavy metals, Vegetation, Karachi.

Introduction

The use of motor vehicles has become wide spread, in industrialised as well as in developing countries. Alongwith its many advantages, vehicular traffic introduces dust, soot, carbon dioxide, sulphur dioxide, and carbon monoxide into the air. Exhaust gases of petrol engine contain CO, petrol vapour, aldehydes, straight chain and poly-cyclic hydrocarbons and lead. Lead is derived from the lead containing tetraethyl additives (Kovak 1985). In Pakistan lead additives are still used as antiknock agents. The Pakistan standard specification for lead in ordinary petrol is 0.4 g l^{-1} and 0.84 g l^{-1} for super petrol (PSI 1985). There are more than 6,50,000 registered motor vehicles playing in Karachi, emitting exhaust laden with lead and carbon. A mean concentration of 2989 ppm lead was found in the street dust of city. It has been calculated that about 28,447 kg of lead is being spread into the environment of Karachi every year (Yousufzai 1991).

Periodic surveys, carried out for the measurement of some air pollutants specially CO, smoke & particulate matter in Karachi city (Yousufzai *et al* 1970,1984,1987; Zaidi 1972; Chotani *et al* 1975; Beg 1982) have indicated high amount of pollutants. The uncontrolled motor vehicular emission of smoke and tarry material has started damaging important monuments such as Quid-e-Azam Mausoleum and Mere-weather Tower etc. The pollution specially smoke particles are carried away from M. A .Jinnah road by the air to far off distances. The analysis of dust deposited on the top window of Quaid's Mausoleum at a height of about 200 feet contain black particles of smoke and lead upto 0.006% in the deposited matter (Zaidi 1972).

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Particulate type air pollutant such as ash, dirt and grit land on the top of leaves. They do not enter the leaf but may damage it by mechanical abrasion of the surface. Particulate matter can also block out the sunlight and thereby reduce the food-making ability of plant. Deposition of lead on leaves depends upon the characteristics of the leaf surface as well as the wind speed, and to lesser extent on the environmental conditions (Agarwal 1991). The plants growing near highways are usuallys exposed to more automobile lead discharge than any other location (Sahu and Warrier 1985).

Small amount of lead can penetrate the cuticle probably through stomata and other openings (Arvik and Zumidah 1974). Removal of wax from the surface of the leaves due to tarry deposits increases the penetration of heavy metals. Foliar uptake mainly depends on the species, plant age and environmental variables. As low as 1 ppm of lead inhibits photosynthesis and respiration from the surface of the leaf (Miles *et al* 1972). The stomata of plant growing on the road side in central district of Karachi are blocked to the extent of 20 to 50% depending on the location (Beg and Iqbal 1989). This shows that a serious problem has arisen now in the congested part of the city. Tarry deposit have already started damaging plants and various sensitive species to the extent that they are dwarfed and colour 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 .

In recent years, there have been many investigations into the distribution and accumulation of lead discharged from motor vehicle exhaust. Most of these studies have involved analysis

of soil and vegetation taken at various distances from the centre of traffic flow along major urban or inter city high ways. Lead levels of 100-3000 $\mu g\ g^{-1}$ have commonly been reported both in soils and in ash of plants taken near roads carrying a high volume of traffice e.g. more then 10,000 vehicles/day (Ward *et al* 1975).

The primary objective of our study is to obtain relative estimate of total aerial burden of metals in the materials deposited on the surface of leaves which serve as sink especially for particulate matter in various areas of Karachi because the deposited particulate matter has changed the colour of the tree leaves growing along the roads from green to grey and plant growth has been adversely affected at traffic congestion points in the city areas.

Materials and Methods

Samples of tarry deposits were collected from leaves of trees at thirty two sampling sites mostly from the inter section of main roads where the traffic density was very high in the month of May, June and July for summer and December, January and February 1995 for winter where the traffic density was very high.

About 20 leaves from each tree were collected from different heights. Tarry deposits on the leaves were removed and washed with petroleum ether in a tarred dish with the help of brush. Samples of tarry materials were gently reflaxed with 2M nitric acid for 30 minutes .After cooling the flask, contents were filtered through Whatman 42 filter paper into a graduated flask and diluted to mark. All glass ware was extensively socked in dilute HNO_3 and rinsed twice with distilled water. Leaf area was measured by using a graph paper.

The analysis was performed by Hitachi Z-8000 atomic absorption spectrophotometer with Zeeman correction using air acetylene flame. Standard addition method was used for the determination of lead, copper, maganese and zinc. Daily average traffic was recorded from the data prepared by the Traffic Engineering Bureau (1993) Karachi Development Authority (KDA).

Results and Discussion

Present study describes the composition and quality of dust fall on the trees growing along the main roads of Karachi.

Quantity of tarry deposits and such heavy metals as lead, copper, manganese and zinc analysed in the tarry deposits on leaves are presented in Table 1 and 2 for summer and winter respectively. Results are given location wise and also include the average traffic density.

The maximum average concentration of tarry deposit in summer was 1647 mg m^{-2} found at Tibet Centre and minimum amount 764 mg m^{-2} was recorded at Sindhi Muslim Society. Tibet Centre is the busiest intersection in Karachi on M.A Jinnah Road where traffic is held up by traffic lights. Moreover the high-rise buildings are also located at both sides of the road which act as tunnel effect in this area. Here the daily average traffic density was recorded to be 4,24,156 which was earlier reported to be 94831 (Traffic Engineering Bureau 1993). The study carried out earlier at this location recorded 4831 mg m^{-2} of tarry deposit. The four fold higher concentration found in the present study may be due to the increase in the number of vehicles in Karachi during the past years.

The higher lead concentration at Tibet Centre, Lee Market, Lesbella Chock, Taj Mahal hotel and Sabil Masjid is due to

Table 1

Heavy metal accumulation on leaf at various locations in Karachi (Summer)

S. No	Locations	Pb ppm	Cu ppm	Mn ppm	Zn ppm	Tarry deposite mg m^{-2}	Daily average traffic
1	Sohrab Goath	365	257	426	701	4807	4,40,613
2	Water Pump	704	401	254	572	4874	N.A
3	Aisha Manzil	502	845	437	457	3475	N.A
4	Hussain Abad	684	442	627	397	3233	N.A
5	Liaquat Abad Market	367	109	427	373	2534	2,85,899
6	Liaquat Abad Chock	370	432	341	362	3060	2,65,775
7	Dak Khana	325	96	192	349	2283	2,97,341
8	Teen Hatti	491	121	241	552	2256	2,69,792
9	Gru Mandir	833	357	623	436	3692	3,19,431
10	Numaish	526	366	365	455	4653	4,66,625
11	Quaid-e-Azam Tomb	569	100	313	364	4662	6,32,335
12	Garden Road	506	179	296	367	5681	N.A
13	NIPA Chourangi	628	329	722	403	2905	3,23,249
14	Tibet Centre	1555	389	379	289	16416	4,24,156
15	Denso Hall	667	141	386	519	4471	N.A
16	Tower	551	120	297	706	4025	3,72,249
17	Nazimabad	356	310	466	447	3996	2,59,172
18	Habib Bank	351	144	650	575	2601	1,47,248
19	Empress Market	644	218	494	667	4735	N.A
20	Lesbella Chock	1208	556	418	547	6163	5,77,199
21	SITE	230	149	159	500	1441	1,46,,389
22	Lee Market	1451	512	452	429	4047	5,41,206
23	Taj Mahal Hotel	945	452	331	278	824	N.A
24	Metropole Hotel	231	184	187	255	1178	N.A
25	Shaheen Complex	291	145	180	195	1462	N.A
26	Chamber of Commerce	478	261	221	253	1908	N.A
27	Uni Plaza	681	137	211	150	885	N.A
28	Society	251	191	195	108	1836	1,06,428
29	Sindhi Muslim	250	169	162	180	764	N.A
30	PIDC House	220	147	110	174	1121	N.A
31	Jodhia Bazar	357	167	187	336	798	N.A
32	Sir Syed Road	289	126	171	103	1472	N.A
33	PCSIR Laboratory (control)	23	12	28	28	181	N.A
	Total Average	559	267	341	391	3383	
	Maximum	1555	845	722	706	16416	
	Minimum	220	96	110	103	764	

Table 2

Heavy metal accumulation on leaf at various locations in Karachi (Winter)

S. No	Locations	Pb ppm	Cu ppm	Mn ppm	Zn ppm	Tarry deposite mg m^{-2}	Daily average traffic
1	Sohrab Goath	288	141	127	493	3989	3,04,932
2	Water Pump	278	230	156	476	3992	N.A
3	Aisha Manzil	687	450	197	494	3883	N.A
4	Hussain Abad	682	482	373	340	3060	N.A
5	Liaquat Abad Market	388	458	297	280	3605	4,99,693
6	Liaquat Abad Chock	381	425	258	244	3255	2,06,945
7	Dak Khana	481	344	338	253	3017	2,64,692
8	Teen Hatti	409	161	178	274	4515	2,98,464
9	Gru Mandir	645	127	332	456	4374	3,13,211
10	Numaish	687	359	274	474	3347	4,41,735
11	Quaid-e-Azam Tomb	619	262	311	241	6540	4,17,892
12	Garden Road	800	229	242	540	9004	N.A
13	NIPA Chourangi	292	221	139	338	3414	3,15,488
14	Tibet Centre	1671	424	473	472	15827	3,44,262
15	Denso Hall	652	159	240	440	4486	N.A
16	Tower	641	383	177	594	4541	3,14,156
17	Nazimabad	378	397	160	206	4565	2,36,244
18	Habib Bank	805	304	684	460	3562	5,45,120
19	Empress Market	797	186	282	451	4943	N.A
20	Lesbella Chock	1412	533	356	460	8561	5,24,286
21	SITE	278	117	117	409	3223	140,,648
22	Lee Market	1191	363	460	461	4750	1,39,214
23	Taj Mahal Hotel	670	191	250	206	1534	N.A
24	Metropole Hotel	414	202	168	212	3945	N.A
25	Shaheen Complex	371	154	126	204	4175	N.A
26	Chamberof Commerce	577	150	194	260	3773	N.A
27	Uni Plaza	807	145	203	304	5922	N.A
28	Society	334	51	158	135	3562	1,52,314
29	Sindhi Muslim	290	79	115	139	2147	N.A
30	PIDC House	422	165	199	164	3412	N.A
31	Jodhia Bazar	487	155	158	25	3751	N.A
32	Sir Syed Road	275	135	127	98	2092	N.A
33	PCSIR Laboratory (control)	28	8	35	42	195	N.A
	Total Average	597	256	248	331	4524	
	Maximum	1671	533	684	594	15827	
	Minimum	275	51	115	25	1534	

higher traffic density in these areas where as at the Lee market the road is narrow and congested. The maximum lead concentration of 1,555 ppm was found at Tibet Centre. Most of the lead present in the atmosphere of urban centres is in the form of aerosols and particulate matter. The constant use of lead additives in gasoline is the main cause of lead in the urban environment of Karachi due to traffic.

The high concentration of zinc present in the tarry deposit on leaf may be due to the fact that most of the vehicles (60%) are using old out-dated imported tyres . These tyres are prone to tear off quickly as compared with new tyres and add more particles in the atmosphere as zinc is the component of tyres, copper and manganese are the component of engine (Miclke *et al* 1984). The average concentration of lead, copper, manganese and zinc are of same order of magnitude. All these metals present are correlated with the traffic density. This indicates that the metals present in the tarry deposit originate from vehicular emission.

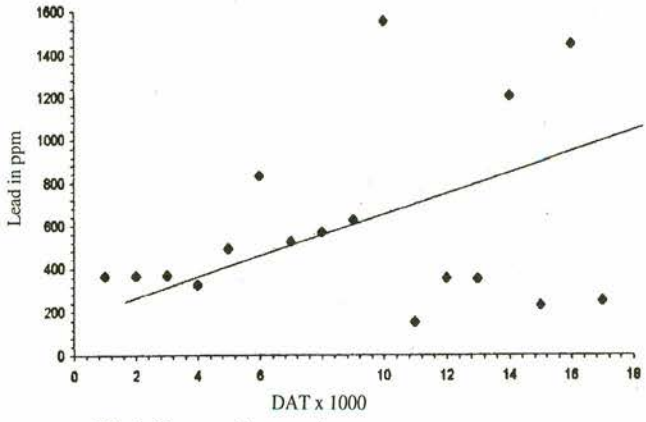

Fig 1. Scatter diagram for summer.

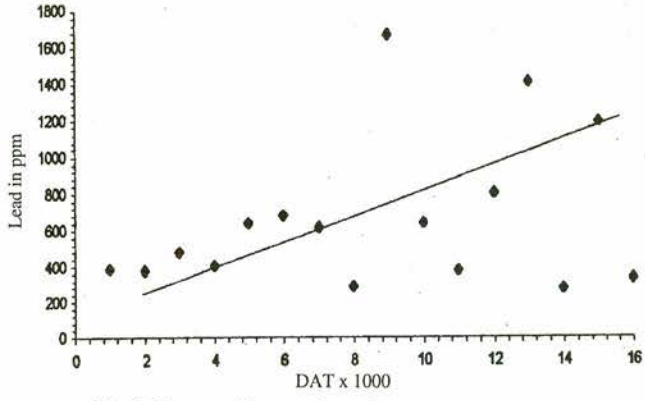

Fig 2. Scatter diagram for winter.

Table 2 shows the average concentration of heavy metal accumulation on leaf in winter. Highest concentration of tarry deposits 15827 mg m^{-2} was found at Tibet Centre and minimum 1534 mg m^{-2} at Taj Mahal Hotel. The average concentration of lead in tarry deposits was found to be 4524 mg m^{-2}. The maximum average concentration of 1671 mg m^{-2} in tarry deposit was recorded at Tibet Centre and minimum 228 mg m^{-2} at Sir Syed road. Maximum concentration of copper, manganese and zinc was found to be 533,684 and 594 mg m^{-2}. The minimum concentration of copper, manganese and zinc was found to be 51,127 and 98 mg m^{-2} respectively. Overall, heavy metal concentration in tarry deposits was higher in winter than summer. This may be due to low humidity in winter as compared to summer. The particles can remain in suspension for longer period of time and the blown up street dust is resuspended in the atmosphere. It has been reported earlier that the mean concentration of heavy metals in street dust contain 2989 ppm lead, 224 ppm copper, 349 ppm man-

ganese and 1169 ppm zinc (Agarwal 1991). This may be one of the causes of high concentration of tarry deposit in winter.

The data collected when compared with the control site (PCSIR Laboratories) shows that almost all the pollution (> 90%) is being generated by the automobile exhaust in the urban areas of Karachi. Mean lead levels in the tarry material deposited on leaf and daily average traffic (DAT) for 17 locations are presented in the form of scatter diagram for summer and winter as shown in Figures 1 & 2. A positive linear line between these two variables suggests that the lead present on the leaves may be ascribed to the automobile exhaust.

Conclusion

Continuous use of lead additives in Pakistan and the growing numbers of vehicles in Karachi has deteriorated the urban environment. The data collected show that almost all the pollution is being generated by automobile exhausts in the urban area of Karachi. Trees and shrubs not only beautify our cities but are also effective particulate interceptors. This ability of vegetation acting as sink for particulate matter contamination is specially beneficial in populated urban areas where ambient pollution level tends to be high.

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