"Measurement of Lead and Heavy metal Accumulation in the Soils of Urban Area of Karachi"

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Summary:Lead and heavy metal accumulation in the soils of urban area of Karachi has been determined. The measurement of these heavy metal accumulation in soil appears to be a useful tool for evaluating the potential hazard of the environment. Samples of the soils were collected from various intersections of major roads where traffic density was very high. The range of average concentration of lead was around 61 to 635 ppm, copper 58 to 196 ppm, manganese 64 to 186 ppm and zinc was 56 to 301 ppm. The gravitational sedimentation and impact on vegetation of coarse fraction is responsible for the high lead contamination of vegetation and soils. The data collected shows that almost all the pollution is being generated by automobile exhaust in the urban area of Karachi. Soil acts as important sink for pollutants released through different activities.

Introduction

Economic development has always been accompanied with the problems of environmental pollution. An improved standard of living and increased demand on the transport sector and rapidly increasing population lead to congestion in cities, to noise, toxic and corrosive fumes, less room for pedestrian and to a growing number of injuries and death. It is generally accepted that since the advent of Industrial times human activities have had a major impact on the global biogeochemical cycles of many trace elements. The biogeochemical cycle specially of Lead has possibly been affected by man to a greater degree than that of most other heavy metals. In a study of historical emission pattern, it has been estimated that human activities over the hundred years period from 1880-1990 have resulted in a doubling of Lead concentrations in soils in some parts of Sweden [1].

Lead contamination arises from the combustion of petrol, to which alkyl lead compounds in the form of tetraethyl lead and tetramethyl lead have been added during refining as an antiknock agent, in order to prevent the fuel from spontaneously exploding before its ignition by spark plug [2]. Lead was first introduced into the gasoline in 1923 to make the fuel burn evenly and prevent spontaneous combustion [3]. Lead additives are being used antiknocking agents in Pakistan. Lead standards were established in 1985 and are still being used in Pakistan. These standards allow refineries to put 0.6 g/lit. of Lead in ordinary petrol and 0.84 gm in super petrol [4].

In USA about 140 to 150 million tons of pollutants are given off to the air every year. Industries account for 20 to 30 millions tons, space heating 10 to 15 million tons, refuse disposal 5 to 10 million tons and the motor vehicles 90 million tons or more [5]. The principle source of lead in the urban atmosphere is the combustion of leaded petrol used in the automobile. Transportation source contribute 60-70 % of total air pollution. There are more than six hundred and fifty thousand registered motor vehicles plying 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 [6].

In recent years there have been many investigations into the distribution and accumulation of lead discharge from motor vehicle exhaust. Most of these studies have involved analysis of soil taken at various distances from the centre of traffic flow along major urban or inter city high ways. Lead levels of 100-3000 μg/g have commonly been reported both in soil and in ash of plant taken near roads carrying a high volume of traffic e.g. more than 10,000 vehicles/day [7]. The air born 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 ih water in the soluble form [8].

Soil acts as an important sink for pollutants released through industrial discharges and other human activities. Soils are mostly contaminated by pesticides, trace metals, industrial waste, oil, mineral acids and other substances. This function is irrespective of whether the pollutants have been released into the air, river or directly to the soil [9].

Lead has been found to be one of the major elements of air pollution in the urban environment. Growing air pollution has led to an increase in the respiratory diseases, cardiovascular deaths and infant mortality. Very high number of vehicles consuming leaded gasoline are the major cause of high lead level in the environment of Karachi. Lead and other heavy metals in the environment are strongly adsorbed on to sediments, plant foliage and soil. The measurement of lead accumulation in soil appears to be a useful tool for evaluating the potential lead hazard of the environment. The main objective of this investigation is to estimate the content of heavy metals with particular reference to lead in the soil of urban areas of Karachi.

Results and Discussion

Karachi is located in a semiarid zone on the coast of Arabian Sea between Lat: 24°.52 N, Long: 67° E. It is also a sea shore and a busy port encountering both the sea and land breeze periodically. The city is growing rapidly because it is the biggest industrial and commercial centre in Pakistan and offers immense employment and business opportunities. Annual growth rate of Karachi is about 6% of which approximately half are new comers from the up country [10]. The total population is now estimated to be more than ten millions. Karachi has been declared as a megacity among the 20 megacities of the world by Global Environmental Monitoring System (GEMS) [11]. No attempt has been made in Karachi to assess the contribution of various emission sources of heavy metals to the total aerial burden and their accumulation in soul of parks and small gardens of the city. Urban smoke and cement dust from uncontrolled cement factories, lead from gasoline in street dust, all are the major sources affecting soils and biota in the city [12-14]. Dramatic expansion of the city and poor conditions of the road network has further aggravated the pollution problems.

Thirty two samples of soils were collected from small gardens near major intersections, roundabouts and flower beds along the busy roads. Samples were collected from four directions of the roundabouts and parks in the month of Sept, Oct and Nov. 1995. Analysis of these samples were carried out for Pb, Zn, Cu and Mn. Total average concentration of these heavy metals are presented in table-1 along with the daily average traffic data.

The range of total average concentration of lead in soil was found to be between 61 to 635 ppm, copper 58 to 196 ppm, manganese 64 to 186, and zinc and 56 to 301 ppm respectively. The generated data has also been compared with the data collected earlier for the terry deposits on the road side tree leaves and heavy metals in the street dust.

Maximum average concentration of lead 635 ppm was found at Lesbella chowk and minimum concentration 61 ppm was recorded near Shaheen Complex. There are several automobile workshops located around Lesbella chowk and there is large parking place for hundreds of rickshaws near this round about. The high concentration of lead may be due to these workshops. Moreover this intersection is also one of the busiest having an average traffic density of 5,77,199 vehicles per day. The highest concentration of lead found at this place can be attributed to the high traffic density. Lead has been found to be one of the major toxic elements generated through the motor vehicles exhaust using leaded gasoline. It is a non degraded pollutant and it not only accumulate in the body but also modifies itself as it moves through biological cycles and food chain [15].

PCSIR Laboratories is located about 20 km away from the city centre in the down wind direction. This site was used as background site in this investigation. The highest concentration of lead found in the urban area of Karachi was more than 60 times greater than the lead found at background site of Karachi (location number 22 and 33). The high increase in the concentration of lead in the urban

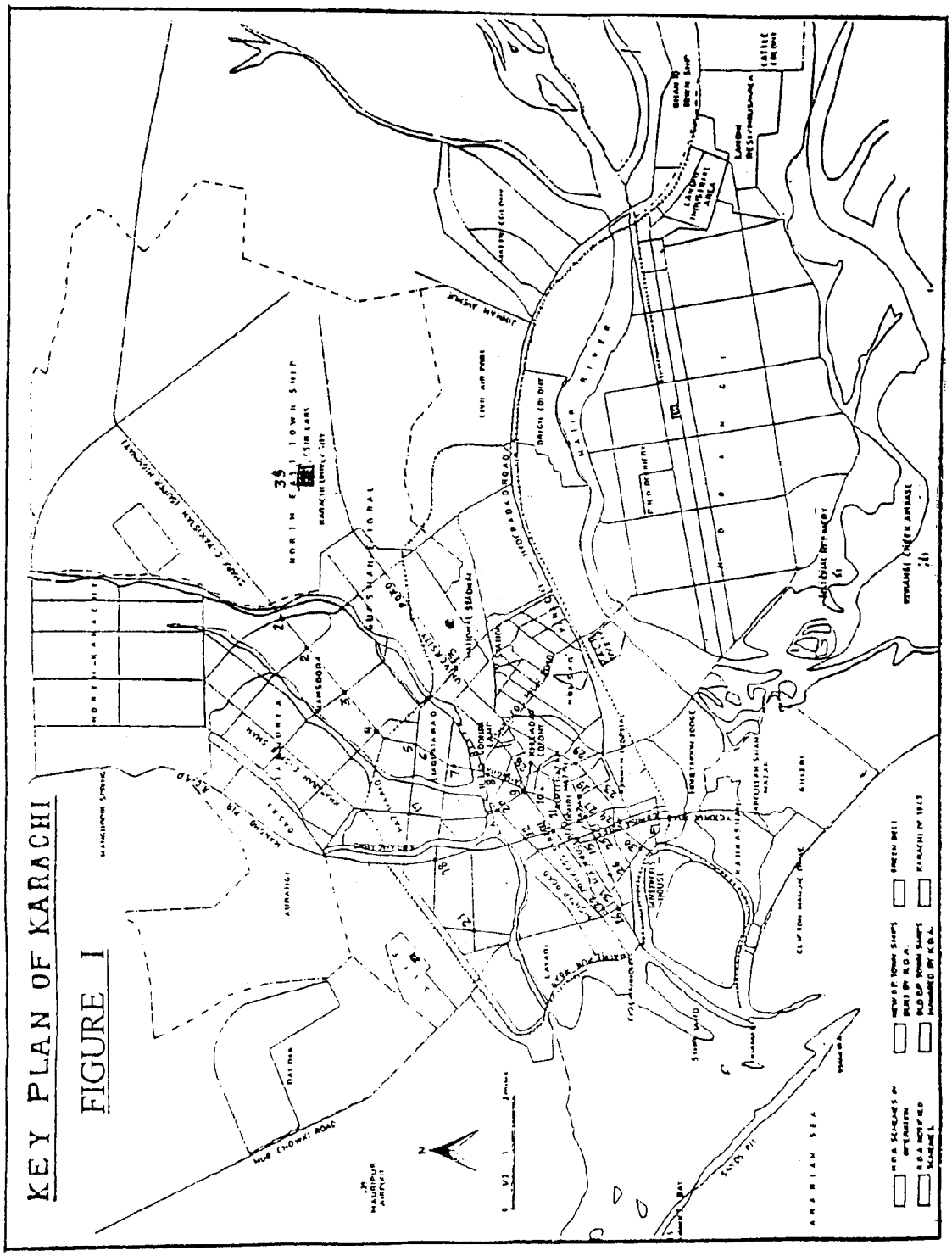

Fig. 1: Plan of Karachi

area is due to very high number of vehicles plying (5,77,199, vehicles per day) at this intersection. Whereas at background site the daily average traffic was only 1631. The average concentration of lead was found to be 10 ppm, zinc 11 ppm, copper 6 ppm and manganese 12 ppm. The data collected for soil from other locations when compared with the background site (PCSIR Laboratory) shows that almost all the pollution (> 90%) is being generated by the automobile exhaust in the urban area of Karachi. The study conducted to compare road side soils of some rural and urban parts of Zagreb also shows seven time greater concentration of lead in the urban soil than the average background concentration [16].

Figure II shows the distribution pattern of total average concentration of lead, copper, manganese and zinc at various locations in the urban areas of Karachi. The distribution pattern of total average concentration of lead shows that relatively high concentrations of lead was found at, Lesbella chowk, Lee Market Grumandir, Uni Plaza and Tibet Centre. These are the areas where traffic density was usually high, whereas at Lee market the road is narrow and congested. The factor responsible for tremendous increase in pollution level at Tibet centre and Uni Plaza are multistoried buildings located at both sides of the road which also produce a tunnel effect in this area. A definate correlation was also observed between the heavy metals in most of the location. The lowest lead level 61 ppm was found at Shaheen Complex round about. The low lead value obtained here may be because the location is a relatively open place and situated on the intersection of very wide road (400 ft) having large round about.

The trend of heavy metals accumulation can be observed from table-1. The highest deposits of heavy metal concentration were found in the street dust than in the tarry material deposits on leaves and lowest in the soil. The maximum concentration found in street dust may be because the vehicular emissions are at the ground level, which readily deposits on the street dust. The particles of all sizes ultimately deposits on the street dust. The relatively lower concentration of heavy metals deposits found in the tarry material deposited on the leaves grown along the main roads in the urban area of Karachi. This can be explained by the fact that the gaseous emissions from the vehicles which contain carbon and unburned fuel along with the decomposition product of tetra ethyl lead additives in gasoline. These are relatively lighter particles blown up by the moving traffic and form agglomerates during the time between emission and deposition. Moreover 60% of the vehicles plying on the roads of Karachi are old and prone to emit smoke. The auto rickshaws use a mixture of motor oil and petrol and they do not use specified silencer, thus emits black smoke along with unburned fuel. These auto rickshaws are a major contributor of tarry material. The lowest concentration of heavy metals was found in the soil. The low concentration of heavy metal found in the soils because the parks and roundabouts are few meters away from the main roads. The deposits may be due to the blown up dust, further more periodical mixing of manure and fresh soil were the main causes of low concentration of heavy metals found in the soil.

The importance of air born sources in verified by the concentration of lead in plants and soils along heavily congested highways. The air born particles are moved far from the point of exhaust and are an important factor in determining the lead content in foods. There are various factors responsible for the deposition of tarry deposits and lead on the leaves of road side trees. The major factors are meteorological conditions and particle size. The direct deposition of lead on the surface of lead and on the soil is still not fully understood, however behaviour of this element in soil would suggest that much of the lead in food crops comes from atmospheric contamination.

Deposition of lead is not only depends on the number of vehicles but also on surface run off, particle size, wind direction, wind velocity and humidity. Soil lead is largely unavailable to plants. Lead is quite insoluble in soil, especially if the soil is not too acidic. Most lead is found in the surface soil indicating little downward movement. The highest lead concentration was usually found at 0.5 cm depth [17]. It is obvious that soils are only a part of biological cycles relative to heavy metals and other inorganic toxic contamination. At the same time, soils are the ultimate depositories of large quantities of these compounds. Further more, the variety of chemical reactions which these elements undergo in soils controls to a considerable extent, their rate of

Table-1: Mean concentration of heavy metal accumulation in soils, compared with deposits on leaf and street dust in the urban area of Karachi, Pakistan

S.No.	Locations	Soil					*Tarry Deposits on Leaves				**Street Dust			
		Pb ppm	Cu ppm	Mn ppm	Zn ppm	Daily Average Traffic (DAT)	Pb ppm	Cu ppm	Mn ppm	Zn ppm	Pb ppm	Cu ppm	Mn ppm	Zn ppm
1	Sohrab Goath	196	68	121	194	440419	365	257	426	701	1615	139	159	346
2	Water pump	214	90	116	122	N.A	705	401	254	572	N.A.	N.A.	N.A.	N.A.
3	Aisha Manzil	152	98	110	103	N.A.	503	845	437	457	810	87	128	244
4	Hussainabad	241	131	145	119	109965	685	442	627	397	2112	115	229	1005
5	Liaquatabad Market	231	89	108	106	283852	367	109	427	373	3517	274	321	1217
6	Liaquatabad Chock	209	96	112	92	265162	370	432	341	362	3923	256	386	1181
7	Dakkhana	215	83	102	111	397038	325	96	192	349	3117	315	331	1640
8	Teen Hatti	219	95	129	149	169188	491	121	241	552	2722	187	280	1324
9	Sabil Masjid	250	120	195	136	319816	833	357	623	436	2986	174	319	1448
10	Numaish	227	94	118	151	662602	526	366	365	455	2798	162	387	764
11	Quaid-e-Azam Tomb	208	69	102	129	632908	569	100	313	364	2677	181	305	638
12	Garden Road	239	91	100	116	N.A.	505	179	296	367	2027	361	427	817
13	NIPA Chourangi	201	76	86	109	325252	628	329	722	403	1317	46	176	112
14	Tibet Centre	363	104	136	121	N.A.	556	389	379	289	4527	275	481	2215
15	Denso Hall	98	92	106	108	N.A.	167	141	386	519	1272	148	132	1095
16	Tower	92	90	99	181	372523	151	120	297	706	2955	230	327	955
17	Nazimabad	195	101	101	102	259758	356	310	466	447	3411	198	330	540
18	Habib Bank	184	86	109	119	147694	351	144	650	575	1212	144	187	897
19	Empress Mrket	101	102	191	214	N.A.	144	218	494	667	2746	185	227	1671
20	Lesbella Chock	635	196	186	301	177298	1208	556	418	547	N.A.	N.A.	N.A.	N.A.
21	SITE	109	82	96	139	N.A.	282	149	159	500	N.A.	N.A.	N.A.	N.A.
22	Lee Market	465	110	114	141	141399	1451	512	452	429	2330	210	360	803
23	Taj Mahal Hotel	349	79	94	91	146526	945	452	331	278	2604	144	375	564
24	Metropole Hotel	190	85	69	99	92207	231	184	187	255	2445	254	227	270
25	Shaheen Complex	61	72	97	84	N.A.	91	145	180	195	N.A.	N.A.	N.A.	N.A.
26	Chamber Commerce	93	84	89	76	N.A.	178	261	221	253	3119	227	213	1219
27	Uni Plaza	272	69	92	69	N.A.	1681	137	211	150	1532	191	210	290
28	Society	103	65	86	56	51628	361	191	195	108	1228	57	125	241
29	Sindhi Muslim	99	58	64	79	146023	150	169	162	180	1030	127	202	286
30	PIDC House	85	67	81	64	N.A.	220	147	110	174	N.A.	N.A.	N.A.	N.A.
31	Jodia Bazar	91	78	91	94	N.A.	157	167	187	336	N.A.	N.A.	N.A.	N.A.
32	Sir Syed Road	94	60	79	66	N.A.	289	126	171	103	N.N.	N.A.	N.A.	N.A.
33	PCSIR Laboratory	10	6	12	11		23	12	28	28	4	3.2	4.2	5.5

*Leaf; A.H. Yousufzai, et al., Submitted for publication in *Pak. J. Sci. & Ind. Res.*, 09/97

Street Dust: A.H.K. Yousufzai, *Pak. J. Sci. & Ind. Res.*, **34(5), 167 (1991).

cycling, if not their removal from the cycle altogether.

The availability of lead to organisms in the environment is limited by its strong adsorption to environmental components such as oil, sediments, organic matter and biota. It is accepted that biomagnification of lead does not take place. However, environmental contamination with lead is widespread and organisms do accumulate high body burden [18].

Recently decrease in lead content of air, snow and soils have been reported with the reduction in emission of lead to the atmosphere following the phasing out of lead in petrol in many developed countries. Seventeen percent decrease in lead concentration between 1980 and 1990 was observed in top 4 cm of forest soils from the North - Eastern USA [19].

Relatively high concentration of zinc were found at Teen Hatti, Gru Mandir, Tibet Centre, Empress Market, Lesbella Chowk and Lee Market. The maximum concentration of Zinc in the soils was found to be 301 ppm at Lesbella chowk and lowest 56 ppm at Society. The highest concentration of zinc in soil at Lesbella chowk may be due to the fact that this area is mostly surrounded by the automobile workshops and has a high traffic density. Most of the vehicles (60%) plying on the road are using old and out dated imported tyres. These tyres are prone to tear off quickly as compared to new tyres and add more zinc in the soil as zinc is the component of tyres [20].

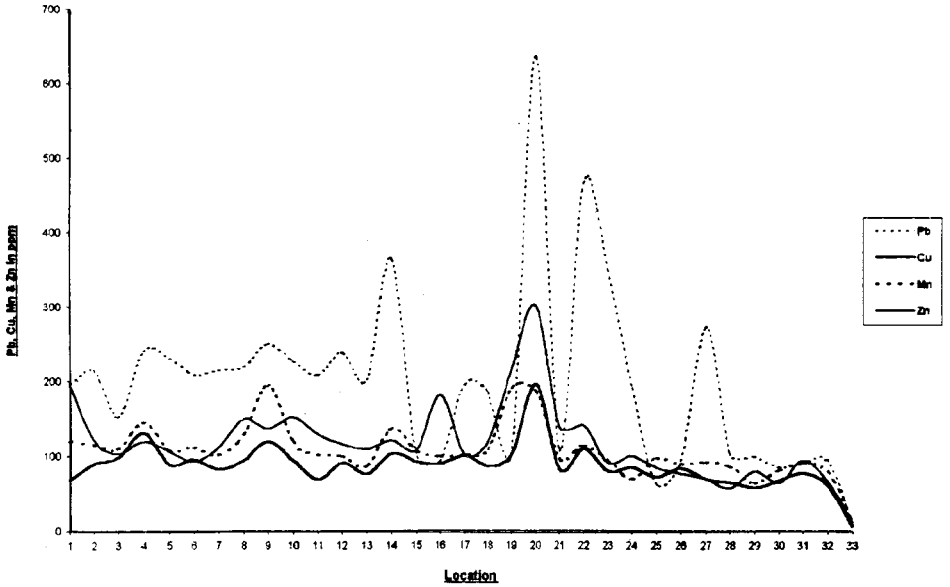

Fig. 2: Distribution pattern of total average Pb, Cu, Mn and Zn at various locations in Karachi, Pakistan

It can be observed from the graph that the maximum concentrations of both copper and manganese are found at Lesbella chowk. Copper and manganese both are engine components. The average values of lead, copper manganese and zinc are of same order of magnitude. All these metals present can be correlated with the traffic density. This indicates that the metals present in the soil originate mostly from the vehicular emission. Lead is used as antiknocking agent in petrol, copper is used for engine parts, manganese and zinc are the components of tyres and motor oil [21].

The reaction of copper, zinc and manganese in soil is definitely affected by the pH, organic matter content and oxidation reduction status of soil. At pH values 6.5 and above they tend to become only slowly available to plants especially if the are present in their high valent or oxidizing forms. The tendency of cations of these elements to form "chelate" in presence of organic matter also influences their behaviour. The heavy metals such as Zn, Cu and Mn have similar chemical characteristics and undergo similar reactions in soils [22].

The climate of Karachi is tropical and dominated by the monsoon region. The average rain fall in Karachi amounts to about 20 mm, and wind direction is SW in summer, and during winter it is usually in the NE. Wind velocity is 10 m/sec during the June - July and 3.5 m/sec from January to March. Because of dry climate in Karachi lead contamination in the soil is not easily eliminate nor fixed.

The working guidelines for lead in garden soils suggested that lead levels below 500 μg/g of soil as generally safe for gardening purposes and having low to medium potential for health hazard to children. Soil with lead levels from 500 to less than 1000 μg lead/g of soil are listed as being potentially hazardous to children due to health risk of soil lead. At lead levels equal to or greater than 1000 μg/g the soils are considered to be hazardous for children and replacement or other remedial action is recommended [23]. Although small amount of lead is toxic to children playing in these garden and parks.

There is also evidence that lead aerosols collected on the sites of the buildings and plants are washed down into the soil during rain. This mechanism provides the link between traffic and elevated lead levels which can be observed from data already collected [6,11,13-15]. Moreover it was observed that some plant species in Karachi absorbed more heavy metals than the others [24].

The presence of high concentration of surface soil lead in inner city area present an obvious risk specially to children living in these areas. It has been established that particulate matter, soil and dust are the potential sources of lead in Karachi. The ingested poisonous levels of lead in young children is hazardous and this fact is well established by the scientists of modern era.

Experimental

Soil samples were collected from various roundabouts, small gardens, flowers beds and open spaces near the main roads of Karachi city. Soil samples were also collected next to side walks of round about at sites where grass or other vegetation was grown. The samples were collected from a depth between 5-12 cm. Fig. 1 shows the locations from where the samples were collected. Samples were dried at 120°C and homogenised, passed through 106 μm size sieve. 1 gram portions of prepared soil samples were gently reflexed with 2M nitric acid for 30 minutes. After cooling the contents were filtered through Whatman 42 into a graduated 50 ml flask and diluted to mark. All glass ware were extensively socked in dilute HNO_3 and rinsed with double distilled water.

The analysis was performed by Hitachi Z-8000 atomic absorption spectrophotometer with zeeman correction using flame. Standard addition method was used for the determination of lead, copper, manganese and zinc. Daily average traffic (DAT) was recorded from the data prepared by Traffic Engineering Bureau Karachi Development Authority (K.D.A.) [25]. Table-1 shows the mean concentration in ppm of lead, copper, manganese and zinc in the soil along with daily average traffic density at different intersections in the urban areas of Karachi.

Conclusion

Growing number of vehicles, leaded gasoline consumption and poor conditions of roads are the major causes of high lead and heavy metals level in the environment of Karachi. The data collected shows that almost all the pollution in soil is being generated by automobile exhaust. Soil acts as an important sink for pollutants released through industrial discharges and other human activities. It is suggested that in polluted areas, such species of plants should be grown which not only clean the atmosphere but also grow well in the polluted atmosphere.

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