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LEAD AND THE HEAVY METALS IN THE STREET DUST OF METROPOLITAN CITY OF KARACHI

A.H.K. YOUSUFZAI

PCSIR Laboratories Complex, Karachi-75280, Pakistan

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Street dust has been used as a mean of describing the level of heavy metals present in the metropolitan city of Karachi. Samples of road sides dust were collected in the months of April, May and June 1990 from forty one location along the intersection of major roads where traffic density was found to be high. Heavy metals such as Pb, Zn, Mn, Cu, and Cd were estimated. The range of average concentration of Pb was around 810 to 4527, Zn 112 to 2215, Cu 46 to 315, Mn 72 to 481 and Cd 0.2 to 4.5 ppm. The daily average traffic was also recorded. A definite correlation was found between mean lead level and daily average traffic. It was concluded that the major source of lead in road side dust of Karachi city was mostly contributed by leaded gasoline from vehicular traffic. Raising children in high leaded environment will definately have long term effect on mental and physical behaviour in future.

Key words: Street dust, Lead, Heavy metal, Traffic density, Correlation.

Introduction

Many additives are put into gasoline to ameliorate the quality of fuel. The most important, as far as air pollution is concerned, is the lead additive. Lead was first introduced into gasoline in 1923 [1] to make the fuel burn evenly and prevent spontaneous combustion when the fuel is compressed in the engine cylinder.

Lead is a natural constituent of air. But it is difficult to know the natural lead level in the absence of man's activities. Natural conditions are estimated to have consisted of 0.01ppm in food, 0.0005ppm in water, and 5x10 $\mu g/m^3$ in air [2]. Lead in air is mostly from silica dust with very small contribution from volcanic gases. The analysis of lead in annual ice layers from northern Green-land and the Antartic continent show an increase of lead concentration from less than 0.001 µg/kg at 800 BC to over 0.2 µg/kg today with sharpest rise occuring after 1940 which coincides with sharp rise in the use of tetraethyle lead in gasoline as an antiknock additive.

Transportation sources contribute over 60% of total air pollution now exists in the atmosphere of USA. There were six hundred fifty thousand registered motor vehicles in Karachi upto 31st Dec. 1990. Figure 1 shows the mean growth rate of various categories of vehicles during the years 1980 to 1984 and 1984 to 1989. Decrease in the growth rate has been observed during the period 1984-89 as compared to 1980-84. The decrease in growth rate of various categories was, motorcycles and scooters 8.52%, cars, jeeps and station wagons 1.99%, motorcycle rickshaws 4.34%, taxis 18.25%, buses, mini buses 20.85%, trucks 13.90% and other vehicles delivery vans, pick ups, etc. 50.2%. The present growth in the population of auto vehicles during past ten years in Karachi was 9.07% per year. It has been reported earlier [4] that the expected growth rate would be 20.8% per year but due to inflation and less industrial development in Karachi, growth rate during the past 10 years was reduced to 9.03% per year. Still this high rate of growth will obviously have more effect on some intersection than the other in the city.

Lead has been found to be one of the major elements of air pollution in urban environment. It is non -degradable pollutant with the result that it not only accumulate in the body but modifies itself as it moves through biological cycles and food chain [5]. The danger of lead pollution especially in children is now receiving particular attention because they absorb and retain about 50% of lead they ingest as compared with 8% absorbed and retained by adults [6].

There are several direct and indirect methods of estimating the lead levels in urban environment, and street dust has been used by many investigators for evaluating the potential lead hazard of environment [3-6,8,9].

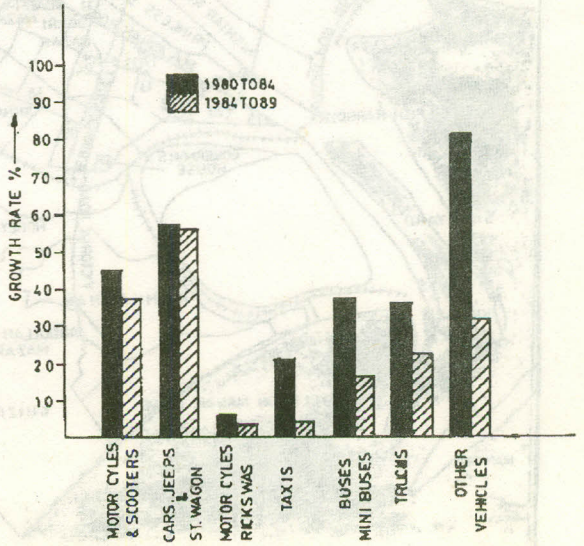


Fig. 1. Five years mean growth rate of vehicals.

The main objective of this investigation was to estimate accurately with the help of modern facilities now available, the content of heavy metals with particular reference to lead in the atmosphere of Karachi. It is presumed that this would bring awareness among masses to gaurd against the proliferation of this toxic hazard which if remained unchecked, would affect the health of millions of urban residents specially children.

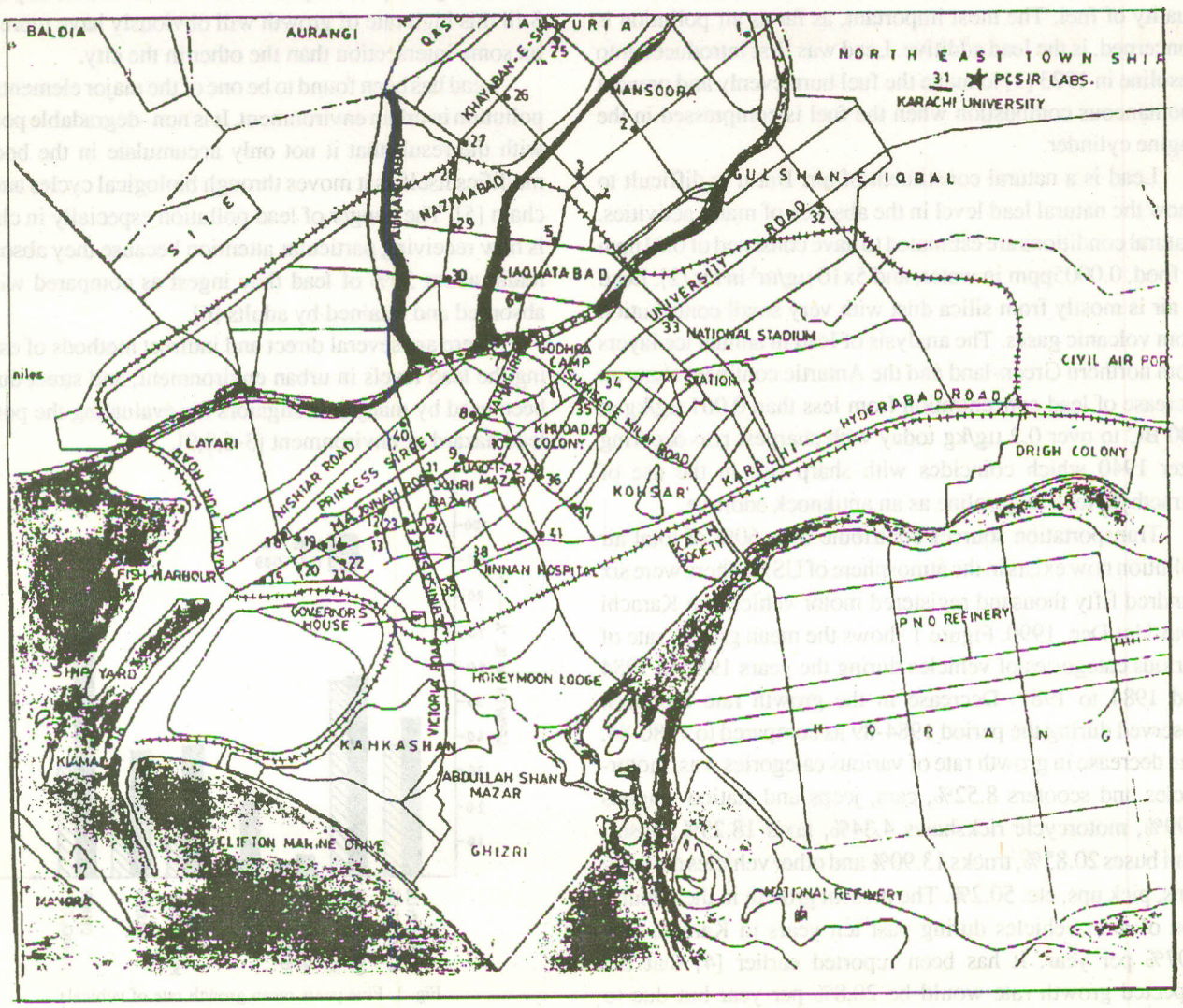
Materials and Methods

Samples of road side dust were collected from forty one locations along the intersections of major roads, where traffic density was found to be high. Most of the samples were collected along the M.A. Jinnah Road which passes from the centre of the city in SW to NE direction. Samples of dust and surface dirt were collected from large parts of the city from pavements, roads side gutters, foot paths etc. over an area within 15km of the city centre. Samples were also collected from Manora, an island 2km away from harbour. Figure 2 shows the different location from where the samples were collected.

Dust samples were dried at 120° and homogenised, passed through 106 µm size sieve. One gram portions of prepared dust samples were gently reflexed with 2M nitric acid for 30 mins. After cooling the flask content was filtered through whatman 42 into a graduated flask and diluted to mark. All glassware were extensively, soaked in dil. HNO_3 and rinsed with double distilled water [9].

The analysis was performed by Hitachi Z-8000 atomic absorption spectrophotometer with Zeeman correction using flame. The accuracy and precision was much better in flame due to high concentration of lead in samples.

Traffic density was recorded from the data prepared by the Traffic Engineering Bureau [7]. The survey was carried out on three working days especially Monday, Tuesday and Wednesday from 0700 to 2200 hrs. (15 hrs) at different intersections. The daily average traffic density was recorded in Table 1 alongwith concentration of lead, zinc, copper, manganese and cadmium in ppm.



Results and Discussion

Karachi has a population of nearly seven million and is growing about 0.2 million every year. The dramatic expansion of city and the poor condition of the road network has aggravated the pollution problem. Most of the business centres are situated on one side of the city and as such the traffic flow is mostly in one direction during working hrs.

Forty one road side dust samples were collected from large area of the city in the months of April, May and June, 1990. These samples were collected mostly from the intersec-

TABLE 1. MEAN CONCENTRATION (ppm) OF VARIOUS HEAVY METALS IN ROAD SIDE DUST AND DAILY AVERAGE TRAFFIC AT DIFFERENT INTERSECTION IN KARACHI.

S. No	Location	Lead	Zinc	Copper	Manganese	Cadmium	Daily average traffic
1.	Suhrab Goth	1615	346	139	159	0.9	60,246
2.	Aysha Manzil	810	244	67	128	0.8	N.A.
3.	Karimabad Chowrangi	880	283	87	118	1.7	N.A.
4.	Meena Bazar	2112	1005	115	229	1.9	57,947
5.	Liaquatabad No. 10	3923	1181	256	386	2.2	1.64,156
6.	Liaquatabad P.O.	3117	1640	315	331	3.0	1.09,965
7.	Teen Hatti	2722	1324	187	280	1.5	1,11,575
8.	Sabil Wali Masjid	2986	1448	174	319	2.2	1,01,474
9.	Numaish	2798	764	162	387	0.8	1,31,615
10.	Quaid-e-Azam Mazar	2677	638	181	305	1.2	1,29,675
11.	Tibet Centre	4527	2215	275	481	4.5	94,831
12.	Jamia Cloth Market	1272	1095	148	132	2.4	22,232
13.	Burns Road	3156	1873	305	330	2.8	42,565
14.	Boulton Market	1097	392	84	181	0.9	N.A.
15.	Tower	2955	955	230	327	2.8	78,490
16.	Kemari	3827	1251	290	345	3.8	N.A.
17.	Manora	969	290	310	173	1.0	N.A.
18.	Lee Market	2330	803	210	360	1.4	68,511
19.	Chaki Wara	1871	748	217	187	1.2	26,281
20.	Chamber of Commerce Bldg.	3119	1219	227	213	2.9	N.A.
21.	City Station	1532	290	191	210	1.2	20,330
22.	G.P.O.Mecllod Road	3527	929	256	381	0.9	N.A.
23.	Regal Saddar	2315	1767	171	245	1.8	22,232
24.	Empress Market	2746	1671	185	227	1.6	N.A.
25.	Nagan Chowrangi	997	630	89	72	0.6	44,956
26.	North Nazimabad Ch.	1812	264	170	201	0.9	86,007
27.	Sakhi Hassan	979	256	91	152	1.0	47,422
28.	Paposh Nagar	1013	337	152	227	0.8	N.A.
29.	Nazimabad Petrol Pump	3411	540	198	330	1.9	1,47,570
30.	Nazimabad Chowrangi	1212	897	144	187	1.3	46,988
31.	PCSIR Labs. Complex	4	5.5	3.2	4.2	–	N.A.
32.	NIPA Chowrangi	1317	112	46	176	0.8	49,502
33.	Hasan Square	1921	230	187	154	0.2	1,11,040
34.	Jail Road	1815	311	176	245	0.5	1,03,204
35.	Shaheed-e-Millat Road Ch.	1847	288	96	112	0.9	N.A.
36.	Society Office	1228	241	57	125	1.1	N.A.
37.	Tariq Road	1636	417	102	230	1.4	55,302
38.	Taj Mahal Hotel	2604	564	144	375	1.8	N.A.
39.	Metropole Hotel	2445	270	254	227	1.0	92,207
40.	Zoological Garden	2027	817	361	427	1.8	N.A.
41.	S.H.M. Society/Shara-e-Faisal	1030	286	127	202	0.9	51,628

tions of main roads where traffic density was high. More than twenty one samples were collected from 10 km diameter of city centre. Samples were analysed after passing through 106μm sieve because particles of this size can easily be blown by gentle wind and stay suspended for relatively long period of time and can penetrate into houses easily (appox. settling velocity for particles size 100 μm having density of 1gm/cm^3 in 30cm/S) [10], Table, shows mean concentrate of lead, zinc, copper, manganese and cadmium in ppm. alongwith daily average traffic at various locations.

The maximum concentration of lead 4527 was found at Tibet Centre and minimum concentration 810 ppm at Aysha Manzil. The range of average concentration of zinc in road side dust was from 112 to 2215 ppm, copper from 46 to 315 ppm, Manganese from 72 to 481 ppm and cadmium from 0.2 to 4.5 ppm. The highest values of lead concentration 4527 ppm was found at Tibet Centre with daily average traffic of 94,831, whereas the highest daily average traffic 1,64156 was found at Liaquatabad No. 10 and lead concentration was found to be 3923 ppm. The highest value of lead concentration at Tibet Centre may be due to the fact that this point is surrounded by multistoryed buildings and situated on the bussiest M.A. Jinnah Road which starts from the Kemari and passes through city centre in SW to NE direction. It has already been reported [11] that in most of day time of the year the predominant wind direction is SW. The clean air masses comming from the sea passes directly towards Tibet Centre through M.A. Jinnah Road carries pollution load of vehicular emission. The multistoryed buildings at Tibet Centre form a sink and thus a tunnel effect is created. The other factor responsible for tremendous increase in pollution level here may be due to traffic held up at traffic light and high volume of vehicles using low gears emit substantial quantity of lead alongwith smoke and simultaneously contaminate the area by toxic and unwanted gases.

The lowest lead leve l 810 ppm was found at Aysha Manzil round about although this location is between Sohrab Goth and Meena Bazar and daily average traffic may not be less than 50,000. The low lead value obtained here may be because this location is relatively open place situated on the intersection of a very wide roads (400 ft.) having large roundabout. Deposition of lead is largely dependent on the number of vehicles plying on that intersection but it is greatly influenced by many factors such as wind velocity, wind direction, surface run off, particle size of emission, precipitation and humidity.

The concentration of lead found (4 ppm) in the dust collected from PCSIR Laboratories Complex which was used as control site for this investigation. The amount of pollutant at ground level depends upon the amount emitted, dispersed and diluted by the atmospheric currents. The source of emission of lead here (automobile exhaust) is almost at ground level, thus the presence of lead in dust at a location 17km down wind direction from the city centre indicate that pollution load can spread into large area. This low level lead found compares with the data obtained for Manchester city UK [9], where no significant general rise or fall in lead level was observed with distance except for sharp reduction at the distance corresponding to the edge of urban area. A marked diruhal pattern was also reported [12] near the same location, where fairly high value of lead (23 ng/m^3) was found in samples of air aerosole during evening hrs and comparatively low concentration of lead (11 ng/m^3) was found in morning hr. (00.00 hr-12 hrs.) which perfectly related to traffic pattern of normal working schedule and also confirmed that main contributor of lead in the urban environment of Karachi is automobile exhaust.

It can be observed from the Table 1 that 13 out of 41 intersection have daily average traffic more than sixty eight thousand vehicles per day. 10 out of 13 sample location have more than 2500 ppm of lead in dust samples whereas 3 location i.e. North Nazimabad chowrangi, Hasan Square, and Jail Road chowrangi show less than 2000 ppm of lead in the dust samples, low values obtained here may be because these three intersections have fairly large roundabout and are not surrounded by multistoryed buildings.

The mean concentration of lead and zinc and those of copper and manganese are of the same order of magnitude. The correlation of metal present in urban dust with the traffic density probably indicate that most of these metals present in the street dust belong to vehicular emission because lead is used as antiknocking agent in petrol, copper is used for engine parts, zinc and cadmium are the components of car tyres and motor oil [5]. The scattered diagram (Fig. 3) shows mean lead level in 27 locations with respect to their daily average traffic value. A positive and linear line between these two variable

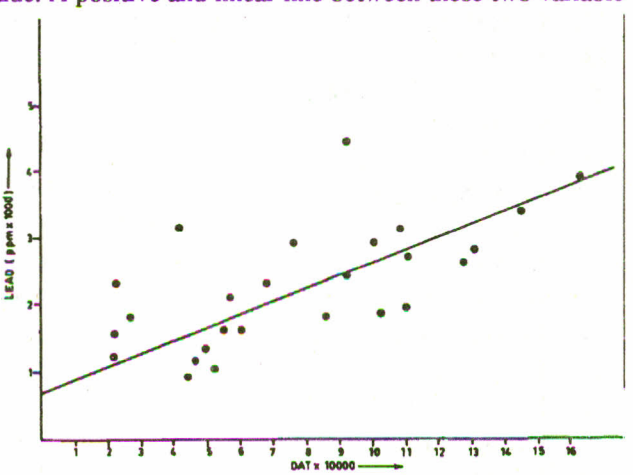


Fig. 3. Scattered diagram of mean lead level with respect to their daily average traffic (DAT)

clearly shows relationship between lead and daily average traffic value suggests that main contributor of lead in the street dust may be ascribed to automobile exhaust.

The mean concentration of pollutants of city centre (seventeen locations) was found to be lead 2989 ppm, zinc 1169 ppm, copper 224 ppm, manganese 349 ppm and cadmium 2.1 ppm. Table 2 compare the mean lead concentration in the samples of road side dust in various cities of the world. The present study indicates that the lead level of road side dust in Karachi is 2989 ppm, which is not as high as in Urbana III (USA) 3600 ppm, but higher than Hongkong 1,627 ppm, Riode Janero (Brazil) 700 ppm, Birmingham (UK) 1800 ppm, Lancaster (UK) 1890 ppm, Manchester (UK) 970 ppm, London (UK) 1200 ppm, Jeddah (Saudi Arabia) 745 ppm, and also higher than Belgium 2255 ppm. and USA (average 77 cities 240-1500 ppm). The comparison of lead level is however unjustified because of lack of knowledge regarding industrial activities in various cities. But the analysis of road side dust was carried out with nearly similar method [9] from the samples collected from the major roads of these cities. It seems reasonable to assume that bulk of the lead in the urban dust was air borne and the principal source of air borne lead is probably vehicles emissions.

Table 3 presents the calculated quantity of lead released by different types of vehicles in Karachi, types and number of vehicles were obtained from motor registering authority, Karachi, government of Sindh. Average run and petrol consumption of good condition vehicles were calculated from the data obtained from the users. Quantity of lead was calculated on the assumption [1] that upto 70% of lead in gasoline is released with automobile exhaust and it is estimated that approximately half of the exhausted lead become air borne. It may be seen from the calculated quantity of lead that about 28447 kg of lead is being spread into the streets of Karachi every year. These data explain the relatively high lead pollution in the street dust and probably prove that the major source of environment lead in Karachi is automobile exhaust.

The weather of Karachi is mostly dry and average number of rainy days (2.5mm and above) are not more than 10 days per year [13]. The total average annual rainfall is 6-8 inches (150-200mm). Average maximum temperature in summer March-Oct. is 38.7° and average minimum temperature in winter (Nov.-Feb.) is 20.15°. Because of the dry climate and scarce vegetation, lead containing dust particles are not easily eliminated nor fixed. The blowed up soil are resuspended and dust particles can easily penetrate into the houses. Lead containing dust contaminate goods, vegetable, food and may be a major route to lead exposure.

These data explain the relatively high lead pollution in street dust of Karachi. Inspite of the fact that relatively very pure sea breez blow across the city, traffic jams, poor conditions of the engines and heavy traffic are the major cause of high lead pollution (2989 ppm) in the city centre of Karachi.

TABLE 2. COMPARISON OF MEAN LEAD CONCENTRATION (PPM) IN THE STREET DUST IN DIFFERENT CITIES OF THE WORLD.

Location	Pb (ppm)	References
Karachi	2989	Present study
Jeddah	745	Nasralla, 1984
Hong Kong	1,627	Lau & Wong, 1982
Birmingham	1630	Archer & Barratt, 1976
Lancaster	1890	Harrison, 1979
London	1200	Duggan & Williams, 1977
Glasgow	960	Farmer & Lyon, 1977
Manchester	970	Day *et al.*, 1975
Belgium	2255	Bruaux & Svartengren 1985
Malta	1828	Bruaux, *et al.*, 1987
Urbana Ill. USA	3600	Solomon & Hartford, 1976
USA (Average of 77 cities).	240–1500	Hunt *et al.*, 1977

TABLE 3. CALCULATED QUANTITY OF LEAD RELEASED BY DIFFERENT TYPES OF VEHICLES IN KARACHI.

Type & number of vehicles stood registered upto 1st Jan. 1990*	Average run per day (Km)	Average petrol consumed per day	Calculated quantity of lead released Kg per day (0.4gm. lead/lit)**
Motor cycles & scooters 277209	10 km	50401 @ 55 km/lit.	7.05
Cars, Jeeps & Station Wagon 278983	20 km	464971 @ 12 km/lit.	65.09
Motorcycle Rickshaw 16933	100 km.	67732 @ 25 km/lit.	9.48
Taxis 10608	100 km.	88400 @ 12 km/lit.	12.37
Other vehicles delivery vans pickups etc. (Say half 19523 on petrol out of 39047	50 km.	81345 @ 12 km/lit.	11.38
		Total:	105.37 kg/day
		If 75% vehicles are playing on the road:	79.02 kg/day
		Total lead release per annum:	28447.2 kg

*Excise and Taxation (Admn) Motor Registration Authority Karachi,
**Specification for petrol (motor gasoline), Pakistan Standard 1430 ammendment 1985 (UDC: 665.733.5)

Conclusion

Probably no other chemical has a greater compilation of toxicological literature than lead. Lead can be absorbed through skin, inhalation and by ingestion. Lead deposited through air pollution on plants which are eaten by foraging animals can inturn, be eaten by man resulting in lead poisoning. Lead is a commulative poison and even sub clinical lead exposure has been demonstrated to cause a variety of mental and behavioral disorders. Very high number of vehicles consuming leaded gasoline are the major cause of high lead level in the environment of Karachi which may be encountered by the urban population and dust contaminated with lead is known to be very hazardous to children (400 ppm soil lead was considered as the appropriate upper limit) [6]. It may be observed from the data presented here that high level of lead is present in the road-side dust of Karachi. Because lead depresses high level mental function raising children in an environment containing hazardous level of lead, existance is in danger for future generation. It is hoped that this baseline study can be used to indicate the present level of lead contamination in densely populated are a of Karachi with increasing number of vehicles.

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