Study of Lead Pollution in Air, Soil and Water Samples of Quetta City

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Summary: This study briefly presents the collected data of lead pollution in the environment of Quetta City in Balochistan, Pakistan .The samples were collected from different sites. The analysis of lead was carried out in underground water samples, the exhaust of different vehicles, roadside and sewage soils from selected points of Quetta City.
The average discharge resulted in deposition by motorcycles (29.12g/h), cars (44.47g/h), wagons (176.54g/h) and buses (141.52g/h). The maximum deposition was 222.96 g/h from auto-rickshaws. The value for lead in smoke of different vehicles seems quite high when extrapolated to the large number of such vehicles for a longer time. The concentration of lead in roadside soil varied from 73.3 mg/kg (T & T closed colony) to 731.9 mg/kg (Sirki road bus-stop). The average content of lead in sewage soil of City Nala is 1250.6 mg/kg. The level of lead was more than WHO standards for such soils. The lead quantity in all 24 tube- well water samples, was slightly above the WHO standards (10 µg/L).The results of this study were comparable to similar study [7] in twin cities of Rawalpindi and Islamabad.

Introduction

Hazards of heavy metals [1-3] contamination in general and lead in particular have been extensively studied by researchers [1-8].Their effects on human health are regularly reviewed by different international bodies such as WHO and EPA.

One of the handicap of modern civilization, particularly motor vehicles, is causing dramatic increase in lead usage both as a component of lead acid storage batteries and as an organic lead alkyl "antiknock" additive in petroleum products [6]. A co-relation has been established [7-11] between increasing lead concentration in roadside soils and vehicle traffic density. Other uses of lead are in manufacturing process of plastics, insecticides, rubbers, X-ray plates/shields, dyes, paints and match sticks. The consumption of lead and corresponding lead pollution has been increased many folds [6-12]. Metallic lead used in batteries, pipes, ammunition and alloys with other metals, may trigger synthesis of hemoglobin, effecting kidneys, GI(gastro intestinal) tract, joints, reproductive system and severe damage to the nervous system specially with developing fetus[13-14]. It is observed that ingestion of large amount of soluble lead salts (lead nitrate, lead oxide, lead sulphate and tetraethyl lead**)** can cause poor appetite, nausea, leg cramps and muscle weakness [13]. The continuous increase of lead pollution is causing numerous health hazards [14]. According to WHO report, if lead concentration increases above 1.2 mg/kg, it is toxic to health [15]. Airborne lead can be deposited in soil and surface water and reaches human beings via the blood chain. Lead is accumulated in the skeleton and slowly released; half-life of lead in blood is about one month while 20-30 years in the skeleton [15].

Quetta (Fig -I) is the capital of Balochistan. It lies between 29° – 59′ to 30° – 15′ latitude and 66° – 55′ to 67° – 48′ longitude. The climate of the area is arid with cold winter and hot summer. Average winter temperature is – 4 °C and average summer temperature is 35°C [16]. Snow fall occurs only in winter (December-February). Persistent dry winds blow in the area throughout the year, which become stronger and persistent in winter. Wind blows from North and North-west to South and South-east.

Quetta valley is surrounded by the mountain ranges commonly known as Murdar (to the east), Chiltan (to the west), Zarghoon (to the N.E) and Takatu (far to the north). Further, Chiltan limestone range, is composed of Hazarganji and Karkhasa sub-ranges, whereas Zarghoon range is composed of mainly Urak and Walitangi sub-ranges [16]. The soil of Quetta is formed from the parent rocks. Different types of parent rocks produce weathered particles of different size and chemical composition, high in particular trace minerals. Weathering merely changes the size of the soil. The soil that accumulates on limestone contains practically, the same minerals that were in the original rock [16].

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Environmental pollution in municipal drinking water is normally due to waste water from residential and commercial establishments. whereas in rural areas, the usage of pesticides/insecticides and usage of different chemical often pollute underground water as well as surface canal water.

In Quetta, underground water is an important source for domestic use and irrigation purposes. Sewage and industrial water is also used for cultivation of local vegetables. Therefore the main objective of this study is to evaluate and monitor the lead contamination in vehicular exhaust, roadside soil, sewage soil and drinking water in urban environment of Quetta City.

Results and Discussion

The selected sites, from where the data of Tables 1-5 were collected, are clearly marked on the map of Quetta (Fig.1).

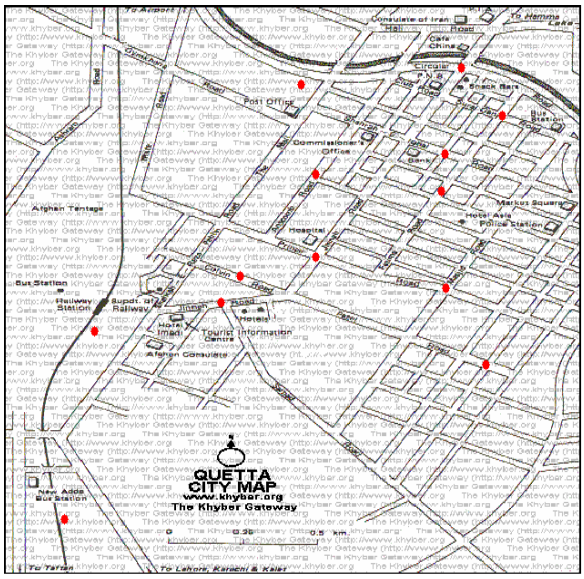

Fig. 1: Map of Quetta showing sampling points.

The data gathered for number of light / heavy vehicles plying in Quetta City.(Fig 2)shows the traffic flow chart. The amount of smoke released per hour by each type of vehicle and resulting quantity of lead (mg/kg) deposited on roads is summarized in Tables 1-3.

From the data of different vehicles running on the City main and side roads daily (depicted in Fig. 2 as traffic flow chart) and the amount of exhausted emission particle released in their smoke (Table-1), follows that a substantial quantity (Table-2) of exhausted emission containing lead particle, is accumulated daily in the environment of Quetta City. The data (Table-2) shows that the values of lead concentration (mg/kg) emitted from different vehicles is; 9.07 mg/kg for buses, 7.15 mg/kg for wagons, 6.23 mg/kg for rickshaws, 5.18 mg/kg for motorcars and 2.17 mg/kg for motorcycles. The value seems quite high when extrapolated to the large number of such vehicles for a longer time.

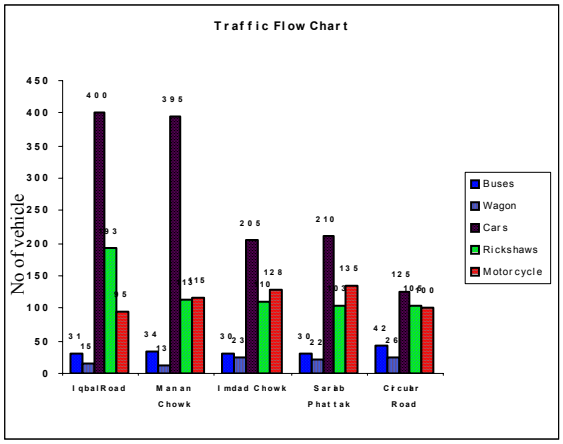

Fig. 2: Comparison of Vehicle Flow Density.

Table-1: The amount of smoke particles released per hour from different vehicles at different Junction Points of Quetta.

S. No	Type of Vehicles	JP_1 Iqbal Road (g/h)	JP_2 Manan Chowk (g/h)	JP_3 Imdad Chowk (g/h)	JP_4 Sariab Phattak (g/h)	JP_5 Circular Road (g/h)	Mean
1	Buses	133.50	142.41	124.62	129.06	178.01	141.52 ±0.02
2	Cars	29.98	24.98	49.97	54.97	62.46	44.47 ±0.02
3	Wagons	231.00	339.73	118.85	121.82	71.29	176.54 ±0.02
4	Rickshaws	347.58	201.52	194.12	183.03	188.58	222.96 ±0.02
5	Motorcycle	22.92	29.40	32.36	33.71	27.24	29.12 ±0.02

*JP: Junction point

Table-2: Quantity of Lead in the smoke of different vehicles of Quetta City.

S.No	Type of Vehicle	Lead (mg/kg)
1	Buses	9.07 ±0.03
2	Wagons	7.15 ±0.03
3	Cars	6.23 ±0.03
4	Rickshaws	5.18 ±0.03
5	Motorcycle	2.17 ±0.03

It is evident from the Table-1 that the minimum discharge of leaded smoke is for motorcycles (22.92 g/h), followed by cars (24.98 g/h) and wagons (71.29 g/h), while it is maximum (178.01 g/h) for buses. The worst affected areas are Circular road (178.01 g/h) for buses and (62.46 g/h) for cars, Manan Chowk (339.73 g/h) for wagons, Iqbal Road junction for rickshaws (347.58 g/h) and Sariab Phattak for motorcycles (33.71 g/h). For rickshaws and cars, Manan Chowk and Iqbal road, where traffic is dead slow; are smoke chokers. The motorcycles being kept started on Sariab Phattak during train-crossing, release lot of leaded smoke, which is main reason for high deposition there. The lead particles thus emitted are deposited on the surface of the soil, which when washed by rain to drains, hence accumulating lead in sewage water and some quantity may leach to the water bodies exposed to the surface.

Table-3: Comparison of lead contents in different Pakistani gasoline samples.

S.No	Gasoline	Range of lead (mg/L)	Average
1.	Super	1.3 – 888.4	613.3 ±209
2.	High octane	458.3 – 741.0	603.2 ±141
3.	Regular	616.8 -1065	771.5 ±125
4.	Diesel	20.8 - 84.5	42 ±48.9

*Source. [7]

Table-4: Comparison of lead contents in different gasoline samples collected from various petrol pumps, in twin cities.

S. No	Petrol pumps	Range of lead (mg/L)	Average
1.	PSO	21.0 – 888.4	462.8 ±345
2.	SHELL	1.3 – 800.3	545.1 ±380
3.	CALTEX	412 – 874.5	647.4 ±284
4.	PBS	53.2 – 796.6	507.6 ±422

*Source. [7]

The contents of lead in gasoline products sold in Pakistan are detailed in Table-3 -4.The quantity of lead being added in different fuels is 0.4g/L (regular), 0.63 g/L (Super) and 0.84g/L for high octane. It is estimated that major part of added lead is exhausted in air. This airborne lead is settled down as a particulate matter making leaded gasoline as a significant source of lead [14].

It was reported [17] that the average content of lead in gasoline is 0.19g/L and was estimated that 70-80% of gasoline lead content emitted to the atmosphere -automobile exhaust fumes.

It was also observed [7] that the soil deposited on the road side near petrol pumps had higher lead concentration as compared to the area away from petrol pumps so petrol pumps can also be taken as major source of lead hazard in addition to motor vehicle intensity, air traffic, fossil fuel, agricultural and municipal industrial waste.

It has been reported earlier [1] that 50% of lead emission to ambient air originates from petrol. In the countries opting introduction of unleaded petrol has shown remarkable decline in lead emission resulting decrease in blood level of the public. Children can be specially exposed to lead pollution. The blood level in children may be reduced below the acceptable levels. Airborne lead deposited in soil and surface water can easily reach human through the food chains.

Lead that is discharged into air over areas of high traffic density falls out mainly within the immediate metropolitan zone. The fraction that remains in air is widely dispersed. Residence time for those small particles is of the order of days and is influenced by rainfall [9-11].

The agriculture soil usually contains 40-50 mg / kg of Lead. However only a limited proportion of lead in soil is generally taken up by the plant roots [18].Vegetables contains very small amount of metals of the order of micro grams per kg vegetable weight which are termed as trace or heavy metals [19]. Untreated sewage and industrial waste water is commonly used for the cultivation of vegetables in and around the Quetta City.

Table-5 gives a summery of data for concentration of lead in soil deposited on roadside of Quetta City. It is observed that the quantity of lead varies in various areas, generally dependent on traffic intensity. The other workers [20, 21] have inferred that roadside soil lead levels are correlated to traffic density which increases towards the centre of the city and on junctions and highways.

Table-5: Lead in roadside soil of Quetta City.

S. No	Location	Pb (mg/kg)
1	Gulistan Town	123.42 ±0.02
2	Serena Hotel	200.31 ±0.02
3	T&T Colony	73.32 ±0.02
4	GPO Chowk	473.34 ±0.02
5	Manan Chowk	523.03 ±0.02
6	Meezan Chowk	549.41 ±0.02
7	Gawalmandi Chowk	430.73 ±0.02
8	Bus Stand /Sirki Road	731.90 ±0.02
9	University of Balochistan	432.03 ±0.02
10	Chowk	140.43 ±0.02
11	Sabzal Road / Golimar Chowk BMC Chowk	283.84 ±0.02

The concentration of lead was maximum (731.9 mg/kg) in soil collected from Sirki Road Bus-stop; (heavy traffic) and minimum (73.3 mg/kg) in T&T colony, where the closed boundary and minimum traffic does not favor high lead deposition. The lead level in roadside soil varied from 73.3 mg/kg to 731.9 mg/kg in Quetta City. The results are comparable to a similar study [7] for twin cities Rawalpindi and Islamabad where variation is, from 75.3 mg /kg to 632.8 mg/kg, largely attributed to vehicle flow density, in the region.

It was observed that concentration of lead in agricultural soil samples varied from 5.2 to 56.1 mg/L [2] and yet a wide variation in soil lead levels reported [22] from 100 mg/L to 1100 mg/L against standard value of 50 mg/L[23].

In a recent study [5] it was also observed that heavy metal concentration (especially lead) is closely related with traffic intensity and resulting lead toxicity. Increasing population, human activities, industrial development and traffic density has resulted increased lead emission and hence serious risk of environmental pollution. It has been reported [24] that heavy metals (Cd, Sn, Ag, Pb) deposited in the environment may negatively affect the behavior and brain activities of humans.

In another study [4], the concentration levels of heavy metals (Cu,Cd,Pb,Zn) taken along highways and different distances from main road revealed that the lead level fell sharply(reaching normal soil lead level) as the distance from the road increases, which was attributed to variable vehicle frequency. The lead level in Jordan [25], Riyadh [26], Cairo [27] and Taiwan [28] were also compared showing similar pattern, though indicating varied lead levels. The leaded fuel used by automobiles was the main cause as emitted lead particulate matter settles not far from the high way.

The data of Table-6 shows that the amount of lead in sewage sludge soil of Quetta City Nala (main drainage system where all sorts of effluents are disposed off daily) ranges from 897.55 mg/kg in Hudda (midway) to 1441.17 mg/kg in Brewery (end of city). The Grammar school area of sewage soil (1346.32 mg/kg) and Samungli sewage soil contain (1317.18 mg/kg) almost same quantities. The concentration of lead in sewage soil of City Nala average 1250.56 mg/kg, which is alarming in a sense that fresh vegetables are grown by using this sewage water without treatment. The uptake of lead by vegetables routes directly to livestock and human being may cause health problems. This is because different sources near the effected area contaminate the agricultural soil, possibly raising lead concentration.

Table-6: Lead concentration in Sewage Soil of Quetta City Nala (mg/kg).

S. No	Station	Average Sample A	Average Sample B	Average Sample C	Mean Average
1.	Grammar School	1348.20	1335.03	1355.44	1346.32 ± 0.04
2.	Huddah	897.63	975.45	819.57	897.55 ± 0.04
3.	Samungli	1337.42	1294.93	1319.21	1317.18 ± 0.04
4.	Brewery	1417.82	1451.19	1454.50	1441.17 ± 0.04

R_1 = 6 ″ beneath the soil surface.
R_2 = 12 ″ beneath the soil surface.

Average Sample = $\frac{R1 + R_2}{2}$

Table-7: Standards of WHO and EPA (Environmental Protection Agency Pakistan).

S. No	Samples	Heavy Metal	µg/L	Standards
1.	Drinking water	Lead	10	WHO
2.	Sludge Soil	Lead	60×1000	EPA
3.	Sewage and industrial effluents	Lead	500	EPA

Source: EPA / PCRWR reports

A recent study [3] on 187 water samples in Karachi showed that lead levels are high in almost all ground water sources, especially in industrial areas, compared to maximum acceptable concentration (MAC) of lead in drinking water 10 µg/L established by WHO (Table-7).

Table-8: Lead in underground water of different locations in Quetta City.

S. No	Location of Tube Wells	Pb(mg/L)	S.No	Location of Tube Wells	Pb (mg/L)
1	Saraib Custom	0.0168 ±	13	Wahdet Colony	0.0221 ±
2	Kechi Baig	0.002	14	Spini Road	0.002
3	Degree College	0.0166 ±	15	Jemkhana	0.0156 ±
4	Quetta	0.002	16	Liquat Road,	0.002
5	Burma Hotel	0.011 ±	17	Quetta.	0.0145 ±
6	Balochistan	0.002	18	Jamiat-rai-	0.002
7	University	0.0247	19	Road	0.0222 ±
8	Killi	±0.002	20	Mali Bagh	0.002
9	Qumbrani	0.0120 ±	21	Syedabad	0.0118 ±
10	Arbab Karam	0.002	22	Jan	0.002
11	Road	0.0173 ±	23	Muhammad	0.0276 ±
12	Sariab Pattak	0.002	24	Road	0.002
	Killi Khaizi	0.0169 ±		Pashtoon Abad	0.0118 ±
	P.A.F Base	0.002		Industr: Area	0.002
	Baleli Check	0.0231 ±		Sirki Road	0.0203 ±
	Post	0.002		New Bus Stand	0.002
	Sheikh Manda	0.0216 ±		Satellite Town	0.0237 ±
		0.002			0.002
		0.0237 ±			0.0341 ±
		0.002			0.002
		0.0165 ±			0.0299 ±
		0.002			0.002
		0.0305 ±			0.0112 ±
		0.002			0.002

Lead content in 24 underground tube well water samples of Quetta City, were analyzed by AAS. The results as given in Table-8, show that the

lead quantity varied between 0.0112 mg/L for Satellite town (newly developed area) to 0.0341 mg/L for Sirki road (Industrial area). These results are not very high as compared with WHO standard values. Being 600-800 feet deep [29 - 30], underground drinking water of Quetta City, is almost free from environmental lead affect. The slight variation of lead content in different samples is attributed to surface exposure and old lead pipes of tube wells and /or old water supply system lead lines.

It was reported earlier[31] that drinking water generally contains less than 10 micro gram /L of lead which may reach extremely to dangerous limits (2000-3000 micro gram / L), when lead water pipes and tanks are used and the water is chemically able to attack them. Plants are also affected by acidity of rain water and deposition of toxic solids on leaves.

However, the present level of lead in Quetta City soil (Table.6) together with given level of lead in tube well water (Table.9) is going to reach a hazardous level, if not currently at least in the near future. Such a level of lead is quite disquieting as the combined effect of above said two values, that is for soil and water because of high concentrations in vehicle's emission or industrial effluents, may lead to alarming high levels of the pollutant possibly endangering life. This should be a cause of serious concern to the people in general, government and environmentalists in particular, in view of the common axiom that, it is considerably easy to control the spread of pollutant into the environment than to clean the once polluted environment.

Lead particles insoluble in water initially, are easily oxidized to Pb^{+2} ion in the oxygen - abundant atmosphere. The Pb^{+2} ions are highly soluble in water and transportable into the soil strata and surface water bodies which can lead to the raising levels of lead in the drinking water, locally grown vegetables, fruits and the crops. The WHO standard for lead concentration, in drinking water extremely a low level, can very easily be exceeded if the current level of lead addition to the environment continues unabated. Though leaded petrol is discouraged in Pakistan yet some fuel brands (Table 3 - 4) still contain added lead. In addition, the smuggled leaded petroleum products are extensively used in Balochistan, particularly in Quetta City. The old lead pipe lines may also cause lead pollution. As the drinking water of Quetta is drawn from 600-800 feet deep tube wells, there is little possibility that industrial discharge, municipal waste water and agriculture activities can pollute underground water resources of such depth, which is also evident from data in Table-8.

Experimental

All sampling points are marked on map of Quetta City (Fig. 1).

Analysis of Air Samples (Bladder Method for Collection of Air Samples)

Samples of smoke particles were collected by linking the preweighed bladder, to exhaust of different vehicles, for known period of time recorded by a stopwatch [32]. After filling, bladder was tightly closed for 24 hrs, and the air was released very carefully and weighed again. After that these bladders were rinsed internally several times with 25% Acetic Acid. These solutions were shaken for three hrs by a shaker and volumes were made to 100 mL with distilled water before running on Atomic Absorption Spectrophotometer Sollar (GE 711209 AAS). Details of sampling points and results are in Tables (1-2).

Analysis of Roadside Soil Samples

In the study area, samples were collected from 11 selected sites along main and side roads (Gulistan Town, Serena Hotel, T&T Colony, GPO Chowk, Manan Chowk, Meezan Chowk, Gawalmandi Chowk, Bus Stand /Sirki Road, University of Balochistan Chowk, Sabzal Road / Golimar Chowk and BMC Chowk). Samples were scooped from top surface of soil layer (0-2 cm) using stainless steel spoon [32]. Each 0.5 g of air dried soil samples were weighed in boiling tube then 5 mL of Aqua Regia was added and left to digest overnight at room temperature. It was heated on a hot plate first at 60 °C for 2-3 hrs, and then at 140 °C till dryness. Finally, 5 mL of 20% HNO_3 was added and contents reheated at 80 °C for 30 min and cooled before diluting to 50 mL in a volumetric flask with deionized water. Samples were run on Sollar AAS for lead concentration as before. Results are shown in Table-5.

Analysis of Habib Nala Sewage Soil

Sewage soil samples were collected from 4 selected sites (Grammar School, HuddaSmungli and Brewery).Two samples were collected from each site, one from the surface 0 – 6 inches and second from 6 – 12 inches beneath the soil, with the help of the auger and preserved in the polythene bags for further analysis. These soil samples were transferred into a

metal tray forming a thin layer to remove stones then grounded with the help of pestle and mortar and finally sieved from 2mm wire mesh. Further treatment and analysis of these samples on AAS was as detailed above (b) .Results are given in Table 6.

Analysis of Water Samples

Sollar AAS (GE 711209) was used for determining lead in water samples collected from 24 selected underground tube wells (Saraib Custom, Kechi Baig, Degree College, Burma Hotel, Balochistan University, Killi Qumbrani, Arbab Karam Khan Road, Sariab Pattak, Killi Khaizi, P.A.F Base, Baleli Post, Sheikh Manda, Wahdet Colony, Spini Road, Jemkhana, Liquat Road, Jamiat-rai-Road, Mali Bagh, Syedabad, Jan Muhammad Road, Pashtoon Abad, Industrial Area Sirki Road, New Bus Stand and Satellite Town). Samples of Tube-Well water collected in clean rinsed plastic bottles and with 4-5 mL concentrated HNO_3 and shaken well. The general method for estimation of lead by AAS [33 - 34] involves aspirating aliquots of different standards and 24 samples to the instrument. The results are given in Table 8.

Conclusion

The motor vehicle exhaust resulted in deposition of lead as particulate matter. The roadside surface soil contained highest concentration of lead metal varying from place to place. Roads near junctions, petrol pumps and bus stops were more polluted. Sewage dust was also polluted with lead, while lead in underground tube well water was slightly higher than the standard values. It can be inferred that motor vehicles that burn leaded gasoline are mostly responsible for the build up of heavy metals especially lead in soil and in air borne gases along the main road and nearby areas, through the emission of particulate. The lead level increased with increasing traffic intensity. Total lead free gasoline fuels may be used in vehicles. A major switch from leaded petrol to CNG (Compressed Natural Gas) or green fuel in vehicles is recommended. Measures may also be taken to discourage the increasing use of smuggled leaded petroleum products in Balochistan, particularly in Quetta City. The agricultural activities may be prohibited using sewage water without appropriate treatment. The effect of traffic based pollution is adverse and this factor must be taken into account while developing new industrial areas, establishment schools, playgrounds and residential colonies. It is necessary that special importance should also be given to air, road and railway traffic as much as possible, while planning to develop new pollution free areas. Therefore it will be advisable to take remedial steps to minimize the heavy metal hazard in the affected region.

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