A SURVEY OF DUST-BORNE LEAD CONCENTRATION IN BAGHDAD CITY

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ABSRTACT

A reconnaissance sampling of air-borne dust in Baghdad city has been carried out in 14 sampling stations in addition to streets dust in 12 stations. The analysis of these samples showed that Pb concentration in the former ranged between (14 – 95) ppm (mean 49 ppm) and in the latter between (24 – 280) ppm (mean 92 ppm) compared to about 7 ppm average Pb concentration of more than 20 000 samples of unpolluted soil samples collected from the dust source areas (Western and Southern Deserts of Iraq). These anomalously high concentrations of Pb in the air-borne dust are extremely hazardous for human health, being directly introduced to the respiratory system by unavoidable inhalation causing health defects and fatal diseases. The source of air-borne Pb-rich dust is obviously local and can be directly related to Pb pollutants in the city, especially Pb-additives to the gasoline, still used in Iraq, and to the illegal primitive Pb smelters.

مسح لتركيز الرصاص المحمول مع الغبار في مدينة بغداد

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المستخلص

الغبار والعواصف الغبارية ظاهرة معروفة في العراق خاصة في وسطه وجنوبه وتنشط اعتيادياً في الربيع والخريف وتعتمد شدتها وتكرار حدوثها بشكل كبير على الظروف المناخية من ناحية الساقط المطري الذي يعمل على تثبيت التربة. وفي ظل سنوات الجفاف الحالية التي يعاني منها العراق والمنطقة بشكل عام ازدادت هذه الظاهرة في السنوات الأخيرة بشكل ملفت للنظر وأسهمت في زيادة معاناة المرضى في المجاري التنفسية، إضافة الى خلق حالات مرضية جديدة في هذا المجال.

الجديد في هذا البحث هو دراسة خطر بيئي أكثر جديةً وأكثر تأثيراً على صحة الإنسان يحمله هذا الغبار ولم تتم دراسته بشكل وافي ولا توجد توعية صحية اجتماعية بشأنه وذلك هو عنصر الرصاص الذي يحمله هذا الغبار والذي يمكن ان يتسبب عند استنشاقه بأمراض في غاية الخطورة لسهولة امتصاص مركباته، وخاصةً الدقيقة الحجم منها من قبل الجهازين التنفسي والهضمي.

تناولت الدراسة جمع لعينات من الغبار من 14 محطة نمذجة في مدينة بغداد وتشمل جانبي الكرخ والرصافة، فضلاً عن جمع عينات من أتربة الشوارع في المدينة من 12 منطقة موزعة على الجانبين، وقد جمعت العينات في شهر أيار 2004، وتم تحليلها لعنصر الرصاص باعتماد تقنية مطياف الامتصاص الذري. تراوح تركيز الرصاص في عينات الغبار بين (14 – 95) ppm بمعدل 49 ppm وفي أتربة الشوارع بين (24 – 280) ppm وبمعدل 92 ppm بالمقارنة مع معدل تركيز الرصاص في تربة الصحراء الغربية والجنوبية (مناطق المصدر للغبار) والبالغ حوالي 7 ppm والمقارب للخلفية الطبيعية لتركيز الرصاص في الترب غير الملوثة المتكونة في مناطق جافة تسود فيها صخور رسوبية كاربونيتية. تشير هذه النتائج الى مصدر تلوث في غاية الخطورة على الصحة يتم دخوله الى الجسم البشري عبر الجهاز التنفسي، حيث يتم امتصاصه وينتقل الى الأغشية الرئوية والى مجرى الدم مسبباً عدة مشاكل صحية وأمراض قاتلة.

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ان الدراسة الحالية تثبت ان مصدر هذا الرصاص موقعي المنشأ ومن داخل المدينة المزدحمة بكافة أنواع الملوثات الحاملة لعنصر الرصاص ومركباته، وأهمها بنزين السيارات الحامل للرصاص بشكل رابع أثيلاته ونواتج مصاهر الرصاص الأهلية البدائية. ُبنيَ هذا الاستنتاج على أساس المقارنة البسيطة بين تركيز الرصاص في أكثر من عشرين ألف عينة تم جمعها في دراسات سابقة من ترب الصحراء الغربية والجنوبية، حيث مناطق المصدر الطبيعية والأساسية للغبار في العراق مع تركيزه في الغبار المترسب في مدينة بغداد ومع تركيزه في أتربة الشوارع التي تحمل أعلى التراكيز من هذا العنصر السام.

INTRODUCTION

Baghdad is the largest and most crowded and populated city in Iraq. Several workers have shown various pollution cases related to Pb in Baghdad, expressed in soil and water as well as in plants and human body (Khalid and Salih, 1981; Hana and Al-Bassam, 1983; Al-Ghabban, 1986; Haqus and Hameed, 1986; Hana and Al-Hilali; 1986, Al-Hamdani, 1987; Hana *et al*., 1988, among others).

Lead is a heavy metal present in nature in various concentrations and in different phases. It is present in nature as PbS and its carbonate and sulfate weathering and alteration products. It is present also as a trace metal in various rocks; (10 – 20) ppm in igneous and metamorphic rocks and (7 – 10) ppm in sedimentary rocks (Aubert and Pinta, 1977). In unpolluted soil, it is about 10 ppm (Aubert and Pinta, 1977; Davies, 1980 and IPCS, 1995). In air-borne particles, Pb content was reported as 0.005 µgm/m^3 in unpolluted areas (WHO, 1977) and more than 2500 µgm/m^3 in polluted areas (IARC, 1986).

Lead is heavily used in industry including batteries, additive to gasoline, paints, explosives, pesticites, soldering, cosmetics, radiation shields, crystal glass, among others (Carolyn, 1997). However, due to its highly toxic effects, its uses in industry have been highly limited in recent years.

Several diseases and syndromes were attributed to lead exposure. The nervous system is the most affected, expressed mostly as sensory deficits and encephalopathy (Goyer, 1996). Enemia is one of the common symptoms (Gossel and Bricker, 1994). Moreover, Pb influences the kidney by development of hyperuricemia (Thomas *et al*., 2004), and above (40 – 50) µgm/dl causes testicularatrophy and hypospermia (lower fertility in men) as well as miscarriage in pregnant woman.

One of the most identified health problems of Pb is the deterioration in the bone strength, where Pb^{2+} may replace Ca^{2+} in the bone mineral phases and causes osteoporosis (Kemedy *et al*., 1992 and James *et al*., 2004). Lead may causes mental retardation in children when exposed to more than 25 mgm Pb/dl (Richard, 2004).

PREVIOUS WORK

To the best of the authors knowledge, Pb content in air-borne dust was not systematically studied previously in Baghdad. However, in view of the international concern about Pb as an environmental pollutant, several workers in Iraq have attempted to focus on the Pb-pollution problems in various environmental systems. Some of these works are listed below:

Khalid and Salih (1981): Studied pollution problems in Baghdad city using soil sampling and Pb analysis. The study showed higher Pb concentrations in some highly populated areas, which were attributed to leaded gasoline.

Hana and Al-Bassam (1983): Studied Pb pollution in Baghdad city and other less populated cities in Iraq using plants as a sampling media and found much higher Pb concentrations in Baghdad samples. They also found toxic levels of Pb in human blood, especially in traffic policemen working in crowded areas, and workers of gasoline stations and battery manufacturing.

Al-Bassam *et al*. (1985): Studied Pb concentration among other metals in the soil samples of the Western and Southern Deserts of Iraq and found that average Pb concentration in the soils of these unpolluted regions is less than 10 ppm.
Haqus and Hammed (1986): Studied Pb concentration in natural plants along highways in Erbil Governorate. They observed decrease in concentrations away from the highway.
Hana and Al-Hilali (1986): Studied Pb distribution in soil and palm-tree leaves in Baghdad. Their results showed (15 – 20) times higher than normal Pb concentrations.
Al-Hamadani (1987): Studied heavy metals distribution, including Pb, in soil and plants around Hamam Al-Alil cement plant and recognized that higher Pb concentration is related to industrial waste disposal and heavy truck traffic.
Jamil (1987): Recognized high Pb concentrations in workers working in lead-related industries.
Hana *et al*. (1988): Studied Pb concentration in soil inside acid-battery plant in Baghdad and reported (1210 – 43500) ppm Pb in the analyzed samples.
Al-Ubaidi (2000): Studied Pb concentrations in soil and plant around Kufa cement plant and recognized higher concentrations in samples nearer to the plant.
Shanshal (2004): Studied Pb concentration in soil and near-surface ground water in the Nahrawan industrial area crowded with brick factories and leather tanning plants. She reported a mean Pb content of 38 ppm in surface soil and 43 ppm in deeper soil samples.
Salman (2007): Studied Pb concentration in various ecological environments in Basrah city. He found a mean Pb content of 26 ppm (7 – 32 ppm) in the dust samples collected in one month (10/ 4/ 2005 – 10/ 5/ 2005).

On the other hand, the study of Pb pollution in various environmental and ecological systems have been a common topic of research in the industrial countries for more than a century. Most of the international literature on this topic is related to soil, plants and to some extent water. However, in view of the increasing concern about air quality and Pb pollution related to leaded gasoline, more research was conducted on air-borne dust and street dust (Duggan and Williams, 1977; Harrison, 1979; Duggan, 1980; Thakur and Deb, 2000; Charlsworth *et al*., 2003; Xinwei *et al*., 2009, among others).

WORK PROCEDURES

▪ Sampling

Dust samples were systematically collected from 14 stations in Baghdad; seven on each side of the Tigris River (Fig.1). The samples were collected, as precipitated dust, in plastic containers, 12 cm in diameter, with a nylon mesh on top. The containers were placed on the roofs of houses; about 6 m high, for 30 days. In two sites: one in Rusafa and one in Karkh, three sampling stations were taken at the same site but at different elevations, ground level, 3 m and 6 m high. After 30 days, the dust in the containers was carefully removed until the container is completely clean. The weight of the samples was determined by a sensitive two digital balance (Table 1).

Dust accumulated in streets was collected directly from near the kerbs from 12 stations; five in Rusafa side and seven in the Karkh side (Fig.1). Half of the samples were collected from traffic-crowded streets and the other half from streets in quiet residential areas (Table 2). The samples were sieved to remove trash and garbage and the –1 mm fraction was collected for analysis.

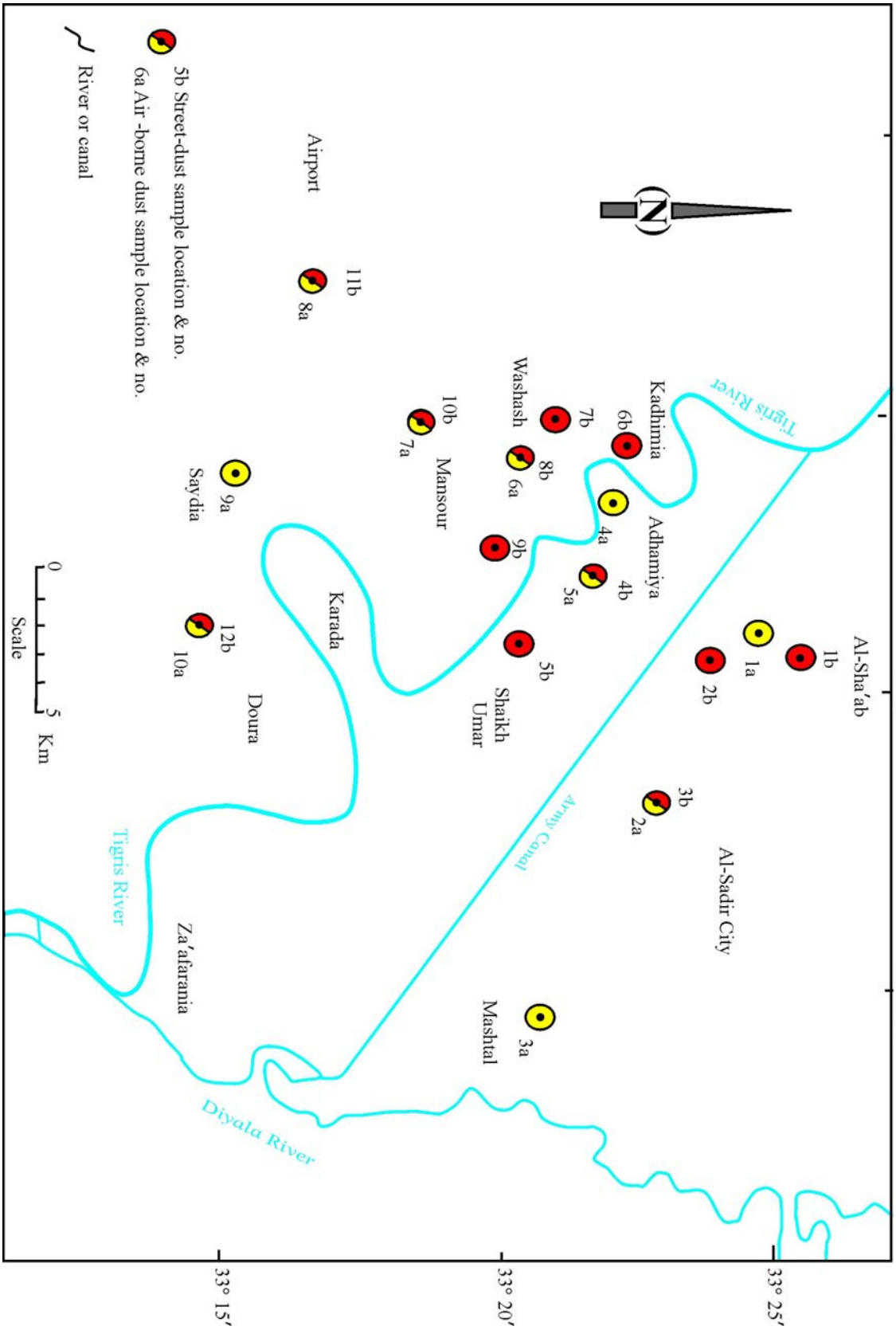

Fig.1: Location map

Table 1: Air-borne dust sampling details

Sample no.	District name	Sampling height (m)	Sampling site
1a	Bunouk	6	Residential area
2a	Al-Sadir	6	Commercial area
3a	Mashtal	6	Commercial area
4a/0	Adhamiya	Ground	Residential area
4a/3	Adhamiya	3	Residential area
4a/6	Adhamiya	6	Residential area
5a	Waziria	6	Industrial area
6a	Washash	6	Commercial area
7a/0	Mansour	Ground	Residential area
7a/3	Mansour	3	Residential area
7a/6	Mansour	6	Residential area
8a	Al-Atiba'a	6	Residential area
9a	Saydia	6	Residential area
10a	Doura	6	Residential area

Table 2: Street-dust sampling details

Sample no.	District name	Street details
1b	Sha'ab	Minor street, residential area
2b	Talbiya	Main street, commercial area
3b	Al-Sadir	Minor street, residential area
4b	Waziriya	Minor street, industrial area
5b	Shaikh Umar	Major street, industrial area
6b	Kadhimia	Major street, commercial area
7b	Al-Salam	Major street, commercial area
8b	Washash	Minor street, residential area
9b	Shaikh Ma'arouf	Minor street, industrial area
10b	Mansour	Major street, residential area
11b	Al-Atiba'a	Minor street, residential area
12b	Doura	Major street, garage, bus and car station

- **Pb Analysis**

The analytical procedure for trace elements analysis in soil, adapted by the Geological Survey of Iraq, was used (Al-Janabi *et al*., 1992; see appendix). It ensures total digestion of all Pb present in the sample. Furthermore, partial digestion was investigated by using 10% HCl, room temperature stirring for 1 hr, filtration and analysis. The analysis was performed using atomic absorption spectrometry in Central Laboratories of the Ministry of the Environment, Baghdad.

- **Accuracy and Precision**

These were determined using the methods described in Shaw (1969). A standard from the Geological Survey of Iraq (LST-1) was used to estimate the accuracy, which came to be $\pm$ 8% (at 95% confidence level). The precision was found to be better than 10% (at 95% confidence level), which is acceptable for trace elements analysis.

RESULTS

The results obtained in this study are shown in Table (3) and compiled in Figs. (2, 3, 4 and 5).

Table 3: Lead concentration (ppm) in air-borne dust and streets-dust samples

Air-borne dust			Street-dust	
Sample no.	**Sample weight (gm)**	**Lead concentr.**	**Sample no.**	**Lead concentr.**
1a	0.35	61	1b	42
2a	0.42	73	2b	55
3a	0.68	95	3b	51
4a/0	0.98	29	4b	95
4a/3	0.78	22	5b	211
4a/6	0.37	15	6b	40
5a	0.47	85	7b	51
6a	0.40	45	8b	47
7a/0	1.05	35	9b	170
7a/3	0.88	28	10b	38
7a/6	0.50	18	11b	24
8a	0.68	46	12b	280
9a	0.55	14	Mean	92
10a	0.40	35		
Mean of 6 m high samples	0.48	49		

DISCUSSION

The results obtained in this survey are highly alarming and represent one of the most serious and hazardous air pollution problems in Baghdad. A mean of about 50 ppm (range 14 – 95 ppm) in air-borne dust is far too much for any environmental standard. Lead is a poisonous metal at all levels and forms, so there is no threshold for a safety level of exposure (ATSDR, 1992).

Monitoring air quality in modern industrial countries detected high air-borne Pb concentrations, but only near industrial sources, such as Pb smelters (Vedenov, 1996). The pollution influence diminishes away from the source. The suspended particles, more than 2 μm in size, are limited to the source area, whereas those less than 1 μm in size may be air-borne for hundreds of meters or several kilometers away from the source.

The variation in the concentration of dust-borne Pb in Baghdad is not so controlled by the nature of the sampling site. It is higher than mean value in most samples of the Rusafa side (Fig.2). Higher values were especially noticed in southeastern parts of the Rusafa side (up to 95 ppm).

On the other hand, the spatial distribution of Pb concentrations in street-dust is well correlated with the nature of the sampling site. Anomalous values were noticed in four locations (Fig.3); these are: Doura (280 ppm), Shaikh Umar (211 ppm), Shaikh Ma'arouf (170 ppm) and Waziria (95 ppm). Lower concentrations (about 50 ppm or lower) were noticed in less crowded streets and residential sites. Shaikh Umar and Shaikh Ma'arouf are

located in central Baghdad and are among the oldest areas of the city; they represent old Baghdad. Moreover, both are highly industrial areas for more than half a century. Waziria is also an industrial area, established in more recent times. It hosts the largest battery manufacturing plant in Iraq, which is known, from previous work, as a Pb-polluted hot spot (Hana *et al*., 1988). The fourth hot spot and the highest in street-dust Pb concentration is Doura, where the oldest oil refinery in Iraq exists; working for more than 60 years now. The sampling site is a large bus and car station.

Questioning the source of Pb in the air-borne dust conclusively leads to exclude the Western and Southern Deserts of Iraq, as well as the Mesopotamian Plain, as potential source areas of Pb enrichment in the air-borne dust. This judgment is based on simple comparison with the low Pb concentration in soils of those regions; the former is 7 ppm and the latter is 9 ppm (average values of several thousand samples) (Al-Bassam *et al*., 1985). These average values are well within the background levels of Pb concentration in unpolluted soils, estimated by 7 ppm (Aubert and Pinta, 1977 and IPCS, 1995). In contrast, the soils of Baghdad city are characterized by high Pb concentrations, proved in several studies. Hana and Al-Hilali (1986) reported a mean of 96 ppm Pb and Abdul Karim (2004) reported a mean of 103 ppm Pb. The high values of Pb concentration in street-dust of Baghdad add another potential source to the enrichment of air-borne dust with Pb in the city. Hence, the source of Pb in the air-borne dust is definitely local. The results clearly points towards multisource Pb pollution in Baghdad.

In the opinion of the authors, as well as almost all previous workers on Pb pollution in Baghdad, leaded gasoline is the major source. Iraq is one of a few countries in the world still using leaded gasoline; a source of Pb pollution outlined more than half a century ago in the industrial countries and more than 25 years ago in Baghdad (Hana and Al-Bassam, 1983). Most countries banned the use of leaded gasoline. Lead is usually added as Pb $(C_2H_5)_4$ or Pb $(CH_3)_4$ in quantities ranging between (1.5 – 2.2) gm/ gallon.

In addition to leaded gasoline, there are tens of illegal and primitive local lead smelters in Baghdad outskirts, recycling old acid batteries and other, Pb-made, used objects. Heavily crowded industrial areas in the middle of Baghdad, such as Shaikh Umar and Shaikh Ma'arouf, as well as the battery plant in Waziria and the Daura Refinery are important, but local hot spots of pollution. In this way, their hazardous influence is more restricted compared to leaded gasoline.

The present results and argument clearly point towards the old city as the main source of Pb-enrichment in the air-borne dust. Particles of Pb and Pb-compounds as fine as one or few microns in size are polluting the city streets, soil and air. Dust storms usually occur when there is a noticeable decrease in the atmospheric pressure. Under such conditions settled ground dust and friable soil, rich in Pb, are elevated from the ground by wind, enhanced by low pressure and hot ambient temperature, forming an extensive cloud of dust, hundreds of meters thick, which takes a day or more to settle. The heavier particles will be concentrated at the lower levels where the density of the dust is high. This is illustrated in Fig. (4), which shows decreasing dust content at higher levels. Lead particles are among the heavy particles that are more concentrated at low levels, which is illustrated in Fig. (5), showing higher Pb concentration at ground levels.

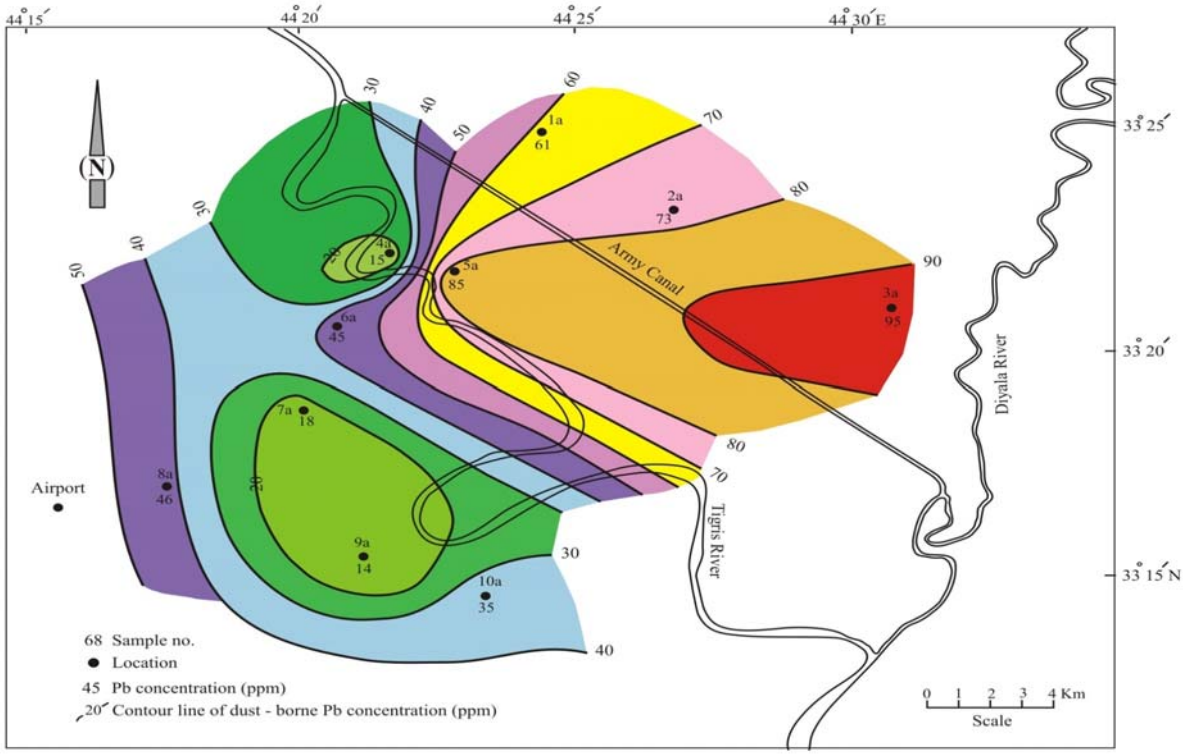

Fig.2: Spatial distribution of Pb concentration in air-borne dust

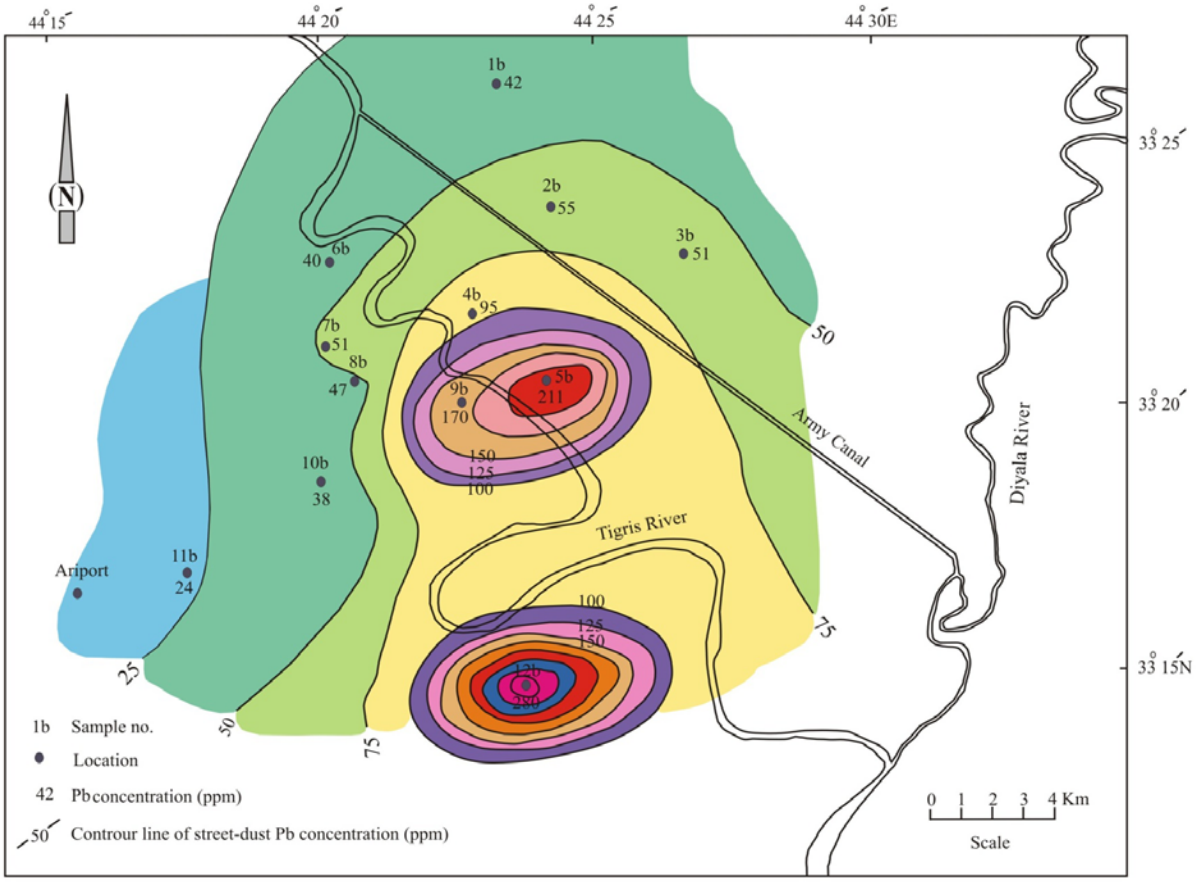

Fig.3: Spatial distribution of Pb concentration in streets-dust

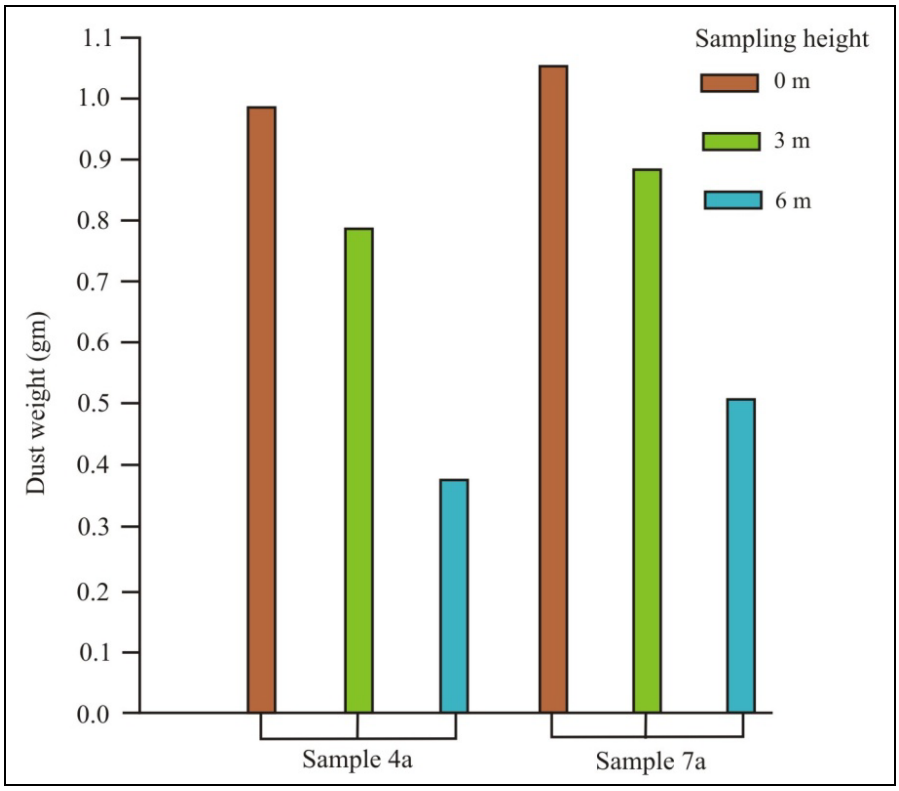

Fig.4: Variation of dust weight with sampling height

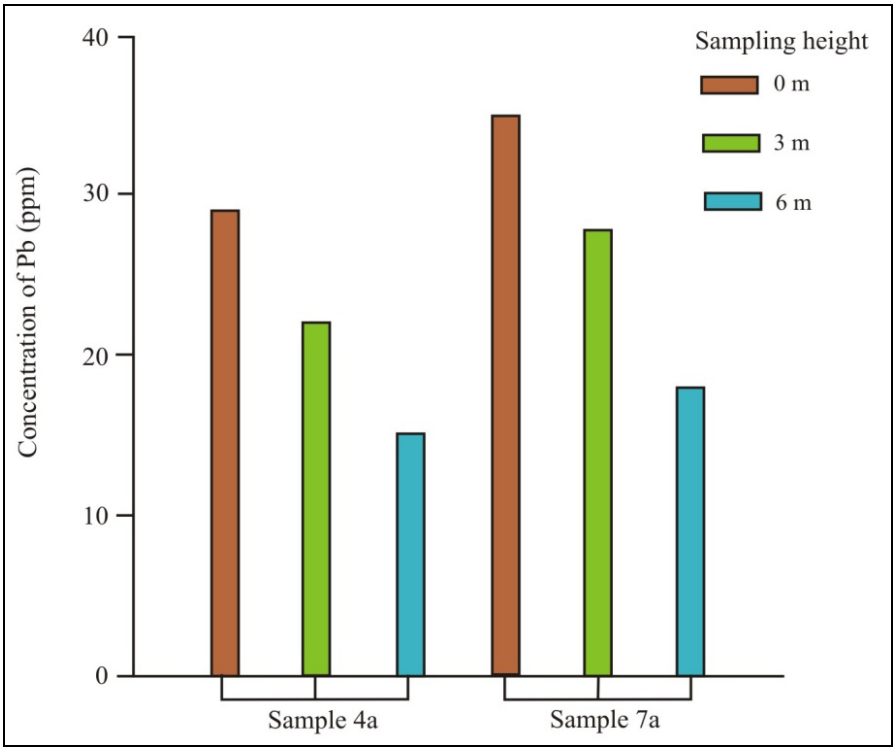

Fig.5: Variation of Pb concentration with sampling height

Lead pollution of such sources and in a city like Baghdad is accumulative in view of the extremely dry weather and the lack of any municipal streets-washing for the past decade or two. Consequently, Baghdad can be classified as a lead-polluted city in all respects. There is a general high background of Pb (as fine and mobile particles) and polluted hot spots in the city. Very fine Pb particles are mobilized and disseminated in the air in each and every dust storm; where they become amenable for humans intake. Dust is the carrier of these Pb particles. Eventually, Pb particles generated in the pollution sources (hot spots) will be carried away, dust borne, following the wind direction, which is generally from WNW to ESE, and finally deposited again due to the heavier weight. The generally anomalous dust-borne Pb-high zone in the eastern part of Baghdad (Mashtal area, Fig.2) could have been generated from the hot spots in central Baghdad; shown in Fig. (3). The eastern and southeastern parts of Baghdad city represent the depository terminal for the fine, but heavy, Pb particles, transported from all parts of the polluted city, especially from the hot spots in the center as well as Daura Refinery. Almost all the Rusafa dust samples showed Pb concentrations above mean value, probably for the same reason (wind direction).

Hence, Baghdad residents are exposed directly to high Pb intake during dust storms via the respiratory system, by inhalation, and to a lesser extent via the digestive system via the mouth and nose. Both ways are extremely harmful and most of the lead introduced to the body ends into a soluble form and settles in various parts of the body, as organic complexes or inorganic compounds, causing all sorts of health problems; some of which are fatal.

Lead tends to accumulate in the human body and may replace calcium in the bone inorganic component leading to destruction of the bone structure (Baird, 2001 and James *et al*., 2004). The poisonous effects of Pb on the human body are its tendency to form organic bonds with the protein constituents of many enzymes (Gossel and Bricker, 1994). In a single exploratory experiment in this study, it was found that 80% of the lead present in the air-borne dust of Baghdad is soluble in 10% HCl at room temperature and 1 hr extraction time.

CONCLUSIONS

Air-borne dust in Baghdad contains anomalously high concentrations of Pb; 80% of which is soluble in diluted acid. The source of Pb contamination is local and found in highly polluted soil and streets-dust of the old city. Lead has been accumulating in the soil and streets of Baghdad for tens of years and especially since leaded gasoline was introduced to the country. Illegal and irresponsible primitive and local Pb smelting is another source of Pb in Baghdad environment. The accumulation of Pb is enhanced by the dry weather, shortage of water and negligence of the municipal authorities.

RECOMMENDATIONS

To the government:

- Stop using leaded gasoline.
- Stop illegal primitive Pb smelters.
- Remove all industrial centers and districts from Baghdad metropolitan area.

To the people:

- When there is a dust storm wear a mask.
- Tell your colleagues, students and family about the results of this study.

ACKNOWLEDGMENTS

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EDITORIAL NOTE

When this bulletin was first issued, the Editorial Board agreed and committed itself not to publish more than one paper for the same author (single or as senior author) in the same issue. However, in view of the serious environmental hazard presented in this paper and its importance for public health, the board decided to make an exception of the rule and accepted its publication in this issue together with another paper by the senior author.

REFERENCES

Abdul Karim, N.Z., 2004. A study of lead pollution in Baghdad city. M.Sc. Thesis, College of Science for Women, University of Baghdad, 90pp, (in Arabic).

Al-Bassam, K., Hana, A. and Al-Hilali, M., 1985. Concentration of some heavy elements in Iraqi soil. Proceedings of the Conference on Environmental Protection from Industrial Pollution. Ministry of Industry and Minerals, Habbaniya, Iraq.

Al-Ghabban, S., 1986. Prevalence of increased lead absorption among lead-exposed workers. M.Sc. Thesis, College of Medicine, University of Baghdad, 199pp.

Al-Hamdani, R., 1987. Industrial pollution by heavy elements on soil and plant. M.Sc. Thesis, College of Agriculture, Mousul University, 157pp, (in Arabic).

Al-Janabi, Y., Al-Sa'adi, N., Zainal, Y., Al-Bassam, K. and Al-Delaimy, M., 1992. GEOSURV Work Procedures; Part 21: Chemical Laboratories. GEOSURV, int. rep. no. 2002.

Al-Ubaidi, A., 2000. Influence of Kufa cement plant on soil, plants and air in surrounding areas. Ph.D. Thesis, College of Science, University of Baghdad, 219pp, (in Arabic).

ATSDR, 1999. Research Triangle Institute for U.S. Dept. of Health and Human Services. Agency For Toxic Substance and Disease Registry, Atlanta, U.S.A.

Aubert, H. and Pinta, M., 1977. Trace Elements in Soil. Elsevier Sci. Publ. Co., Amsterdam, 392pp.

Baird, C., 2001. Environmental Chemistry. University of Western Ontario, W.H. Freeman and Co., New York, Vol.1, 401pp.

Carolyn, K., 1997. Lead contamination in our environment. Yale-New Haven Institute, Vol.1, p. 15 – 18.

Charlsworth, S., Everet, M., Mc Carthy, R., Ordonez, A. and de Meguel, E., 2003. A comparative study of heavy metal concentration in deposited street dusts in large and small urban areas: Birmingham and Coventry, West Midlands, U.K. Environ. Intern., Vol.29, p. 563 – 573.

Davies, B.E., 1980. Applied Soil Trace Elements. John Wiley and Sons, New York, 482pp.

Duggan, M.J., 1980. Lead in Urban dust: an assessment. Water, Air and Soil Pollution, Vol.14, p. 309 – 321.

Duggan , M.J. and Williams, S., 1977. Lead in dust in city streets. Sci. Total Environ., Vol.7, p. 91 – 97.

Gossel, T.H. and Bricker, J., 1994. Principles of Clinical Toxicology, 3rd edit., New York, 197pp.

Goyer, R.A., 1993. Lead toxicity. Current concerns. Environmental Health Perspectives, Vol.100, p. 117 – 127.

Hana, A. and Al-Bassam, K., 1983. A survey of lead pollution in Baghdad. Water, Air and Soil Pollution, Vol.19, p. 3 – 14.

Hana, A. and Al-Hilali, M., 1986. Investigation of some environmental aspects in Baghdad. GEOSURV, int. rep. no. 1529.

Hana, A., Humadi, M. and Mohamad, A., 1988. Pollution investigation inside the State Factory of Battery Manufacturing. GEOSURV, int. rep. no. 1609, (in Arabic).

Haqus, M.D. and Hammed, H.A., 1986. Lead content of green forage growing adjacent to express ways and roads connecting Erbil city (N. Iraq). Jour. Bio. Sci. Res., Vol.17, p. 153 – 164.

Harrison, R.M., 1979. Toxic metals in streets and household dusts. The Science of the Total Environment, Vol.11, p. 89 – 97.

IARC, 1986. Some metal and metallic compounds. International Agency for Research on Cancer. Monograph on the evaluation of the carcinogenic risk of chemicals to human, Vol.23, p. 325 – 385.

IPCS, 1995. Environmental Health Criteria no. 165; Inorganic Lead. WHO, Geneva, 300pp.
James, R., Randy, N. and Leonare, N., 2004. The association between environmental lead exposure and bone density. Environ. Health Perespec., Vol.12, p. 1200 – 1203.
Jamil, H., 1987. Lead pollution in Baghdad. 2nd Conference of Higher Council of Scientific Societies, Baghdad, (Abstracts), p. 118, (in Arabic).
Kemedy, C.H., Hatch, G.E, Slade, R. and Mason, R.P., 1992. Toxicology. Applied Pharmacol., Vol.14, p. 41.
Khalid, B.Y. and Salih, B.M., 1981. Lead contamination of soil in Baghdad city. Iraqi Bull. Environ. Contam. Toxical, Vol.27, p. 634 – 638.
Richard, L., 2004. Very low lead linked with IQ deficits. Ace. National England Jour., Vol.210, p. 520 – 531.
Salman, K.H., 2007. Study in the environmental situation of Basra Governorate. Ph.D. Thesis, College of Science, University of Baghdad, 180pp, (in Arabic).
Shanshal, S.M., 2004. Pollution impact resulting from tannery and brick factories on soil and water at Nahrawan area, eastern Baghdad. M.Sc. Thesis, College of Science, University of Baghdad, 135pp, (in Arabic).
Shaw, D.M., 1969. In: K.H. Wedepohl, (Ed.), Handbook of Geochemistry, Vol.1. Springer Verlag, 442pp.
Thakur, M. and Deb, M.K., 2000. Lead levels in airborne dust particulate of Urban city of central India. Environ. Monit. Assess., Vol.62, p. 305 – 316.
Thomas, E., Andreoli, M.D., Charles, E. and Carpenter, M.D., 2004. Cecil Essentials of Medicine, 6th edit., 458pp.
Vedenov, P., Ivancheva, J. and Asenova, L., 1996. Preliminary assessment of the Bulgarian lead emissions. In: Report and proceedings of the Workshop on the Assessment of MEP Activities Concerning Heavy Metals and Persistent Organic Pollutants and Their Further Development, Vol.2, no.117, p. 125 – 128.
WHO, 1977. Environmental Health Criteria, no. 3: Lead, Geneva.
Xinwei, L., Wang, L., Lei, K., Huang, J. and Zhai, Y., 2009. Contamination assessment of copper, lead, zinc, manganese and nickel in street dust of Baoji, NW China. Jour. Hazard. Mater., Vol.161, p. 1058 – 1062.

APPENDIX

Digestion procedure for Pb-analysis (Al-Janabi *et al*., 1992).

1. Grind the dust sample using agate mortar.
2. Dry in an oven at 110° C for 2 hrs.
3. Weigh 0.25 gm of air-borne dust, or 1.0 gm of streets dust, using sensitive balance and place in a 250 ml. breaker.
4. Add 15 ml conc. analar HCl and 5 ml conc. analar HNO_3.
5. Heat in a sand-bath until brown fumes are over and the sample is completely dry (takes 45 – 60 min).
6. Cool to room-temperature and add 5 ml of analar conc. HCl.
7. Heat in a sand-bath until dryness (takes 5 – 10 min).
8. Cool to room temperature and add 5 ml of conc. analar HCl and 12.5 ml (air-borne dust) or 50 ml (street dust) of hot distilled water.
9. Boil for (2 – 3) min.
10. Filter, using Wattman no. 42, in a volumetric flask.
11. Wash the residue, several times with distilled water and add to filtrate.
12. Complete the volume by distilled water to 25 ml (or 100 ml for street-dust samples).
13. Analyze by atomic absorption spectrophotometry.

Note: Using 0.25 gm of air-borne dust is due to the limited amount of sample available for analysis. Otherwise, use 1.0 gm.