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Lead Contamination of Soil in Baghdad, Iraq

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ABSTRACT

Lead (Pb) levels in soils for different sites in Baghdad were determined to assess the soil contamination by lead in the city. Around sixty-three soil samples were collected as indicator of Pb pollution from different sources. The mean Pb concentrations in the soils ranging from 15 mg Pb/kg at the bus station, 800-2300 mg Pb/kg in the city center, and 8-350 mg Pb/kg along the highway. Value up to 9350 mg Pb/kg found in the soils near the batteries factory.

The mean Pb concentrations in the city centre were substantially higher than values found in other places; they were also higher than the standards for soil in residential areas and in playgrounds for children. Pb soil concentrations at the downwind sides were some 60% higher than the upwind area. Bioavailable Pb (extracted with 0.04 M Na2EDTA solution) was also determined in this study. This parameter showed significant correlation with total Pb.

Control measures should be adopted to reduce emissions of mobile-exhaust Pb and lead smelters. Nearby pollution sources such as highways, major streets, and batteries factories should be considered when locating new, schools and land use projects. At the same time, vegetable production and animal grazing should also be avoided in areas near highways.

Keywords: Total Lead, Bioavailable Lead, batteries factory, Soil contamination

1.INTRODUCTION

Trace elements are elements that are normally found at low concentration in soils, plants, and water, and which may or may not be essential for the growth and development of plants, animals, or humans. Lead (Pb) is one of the non-essential trace elements; it is useful but toxic, and lead is one of the commonest and most widely distributed of the environmental metal poisons (Pierzynski et al, 2000; Reilly, 2002). Natural processes such as chemical weathering of rocks and soil, volcanoes and forest fires contribute in a large amount to global input of lead into the environment (Khans, 1980). Pb occurs naturally in soil in low concentration, and transfers to the food chain from soil to plants and then to the animals and so on. However, when the concentration increase it will become toxic and hazardous for the health and the balance of the environment itself, so knowledge of concentrations of lead is important (Khans, 1980). Pb can introduce to the environment from both natural and anthropogenic sources such as: mining and smelting activities, lead recycling factories, Emission from leaded gasoline, combustion of coal and oil, manures, sewage sludge usage in agriculture, use of lead compounds e.g. fungicides, insecticides, anti-fouling paints (Harrison and Laxen, 1981; WHO, 1989; Tong, 2000). From 1920 petrol contained lead alkyls as anti-knocking agents was used and that lead to increase in lead concentration in air, surface water and soil. (Smith, 1986). Even under strict environmental controls applied on a large scale in the modern lead industry, there are accumulations of lead in soils around the works sites (Davies, 1995). Other sources of lead in the environment are agricultural chemicals such as pesticides, fertilizers and lime; sewage sludge containing lead is commonly used in agricultural land. All contribute to soil contamination by lead (Khans, 1980; Reilly, 2002). Because the lead enters the soil through the soil surface and the accumulation occurs also through the deposition of contaminated plant residues, the higher accumulation of lead occurs in the top layer (Khans, 1980; Wixson and Davies, 1993). Many studies have been carried out on the toxicity of lead to humans being and these studies showed that the foetus and young child population groups as those at greatest risk for adverse health effects of lead. In addition, these studies proved that there are some factors infusing susceptibility to lead toxicity such as dietary, metabolic, and sociological factors (Nriagu, 1978; Burke, 1983). Pb exposure has increased throughout the world. In many developing and industrializing countries, as well as in some developed countries, exposure to lead remains a serious problem. While in most developed countries introduction of lead into human environment has decreased in recent years, due to public health campaigns and the decline in lead commercial usage especially as petrol additives, chronic exposure to low levels of lead is still a public health issue in developing countries. (Tong, 2000). The segment of the population at risk is the very young, i.e. foetus, infants and children, and Pb poisoning is one of the most important chronic environmental illnesses affecting modern children. Despite efforts to control it and despite apparent success in decreasing incidence, serious cases of lead poisoning still appear (Burke, 1983). Pb is more dangerous to children than adults because babies and children often put their hands and other objects in their mouth; also the children's growing bodies absorb more lead, and children's brain and nervous system are more sensitive to the damaging effects of lead (U.S EPA, 2005).

Hence, the objectives of this study it to investigate and monitor Pb contamination in soil samples from different parts of Baghdad. Also, to lay relationships between the Pb contents and the activities that may be connected to high Pb discharges.

2. MATERIALS AND METHODS

The research was carried out in Baghdad city, the capital of Iraq. Baghdad is the biggest city in the country, with a population of about six million and population density about 1160 persons per km^2. The area is about 660 km^2; it is situated on the Tigris River at 33.23N latitude and 44.23E longitude. The dominant wind direction in Baghdad is North-West (Abdullah, 1990). For this research, 63 surface soil samples from Baghdad soil were collected in a way to achieve a spatial coverage of the entire city, from areas exposed to industrial and traffic emissions, highways, city centre, and from rural area to serve as control (background levels). Special attention was paid to the Pb spatial distribution around the batteries factory, and on highways. On each sampling site, one(1) kg surface soils, 0-5 cm deep were collected. For each sampling point, four samples were taken and mixed onsite for better samples representivity (Wixon and Davie, 1993). The samples were collected with a stainless steel corer (15 cm length; 5 cm diameter). The samples were placed in polyethylene bags and were later transferred to aluminum dishes for drying. The sampling period was from 20 September- 4 October 2005. Twenty two soil samples were taken on both sides of the major highway in Baghdad (Al-Doraa) highway (see Fig.1).The highway is about 15 km long and has a traffic density around 4100 vehicles/day. The samples were distributed to such way to help in study the relation between the distance from the highway and the Pb levels in soils. In order to indicate the wind effect on Pb distribution around the highway, 10 samples were taken down-wind, 12 samples in the upwind direction. The spatial distribution of the samples were: at the fence of the highway, 2m from the highway, 5m, 20m, 30m, 40m, 50m, 75m, 100 m, and 200 m from the highway downwind direction. The same distance distribution was applied in sampling the upwind direction; 10 and 15 m were additionally sampled.

Batteries factory (Babylon), with one of the highest production capacities in the Middle East. It was established in 1953. The smelting sections in the factory have three blast furnaces with < 30 m heights of chimneys (Alusi, 2004). Eight samples were taken in the downwind direction and the same numbers of samples upwind were taken as well; the spatial distribution of the samples was: at the factory fence, 2m from the factory's fence, 5 m, 10 m, 15 m, 25 m, 50 m, and 100 m. Because of the difficulties of the situation in Baghdad at the sampling time, it was not possible to sample at a distance further away from the Babylon factory. For the city centre 10 samples were taken randomly from the Bab Al- Shargy area, which represents one of the highest traffic densities in the city and the most air polluted area (Environmental Protection Center, 1990). Wind effect was not considered in sampling because of the surrounding buildings, which almost delete the wind effect inside the urban area (Khalid et al, 1981).From other hand one of the major stations in Baghdad (AL-Bayaa Bus station) was used as study area, five samples near the target station were sampled randomly. 10 samples were taken from rural areas (agricultural area was avoided in the sampling) around Baghdad city to serve as control samples. Total Pb was determined in the soil samples by using atomic absorption spectrophotometry (AAS) (Cheremisinoff and Cheremisinoff, 1993; Wixon and Davies, 1993; Kruis, 2002; Popek, 2003).

To estimate the bioavailable Pb, a Na_2EDTA solution was used to extract soil Pb according to Ure et al, (1993). Pb concentration in the filtrate (Pb extract) was determined using flame atomic absorption spectrophotometers (AAS).A wavelength of 283.3 nm and a flame air-acetylene mixture were used.

Figure 1: Map for the location of the study. Source: Google 2018.

3. RESULTS AND DISCUSSIONS

The result showed a mean value of 6 ± 0.2 mg Pb/kg with a range of 4.5-8.3. The values of bioavailable Pb for the background area showed a mean of 0.3 ± 0.1 mg Pb/kg with range from 0.1- 0.5 mg Pb/kg. It was observed that bioavailable Pb followed the same trend as total Pb followed), and there was a high correlation (r^2 =0.85) between the two parameters see fig (2).

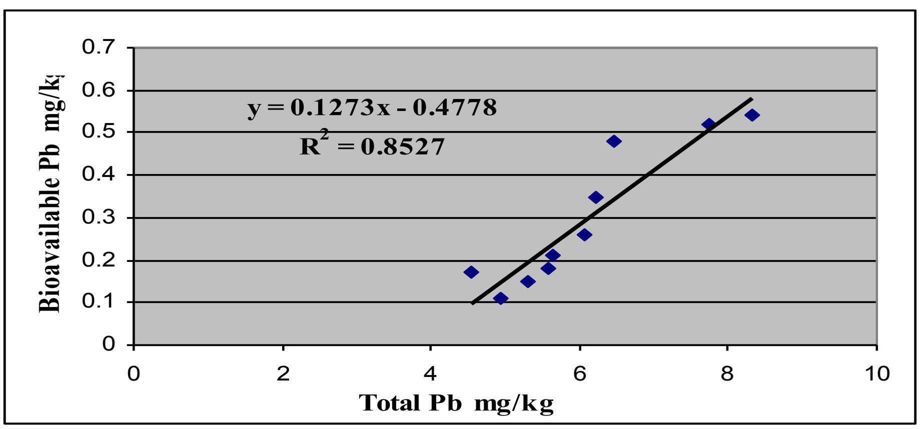

Figure 2: Correlation between bioavailable and total Pb for the background area

The mean background Pb value for Baghdad soils is comparable to the findings of Kharnoob (2004), who reported background concentrations for some Iraqi cities of 5, 7.5, 4.2, and 5 mg Pb/kg for Baghdad, Kut, Mousel and Nassiria, respectively. The results lie also within the range of background concentrations in other part of the world; Ratcliffe (1981) stated that Pb concentration for unpolluted soil ranges between 5-30 mg Pb/kg, Khans (1980) found a concentration in a number of Canadian soils varying from 7-23 mg Pb/kg with an average of 17 mg Pb/kg. While the results for the city centre showed an average of 1253 ± 129 mg Pb/kg with a range of 783-2356. The highest concentration was found in the area close to the roads junctions. Pb concentrations found in city centre were significantly higher than in other areas in the city. The values of bioavailable Pb for the city centre area showed a mean of 366 ± 190 mg Pb/kg with range from 148-875. The bioavailable Pb distribution trend was similar to that of total Pb; the two parameter showed high correlation (r^2 = 0.96) see fig (5).

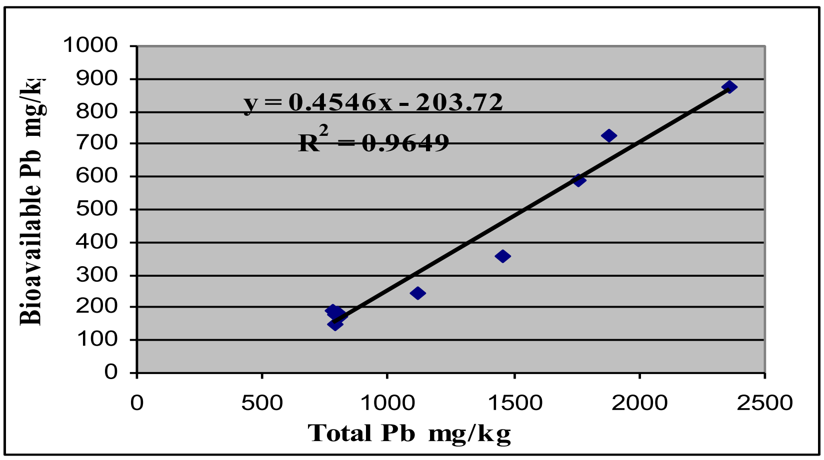

Figure 3: Correlation between total and bioavailable Pb for the city centre

The value of 1253mg Pb/kg was determined as the mean concentration in the Baghdad City centre; which has the highest traffic density in the city (Khalid et al, 1981; Environmental Protection Centre, 1990); this result showed that the city centre is around 208 times more contaminated compared with the city background concentration. Above result is also significantly higher than the value of 320 mg Pb/kg which was reported by Kharnoob (2004), as a mean Pb concentration in some Baghdad residential areas. However, it is comparable to the findings of Jackson (2005) who studied the Pb concentration in Dar-es-salam City, Tanzania; he found the highest Pb concentrations in areas of highest traffic density. This indicates that Pb contamination can largely be related to the burning of leaded gasoline by automobiles. Also, these results are above the US.EPA standard for Pb concentration in children's play areas (400 mg/kg) and 1200 mg/kg as the hazard standard for bare soil in residential areas (US.EPA, 2005). It lies within the intervention value (remediation is necessary) of the Dutch standard of 530 mg/kg (Chen, 2003); also this value is significantly higher than the Italian Pb concentration limit (100 mg/kg) for Pb in public residential and private areas (Imperato et al, 2003), and higher than the UK critical value of 500 mg/kg for gardens and allotments. Finally the value lies above the Canadian values for agricultural

(375 mg/kg), residential (500 mg/kg) and industrial areas (1000 mg/kg) (Jonathan and Flora, 2005). The mean Pb soil concentrations recorded in this research were significantly higher than the average concentrations found in other researchers (see Table 1).

Table 1: Mean Pb concentrations of soils in different cities (mg/kg)

Place	Mean Pb concentration mg/kg	Applied gasoline phase out strategies at time of research	Source
Baghdad, Iraq-2005	1250	No	This study
Baghdad, Iraq-1980	255	No	Khalid et al. (1981)
Kuwait city, Kuwait	680	No	Malik et al. (1985)
Jeddah, Kingdom of Saudi Arabia	783	No	Nasralla (1984)
Hong Kong	991	No	Ho and Tai (1988)
Nairobi, Kenya	659	No	Onyari et al. (1991)
Bahrain city, Kingdom of Bahrain	680	No	Akter and Madany (1993)
Tel Aviv city, Israel	177	Partially phased out	Foner (1993)
Taejon, South Korea	60	Completely phased out since 2001	Kim et al. (1998)
Beirut city, Lebanon	353	Partially; since June 2001, 80 % of total consumption was shifted to unleaded gasoline	Hashisho and El-Fadel (2004)

The mean concentration of 1250 mg Pb/kg for this research is 4 times the Pb concentration found in the city centre for the 1980 study (308 mg/kg) (Khalid et al, 1981); this result indicates a continuous accumulation of Pb into Baghdad soils over the last 25 years. The results of Al-Doraa highway up to 200 m from the highway showed an average of 75.9 ± 78 mg Pb/kg with a range of 8-350 mg Pb/kg. The highest concentration of 350 mg Pb/kg was found in the sample close to the highway at almost 0 m distance; then soil Pb concentration decreased rapidly following an exponential decline. Distance around the 20 m from the highway have the higher Pb concentrations; after this the Pb concentrations were almost normal. To examine the final influence point of the highway emissions on the nearby soils, a comparison between the 100 and 200 m Pb soils concentrations can be made. At 200 m the concentration was so close to the background concentration indicating that the final influence point of the highway emissions was estimated at 100 m distance from the highway. The values of bioavailable Pb for the downwind part of the highway showed a mean of 13.2 ± 10.7 mg Pb/kg with range from 2.1-39. The bioavailable Pb distribution along the distance from the highway followed the same trend as total Pb followed. the bioavailable Pb showed significant, and positive correlation with total Pb (r^2 = 0.90) see fig. (4 and 5).

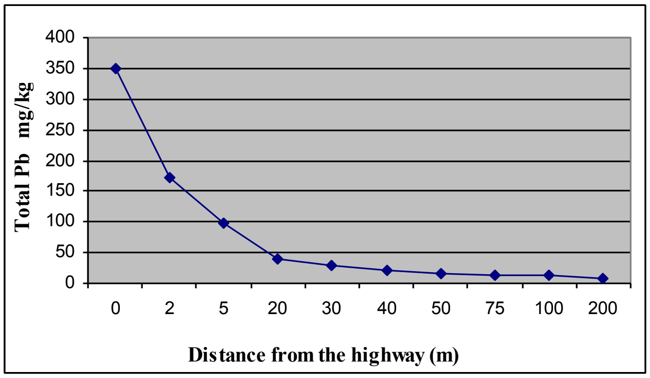

Figure 4: Total Pb concentration at Al-Doraa highway down-wind (mg Pb/kg)

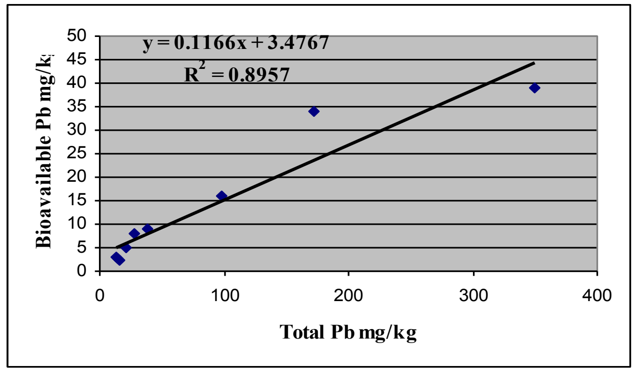

Figure 5: Correlation between total and bioavaliable Pb (downwind)

Upwind direction of the samples up to 200 m showed an average of 43.9 ±10.3 mg Pb/kg with a range of 14-210. Similar to the downwind side the highest Pb concentration of 210 mg Pb/kg was found in the sample close to the highway, the soil Pb concentration then decreased rapidly following exponential decline. Similar to the downwind side, the distance up to 20 m from the highway showed the higher Pb contamination. The influence for the up-wind direction was estimated at around 100 m. The values of bioavailable Pb showed a mean of 9.9 ± 6.4 mg Pb/kg with a range from (1.8-29). Similar to the down-wind side, the bioavailable Pb followed the same trend as total Pb. Bioavailable Pb showed a significant and positive correlation with total Pb ,see fig.(6 and 7) .

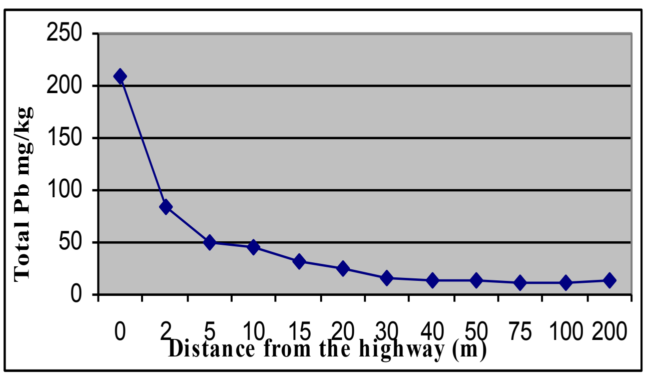

Figure 6: Total Pb concentration at Al-Doraa highway down-wind (mg Pb/kg)

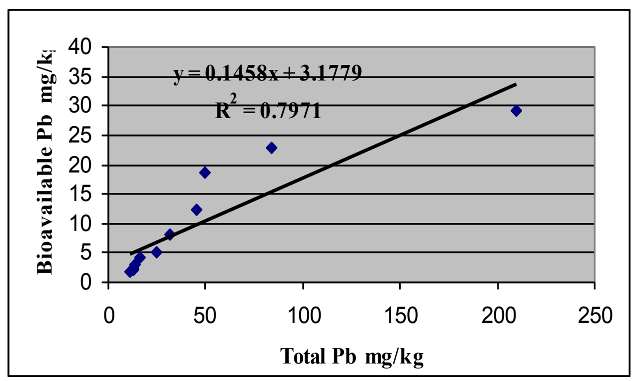

Figure 7: Correlation between total and bioavailable Pb (upwind)

The Pb concentration along the distance from the highway (both side) decreased sharply following anexponential decline; this trend is comparable to other researches (Ward et al, 1975; Wheeler and Rolfe, 1979; Khan, 1980; Flores and Castellon, 1982; Ndiokwere, 1984; WHO, 1989; Jaradat and Momani, 1999). Jaradat and Momani (1999), in their estimations of Pb concentration along the distance from highways in Jordan, found maximum Pb concentration between 1.5- 10 m distance from highway; Viard et al. (2004) reported a distance between 5 and 20 m as area with maximum Pb contamination. It was found that Pb distribution along the highway (both sides) followed a very significant (r^2 = 0.93-0.97) exponential decay with distance, according to: $Y_s = A_s \cdot e^{-KD}$, where Y_S is the soil Pb concentration (mg Pb/kg); A_S is the

Pb concentration at the pavement edge (mg Pb/kg); K is a constant (1/m) (K values: 0.25 and 0.28 for downwind and upwind respectively) and D is the distance from the road edge (m). Ward et al. (1975) found a very similar result but included the background concentration B_S (mg/ kg) in the formula as follows: $Y_S = B_S + A_S \cdot e^{-K D}$ see fig.(8 and 9).

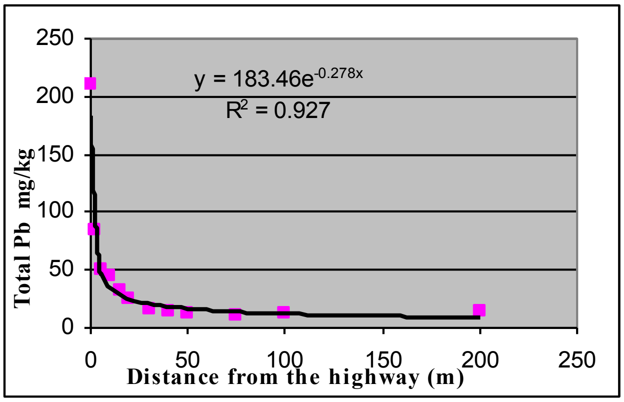

Figure 8: Correlation between total Pb and distance from the down-wind side of the highway

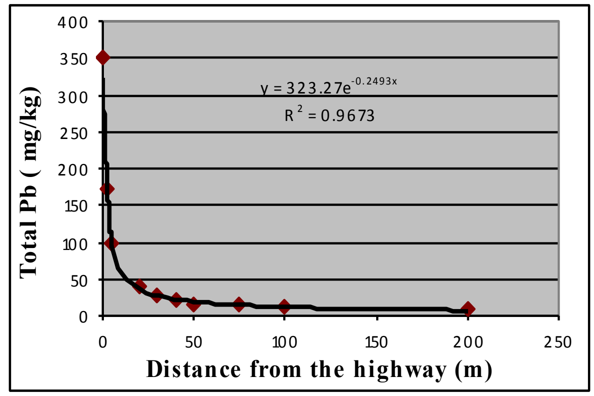

Figure 9: Correlation between total Pb and distance from the up-wind side of the highway

For both sides, the influence of the highway emissions was estimated at around 100 m. These results are comparable to the results of most other researches (Wheeler and Rolfe, 1979; Flores and Castellon, 1982; Ndiokwere, 1984; WHO, 1989; Turer et al, 2001; Al-Kendy, 2005Viard et al. ,2004). To indicate the wind effect on Pb distribution for both sides of the highway a two-tailed "paired t-test'' was carried out to examine the significance of wind effects; the result showed significant difference between the mean values of each side of the highway(both at $p<0.05$ and $p<0.01$) indicating that the wind direction has strong effect on Pb distribution, this result is comparable to other researches (Flores and Castellon, 1982; Jaradat and Momani, 1999; Al-Kendy, 2005).see fig. (10).

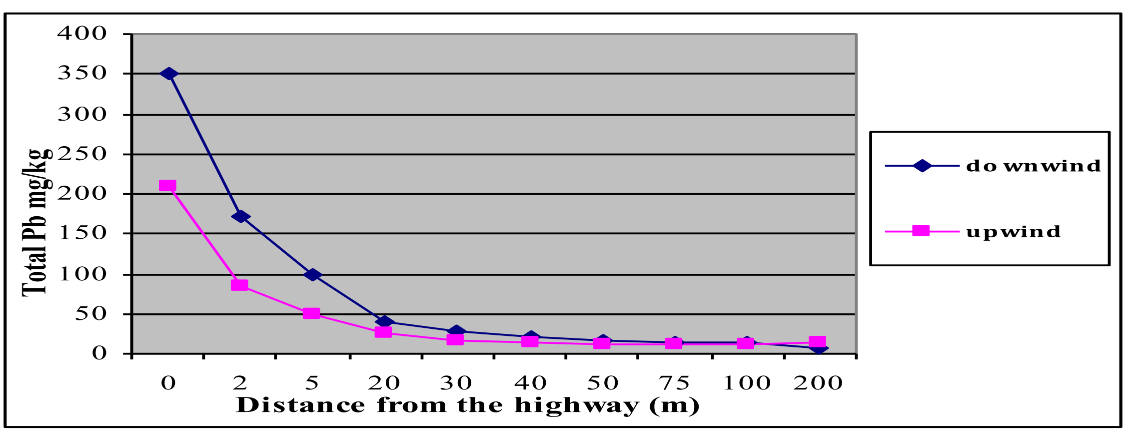

Figure 10: Total Pb distribution along the highway for both sides

The results of total Pb for the samples up to 100 m from the batteries factory (down wind) showed an average of 7294 ± 2050 mg Pb/kg with a range of (3210-9350) The highest concentration of 9350 mg Pb /kg was found in samples close to the factory; then the soil Pb concentration decreased following exponential decline. The values of bioavailable Pb showed a mean of 2457 ± 880 mg Pb/kg with a range from (540-3269). The bioavailable Pb distribution along the distance from the factory followed a similar trend as the total Pb. The bioavailable Pb showed significant positive correlation with total Pb with correlation coefficient $r^2 = 0.97$ (see fig. 11).

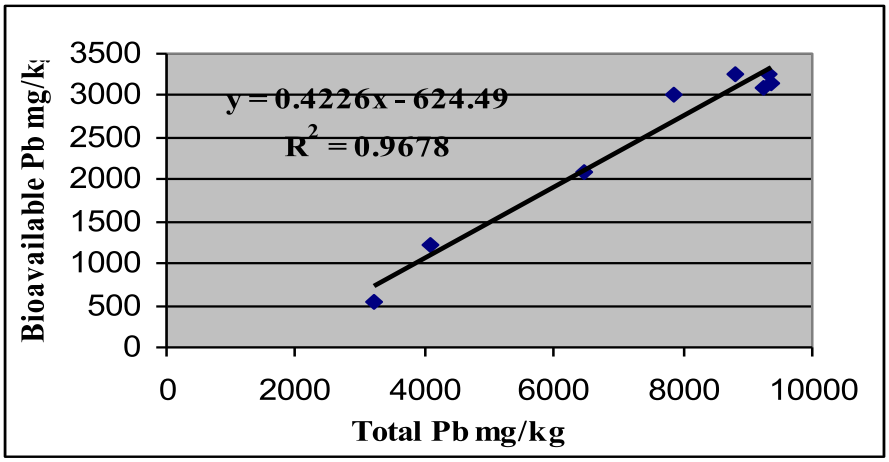

Figure 11: Correlation between total and bioavailable Pb for the down-wind side of the Babylon factory

For up- wind direction, the results of the total Pb for samples up to 100 m from the factory showed an average of 2280 ± 1311 mg Pb/kg with a range of (733-5550). Meanwhile the mean Pb concentration in down-wind side was significantly higher than that of the up-wind side. The trend of Pb distribution along the distance from both sides of the factory showed a gradual rapid decline away from the source, and significant correlation with distance (r^2 =0.94 and 0.66) for down-wind and up-wind, respectively. See fig. (12 and 13).

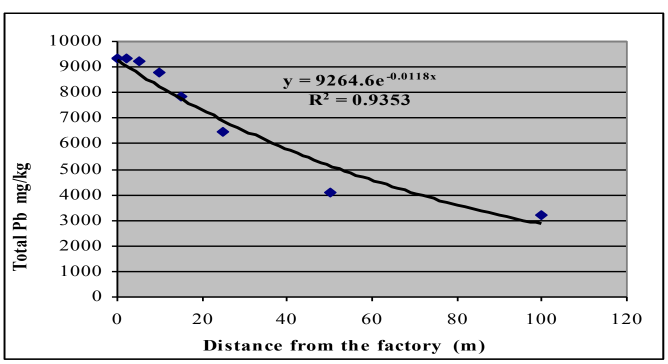

Figure12: Pb distribution along the distance from the Babylon factory down-wind

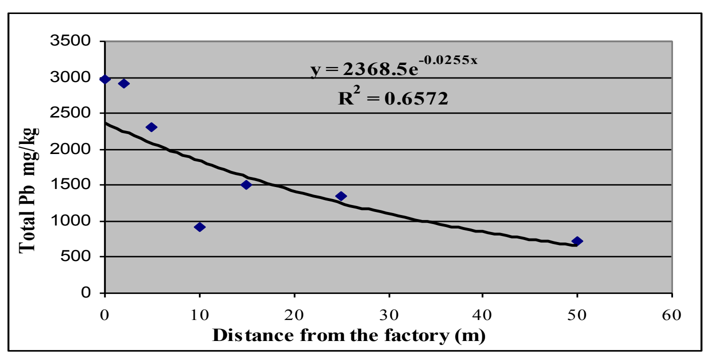

Figure 13: Pb distribution along the distance from the Babylon factory up-wind

The values of bioavailable Pb for the up-wind factory showed a mean of 791 ± 408 mg Pb/kg with range (278-1897). Similar to the downwind side, the bioavailable Pb showed similar trend as total Pb distributed along the distance from the plant, and showed significant positive correlation with total Pb with(r^2 = 0.84)see fig.(14).

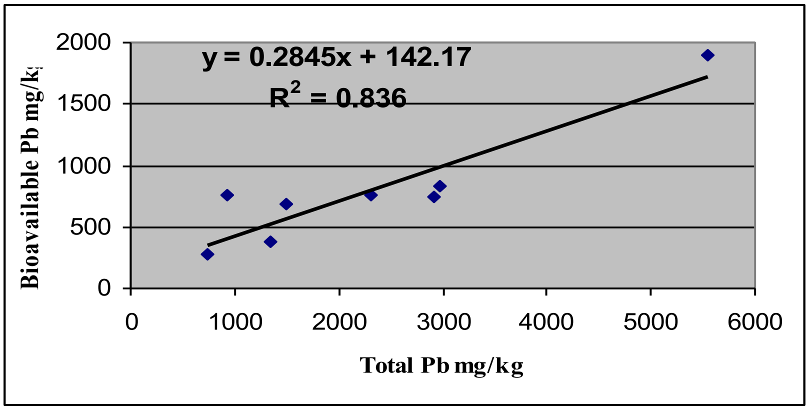

Figure 14: Correlation between total and bioavailable Pb for the up-wind side of the Babylon factory

These results is comparable to results reported by Khans (1980), Kotuby et al.(1992), Skinner and Salin (1995), Davies (1995), US.EPA (1998) and Sridhar (2005) who reported maximum Pb accumulation close to the source, and a rapid decline along the distance from the source. To indicate the effect of the dominant wind direction on Pb distribution for both sides of the factory a two-tailed" paired t-test' was carried out. The result showed significant difference between the mean values of each side of the factory, indicating that the dominant wind direction has a strong effect on Pb distribution. Similar results were obtained by Baghaie et al. (2003) who examined Pb distribution around two steel factories in Isfahan, Iran, and by Rieuwerts et al. (1999) and Cartwright et al. (2005).see fig.(15).

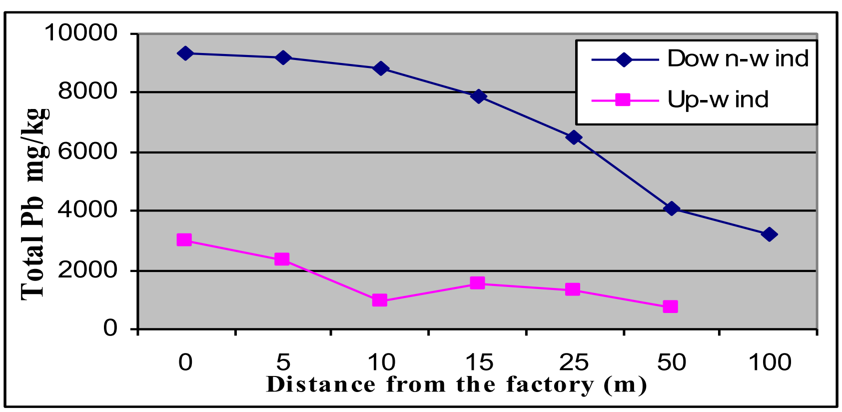

Figure 15: Pb distribution along the distance from the Babylon factory both sides

The results for the Bus station area showed an average of 14.6 ± 1.4 mg Pb/kg with a range of 11.8-18.7. It is interesting to find that the samples in this area were less contaminated with Pb compared with other sampling areas. Similar to the other sampling areas, the bioavailable Pb distribution trend was the same as the total Pb. The values of bioavailable Pb for the bus station area showed a mean of 1.96 ± 0.96 mg Pb/kg with range varied from 0.8-2.9 mg Pb/kg. The bioavailable Pb showed high correlation with total Pb (r2 = 0.93). This result is comparable to the finding of Kharnoob (2004) .After laboratory analyses were finished and the above results appeared, a personal communication with the supervisor of the bus station was made to investigate the reason behinds the low soil contamination; from that communication, results showed that more than 90% of the cars (mini-buses) that serve this bus station uses gas-oil as fuel rather, than (leaded) gasoline. Other reasons for the relatively low Pb contamination are the Al-Bayaa bus station was the fact that it was built in 2002, so its area will have less Pb compared to other areas in the city.

4. CONCLUSIONS

The Maximum Pb levels were found in soils near to the Pb emissions sources (highway, batteries factory and urban streets), therefore residents near these areas are at high-risk for Pb pollution and these sites can be a significant source of Pb intake by children. For the highway the maximum Pb concentration was found close to the highway fence; the distance (0-20) m from the highway (both sides), represent the most effect zone for Pb emission; while after 100 m distance, highway influence had nearly disappeared. More Pb in the soil was observed on the downwind side for both the highway and Babylon factory zones; the dominant wind direction have a significant effect on the Pb distribution.

The Pb concentration in the Baghdad city centre and the area near the Babylon factory was above the standards of Pb in soil, indicating that the soil pollution with Pb has reached critical values that need remediation. Although the highway samples are within the Pb standards, they may reach to critical levels in future, as Pb is still introduced in the highway environment. The area around the bus station showed very low Pb contamination compared with the other studied areas (highway, Babylon factory, city centre).This can be ascribed to the relatively clean fuel used by the buses Relatively high percentages of bioavailable Pb were found in polluted areas (Babylon factory zone, city centre and highway), compared with background zone. This indicates that the bioavailable Pb especially comes from anthropogenic sources. Bioavailable Pb may easily transfer into the food chain rather than the Pb in the background area.

5. REFERENCES

Abdullah S.A, 1990. Climatologically Atlas of Iraq, Iraqi Metrological Organization, Baghdad.

Akter MS and Madany IM, 1993. Heavy Metal in Street and House Dust in Bahrain. *Water, Air & Soil Pollution* .66(1-2):111-119.

Al-Kendy GY, 2005. Lead Concentration in Soil of Mohamed Al-Kasim Highway.*M.Sc thesis, Technological University, Baghdad, Iraq.*

Alusi OA, 2004. Risk Assessment for Lead Emissions from Babylon Batteries Manufacturing Factory in Al-Waziriya, *M.Sc thesis, Baghdad University, Bghdad, Iraq.*

Baghaie AH, Khademi H, Afyuni M, and Mohammadi J, 2003. Spatial Variability of Pb, Zn and Ni around Two Industrial Factories Based on Wind Direction. *Paper Presented at 2nd International Workshop of Center Stefano Franscini, Ascona, Switzerland.*

Burke T., 1983. *Lead in Drinking Water*. Technical Report, TR 187, WRC Environment, *Medmenham Laboratory.*

Cartwright B, Merry RH and Tiller KG, 2005. Heavy Metal Contamination of Soil around a Lead Smelter at Port Pirie, South Australia. *Australian Journal of Soil Research* 15(1):69-81.

Chen SZ, 2003. Relationship Between Heavy Metal Concentration in Soil of Taiwan and Uptake by Crops, National Taiwan University, http://www.agnet.org/library/data/tb/tb149/tb149.pdf , accessed 2005,Dec.3.

Cheremisinoff PM and Cheremisinoff PN, 1993. Lead: A Guidebook to Hazard Detection, *Remediation, and Control, PTR Prentichall, New Jersey.*

Davies BE, 1995. Lead .In Alloway BJ (Ed) *Heavy Metals in Soils* (2nd ed), *Blackie Academic Professional, Glasgow.*

Environmental Protection Centre (1990). Pollution Emissions from Cars. Technical Report, Iraqi Ministry of Health.

Flores MR and Castellon ER (1982). Lead and Cadmium Levels in Soil and Plants near Highway and their Correlation with Traffic Density. *Environmental pollution* .4:281-290.

Foner HA (1993). Lead Pollution in Israel. *Water Science and Technolog*.27 (7-8): 253-265.

Jackson MM (2005). Roadside Concentration of Gaseous and Particulate Matter Pollution and Risk Assessment in Dar-es-salam, Tanzania. *Environmental Monitoring and Assessment*.104: 385-407.

Jaradat QM and Momani KA (1999). Contamination of Road Side Soil, Plants, and Air with Heavy Metal in Jordan, a Comparative study. *Turk.J.Chem*. 23:209-220.

Jonathan O and Flora M (2005). Assessment of Lead Exposure in Thohoyandou, South Africa. *The Environmentalist* 24(3):171-178.

Harrison RM and Laxen DPH (1981). Lead Pollution: Causes and Control, University Press, Cambridge.

Hashisho Z and El-Fadel M (2004). Impact of Traffic-Induced Lead Emissions and Air, Soil and Blood Levels in Beirut. *Environ. Monit Assess*. 93(1-3):185-202.

Ho YB and Tai KM (1981). elevated Levels of Lead and Other Metals in Roadside Soil and Grass and their Use to Monitor Aerial Metal Depositions in Hong Kong. *Environmental Pollution*. 49(1): 37-51.

Imperato M,Adamo P,Naimo D,Arienzo M,Stanzione D,and Violante P (2003). Spatial Distribution of Heavy Metal in Urban Soil of Naples City (Italy).*Environ Pollut*. 124(2):247-256.

Kim KW, Myung JH, Ahn JS and Chon HT (1998). Heavy Metal Contamination in Dust and Stream Sediments in the Taejon area, Korea. *Journal of Geochemical Exploration*.64:409-419.

Khalid BY, Salih BM, and Isaac MW (1981). Lead Contamination of Soil in Baghdad City, Iraq. *Bull.Environm.Contam.Toxicol*.27:634-638.

Kharnoob HH (2004). Lead Distribution in Iraqi Environment and its Effect on Population. General Report, Ministry of Environment, Baghdad.

Khans DH (1980). *lead in the Soil Environment*. Technical Report, Chelsea College. University of London.

Kotuby AJ, Gambrell RP, and Amacher MC (1992). Distribution and Environmental Chemistry of Lead in Soil at an Abandoned Battery Reclamation Site, Lewis Publisher, Boca Raton.

Kruis F (2002). Environmental Chemistry: Selected Analytical Methodes.Lecture Notes EE095/02/1, IHE Delft, the Netherlands.

Malik SR, Atari NA, and Al-Mishwt AT (1985). Uses of Nuclear Technique and SSNTD in the Studies of Lead Pollution in Kuwait. *Water, Air & Soil Pollution*.25 (1):15-32.

Nasralla MM (1984). Lead in Jeddah Urban Dust. *Environmental Pollution*. 8:133-141.

Nidokwere CL (1984). A Study of Heavy Metal Pollution from Motor Vehicle Emissions and its Effect on Road Side Soil, Vegetation and Crops in Nigeria.

Nordic (2003). Lead Review, Nordic Council of Ministers [PDF] http//www.norden.org/milijoe/uk/NMR_lead.pdf.

Nriagu JO (1978) the Biogeochemistry of Lead in the Environment, Biomedical Press, Amsterdam

Onyari JM, Wandiga SO, Njenga Gk and Nyatebe JO, 1990. Road Side Soil Contamination in Nairobi. *Bull.Environ.Contam.Toxicol*. 46:782.

Pierzynski GM, Sims JT and Vance GF, 2000. Soils and Environmental Quality (2nd ed), *CRC Press, Danvers.*

Popek EP, 2003. Sampling and Analysis of Environmental Chemical Pollutants. *Academic Press, San Diego*.

Ratcliffe JM.,1981. Lead in Man and the Environment, Ellis Harwood Limited, Chichester.

Reilly C., 2002. Metal Contamination of Food: it's Significance for Food Quality and Human Health (3rd ed), *Blackwell Science, Oxford.*

Rieuwerts SJ, Farago M, Cikrt M and Bencko V.,1999. Heavy Metal Concentration in and Around Households near a Secondary Lead Smelter. *Environmental Monitoring and Assessment.* 58(3):317-335.

Skinner CD and Salin ED.,1995. Determination of Lead in Soil Surrounding A Lead-Acid Battery. *Water Quality Research journal of Canada*. 30 (2): 299-340.

Smith M., 1986. Lead in History .In: Lansdown R and Yule W (Ed) *Lead Toxicity*. The Johns Hopkins University Press, Baltimore.

Sridhar MKC., 2005. Environmental Lead Levels in African Cities.http://www.cleanairnet.org/ssa/1414/articles-3619pdf.pdf , accessed 2005, Dec.5.

Tong S, Schimding EY, and Prapamontal T., 2000. Environmental Lead Exposure: A public Health Problem of Global Concern. *Bulletin of the World Health Organization*.78 (9): 1068-1076.

Turer D, Maynard BJ and Sansalone J., 2001. Heavy Metal Contamination in Soil of Urban Highways: Comparsion Between Runoff and Soil Concentrations at Cincinnati, Ohio. *Water, Air and Soil Pollution*. 132:293-314.

Ure AM, Quevauviller PH, Muntau H and Griepink B., 1993. Speciation of Heavy Metals in Soil and Sediments an Account of Improvement and Harmonization of Extraction Undertaken under auspices of the BCR of the Commission of the European Communities. *Int.J.Chem*. 51:135-151.

US.EPA., 1998. Source of Lead in Soil: A Literature Review. Battelle Memorial Instiute.http://www.epa.gov/lead/pubs/r98-001a.pdf [2005, Dec.25].

US.EPA., 2005. Residential Lead Hazard Standards-TSCA Section 403. http://www.epa.gov/lead/leadhaz.htm, accessed 2005, Dec. 23.

Viard B, Pihan F, Promeyrat S, and Pihan JC (2004). Integrated Assessment of Heavy Metal (Pb, Zn, and Cd) Highway Pollution: Bioaccumulation in Soil, *Graminaceae,* and Lndsnalis. *Chemospere* 55 (10): 1349-1359.

Ward NI, Reeves RD, and Brooks RR (1975). Lead in Soil and Vegetation Along A New Zealand State Highway with Low Traffic Volume. *Environmental Pollution*. 9: 243-251.

Wheeler GL and Rolfe GL, 1979. the Relationship between Daily Traffic Volume and the Distribution of Lead in Roadside Soil and Vegetation. *Environ.Pollut*. 18:265-274.

WHO, 1989. Lead-Environmental Aspects. Environmental Health Criteria 85. World Health Organization, *International Programme on Chemical Safety (IPCS), Geneva*.

Wixon GB and Davies EB, 1993. lead in Soil: Recommended Guidelines, *Science Review, Northwood*.