International Journal of Advanced Research in Biological Sciences
www.ijarbs.com

Research Article

Determination of Lead Levels in Soil Contributed by Industry in some Areas of Khartoum City and Gezira State, Sudan

Mohammed Mubarek Awad Ahmed

Faculty of science-AL Asmaria University-Ziletin- Lybia

*Corresponding author e-mail: *mmobarek@hotmail.com*

Abstract

Lead is now recognized as a heavy metal poisonous; it affects every system of the body. The present study was designed to examine the concentration of lead in soil in Khartoum, Arbagi, Dagala, Wadshantoor, Saleem by using AAS method. Samples of soil were collected from the bus station- Elsog Elshaabi, Elrobi batteries factory, and specific distances away from them, Arbagi, Wadshantoor, Saleem, Dagala and specific distances from the main road in Soba. Lead concentration in samples of soil in this study was ranging between 0.46 ppm (Saleem) - 11.24 ppm (Elrobi batteries factory). A positive correlation was found between urbanization and lead mean concentration (1.26 ppm) in Khartoum w.r.t (0.46 ppm) in Gezira state. A positive correlation was also found between the concentration of lead as being nearer to the centre of each of the bus station, Elrobi factory, and the main road. To avoid environmental lead pollution all lead – related industries should be far enough from human living.

Keywords: Lead, concentration of lead, AAS method.

Introduction

Lead is a cumulative poison that enters the body from lead water pipes, lead -based paints and leaded petrol (Renner, 1995). Presence of even traces of Pb(II) in environmental samples leads to environmental pollution and many fatal diseases including dysfunction of renal blood and neurological systems. Pb(II) easily deposits in blood, kidney, reproductive system, nervous system and brain, and acute lead poisoning can result in colic shock, severe anemia and irreversible brain damage. Lead compounds as antiknocking agents in automobile fuels cause air pollution. The determination of trace amounts of lead is very important in the context of environmental monitoring. Atomic absorption and atomic emission spectrometry are used for routine trace analysis of lead (Du *et al*., 2002).

Materials and Methods

The technique makes use of absorption spectrometry to assess the concentration of an analyte in a sample. It requires standards with known analyte content to establish the relation between the measured absorbance and the analyte concentration and relies therefore on Beer-Lambert Law. In short, the electrons of the atoms in the atomizer can be promoted to higher orbitals (excited state) for a short period of time (nanoseconds) by absorbing a defined quantity of energy (radiation of a given wavelength). This amount of energy, i.e., wavelength, is specific to a particular electron transition in a particular element. In general, each wavelength corresponds to only one element, and the width of an absorption line is only of the order of a few Pico meters (pm), which gives the technique its elemental selectivity. The radiation flux without a sample and with a sample in the atomizer is measured using a detector, and the ratio between the two values (the absorbance) is converted to analyte concentration or mass using Beer-Lambert Law (Walsh, 1955).

Soil samples:

The present study was carried out in Khartoum and some villages in Gezira (Arbagi, Wadshantoor Dagala, Saleem). Soil samples were collected in Khartoum beginning from the Bus Station in Elsog Elshaabi and at distances away from the bus station 100 m, 200 m, 500 m, 2 km. Other samples of soil collected from specific distances away from the main road in Soba- Khartoum which were 50 m, 200 m, 500 m, 1 km, away from the main road in Soba. Samples of soil also collected from Khartoum Bahri- Industrial area - Elrobi batteries factory and away from it by 100 m, 200 m, 500 m, 1 km. A part of samples were collected randomly from Arbagi, Wadshantoor, Dagala, and Saleem. Soil samples picked up from the surface earth.

Reagents:

●Methyl isobutyl ketone (MIBK)

●Diethyl dithio carbamate (DDC): 20 g of diethyl dithio carbamic acid- sodium salt were Dissolved in 380 ml of deionized water and filtered through a 0.45-micron Millipore filter. The filtrate was Extracted twice with 15 ml portions of MIBK.

● Phthalate buffer: 102 g of potassium biphthalate were dissolved in 500 ml of deionized water, 14 ml of 1 M HCl were added and diluted to 1 liter with deionized water.

● Hydrochloric acid: HCl concentrated.

● Sodium hydroxide: NaOH 1M. 4g of NaOH were dissolved in 100 ml deionized water.

Standard solutions

Standard containing 10, 25, 50, 75 and 100 µg/liter of Pb were prepared (acidified to maintain pH at 1-2) and treated as described below.

Soil Samples preparation:

The sample subjected to analysis required further preparation. Samples were ground and chopped by using a mechanical gate mortar. Cleanness of chopping and grinding equipment is essential, (Perkin- Elmer Co., 1994)

Five gram of an air dried-ground were placed and the sample was sieved in an Erlenmeyer flask.

Twenty ml of extracting solution were added (0.05M HCl + 0.05M H_2SO_4).

The solution was placed in a mechanical shaker for 15 min.

It was filtered through Whatman 42 filter paper into a 50 ml volumetric flask and it was diluted to 50 ml with extracting solution (Cory-Slechta *et al*., 1987).

Results and Discussion

Results of the Atomic absorption spectrophotometry method about the concentrations of lead in soil samples were listed in the table. 1.

From Table (3) it was obvious that the maximum mean concentration of lead in soil samples was found in samples which collected from Elrobi factory of batteries (1C) (11.24 ppm) and this is of course expected because lead was the essential material for batteries industry. Areas around the factory (100 m- 200 m- 500 m) (2C, 3C, 4C respectively) have to some extent high mean concentration of lead (3.62 - 3.46 - 1.35 ppm). Samples from 1 km away from the factory have low concentration of lead with respect to other samples around the factory (0.95 ppm) and this because lead has a high density so it could not dispersed far away.

Table 1. Samples location of soil

Site	Number of Samples	Samples Code
Bus Station-ElsogElshaabi- Khartoum	5	1B
100m away from the bus station	5	2B
200m away from the bus station	5	3B
500m away from the bus station	5	4B
1Km away from the bus station	5	5B
Industrial area - Elrobi batteries factory	5	1C
100m away from Elrobi batteries factory	5	2C
200m away from Elrobi batteries factory	5	3C
500m away from Elrobi batteries factory	5	4C
1Km away from Elrobi batteries factory	5	5C
100m away from the main road-Soba	5	1D
200m away from the main road-Soba	5	2D
500m away from the main road-Soba	5	3D
1Km away from the main road-Soba	5	4D
Rural areas:Arbagi, Dagala,Wadshantoor, Saleem	20	1E
Total	90	

Table 2. Results of lead concentrations in the soil samples as ppm using the atomic absorption method

No.	Sample Code	Lead Conc. (ppm)	No.	Sample Code	Lead Conc. (ppm)
1	1B	1.20	46	5C	0.85
2	1B	1.70	47	5C	0.91
3	1B	1.42	48	5C	1.18
4	1B	1.60	49	5C	1.20
5	1B	1.20	50	5C	0.62
6	2B	1.30	51	1D	2.12
7	2B	1.62	52	1D	1.12
8	2B	1.35	53	1D	1.82
9	2B	1.28	54	1D	1.95
10	2B	1.20	55	1D	1.86
11	3B	1.18	56	2D	2.02
12	3B	1.35	57	2D	1.22
13	3B	1.28	58	2D	1.88
14	3B	1.60	59	2D	1.92
15	3B	1.34	60	2D	1.83
16	4B	1.42	61	3D	0.92
17	4B	1.18	62	3D	0.92
18	4B	1.45	63	3D	0.81
19	4B	1.20	64	3D	0.98
20	4B	0.95	65	3D	1.11
21	5B	0.62	66	4D	0.71
22	5B	0.86	67	4D	0.62

23	5B	0.80	68	4D	0.72
24	5B	1.20	69	4D	0.56
25	5B	0.62	70	4D	0.90
26	1C	12.10	71	1E	0.45
27	1C	10.00	72	1E	0.42
28	1C	11.35	73	1E	0.39
29	1C	12.00	74	1E	0.32
30	1C	10.75	75	1E	0.54
31	2C	5.42	76	1E	0.60
32	2C	1.90	77	1E	0.44
33	2C	5.52	78	1E	0.53
34	2C	2.20	79	1E	0.52
35	2C	3.10	80	1E	0.42
36	3C	3.74	81	1E	0.34
37	3C	2.95	82	1E	0.44
38	3C	3.54	83	1E	0.56
39	3C	1.72	84	1E	0.61
40	3C	5.40	85	1E	0.33
41	4C	1.51	86	1E	0.45
42	4C	1.42	87	1E	0.44
43	4C	1.18	88	1E	0.52
44	4C	1.71	89	1E	0.53
45	4C	0.95	90	1E	0.45

The concentration of lead in the samples of soil which were collected from specific distances from the bus station at El sog Elshaabi (1B-2B-3B-4B-5B) showed that lead concentration decreases proportional to the distance away from the bus station which means that much lead had come to this soil samples from the vehicles exhaust. Also for this reason the concentrations of lead in soil samples which were collected from 100 m, 200 m, 500 m, 1 km (from 1D to 4D) away from the main road in Soba were decreased proportional to the distance away from the road (1.77- 1.77- 0.94- 0.70 ppm).

Low concentration of lead was shown in the rural areas Arbagi, Dagala, Wadshantoor, Saleem (1E) which have mean concentration of lead of 0.46 ppm and the highest concentration of lead in those areas was 0.61 ppm. The concentration of lead in the rural areas was so less than in areas studied in Khartoum and this is means that much lead contamination should come from industrial wastes and vehicles exhaust which both found in Khartoum more than other areas.

From table (4) it is obvious that there was a significant difference between the mean concentration of lead in samples that collected from the bus station (1B) and samples collected from 1 km away from the bus station (5B) (sig. 0.01) but there was no significant difference between the concentration of lead in the bus station samples and the other samples (100 m, 200 m, 500 m) away from the bus station.

Significant difference was found between concentration of lead in samples collected from 100 m (2B) and samples of 1 km away from the bus station (sig. 0.04). Also significant difference between the concentration of lead in the samples from 200 m (3B) and samples from 1 km away from the bus station (sig.0.04). Even the samples from (4B) 500 m had shown a significant difference to that of 1 km away from the bus station (sig. 0.025). So, concentration of lead in sample away 1 km from the bus station had shown a significant difference to all other samples around the bus station.

Table 3 Descriptive analysis of concentration of lead in soil samples

Site	N	Mean	Std. deviation	Std. error	95% confidence interval for mean		Minimum	Maximum
					Lower bound	Upper bound		
1B	5	1.4240	0.22777	0.10186	1.1412	1.7068	1.20	1.70
2B	5	1.3500	0.16031	0.07169	1.1509	1.5491	1.20	1.62
3B	5	1.3500	0.15524	0.06943	1.1572	1.5428	1.18	1.60
4B	5	1.2400	0.20359	0.09105	0.9872	1.4928	0.95	1.45
5B	5	0.8200	0.23791	0.10640	0.5246	1.1154	0.62	1.20
1C	5	11.2400	0.82568	0.36926	10.2148	12.2652	10.10	12.10
2C	5	3.6280	1.73888	0.77765	1.4689	5.7871	1.90	5.52
3C	5	3.4680	1.33891	0.59878	1.8055	5.1305	1.71	5.40
4C	5	1.3540	0.29535	0.13208	0.9873	1.7207	0.95	1.71
5C	5	0.9520	0.24284	0.10860	0.6505	1.2535	0.62	1.20
1D	5	1.7740	0.38338	0.17145	1.2980	2.2500	1.12	2.12
2D	5	1.7740	0.31746	0.14197	1.3798	2.1682	1.22	2.02
3D	5	0.9480	0.10941	0.04893	0.8122	1.0838	0.81	1.11
4D	5	0.7020	0.12892	0.05765	0.5419	0.8621	0.56	0.90
1E	20	0.4600	0.08143	0.01821	0.4219	0.4981	0.32	0.61
	90	1.8813	2.50722	0.26428	1.3562	2.4065	0.32	12.10

Table 4. Multiple comparison of soil lead concentration of the samples of the bus station- ElsogElshaabi

Multiple Comparisons

group
Tukey HSD

(I) AA	(J) AA	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1B	2B	.07400	.12641	.976	-.3043-	.4523
	3B	.07400	.12641	.976	-.3043-	.4523
	4B	.18400	.12641	.601	-.1943-	.5623
	5B	.60400*	.12641	.001	.2257	.9823
2B	1B	-.07400-	.12641	.976	-.4523-	.3043
	3B	.00000	.12641	1.000	-.3783-	.3783
	4B	.11000	.12641	.904	-.2683-	.4883
	5B	.53000*	.12641	.004	.1517	.9083
3B	1B	-.07400-	.12641	.976	-.4523-	.3043
	2B	.00000	.12641	1.000	-.3783-	.3783
	4B	.11000	.12641	.904	-.2683-	.4883
	5B	.53000*	.12641	.004	.1517	.9083
4B	1B	-.18400-	.12641	.601	-.5623-	.1943
	2B	-.11000-	.12641	.904	-.4883-	.2683
	3B	-.11000-	.12641	.904	-.4883-	.2683
	5B	.42000*	.12641	.025	.0417	.7983
5B	1B	-.60400*	.12641	.001	-.9823-	-.2257-
	2B	-.53000*	.12641	.004	-.9083-	-.1517-
	3B	-.53000*	.12641	.004	-.9083-	-.1517-
	4B	-.42000*	.12641	.025	-.7983-	-.0417-

*. The mean difference is significant at the 0.05 level.

Table 5. samples from the batteries factory(1C) showed a significant difference to all other samples at specific distances

Multiple Comparisons

group
Tukey HSD

(I) AA	(J) AA	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1C	2C	7.61600*	.67748	.000	5.5887	9.6433
	3C	7.77600*	.67748	.000	5.7487	9.8033
	4C	9.89000*	.67748	.000	7.8627	11.9173
	5C	10.29400*	.67748	.000	8.2667	12.3213
2C	1C	-7.61600*	.67748	.000	-9.6433-	-5.5887-
	3C	.16000	.67748	.999	-1.8673-	2.1873
	4C	2.27400*	.67748	.023	.2467	4.3013
	5C	2.67800*	.67748	.006	.6507	4.7053
3C	1C	-7.77600*	.67748	.000	-9.8033-	-5.7487-
	2C	-.16000-	.67748	.999	-2.1873-	1.8673
	4C	2.11400*	.67748	.038	.0867	4.1413
	5C	2.51800*	.67748	.011	.4907	4.5453
4C	1C	-9.89000*	.67748	.000	-11.9173-	-7.8627-
	2C	-2.27400*	.67748	.023	-4.3013-	-.2467-
	3C	-2.11400*	.67748	.038	-4.1413-	-.0867-
	5C	.40400	.67748	.974	-1.6233-	2.4313
5C	1C	-10.29400*	.67748	.000	-12.3213-	-8.2667-
	2C	-2.67800*	.67748	.006	-4.7053-	-.6507-
	3C	-2.51800*	.67748	.011	-4.5453-	-.4907-
	4C	-.40400-	.67748	.974	-2.4313-	1.6233

*. The mean difference is significant at the 0.05 level.

Table 6. Multiple comparison of soil lead concentration of the samples of the main road- Soba

Multiple Comparisons

group
Tukey HSD

(I) AA	(J) AA	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1D	2D	.00000	.16624	1.000	-.4756-	.4756
	3D	.82600*	.16624	.001	.3504	1.3016
	4D	1.07200*	.16624	.000	.5964	1.5476
2D	1D	.00000	.16624	1.000	-.4756-	.4756
	3D	.82600*	.16624	.001	.3504	1.3016
	4D	1.07200*	.16624	.000	.5964	1.5476
3D	1D	-.82600*	.16624	.001	-1.3016-	-.3504-
	2D	-.82600*	.16624	.001	-1.3016-	-.3504-
	4D	.24600	.16624	.472	-.2296-	.7216
4D	1D	-1.07200*	.16624	.000	-1.5476-	-.5964-
	2D	-1.07200*	.16624	.000	-1.5476-	-.5964-
	3D	-.24600-	.16624	.472	-.7216-	.2296

*. The mean difference is significant at the 0.05 level.

From table (5) samples from the batteries factory(1C) showed a significant difference to all other samples at specific distances (100m - 200m – 500 m – 1 km) (2C-3C-4C-5C) from the factory (sig. 0.00). A significant difference was found between concentration of lead in samples of 100 m away from the factory (2C) and samples from inside the factory (1C) (sig.0.00) and samples from 500 m (4C) and 1 km (5C) away from the factory (sig. 0.023 - 0.006 respectively). Significant difference between samples of 200 m (3C) and samples of 500 m (4C) away from the factory was found (sig. 0.038).

Samples of 100m away from the main road(1D) showed a significant difference to those collected from 500m(3D) and 1Km(4D) away from the main road in Soba (sig.0.001-0.00). Samples from 200m(2D) also showed a significant difference to (3D) and (4D) (sig. 0.001-0.00).

Table (7) indicated that there was significant differences between the concentration of lead in soil samples of Elrobi factory to all other samples. No significant difference between all other groups(bus station, main road, and the rural areas.)

General Discussion

The density of lead is so high and it is not dispersed so far, so the concentration of lead in soil in areas around the vehicles motion, industries areas, bus station, and ruined building expected to be higher than areas away from it. Soil lead concentrations were associated with level of urbanization. The higher the degree of urbanization, the higher the soil leads concentration. Average concentration of soil lead of the samples collected from Elrobi factory has the highest value as expected. Samples from distances nearer to the bus station and the main road (100 m) have higher lead concentration than others away (1 km).

Conclusion

Atomic Absorption spectrometry method is fairly selective, precise, and more sensitive. The method is free from interferences which is an advantage of this method.

Table7. Multiple comparison of soil lead concentration of all group samples

Multiple Comparisons

Group
Tukey HSD

(I) AA	(J) AA	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Bus station	Elrobi batteries factory	-2.89120*	.59151	.000	-4.4409-	-1.3415-
	Main road-Soba	-.06270-	.62739	1.000	-1.7064-	1.5810
	Rural Areas	.77680	.62739	.605	-.8669-	2.4205
Elrobi batteries factory	Bus station	2.89120*	.59151	.000	1.3415	4.4409
	Main road-Soba	2.82850*	.62739	.000	1.1848	4.4722
	Rural Areas	3.66800*	.62739	.000	2.0243	5.3117
Main road-Soba	Bus station	.06270	.62739	1.000	-1.5810-	1.7064
	Elrobi batteries factory	-2.82850*	.62739	.000	-4.4722-	-1.1848-
	Rural Areas	.83950	.66132	.585	-.8932-	2.5722
Rural Areas	Bus station	-.77680-	.62739	.605	-2.4205-	.8669
	Elrobi batteries factory	-3.66800*	.62739	.000	-5.3117-	-2.0243-
	Main road-Soba	-.83950-	.66132	.585	-2.5722-	.8932

*. The mean difference is significant at the 0.05 level.

Therefore, the method can be used for routine analysis of soil. Today, almost everyone is exposed to environmental lead. Exposure to lead and lead chemicals can occur through inhalation, ingestion or occasionally dermal contact.

One frequent source of lead exposure to adults is home renovation that involves scraping, remodeling, or otherwise disturbing lead-based paint. Adults can also be exposed during certain hobbies and activities where lead is used. Workers may inhale lead dust and lead oxide fumes, as well as eat, drink, and smoke in or near contaminated areas. In conclusion, exposure to lead through soil is undoubtedly occurring in Sudan and due to this lead in blood was also occurring.

According to the above results the concerned authorities should pay attention to this critical problem particularly in the case of children for they were more sensitive and exposure to lead. It should be noticed that all types of contamination may affect each other that means lead from soil may come into water; also lead from air may come into soil, and lead from paint and batteries industry may come into water, soil and air and so on.

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