The Comparison of Bioaccumulation Factor of Lead from Leaves of Random Vegetation

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Abstract—Both natural and anthropogenic contributions are the sources of lead emissions to the environment. The accumulation of lead in agricultural soils is potentially hazardous to human, livestock and plants species. The purpose of this study was: the determination of lead in soil and in the different spontaneous plant species grown it, as well as calculation of determinate bioaccumulation factors (BAF) soil to plant. We have selected 9 sampling points. We have collected a total of 29 samples where 9 samples are surface soil and 20 samples are vegetation. All the representative samples for this study were analyzed using Atomic Absorption Spectrometry for their lead content, at the Institute of Applied Nuclear Physics, University of Tirana, Albania. From results obtained, concentrations of lead in representative soil samples were found in the levels: 105-856 mg/kg while in the biological samples, the levels of lead were: 0.77-2.37 mg/kg. The concentration ranges of lead in soil samples collected at different points are compared with the Maximum Contaminant Levels (MCL) recommenced by European Union according the Directive 86/278/EEC. Also, we have calculated Hazardous Quoted (HQ) for each sampling point of soil. The concentration ranges of lead in biological samples are compared with the Maximum Contaminant Levels specified by the Directive No. 1881/2006, Brussels. Also we have calculated bio accumulation factor (BAF) soil to plant.

Index Terms—Lead, soil and vegetation samples, BAF and Atomic Absorption Spectrometry

1 INTRODUCTION

The presence of heavy metals is dangerous because they have tendency to bio accumulate [1]. Mining, refining, utilization and disposal of heavy metals have increased occupational as well as non-occupational exposure to numerous elements [2]. The environmental protection should be and remain the main goal and task of the society. Heavy metals especially lead; have become impurities, serious environmental pollutions over the last decades.

The sources of emission of lead in the environment are natural and anthropogenic [3]. Over the years lead is extracted from the mines for different purposes, such as: production of batteries, half-done production of metallic sheets and pipes, alloys, additive in benzene, in PVC, in ammunitions [4]. Lead is known as one of the most toxic heavy metals in the environment. Since lead is mostly used for the production of batteries, the major pollution comes exactly from this industry. In general, areas close to Factory of Battery Production are presented with environmental problems, due to increased production and consumption of lead from vegetation and livestock. The contamination of soils has influence on the increase of the level of lead in environment [5]. The high level of lead has a negative impact on the natural environment and the human health. Pollution reaches livestock and human through the food chain.

Exposure of lead to a longer period in the environment result in biochemical and toxic effects on the people, causing problems on synthesis of hemoglobin, effects on kidneys, gastroin testinal tract, joints, reproduction and nervous system, acute or chronic damage and physical and psychological in capabilities on people [6].

Subject area: The area of the former Battery Production Factory in the city of Berat, Albania was elected the scope of this study because its activity has been in about 20 years. The complex of Factory for the production of batteries in Berat, Albania has begun its activity in 1970. It was designed not only to produce batteries for passengers' cars and trucks, but also other military and technical equipment. The Battery Factory conducted its activity as a state-run factory for about 20 years. During its activity except primary production, this factory has produced solid, liquid and gaseous waste, into the surrounding environment.

The purpose of this study is: determination of lead in different spontaneous plant species grown during the street former Factory of Battery Production- Berat as well as calculation of determinate bioaccumulation factors (BAF) soil to plant.

One of the methods for determination of the total contents of heavy metals of their environmental concentrations is Atomic Absorption Spectroscopy (AAS).

The level of Pb in soil samples was compared to the values recommended by the European Community according to Directive 86/278 EEC [7], while for biological samples level of lead was compared by Directive No. 1881/2006, Brussels [8]. In the finally were calculated the BFA soil to plant.

2 MATERIAL AND METHOD

Both representative soil and vegetation were collected around the street ex-Battery Production Factory, Berat. This Factory is located in the north-eastern city of Berat, with respective coordinate: 400 42′ 24.82″ N and 190 58′ 59.42′′ E. During the sampling we have chosen 9 stations and we have collected a total 29 soil and vegetation samples in this area. Surface soil samples are collected at the surface soil (0-5cm) for each

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sampling point while vegetation samples were random vegetation in this area. These sampling stations are marked in map 1, while their coordinates are presented respectively in table 1 with results. Represented soil samples analyzed using Atomic Absorption Spectrometer, Aanalyst 800 Perkin Elmer with Atomic Absorption Spectrometry, Flame method [9].

Fig. 1. • Map of sampling stations of soil

Hollow cathode lamp (HCL), used as radiation source for the determination of lead, according recommended conditions. Instrumental conditions for lead are based on Analytical Methods of Atomic Absorption Spectrometry, from Perkin Elmer (Perkin-Elmer Corp. 1991-1999) [13]. Three applications were carried out for the measurement of calibration standards and measurement of samples. For each element calibration curve equation is linear and passing through point zero. A quality control material IAEA- Soil_7 was analyzed in parallel with the soil samples and IAEA_336_Lichen was analyzed in parallel with the biological samples. To check the instrumental drift, an aqueous standard solution was analyzed after every three samples.

Acids used for the digestion of samples, stock solutions of lead have high grade purity. Reagents are used for treatment, measured and control interference of soil samples are: nitric acid 65%, hydrochloric acid concentration 33%, perchloric acid 70%, stock solutions of lead 1000 ppm, bidistil water and matric modifier 0.05 mg $NH_4H_2PO_4$+0.003mg $Mg(NO_3)_2$. Glass and Teflon vessels used were treated with solution 10% v/v nitric acid, for 24 hours and then washed with water bidistilled. Both depth and area soil samples are digested according Analytic Method Atomic Absorption Spectrometry.

2.1 Digestion of soil samples

About one gram of soil sample (dry) was placed in a digestion tube and was added 10 ml of aqua regia (1HNO_3: 3 HCl). The sample was heated for 40-45min at 90 0C, and then the temperature was increased to 150 0C at which the sample was boiled for at least 3-4 hour until a clear solution was obtained. Concentrated HNO_3 was added to the sample (6 ml was added at least three times) and digestion occurred until the volume was reduced to about 1-2 ml. The interior walls of the tube were washed down with a little bidistilled water and the tube was swirled throughout the digestion to keep the wall clean and prevent the loss of the sample. After cooling, 5 ml of 3% HNO3 was added to the sample. The solution was filtered. And finally it was then transferred quantitatively to a 50 ml volumetric flask by adding distilled water.

2.2 Digestion of biological samples

Each vegetation sample (dry) was weighed and was added an 10 ml HNO_3 solution. For the wet digestion process, an 8 hr period of digestion was provided at room temperature. After the 8 hour cold digestion period, the glass beakers were placed on a hot plate and heated for about 2 hour. Then, eight drops of hydrogen peroxide (H_2O_2) were added to each beaker and the beakers were heated again until the wet digestion process was completed and a small sample volume remained. Subsequent to cooling, the samples were filtered and diluted to a 50 ml volume. After filtration of samples, their solutions were transferred to the atomic absorption lab for analysis.

3 Results and Discussions

We have collected a total 29 samples during the sampling; 9 surface soil samples and 20 biological samples. In the table 1 are presented , sampling points, code in AAS, coordinates, mean concentration of lead as well as Relative Standard Deviation percentage (% RSD), Standard Deviation (SD) and calculated Hazardous Quoted [14], [15] in representative soil samples.

In the table 2 is presented, sampling points, code in AAS, mean concentration of lead as well as Relative Standard Deviation percentage (% RSD), Standard Deviation (SD) and calculated Bioaccumation Factor soil to vegetation in representative vegetation samples, which are collected in the same sampling points with surface soil samples.

(Note: tables 1 & 2 are presented in the end of material).

From result obtained the mean concentration of lead in vegetation samples were found in the order 1.5 mg/kg -12 mg/kg. The mean concentrations of lead in vegetation samples are compared with the (MCL) specified by the Directive No. 1881/2006, Brussels. MCL of lead in vegetation recommended by the Directive No. 1881/2006, Brussels is 0.1 mg/kg (dw).

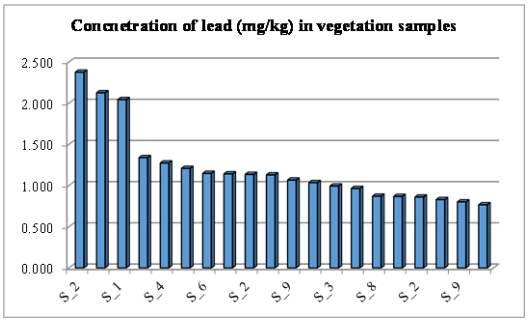

Fig. 2. Mean concentration of lead in (mg/kg) in representative vegetation samples.

Graph in figure 2 is presented variation of lead

concentration in respective vegetation samples.

The mean concentration of lead in surface samples was found in the order 105 mg/kg-856 mg/kg. The mean concentrations of lead in soil samples are compared with the Maximum Contaminant Levels (MCL) specified by the Directive 86/278/EEC, it is 50-300 (mg/kg dm). In addition, from results obtained we have calculated Hazardous Quoted (US EPA 2006). The factor of calculated Hazardous Quoted, HQ in representative soil samples was found in the order 0, 4-2, 9. Four sampling points were found this factor higher than normal

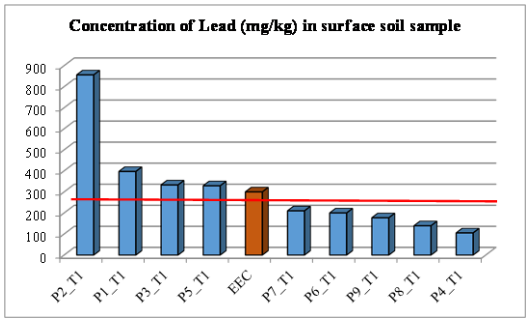

Fig. 2. Mean concentration of lead (mg/kg) in representative surface soil samples. It is compared with Maximum Concentration Level, recommended by Directive 86/278/EEC.

Graph in figure 2 is presented dependence of the lead concentration in respective soil samples.

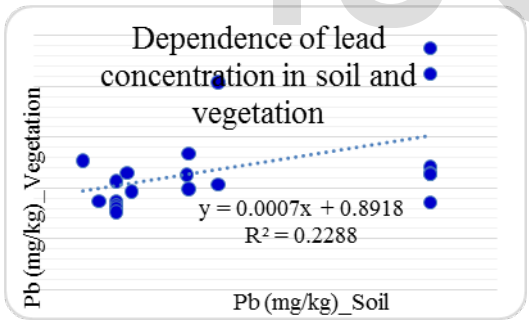

Fig. 4. Variation of lead in vegetation samples and Bioaccumulate Factor for each biological samples.

Graph 4. is presented the relationship between lead concentration in surface soil and lead concentration in the vegetation samples.

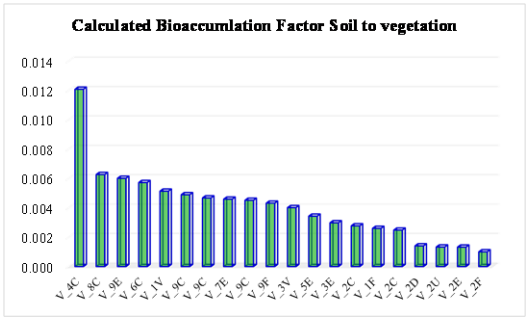

Fig. 5. Variation of lead in vegetation samples and Bioaccumulate Factor for each biological samples.

While graph in figure 5 is presented average bioaccumulation factor soil to plant. It is observed highest ability of accumulated lead had *Verbascum* (length of the plant was about 20-30 cm). Hazardous Quoted for surface soil samples is higher than 1, which means this territory is contaminated and this pollution is associated with the high negative ecological and human effects. We have calculated bio accumulation factors soil to plant [16].

4 Conclusion

During this investigation the level of fraction of lead was found to be present in all of the representative soil and vegetation samples that analyzed. From the results obtained 12 soil samples contained lead concentration above the MCL, recommended by Directive 86/278/EEC for concentration of lead in soil. Lead concentration in vegetation samples was found above the MCL concentration recommended by Directive No. 1881/2006, Brussels. From calculated BAF soil to vegetation samples was low, because the mean concentration of lead in soil and in vegetation was not in the same order. Environment pollution and BFA depends from the concentration of lead in soil and vegetation as well as its duration of exposure. By calculating the average of BAF soil to plant it is observed lead accumulates in plants at different levels. The ability of lead accumulation by random vegetation in descending order was: *Verbascum (sp)*> *Euphorbia (sp)*> *Diospiros (sp)*> *Cynadon dactiyon*> *Ficus carica*> *Ulmus canpestris*. Analysis of this study was performed in the Institute of Applied Nuclear Physics (IANP), Tirana.

Also, observed the mean concentration of lead in surface soil samples there is not unique distribution. Around two representative sampling points S_1 and S_2 which were taken near the factory, respectively in the east and west side, the concentration of lead were found about 2 times higher than normal value.

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References

[1] Censi P, Spoto SE, Saiano F, Sprovieri M, Mazzola S, Nardone G, Di Geronimo SI, Punturo R, Ottonello D, (2006) Heavy metals in coastal water system. *Chemosphere* 64: page1167-1176.

[2] Bencko, V., Geist, T., Arbetova, D., Dharmadikari, D.M. And Svandova, E. (1986). Biological Monitoring of Environmental Pollution and Human Exposure to Some Trace Elements. Journal of Hygiene, Epidemiology, Microbiology & Immunology. 30, I-10.

[3] Carpenter SR, Caraco NF, Correll DL, Howarth RW, Sharpely AN, Smith VH, (1998) Nonpoint Pollution of surface waters with phosphorus and nitrogen, *Ecological Applications*. 8, 559-568.

[4] Demayo, A., M.C. Taylor, K.W. Taylor, and P.V. Hodson. 1982. Toxic

effects of lead and lead compounds on human health, aquatic life, wildlife plants, and livestock. Critical Reviews in Environmental Control, 12:257-305.

[5] [5] Zakrzewski SF (2002). Environmental Toxicology.3Rd Edition.Oxford University Press. USA, pp.5- 45.

[6] Aigbedion LN (2005). Environmental Pollution in the Niger Delta, Nigeria. Inter Disciplinary J. Enugu Niger., 3 (4): 205-210.

[7] EEC, Economic European Communities. (2006). The Council Directive 86/278/EEC on protection of the environment.EEC, Economic European Communities. (2006). Setting maximum levels for certain contaminants in foodstuffs. Official Journal European Communities, L 364/5-L 364/24, Directive No.1881/2006, Brussels.

[8] (Perkin-Elmer Corp. 1991-1999). Perkin-Elmer Corp.: 1964-2000, Analytical Methods for Atomic Absorption Spectrophotometry.

[9] Anonymous, EPA, Method 3050B.http://www.epa.gov/osw/hazard/testmethods/sw846/pdfs/3050b.pdf

[10] AOAC, 1990. AOAC official methods of analysis. 15th ed. Association of Official Analytical Chemists, Arlington, Virginia. Page 84–85 [12] AOAC (1990). Official Method of Analysis. Association of Official Analytical Chemists, Arlington, USA.

[11] **(**Perkin-Elmer Corp. 1991-1999**).** Perkin-Elmer Corp., (1991) Recommended conditions for THGA furnaces.

[12] U.S. EPA (Environmental Protection Agency). 2006. Provisional Peer Reviewed Toxicity Values for Aluminum (CASRN 7429-90-5). U.S. Environmental Protection Agency, National Center for Environmental Assessment, Superfund Technical Support Center, Cincinnati, OH. October23.

[13] U.S. EPA. (Environmental Protection Agency). 2006. Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment), Final. EPA/540/R/99/005. Office of Solid Waste and Emergency Response, Washington, DC. PB99-963312.

[14] Bermond A., (1988), Modalitees de passage en sollution des cations metalliques associes a la matrice organique dans different types de sols, Institut National Agronomique, Paris-Grinon.

TABLE 1
CONCENTRATION OF LEAD IN SURFACE SOIL AND CALCULATED HAZARDOUS QUOTED

Nr	Sampling stations	Code in AAS	Nord	East	Pb (mg/kg)	SD	% RSD	HQ
1	S_1	P1_T1	$40^0$42"22.08''	$19^0$58"55.57''	397	3.00	0.75	1.3
2	S_2	P2_T1	$40^0$42"15.54''	$19^0$58"53.06''	856	24.81	2.9	2.9
3	S_3	P3_T1	$40^0$42"14.45''	$19^0$58"53.43''	333	19.32	5.8	1.1
4	S_4	P4_T1	$40^0$42"09.06''	$19^0$58"35.89''	105	6.53	6.2	0.4
5	S_5	P5_T1	$40^0$42"09.23''	$19^0$58"36.65''	329	35.15	10.7	1.1
6	S_6	P6_T1	$40^0$41"58.97''	$19^0$58"23.74''	200	23.64	11.8	0.7
7	S_7	P7_T1	$40^0$41"58.66''	$19^0$58"22.29''	210	18.67	8.9	0.7
8	S_8	P8_T1	$40^0$42"04.20''	$19^0$57"58.50''	139	3.61	2.6	0.5
9	S_9	P9_T1	$40^0$42"04.20''	$19^0$58"00.48''	177	5.67	3.2	0.6
			Directive	86/278/EEC	300			1

Sn = sampel point, PnTn = Code of sample in laboratory, Nord-East = coordinate of sampling stations, Pb (mg/kg) = concentration of lead in analysed samples, SD = Standart deviation , % RSD= relative standard deviation and HQ = calculated hazardous quoted.

TABLE 2
CONCENTRATION OF LEAD IN VEGETATION AND CALCULATED OF BAF SOIL TO VEGETATION

Nr.	Sampling stations	Material	Code	Pb (mg/kg)	SD	% RSD	BAF
1	S_1	*Ficus carica*	V_1F	1.034	0.2	16.20	0.003
2	S_1	*Verbascum (sp)*	V_1V	2.042	0.1	2.70	0.005
3	S_2	*Cynadon dactiyon*	V_2C	2.125	0.07	3.50	0.002
4	S_2	*Ficus carica*	V_2F	0.859	0.02	2.30	0.001
5	S_2	*Diospiros (sp)*	V_2D	1.207	0.0	2.10	0.001
6	S_2	*Ulmus canpestris*	V_2U	1.141	0.1	6.30	0.001
7	S_2	*Euphorbia (sp)*	V_2E	1.134	0.0	4.40	0.001
8	S_2	*Cynadon dactiyon*	V_2C	2.375	0.1	6.20	0.003
9	S_3	*Verbascum (sp)*	V_3V	1.337	0.1	8.70	0.004
10	S_3	*Euphorbia (sp)*	V_3E	0.994	0.02	2.10	0.003
11	S_4	*Calamagrostis (sp)*	V_4C	1.272	0.05	3.70	0.012
12	S_5	*Euphorbia (sp)*	V_5E	1.128	0.01	1.30	0.003
13	S_6	*Cynadon dactiyon*	V_6C	1.147	0.01	0.80	0.006
14	S_7	*Euphorbia (sp)*	V_7E	0.964	0.00	0.20	0.005
15	S_8	*Cynadon dactiyon*	V_8C	0.870	0.00	0.10	0.006
16	S_9	*Cynadon dactiyon*	V_9C	0.867	0.01	1.50	0.005
17	S_9	*Calamagrostis (sp)*	V_9C	0.828	0.02	2.70	0.005
18	S_9	*Calamagrostis (sp)*	V_9C	0.800	0.1	9.50	0.005
19	S_9	*Euphorbia (sp)*	V_9E	1.065	0.03	2.60	0.006
20	S_9	*Ficus carica*	V_9F	0.765	0.01	1.80	0.004

BAF = Bioacumulation Factor soil to vegatation