BIOMONITORING OF LEAD POLLUTION ON THE URBAN FLORA

Mustafa Dogan[1], Zlatko Nedić[2], Rifet Terzić[3]

[1]International School of Zenica, Bosnia and Herzegovina; mustafadogan74@hotmail.com
[2]High School Orasje, Bosnia and Herzegovina; zlatko8679@hotmail.com
[2]University of Tuzla, Bosnia and Herzegovina; rifet.terzic@untz.ba

ABSTRACT

In this study, the first aim was to find out the measures of lead (Pb) as the heavy metal pollution in Sarajevo, Bosnia and Herzegovina. The second aim was to test if chicory, Cichorium intybus L., can be used as a biomonitor of heavy metal pollution. Twenty-eight sites (urban, suburban and rural) in Sarajevo were investigated during the summer period in 2010. Concentrations of Pb were determined in leaves and roots of Cichorium intybus L. and also in soils collected from a wide range of sites with different degrees of metal pollution. As a result of measurements, the highest values of lead accumulations in plants have been observed in roots as expected. The highest values were detected as 30.10 mgkg-1 dry weight in roots and as 28.20 mgkg-1 dry weight in leaves in the PMF garden in Pofalici. On the other hand, the highest value of lead was detected as 450.05 mgkg-1 dry weight in soil in Museum Garden. Theoretically it is expected to observe highest accumulation in soils, roots and leaves, respectively. After getting results, it is observed the relationship of lead accumulation among soils, roots and leaves as expected. Cichorium intybus L. was found to be a useful biomonitor in the determination of lead pollution.

Key words: Cichorium intybus L., lead pollution, biomonitoring, Sarajevo

INTRODUCTION

One of the common worldwide plants is the common chicory. It is also known as succory, blue sailors, cornflower, and coffee weed. Cichorium intybus L., also known as common chicory, is a bushy perennial herbaceous plant. It has blue, lavender, or sometimes white flowers. It lives as a wild plant on roadsides in many countries of its native Europe, Asia, North America and Australia (Davis, 1975). Various varieties are cultivated for salad leaves, chicons (blanched buds), or for roots (var. sativum), which are baked, ground, and used as a coffee substitute and additive. It is also grown as a forage crop for livestock.

When flowering, *Cichorium intybus L.* has tough, grooved, and some hairy stem, from 25 to 100 centimeters tall. The leaves are stalked, lanceolate and unlobed. The flower heads are 2 to 4 centimeters wide, and bright blue. There are two rows of involucral bracts - the inner are longer and erect, the outer are shorter and spreading. It flowers from July until October. The achenes have no pappus (feathery hairs), but do have toothed scales on top. (Rose & Francis, 1981)

Lower plants, especially mosses and lichens, in view of their higher capacity for metal accumulation are probably the organisms most frequently used for monitoring metal pollution in urban environments (Markert, 1993; Al-Shayeb et al., 1995 & Aksoy et al., 1999). During the past few decades there has been an increase in the use of higher plant leaves as biomonitor of heavy metal pollution in the terrestrial environment (Aksoy & Ozturk, 1996, 1997; Aksoy & Demirezen, 2006). Wild chicory is a leafy vegetable and it has several characteristics for biomonitoring purposes which are worldwide cosmopolitan distribution, ability to tolerate a broad range of climatic and soil conditions, and ability to grow as a weed so it can be used as a biological indicator of heavy metal contamination (Simon et al., 1984). Also, it is a perennial plant that could be another convenient characteristic for biomonitoring purposes.

Numerous organisms have been used to monitor heavy metal pollutions (Augusto et al., 2007). These include invertebrates, vertebrates, cyanobacteria, lichens, mosses, and many parts of plants (tree barks, tree rings, pine needles, grasses and leaves) (Lovett et al., 1997; Aksoy & Öztürk, 1996; Sakurai et al., 2000; Augusto et al., 2007; Aksoy, 2008; Atiq-Ur-Rehman and Iqbal, 2008). Some plant species have more ability of uptaking high levels of metals and other toxic elements, without showing any visible injury. These are later denominated as accumulator or biomonitor plants (De Temmerman et al., 2004). The term biomonitor is defined as an organism that provides quantitative information on the quality of the environment around it. Therefore, a good biomonitor will indicate the presence of the pollutant and also attempt to provide additional information about the amount and intensity of the exposure (Wolterbeek, 2002). With proper selection of organisms, the general advantage of the biomonitoring approach is related primarily to the permanent and common occurrence of the organism in the field, even in remote areas, the ease of sampling, and the absence of any necessary expensive technical equipment (Wittig, 1993; Wolterbeek, 2002).

Many studies on the accumulation of heavy metals by various plant species have been reported (Peterson et al., 1979; Lepp, 1981; Page et al., 1981; Nasu & Kugimoto, 1984; De Temmerman & Hoenig, 2004; Finster et al., 2004; Augusto et al., 2007). Although it is consumed enormously, there are only few data available on heavy metal accumulation of wild chicory in contaminated areas (Simon et al., 1984; Turkan, 1986; Del Rio-Celestino et al., 2006; Aksoy & Demirezen, 2006; Aksoy, 2008).

MATERIALS AND METHODS

Method:
Lead (Pb) concentrations were investigated in the samples of soil, roots and aerial parts of chicory. The analyses were done by Federal Institute of Agriculture in Sarajevo. Concentrations of lead were measured in terms of mg/kg in twenty eight localities.

1. Sample Collection and Identification: The soil, roots and aerial parts of chicory were handpicked carefully into plastic bags at the each locality. All samples were labeled with respect to their localities.

2. Sample Processing: In the laboratory, all samples were exposed to air dry for 5 days. Then the dried samples were grounded to have fine powder.

3. Sample Analysis by ICP-AES (Inductively Coupled Plasma – Atomic Emission Spectrometry): After sample processing, the last step was analytical procedures of ICP-AES analysis. Perkin Elmer Plasma 400 ICP-AES operating in sequential mode was used for all analyses. Atomic spectrometer is very useful for element analysis because every element has its own characteristic set of energy level. By the use of atomic spectrometer, the set of emission wavelengths were measured.

Table 1 Comparison of heavy metal concentrations (mg kg^{-1} dry wt) considered toxic or contaminated, taken from the literature (adapted from Ross, 1994), with values from this study.

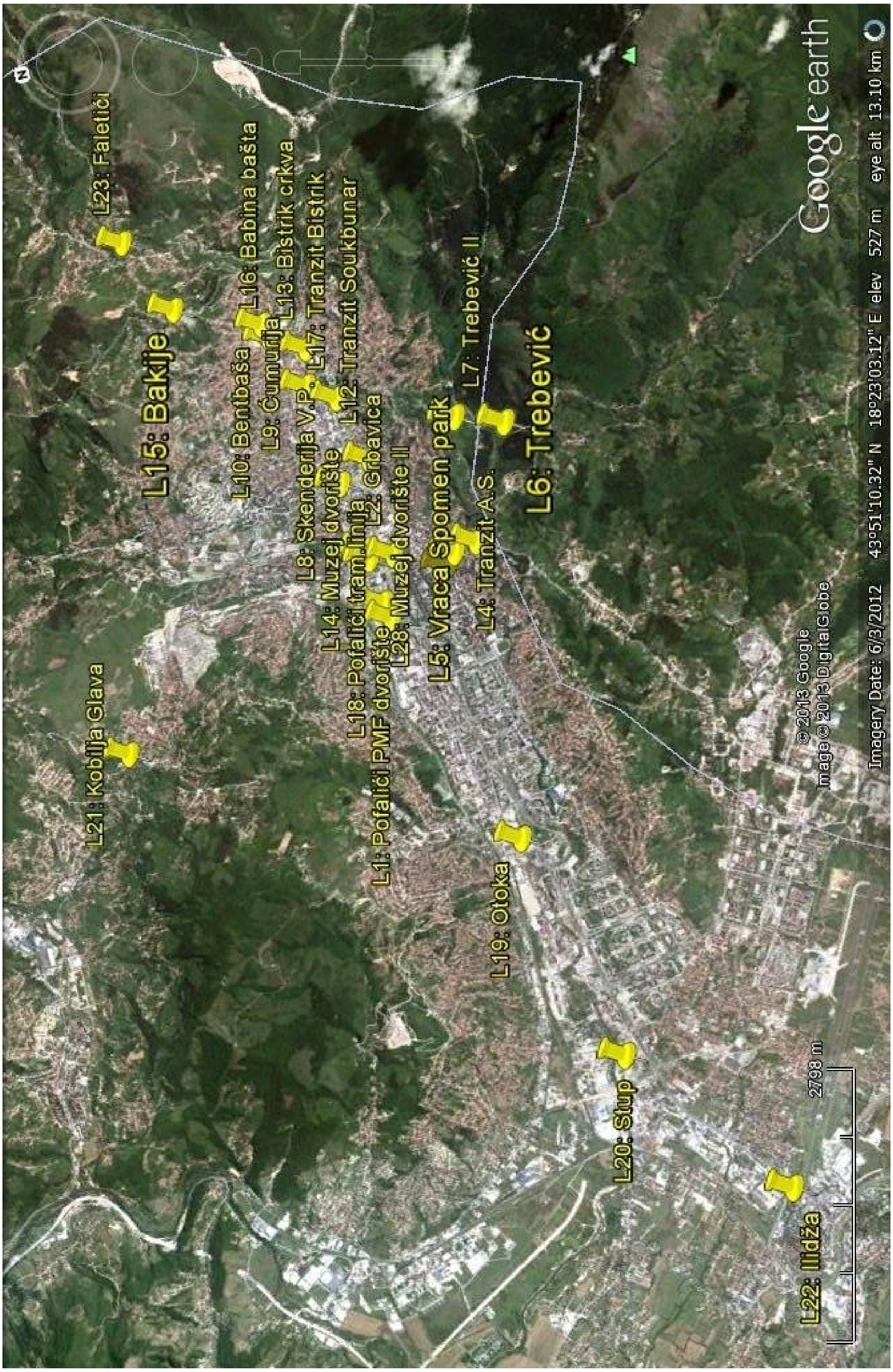
Element	Concentrations in soil Considered toxic	Concentration in contaminated plants	Present results	
			Soil	Plants
Pb	100-400	30-300	4.80 - 450.05	0.60 - 30.10

Study Areas

In this study, Sarajevo City center and around are studied. Twenty eight localities are investigated for heavy metal pollution. These locations are:

Table 2 localities and gps values

	Latitude:	**Longitude:**
L1: Pofalići - PMF garden	43°51'17.40"N	18°23'44.03"E
L2: Grbavica	43°51'9.63"N	18°24'5.55"E
L3: Tranzit road - Vraca	43°50'52.00"N	18°23'53.00"E
L4: Tranzit road - A.S.	43°50'48.38"N	18°23'57.99"E
L5: Vraca - Memorial park	43°50'40.02"N	18°23'59.81"E
L6: Trebević	43°50'20.04"N	18°24'49.01"E
L7: Trebević II	43°50'35.79"N	18°24'57.50"E
L8: Skenderija V.P.	43°51'21.36"N	18°24'45.90"E
L9: Ćumurija	43°51'24.48"N	18°25'36.78"E
L10: Bentbaša	43°51'34.24"N	18°26'12.60"E
L11: Holiday Inn tram line	43°51'19.77"N	18°24'7.66"E
L12: Tranzit road - Soukbunar	43°51'8.84"N	18°24'53.04"E
L13: Bistrik church	43°51'20.79"N	18°25'54.62"E
L14: Museum garden	43°51'18.58"N	18°24'11.37"E
L15: Bakije	43°52'2.40"N	18°26'30.21"E
L16: Babina bašta	43°51'32.76"N	18°26'5.68"E
L17: Tranzit road - Bistrik	43°51'14.43"N	18°25'25.95"E
L18: Pofalići – tram line	43°51'15.95"N	18°23'35.94"E
L19: Otoka	43°50'51.77"N	18°21'37.50"E
L20: Stup	43°50'36.40"N	18°19'47.08"E
L21: Kobilja Glava	43°53'0.56"N	18°23'5.30"E
L22: Ilidža	43°49'53.69"N	18°18'32.10"E
L23: Faletići	43°52'15.03"N	18°27'11.27"E
L24: Semizovac	43°55'15.55"N	18°18'59.09"E
L25: Ćevljanovići	44° 3'8.92"N	18°28'37.14"E
L26: Olovo	44° 7'36.75"N	18°36'50.06"E
L27: Kladanj	44°14'28.91"N	18°42'20.61"E
L28: Museum garden II	43°51'18.24"N	18°24'6.56"E



Picture 1. Satellite record of Sarajevo

RESULTS

Table 3 Results of lead analysis

Localities	SOIL Results of lead (mg/kg)	ROOT Results of lead (mg/kg)	LEAF Results of lead (mg/kg)
L1: Pofalići-PMF garden	206.64	30.10	28.20
L2: Grbavica	49.00	9.40	8.38
L3: Tranzit road-Vraca	103.32	11.90	15.70
L4: Tranzit road -A.S.	25.83	8.70	8.50
L5: Vraca-Memorial park	77.00	5.60	6.80
L6: Trebević	50.10	1.70	1.10
L7: Trebević II	4.80	0.90	0.60
L8: Skenderija V.P.	77.49	8.50	4.30
L9: Ćumurija	99.80	9.70	7.60
L10: Bentbaša	77.50	7.00	6.40
L11: Holiday Inn tram line	154.98	11.00	5.10
L12: Tranzit road -Soukbunar	31.00	5.80	7.50
L13: Bistrik church	97.30	8.90	7.20
L14: Museum garden	542.43	28.00	22.00
L15: Bakije	69.70	5.20	4.80
L16: Babina bašta	25.83	3.80	4.10
L17: Tranzit road -Bistrik	70.34	4.20	3.00
L18: Pofalići -tram line	129.16	10.00	5.80
L19: Otoka	73.34	3.80	1.75
L20: Stup	136.68	3.30	2.20
L21: Kobilja Glava	51.66	6.20	2.80
L22: Ilidža	18.33	4.20	3.30
L23: Faletići	65.50	2.10	2.50
L24: Semizovac	25.00	8.70	5.60
L25: Ćevljanovići	30.60	3.00	2.00
L26: Olovo	73.00	10.10	13.20
L27: Kladanj	5.00	6.40	4.10
L28: Museum garden II	450.05	10.30	9.80

A- DESCRIPTIVE ANALYSIS OF LEAD

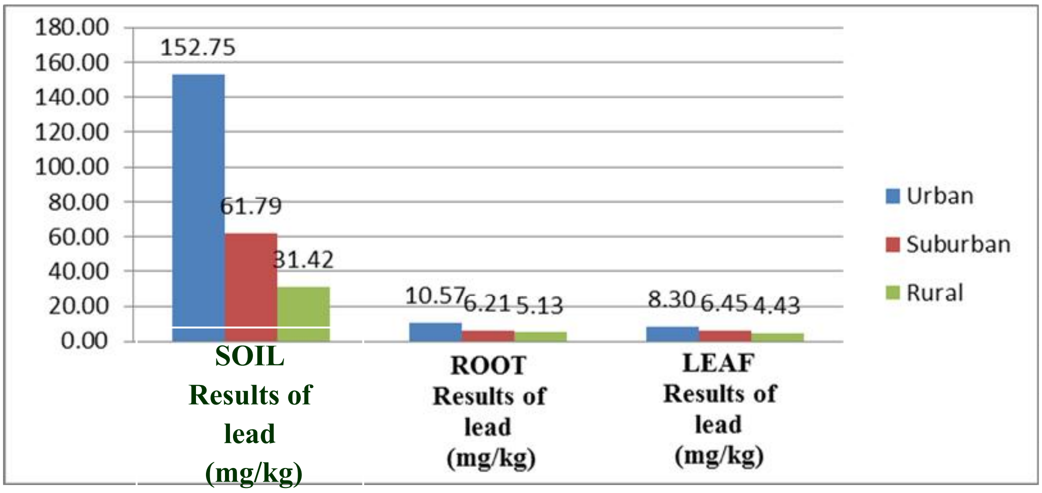
Table 4 Descriptive analysis of lead

LEAD	SOIL Results of lead (mg/kg)	ROOT Results of lead (mg/kg)	LEAF Results of lead (mg/kg)
Mean	100.76	8.16	6.94
Median	71.67	6.70	5.35
max.	542.43	30.10	28.20
min.	4.80	0.90	0.60
st dev	121.60	6.65	6.26

B- DESCRIPTIVE ANALYSIS WITH RESPECT TO URBAN, SUBURBAN AND RURAL AREAS

Table 5 Results with respect to urban, suburban and rural areas

	Urban	Suburban	Rural
SOIL - Results of lead (mg/kg)	152.75	61.79	31.42
ROOT - Results of lead (mg/kg)	10.57	6.21	5.13
LEAF - Results of lead (mg/kg)	8.30	6.45	4.43



Graph 1 Distribution of lead concentration in urban, suburban and rural areas (mg/kg)

C- REGRESSIVE ANALYSIS OF LEAD

Table 6: Regressive analysis of lead – soil

Dependent Variable: SOIL_PB Method: Least Squares		Date: 05/14/14 Time: 21:35 Sample: 1 28 Included observations: 28		
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
LEAF_PB	-6,680899	8,115762	-0,8232	0,4185
ROOT_PB	16,24043	7,899495	2,055882	0,0508
LOCATION	50,69459	40,2297	1,260128	0,2197
C	-10,7494	28,31497	-0,379637	0,7076
R-squared	0,507033	Mean dependent var		100,7636
Adjusted R-squared	0,445412	S.D. dependent var		121,5993
S.E. of regression	90,55576	Akaike info criterion		11,98137
Sum squared resid	196808,3	Schwarz criterion		12,17169
Log likelihood	-163,7392	Hannan-Quinn criter.		12,03955
F-statistic	8,228267	Durbin-Watson stat		1,481338
Prob(F-statistic)	0,000612			

Table 7: Regressive analysis of lead - root

Dependent Variable: ROOT_PB		Date: 05/14/14 Time: 21:32		
Method: Least Squares		Sample: 1 28		
		Included observations: 28		
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
LEAF_PB	0,866314	0,084729	10,22457	0
SOIL_PB	0,00922	0,004485	2,055882	0,0508
LOCATION	0,680752	0,979956	0,694676	0,4939
C	0,878754	0,652479	1,346794	0,1906
R-squared	0,906412	Mean dependent var		8,160714
Adjusted R-squared	0,894713	S.D. dependent var		6,649664
S.E. of regression	2,15768	Akaike info criterion		4,507508
Sum squared resid	111,734	Schwarz criterion		4,697823
Log likelihood	-59,10511	Hannan-Quinn criter.		4,565689
F-statistic	77,48062	Durbin-Watson stat		2,401098
Prob(F-statistic)	0			

Table 8: Regressive analysis of lead - leaf

Dependent Variable: LEAF_PB		Date: 05/14/14 Time: 21:29		
Method: Least Squares		Sample: 28		
		Included observations: 28		
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
ROOT_PB	0,938794	0,091818	10,22457	0
SOIL_PB	-0,00411	0,004993	-0,8232	0,4185
LOCATION	-0,118226	1,03005	-0,114777	0,9096
C	-0,247595	0,70261	-0,352393	0,7276
R-squared	0,885385	Mean dependent var		6,940357
Adjusted R-squared	0,871058	S.D. dependent var		6,255153
S.E. of regression	2,24613	Akaike info criterion		4,587858
Sum squared resid	121,0824	Schwarz criterion		4,778173
Log likelihood	-60,23001	Hannan-Quinn criter.		4,646039
F-statistic	61,79893	Durbin-Watson stat		2,201968
Prob(F-statistic)	0			

DISCUSSION and CONCLUSION

Especially the first half of the previous century has high lead (Pb) emission into the environment because lead has been used as an antiknock agent in gasoline. According to Olendrzynski et al. (1995), about 70% of the total emissions in Europe were related to traffic, 15% to industrial production, 5%-10% to power generation, and 2% to waste burning. Another research concludes that the major source of human lead accumulation in developing countries was found to be airborne lead, 90 percent of which comes from leaded gasoline (MECA, 2003). Similar results indicating lead in the atmosphere mainly emitted from automobiles were investigated by several other researches (Foner, 1987; Gratani et al., 1992; Bahemuka & Mubofu, 1999; Renberg et al., 2000; Yaman et al., 2000; Andrews & Sutherland, 2004; Finster et al., 2004).

Aksoy & Sahin, (1999) indicated that sampling of soil and different parts of plants is useful to determine the source and location of lead contamination.
Table 1 represents a comparison of the toxic heavy metal concentrations (Ross, 1994). Because concentrations of lead in *Cichorium intybus L.* do not exceed generally the upper limit, studied sites of Sarajevo are not highly polluted by lead.

The concentrations of lead as heavy metal found in soil, roots and aerial parts of *Cichorium intybus L.* in different sites are presented in the Table 3. The lead concentrations in different localities show differences. Especially lead concentrations in soil show some excessive amounts in some localities. In terms of root and leaf, results are in the acceptable range. Only two sites exceed the upper limits which are located in the museum garden. Two different localities in museum garden show high pollution levels. Moreover, especially urban samples show values in which the upper limit is higher than the minimum levels of contamination. Aerial deposition of lead over a long time period might cause to that high concentration.

Based on the results of a previous study carried out by Aksoy (2008), It is expected soil lead concentration should be higher than that of roots and leaves. It is clear that the concentrations of lead in soil were significantly higher than that of in roots and aerial parts of plants. Therefore, the concentrations of lead in the soils support *Cichorium intybus L.* in the same areas.

The descriptive analysis with respect to urban, suburban and rural areas shows the practical results as expected theoretically. The mean lead concentrations in soil in the urban samples are significantly higher than that of suburban and rural samples. On the other hand, the mean lead concentrations in root and leaf samples are significantly higher than that of rural and are slightly higher than that of suburban samples.

The similar correlation can be found vertically in the same table. The mean lead concentrations in urban, suburban and rural areas show decreasing relations in soils, roots and leaves, respectively. These results are also expected theoretical results because of exposure time interval to lead pollution. Because soil is exposed to lead pollution more years than root and leaves, more lead is accumulated in soil. Basically, there are two ways whereby plants get contaminated by lead, which are one from soil sources via root absorption (Yaman et al., 2000; Finster et al., 2004; Wong & Li, 2004; Del Rio-Celestino et al., 2006), and the second from aerial deposition onto plant leaves (Aydinalp & Marinova, 2004).

It can be said that the high lead content in urban soils and plant samples is mostly because of the traffic density. Traffic density is considered as one of the major source of heavy metal contamination, especially in terms of lead. Different lead pollution levels among plants are because of the different levels of deposition airborne lead and from soil sources. Lead can increase high elevations after emitted from exhausts so it is very difficult to find lead free plants. When airborne lead precipitates, it accumulates on soil and plants. Consequently, high pollution levels of soil in urban sites are more likely due to the deposition of airborne lead and exposure interval. This study shows that there is no significant pollution level in roots and leaves of *Cichorium intybus L*. at the collected sites.

It is clear that with an increase in the lead concentration in soil due to percolation, the uptake of heavy metals by *Cichorium intybus L.* also increases. So it can be concluded that *Cichorium intybus L.* can be used as biomonitor of heavy metal pollution because it shows the criteria for a species as a biomonitor. Furthermore, because it is common in Europe, Asia and Australia it may be very useful biomonitor in these areas.

As a result this study shows that an immediate action is required to provide sustainable traffic, to use ecological methods to have a sustainable development in the area.

REFERENCES

Aksoy, A. 2008. Chicory (Cichorium intybus L.): Possible biomonitor of metal pollution. Pak. J. Bot., 40(2): 791-797.

Aksoy, A. and D. Demirezen. 2006. Fraxinus excelsior as a Biomonitor of Heavy Metals Pollution. Pol. J. Env. Stud., 15(1): 27-33.

Aksoy, A., W.H.G. Hale and J.M. Dixon. 1999. *Capsella bursa-pastoris* (L.) Medic., as a biomonitor of heavy metals. *Sci. Total Environ*., 226 :177-186.

Aksoy, A. and M. Öztürk. 1996. *Phoenix dactylifera* L. as a biomonitor of heavy metal pollution in Turkey. *J. Trace Microprobe Technol*., 14: 605-614.

Al-Shayeb, S.M., M.A. Al-Rajhi and M.R.D. Seaward. 1995. The date palm (*Phoenix dactylifera* L.) as a biomonitor of lead and other elements in arid environments. *Sci. Total Environ*., 168: 1-10.

Andrews S & Sutherland RA (2004). Cu, Pb and Zn contamination in Nuuanu watershed, Oahu, Hawaii. Sci Total Environ 324: 173182.

Atiq-Ur-Rehman, S. and M. Iqbal, 2008. Level of heavy metals in the foliage of naturally growing

plants collected from Korangi and Landhi industrial areas of Karachi city, Pakistan. Pak. J. Bot., 40(2): 785-789.

Augusto, S., F. Catarino and C. Branquinho. 2007. Interpreting the dioxin and furan profiles in the lichen Ramalina canariensis Steiner for monitoring air pollution, Sci. Total Environ., 377:114123.

Aydinalp C & Marinova S (2004). Lead in particulate deposits and in leaves of roadside plants . Pol J of Environ Studies 13: 233-235.

Bahemuka TE & Mubofu A (1999). Heavy metals in edible green vegetables grown along the sites of the Sinza and Msimbazi rivers in dares Salaam, Tanzania. Food Chem 66: 63-66.

Berrow, M.L. and A.M. Ure. 1981.The determination of metals and metalloids in soil. *Environ. Tech. Letters*, 2: 485-502. *CICHORIUM INTYBUS*, A BIOMONITOR OF METAL POLLUTION **797**

Davis, P.H. 1975. *Flora of Turkey and the East Aegean Islands*, Vol. 5: Edinburgh.

Del Rio-Celestino M, Font R, Moreno-Rojas R & De Haro-Bailon A (2006). Uptake of lead and zinc by wild plants growing on contaminated soils. Industrial Crops and Products 20:230-237.

De Temmerman, L., J.N.B. Bell, J.P. Garrec, A. Klumpp, G.H.M. Krause and A.E.G. Tonneijck. 2004. Biomonitoring of air pollution with plants e considerations for the future. In: Klumpp, A., Ansel, W., Klumpp, G. (Eds.), Urban Air Pollution, Bioindication and Environmental Awareness. Cuvillier Verlag, Go¨ttingen, Pp: 337-373.

Finster ME, Gray KA & Binns HJ (2004). Lead levels of edibles grown in contaminated residential soils: a field survey. Sci Total Environ 320: 245-257.

Foner HA (1987). Traffic lead pollution of some edible crops in Israel. Sci of Total Environ 59: 309-315.

Gratani L, Taglioni S & Crescente MF (1992). The accumulation of lead in agricultural soil and vegetation along a highway. Chemosphere 24: 941-949.

Kartal, S., L. Elçi and F. Kiliçel.1993. Investigation of soil pollution levels for zinc, copper, lead, nikel, cadmium and manganese at around of Çinkur Plant in Kayseri. *Fresenius Envir. Bull*., 2: 614-619.

Koeppe, D.E.1981. *Lead: understanding the minimal toxicity of lead in plants*. *Effects of Trace Metals on Plant Function*. Applied Science, Lepp N.W., Publishers, London, 55-76.

Lepp NW (1981) Effect of heavy metal pollution on plants. Applied Science 1 & 2: 111-114.

Lovett A.A, C.D. Foxall and D. Chewe. 1997. PCB and PCDD/F congeners in locally grown fruit and vegetable samples in Wales and England, Chemosphere, 34:1421–36.

Markert, B. 1993. *Plants as Biomonitors/Indicators for Heavy Metals in the Terrestrial Environment*, p.640. VCH Press, Weinheim.

MECA (2003). The Case for Banning Lead in Gasoline Manufacturers of Emission Controls Association . Washington, DC, USA, 51p.

Nasu Y & Kugimoto M (1984). Effects of cadmium and copper coexisting in the medium on the growth and flowering of lemna paucicostatta in relation to their absorption. Environ Pollut Ser A 33: 267-274.

Olendrzynski K, Anderberg S, Bartnicki J, Pacyna JM & Stigliani W (1995). Atmospheric emissions and depositions of cadmium, lead and zinc in Europe during the period 1955-1987. The International Institute for Applied Systems Analysis , IIASA WP-9535, Austria.

Page AL, Bingham FT & Chang AL (1981). Cadmium effect of heavy metal pollution on plants. Applied Science 1: 77-110.

Paveley, C.F. and B.E. Davies. 1988. Comparison of results obtained by x-ray fluorescence of the total soil and atomic absorption spectrometry assay of an acid digest in the routine determination of lead and zinc in soil. *Commun. Soil Sci. Plant Anal*., 19: 107-116.

Peterson PJ & Alloway BJ (1979). Cadmium in soils and vegetables:The chemistry, biochemistry and biology of cadmium. Topics in Environmental Health. Elsiever/North-Holland Biomedical Press, Amsterdam, Vol. 2: 45-92.

Renberg I, Brannvall ML, Bindler R & Emteryd O (2000). Atmospheric lead pollution history during four millennia (2000 bc to 2000 ad) in Sweden. Ambio 29: 150-155.

Rose, Francis (1981). The Wild Flower Key. Frederick Warne & Co. pp. 390–391. ISBN 0-7232-2419-6.

Ross, M.S. 1994. *Sources and form of potentially toxic metals in soil-plant systems.* In: *Toxic Metals in Soil-Plant Systems* (Ed.): M.S. Ross. pp.3-25. John Wiley, Chichester.

Sakurai T., J. Kim, N. Suzuki, T. Matsuo, D. Li, Y. Yao. 2000. Polychlorinated dibenzo-p-dioxins and dibenzofurans in sediment, soil, fish, shellfish and crab samples from Tokyo Bay area, Japan, Chemosphere, 40:627–40.

Sawidis, T., A. Marnasidis, G. Zachariadis and J. Stratis. 1995. A study of air pollution with heavymetals in Thessaloniki city (Greece) using trees as biological indicators. *Archives Environ. Cont. Toxicol*., 28: 118-124.

Simon JE, Chadwick AF & Craker LE (1984). Herbs: An Indexed Bibliography 1971-1980. The Scientific Literature on Selected Herbs and Aromatic and Medicinal Plants of the Temperature Zone . Archon Books, Hamden, CT, USA.

Tam, N.F.Y., W.K. Liu, M.H. Wang and Y.S. Wong. 1987. Heavy metal pollution in roadside, urban parks and gardens in Hong Kong. *Sci. Total Environ*., 59: 325-328.

Turkan I (1986). Izmir ili merkezi ve çevre yollari kenarinda yetisen bitkilerde kursun, çinko ve kadmiyum kirlenmesinin arastirilmasi. Doga Dergisi 10: 116-120.

Tyler, G. 1981. *Heavy Metal in Soil Biology and Biochemistry*. In: (Eds.): E.A. Paul & J.N. Ladd. *Soil Biochem.*, 5: 371-414.

Wittig, R. 1993.General aspects of biomonitoring heavy metals by plants. In: *Plants as Biomonitors/Indicator for Heavy Metals in the Terrestial Environment*. Markert B., VCH Publisher, Weinheim, 3-28.

Wolterbeek B. 2002. Biomonitoring of trace element air pollution: principles, possibilities and perspectives. Environ. Poll., 120: 11–21.

Wong CSC & Li XD (2004). Pb contamination and isotopic composition of urban soils in Hong Kong. Sci Total Environ 319: 185-195.

Yakupoglu, Guray, Sarica and Kaya. Determination of Airborne Lead Contamination in Cichorium intybus L. in an Urban Environment. Turk J Bot 32 (2008) 319-324

Yaman M, Dilgin Y & Gucer S (2000). Speciation of lead in soils and relation with its concentration in fruits. Anal Chim Acta 410: 119125.

http://www.innvista.com/HEALTH/foods/vegetables/chicory.htm

http://plantanswers.tamu.edu/vegetables/endive.html

http://dolcevitadiaries.co.uk/2009/05/19/wild-chicory-spaghetti/

GPS information of Localities, 2013. Googleearth, Accessed on January 2013.