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Short Communication

Uptake of Heavy Metals from *Plantago major* in the Region of Durrës, Albania

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Abstract

The objective of this study was to determine and compare levels of heavy metals in the leaves of *Plantago major* and the soil near the root zone. The study was conducted in the region of Durrës city, in Albania. The metals studied in this work were Pb, Cu, Zn, Mn, and Ni. Heavy metals presented in leaves of plants and soil have been detected using an atomic absorber spectrophotometer model NovAA400 (Analitik Jena).

The results show that the determined metals were present in the soil and leaves of *Plantago major*. The concentrations of metals found in soil change in the order Zn>Pb>Ni>Mn>Cu. The highest concentration was found for Zn and Pb. In our study, results showed a good correlation between Pb and Zn in the soil, suggesting the same origin of pollution. *Plantago major* showed the ability to absorb metals and the concentration of metals in leaves showed a good correlation with the concentration of metals in soil.

Keywords: heavy metals, *Plantago major*, soil

Introduction

In a study of pollution by heavy metals, bio-indication methods have been more frequently used in the last years [1-4]. The high concentration of heavy metals in soils is reflected by high concentrations of metals in plants, and consequently in animal and human bodies. The ability of some plants to absorb and accumulate metals makes them useful as indicators of environmental pollution. One of the well known plants used as a bio-indicator in a lot of studies is *Plantago major*. It is geographically widely spread and easily identified, it is characterized by a relatively high tolerance to environmental pollutants and shows a good correlation between the pollution level of a given element in the environment (air, soil) and a concentration of this element in plant tissues. Use of *Plantago major* as an indicator plant for heavy metal pollution is reported by many publications [3, 5-9].

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There are studies that have reported levels of heavy metals in different regions of Albania. Particularly, [10, 11] reported levels of heavy metals for the region of Elbasan. A study done for the determination of heavy metals in Albanian coastal sediments is reported by Rivaro P. et al. [12]. The levels of heavy metals in the lagoons of Patok, Kune, and Vilun are reported from Arapi and Cullaj [13].

The purpose of this paper is to give the level of some heavy metals, Pb, Cu, Zn, Mn, and Ni in the soil and leaves of *Plantago major* plants to valuate the ability of *Plantago major* to uptake heavy metals from soils. This study was conducted in the Durrës region in Albania.

Materials and Methods

Sampling Area

Durres is one of the largest cities of Albania, located near the Adriatic shore in western Albania. During the last

Table 1. Concentrations of heavy metals in soil and plant samples.

Metal	Soil samples			*P. major* samples		
	Min	Max	Mean (SD)	Min	Max	Mean
Pb	156	363.6	222.5 (52)	21	85	40.3 (20)
Zn	132.7	452	259.1 (102)	11	159	80 (47)
Cu	9.6	72.1	34.6 (20)	3.5	29	12.4 (9.2)
Mn	98.5	254.8	172 (44)	29	95	69 (17.4)
Ni	145	250	188 (27)	34.6	98.8	60 (25)

20 years the city has grown and the population reached 167,000, making it the natim's second largest city. Main activities for heavy metal pollution in the city are valuated: the factory for metal melting and the navy port [14]. Soil samples and *Plantago major* were collected from five locations (Fig. 1).

The main characteristics of areas selected for sampling were: point 1 Shkozet, near the factory of fusing colored metal and batteries, the most populated area in Durrës city; point 2 near Dajlon bridge, an area with high traffic density; point 3 near Durrës port; and point 4 Taulantia Square, in the centre of the city. This is a controlled traffic area, with low traffic density. Point 5 Ishmi Hill, a partly residential area out of the city atmosphere, chosen as the background point.

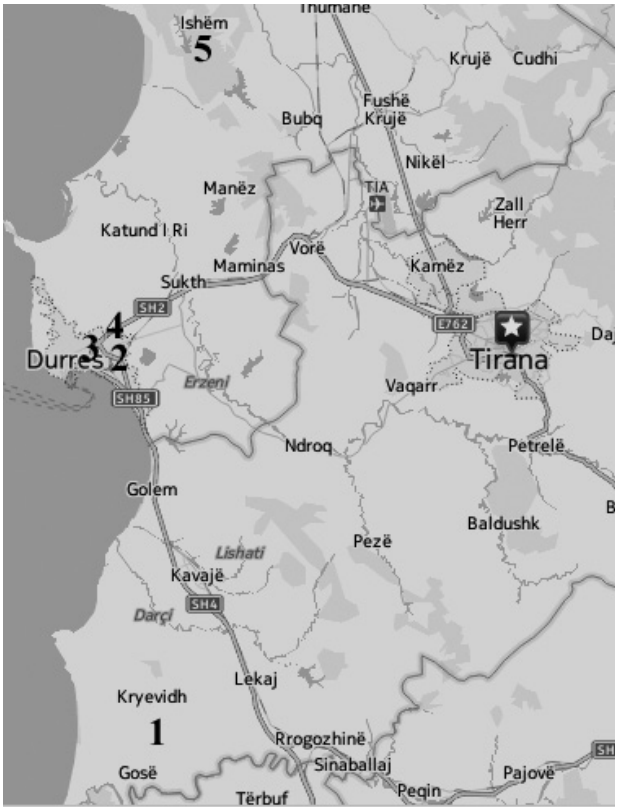

Fig. 1. Sampling points.

Sample Collection and Preparation

Samples were collected in September 2012. Three plants were gathered for every sample point. The entire plants were uprooted with soil around the root area to a depth around 10-20 cm and were collected to a polyethen container. Samples of *Plantago major* with soil were transported to the laboratory, where plants were separated from soil. Leaves from plant samples were washed with distilled water and dried at 70-75ºC to constant weight. Leaves were ground and homogenized. For analyses 1.0 to 1.5 g homogenized leaves were weighed. The analyses followed by digestion with 65% HNO_3 and 30% H_2O_2 using the microwave system ETHOS ONE according to [14]. Soil samples were dried to 105ºC in the thermostat and homogenized. From soil samples 0.3-0.5 g were weighed and the samples were digested with aqua regia according to Campbell C. R. and Plank C. O [15] using the microwave system ETHOSONE.

Sample Analyses

Both clear digested solutions were filtered through a 0.45 μm acid-resistant filter, were sent to 100 ml volume, and metal was determined by atomic absorption spectrophotometer (AAS) model Nova A400 Jena using methods described in Kebbekus B. B [16]. Five standards of known concentration were used to build the calibration curve, 0.05 mg to 2 mg/l. For standards and samples we used demineralized water and high-purity reagents (Perking Elmer-grade reagents). Statistical calculations were based on [17].

Results and Discussion

The concentration of heavy metals measured in the soil and leaves of *Plantago major* samples from the Durrës region in Albania are given in Table 1. The concentrations of samples are expressed in mg metal per kg dried sample (ppm). The standard deviation of 15 measurements is shown in parentheses.

All the metals determined were present in the samples of soil and the leaves of the plant *Plantago major*. The con-

Table 2. Mean concentrations (ppm) and standard deviations of the samples collected in Durrës, Albania.

Sample points	Samples type	Pb	Cu	Zn	Mn	Ni
Point 1	Soil	304.9±52	42.7±9.2	436.5±13.4	198.7±14.8	165.4±18.5
	P. major	77.3±8.6	24.0±5.6	154.3±5.7	85.0±10	46.0±8.9
Point 2	Soil	211.2±7.5	21.3±4	235.3±61	221.4±30	173.9±23
	P. major	37.3±4	7.4±0.6	21.0±8.7	78.5±5.8	40.0±5.4
Point 3	Soil	226.3±7.2	67.8±4.4	255.1±39	176.0±9.2	221.7±33.5
	P. major	31.3±3.5	21.4±3.3	95.7±2.1	73.0±5.6	98.3±7
Point 4	Soil	185.9±34	13.6 ±3.5	206.0±8.7	164.7±9.5	190.5±13.4
	P. major	33.2±3.2	3.8±0.6	81.2±5.4	68.3±3.5	76.5±8.4
Point 5	Soil	184.2±26	27.4±7.7	162.7±36	102.7±6.4	188.1±11.4
	P. major	22.3±1.5	5.3±0.1	47.3±8.6	40.3±12.7	39.5±6.5

centrations of metals found in soil changed in the order Zn>Pb>Ni>Mn>Cu. Zn and Pb were found to be in higher concentration than other metals. The level of Pb we found was higher than that reported by Mankolli H. et al. [10] and Laze P. [11], for Elbasan city, Rivaro P. et al. [12], for coastal zones of Albania and Arapi A. and Cullaj A. [13] for Albanian lagoons. The level of Zn, Mn, Ni, and Cu found in soil samples were at the same magnitude with the results reported by Rivaro P. et al. [12] and Arapi A. and Cullaj A. [13], and the level of Ni was lower than the results reported by Malaj E. et al. [19].

Fig. 2 summarizes the distribution of heavy metals in the soil and leaves of *P. major*.

Table 2 shows the concentrations of every metal in the samples from every sampling point. The concentrations of the metals are given in mg metal for kg dried samples (ppm), standard deviation of 3 measurements is shown in parentheses. There were significant differences on the mean value for Pb Kruskal-Wallis H = 10.8, P = 0.029; for Zn: H = 10.63, P = 0.031; for Cu: H = 12.70, P = 0.013; for Mn: H = 12.46, P = 0.014 whereas for Ni there were no significant differences H = 6.50, P = 0.165.

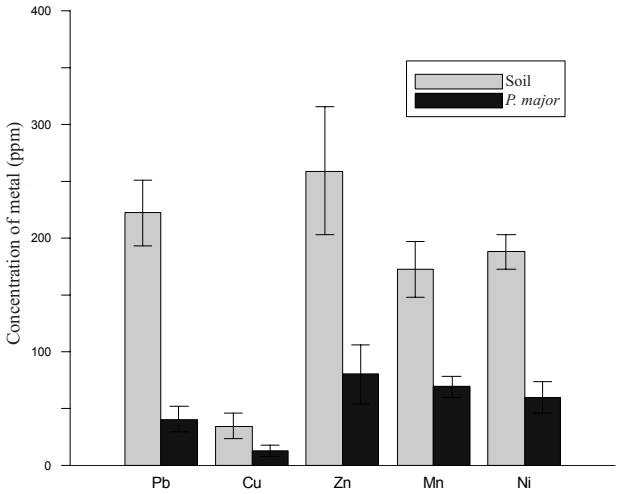

Fig. 2. Mean metal concentrations found in soil and *P. major* leaves. (Confidence interval for 95% of sample mean.)

The highest concentrations of all the metals were found in the samples from point 1. We think higher concentrations of metals in this point are due to the vicinity of point 1, with the factory of welding colored metals and batteries. It is demonstrated from [20-23] that the mines, welding metal factories and industrial activity contribute to the enrichment of metals in soil.

High concentrations of metals, especially for Pb, Zn, and Mn, was found in points 2 and 3. Point 2 is located near Dejlon Bridge and has a high traffic density of all types of automobiles, and we think that traffic was the reason for the high metals level in the samples from this point. It is reported from [24] that traffic density influences the increase of the concentration of heavy metals in the soil and plants alongside roads. It is known from [25] that Zn is used in the production automobile tires and it is reported from [26-28] that Pb and Mn are metals that come from gasoline used in automobiles. Point 3 is located near Durrës port and the high concentration of metals comes from the port activity. Other points were located near Taulantia Square and Ishmi Hill, where the density of traffic is low and there is no industrial activity.

Table 3 shows the calculated Pearson correlation coefficients r between metals in the soil samples used in this study and the P-value. The results showed a strong correlation between Pb and Zn and a moderate correlation between Mn and Zn in soil, suggesting their anthropogenic origin.

The heavy metal concentration found in the leaves of *Plantago major* varied a lot and mainly depended on the concentration of metals in soil. Nevertheless, the degree of accumulation of different metal depends on itself. In our study the concentrations of all metals in leaves of *P. major* vary significantly with the sample points.

A good correlation between metals in the soil and metals in the leaves of *P. major* was observed, too. The calculated Pearson correlation coefficients (r) and P-value between metals in the soil and metal in the leaves of *P. major* samples were shown in Table 4.

The high correlation between metals in the soil and in leaves of *P. major* suggests that the characteristics of cont-

Table 3. Calculated Pearson correlation coefficients (r) and corresponding P-value for metals in soil samples.

		Cu	Zn	Mn	Ni
Pb	r	0.458	**0.818**	0.399	0.318
	P	0.086	**<0.001**	0.141	0.2489
Cu	r		0.357	0.105	0.413
	P		0.192	0.709	0.126
Zn	r			**0.556**	0.267
	P			**0.031**	0.336
Mn	r				0.225
	P				0.420

Table 4 Calculated Pearson correlation coefficient (r) and P-value between heavy metal in soil and leaves of *P. major* samples.

Correlation between soil and leaves	r	P-value
for Pb	0.798	<0.001
for Cu	0.807	<0.001
for Zn	0.775	0.001
for Mn	0.772	0.001
for Ni	0.661	0.015

aminated soil are crucial for metal accumulation by *P. major*. Our results for the accumulation of metals by *P. major* are comparable with the results reported in the studies carried from Kurteva M. K. [3] and Malizia D. et al. [7]. Based on our study, the metal concentrations in the leaves of *P. major* can be determined with high accuracy when the concentration of metals in soil is known.

Conclusion

All metals in the study were present in the soil and leaves of *P. major*. The concentration of heavy metals in soil depended mainly on the characteristics of the sampling point and the distance from the source of contamination. Leaves of *P. major* do absorb the metals and the concentration of metals in leaves was correlated with the concentration of metals in soil. For this reason *P. major* can be used as a good biosensor for the observation of trends in soil metal composition.

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