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Accumulation of Zn, Cu, Pb and Cd by Dandelion (*Taraxacum officinale* Web.) in Environments with Various Degrees of Metallic Contamination

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Abstract

Contents of Zn, Cu, Pb and Cd have been examined in soils and dandelion (*Taraxacum officinale* Web.) in uncontaminated (Biała Podlaska, area of eastern Poland) and contaminated environments (Ruda Śląska and Bytom – Upper Silesia area). Based on the value of the cumulation factor (FC) a reduction of Zn and Cu collection by dandelion has been observed along with an increase of the concentration of these metals in the soil. Such a dependence is not so pronounced in the case of Pb and Cd. Even in an environment contaminated excessively with Cd (IV degree soil contamination) this element is collected by dandelion only in concentrations proportional to its content in the soil.

Keywords: *Taraxacum officinale,* heavy metals, accumulation, cumulation factor, uncontaminated areas, contaminated areas.

Introduction

Bioindicative methods are commonly used in the evaluation of environmental purity levels. Various types of plants are used as popular indicators of contamination, from mosses and lichens to trees or hovel plants. The interest in phyto-indicators arises from the fact that plants quickly react to chemical changes in environmental content. A broad review of literature concerning the use of plants in the environment shows that monitoring can be found, among other places, in paper [1].

Among hovel plants, dandelion (*Taraxacum officinale* Web.) is used as a bio-indicator. It is characterized by a high relative cumulation factor of some contaminants. It uses include evaluating environmental pollution with SO_2 [2], polycyclic aromatic hydrocarbons [3] and heavy metals [3-14]. Dandelion is a plant producing new leaves every year; it is very important when differentiating between atmospheric pollutants and soil contaminants. Dandelion fulfills all criteria adopted for phytoindicators [15]: it is widely spread geographically and easy to identify, characterized by a relatively high tolerance to environmental pollutants, shows a correlation between the pollution level of a given element of an environment (air, soil) and a concentration of this substance in plant tissues.

The assimilability of heavy metals by plants depends on many factors such as: contents of elements in soil, interactions between and the ability of the plant itself to absorb selectively certain metals [16]. Great fitoaccumulation of Cd and Zn [17] and relatively poor absorption of Pb by plants are indicated by literature data [(18) and literature included there].

Investigations on the concentration and the occurance of heavy metals in herbal plants carried out in Poland showed that these plants are heavily contaminated with heavy metals. Furthermore, the more polluted certain areas are, the greater the contamination of herbal plants [19-22].

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The conducted research was aimed at the evaluation of concentration levels of the following metals: Zn, Cu, Pb and Cd in the soil and in leaves and roots of dandelion in two, distinctly different environments with regard to pollution, with indication at the possibility of phytoextraction of these metals by the plant.

Sample Collection

The samples for the investigations were collected in the areas of Biała Podlaska (Southern Podlasie Lowland, eastern Poland) and Ruda Śląska and Bytom (Upper Silesia) in May 2001. 13 samples were collected from the area of Biała Podlaska. 22 samples totally were collected from the area of Upper Silesia (12 from Ruda Śląska and 10 from Bytom). The samples from Ruda Śląska were mainly collected in the vicinity of a coking plant in 1-go Maja Street, while those collected in Bytom came mostly from the sites located in the area of "Bobrek" steel mill. Approx. 1 kg of soil (to a depth of 20 cm) and several specimens of dandelion were collected from each sampling point.

Research Methodology

The collected soil was air dried, sifted through a sieve of 1mm mesh diameter. 5-g subsamples were mineralized in a muffle furnace at 420°C and digested in 4 cm^3 of concentrated nitric acid and in 1 cm^3 of hydrogen peroxide solution (p.f.a.). The solution obtained was then filtered into flasks of 50 cm^3 capacity, and the sediment was washed on the filter with 10 cm^3 of 1M nitric acid. The content of flasks was supplemented up to 50 cm^3 with redistilled water.

Dandelion leaves and roots were washed thoroughly with redistilled water and air dried, and then dried at 50°C. The samples were homogenized. 2-g subsamples of dry mass of leaves and roots were weighed for analysis. The further procedure was identical to the case of soil samples.

Concentrations of Zn, Cu, Pb and Cd have been determined, using AAS technique, with the use of an apparatus manufactured by Carl Zeiss Jena, using acetylene-air flame for analysis, in the solutions obtained through successive dry and wet mineralization. The content of Cd

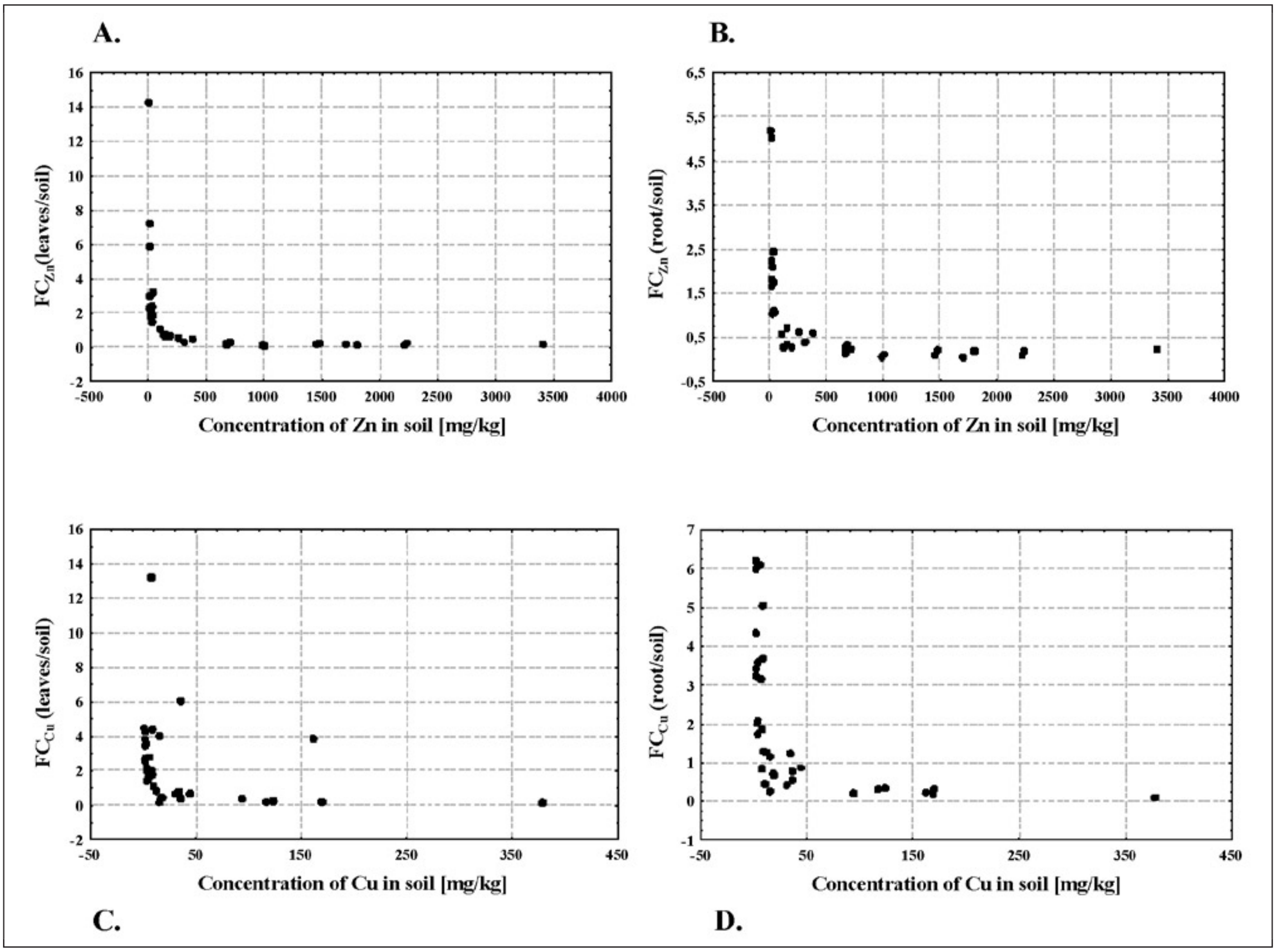

Fig.1. Relation between concentration of heavy metals in soil and cumulation factor (FC) in relation: A – concentration of Zn in soil/ FC_{Zn} (leaves/soil); B - concentration of Zn in soil/ FC_{Zn} (root/soil); C - concentration of Cu in soil/F_{Cu} (leaves/soil); D - concentration of Cu in soil/FC_{Cu} (root/soil).

Table 1. The concentrations of heavy metals in soil [mg/kg] and reaction of soil in the area of Biała Podlaska (BP).

Biała Podlaska	Zn	Cu	Pb	Cd	pH
BP1	37.5	3.8	13.6	0.11	6.6
BP2	14.5	1.7	6.3	0.04	4.6
BP3	103.6	4.0	24.5	0.27	7.0
BP4	7.9	1.5	3.3	0.08	7.2
BP5	24.2	9.7	175.3	0.135	6.9
BP6	32.9	4.1	19.7	0.16	7.2
BP7	16.5	2.2	6.4	0.15	6.8
BP8	20.8	2.9	10.6	0.13	7.0
BP9	19.6	2.3	8.1	0.19	5.9
BP10	37.3	5.6	16.2	0.175	7.8
BP11	22.1	2.5	7.5	0.12	7.6
BP12	19.8	2.0	6.1	0.11	7.0
BP13	34.7	6.3	13.6	0.26	6.7
Mean±SD:	30.1±23.9	3.7 ±2.3	23.9±45.8	0.15±0.005	

and Pb in some samples was determined by means of a graphite cell used as an excitation source. Standard solutions within concentration ranges [μg/cm^3]: Cu: 0.1-1.4, Zn: 0.4 – 4.0 and 5-30, Pb: 0.5-5,0 and 0.02-0.06 and Cd: 0.3-3.0 and 0.001-0.006 were used for the determination of individual metals. In cases of high metal contents in the samples, exceeding the concentration range of standard solutions, the examined samples were diluted.

Data Analysis and Calculations

The concentrations of elements in the soil, leaves and root of dandelion have been calculated for individual samples. The cumulation factor (FC) of particular elements have been calculated for each sampling point using the following dependence: Xa/Xs, in the configuration: root/soil and leaves/soil; where Xa – the concentration of a particular element in the root or leaves, Xs – concentration of a given element in the soil. Besides, the correlations between the content of metals in the soil, leaves and root of dandelion have been calculated using the Statistica computer program, in configurations soil/root, soil/leaves, root/leaves as well as soil-cumulation factor of root/soil and soil-cumulation factor of leaves/soil. Using the U-Mann-Whitney's test the significance of the differences between samples was proved.

Results and Discussion

The concentration of the investigated metals in the soil was, as expected, significantly lower in the area of Biała Podlaska than in the samples collected in the area of Upper Silesia (for all elements $Z<-4.5$, $p<0.001$). The mean concentration of the elements in the area of Biała Podlaska (Table 1) amounted to [mg/kg]: Zn – 30.1, Cu – 3.7, Pb – 23.9 and Cd – 0.15. In the samples collected in the area of Ruda Śląska and Bytom (table 2) it was as follows [mg/kg]: Zn – 969.2, Cu – 69.1, Pb – 508.7 and Cd – 5.1.

The reaction of the investigated soil from the area of Biała Podlaska corresponded in most samples to the pH values assumed for neutral soils (pH: 6.6 – 7.2), while the examined soils from the Upper Silesia region were characterized by a slightly acidic reaction (pH: 5.6 – 6.5), through neutral to slightly basic (pH >7.2).

Out of the investigated elements, zinc was present in the highest concentration in the leaves and root of dandelion (tables 3 and 4). Its mean concentration in the samples from Biała Podlaska amounted to: 72.5 and 48.9 mg/kg respectively, while in the samples from Upper Silesia it was: 213.9 and 186.3 mg/kg. A several-fold lower concentration of copper was also noticed in the tissues of plants collected in eastern Poland than in the area of Ruda Śląska and Bytom. The observed mean Cu concentration in dandelion leaves was: 8.6 mg/kg (Biała Podlaska) and 64.8 mg/kg (samples from Silesia), while the concentration of this element in the root was: 12.6 mg/kg and 25.9 mg/kg respectively. The concentration of toxic metals in the plant was as follows: Pb – 2.6 mg/kg in leaves and 1.7 mg/kg in the root, and Cd – 0.21 mg/kg in leaves and 0.20 mg/kg in the root in the samples collected in the area of Biała Podlaska. Yet, in the plant collected in the area of Ruda Śląska and Bytom it was: Pb – 37.3 mg/kg of leaves and 110.2 mg/kg of roots, and Cd – 1.9 mg/kg of leaves and 2.9 of roots. There was a significant difference ($Z<-4.3$, $p<0.001$) in concentration of metals in leaves and

Table 2. The concentrations of heavy metals in soil [mg/kg] and reaction of soil in the area of Ruda Śląska (R) and Bytom (B).

Area	Zn	Cu	Pb	Cd	pH
R1	1769.0	124.1	344.2	2.2	7.7
R2	1448.4	378.4	684.1	2.7	7.9
R3	3404.2	169.9	1540.5	28.2	8.17
R4	1704.1	93.8	472.6	12.4	7.9
R5	383.9	44.5	154.2	1.5	6.5
R6	986.8	168.9	197.5	1.2	6.4
R7	2232.5	161.8	2257.2	22.7	7.6
R8	2218.2	9.0	1925.1	12.4	8.0
R9	710.6	36.0	218.9	1.2	7.8
R10	46.9	10.3	16.5	0.3	6.6
R11	678.5	36.4	190.5	2.6	7.0
R12	670.0	15.2	136.6	2.5	6.8
B1	671.0	19.0	178.6	3.8	6.7
B2	260.3	8.7	107.7	1.5	6.4
B3	195.1	31.0	86.9	0.62	6.5
B4	1003.9	116.9	489.5	3.9	8.1
B5	1799.1	34.1	707.4	2.9	7.8
B6	151.8	15.6	422.2	1.9	5.8
B7	153.4	7.8	636.8	0.93	6.2
B8	312.1	12.6	226.2	1.9	6.5
B9	687.7	17.7	170.6	3.4	6.9
B10	127.8	7.7	28.7	0.6	7.6
Mean±SD	969.2±872.3	69.1±89.5	508.7±613.8	5.1±7.3	

roots between collected samples in Biała Podlaska and the area of Upper Silesia. The range of particular metal assays fluctuated within a relatively broad spectrum of values; this is especially clearly visible in samples from the Upper Silesia region.

The results of the determination of metal content in soil compared with the values assumed in literature [23] for the soils contaminated with heavy metals to a various degree showed that the mean content of Zn, Cu, Pb and Cd in the area of Biała Podlaska corresponded to their natural content in soil. Mean concentrations of metals in soils of the Biała Podlaska region did not exceed values given by the Agriculture and Country Development Minister's Decree [24] concerning permissible concentrations of metals contaminating soil. These are: [mg/kg] Pb – 50, Cd – 0,75, Cu – 30, Zn – 100 (these values are considered to be permissible for soils of ecological farms). Mean concentrations of metals in soils of Biała Podlaska region also did not exceed values fixed by the Environmental Minister's Decree [25] concerning soil standards and land qualities of grounds belonging to A (land protected on the basis of environmental protection regulations) and B (agricultural land) groups.

The metals were present in distinctly higher concentrations in the soils of the investigated areas of Upper Silesia than in those from Biała Podlaska region. The mean Cd content classified the investigated soils as IV degree of contamination with heavy metals, Zn and Pb content as III degree of contamination, and finally Cu content as II degree of contamination with heavy metals. Metal contents in soils, according to Kabata – Pendias et al. [23], are divided into: I degree of contamination – soils of elevated content of heavy metals, II degree of contamination – soils slightly polluted with heavy metals, III degree of contamination – soils of avarage content of heavy metals, and IV degree of contamination – soils heavily polluted with heavy metals. When compared to the values fixed by the Environmental Minister's Decree [25] (Zn – 1000mg/kg, Pb – 600mg/kg), mean Zn and Pb concentrations in soils of the Upper Silesia region classify

Table 3. The concentrations of heavy metals in Taraxacum officinale (Web). [mg/kg] in the area of Biała Podlaska (BP).

Biała Podlaska	Zn		Cu		Pb		Cd	
	leaf	root	leaf	root	leaf	root	leaf	root
BP1	66.6	41.9	8.1	7.9	3.1	3.4	0.05	0.03
BP2	85.4	26.6	6.5	5.8	7.2	0.52	0.09	0.07
BP3	112.2	60.9	8.0	7.0	6.4	1.7	0.14	0.12
BP4	112.9	41.0	6.7	9.3	3.0	1.4	0.71	0.07
BP5	50.5	50.7	10.8	12.6	2.1	5.4	0.04	0.08
BP6	78.2	80.8	6.0	14.7	1.1	2.6	0.22	0.18
BP7	119.7	83.1	5.7	7.1	0.45	1.4	0.25	0.25
BP8	62.2	46.1	10.3	17.7	0.46	1.6	0.23	0.16
BP9	44.6	32.5	8.0	10.0	0.58	0.58	0.08	0.13
BP10	72.3	65.9	15.7	34.2	4.3	2.3	0.17	0.28
BP11	40.2	22.9	6.7	5.1	2.0	0.22	0.12	0.15
BP12	46.1	44.5	8.6	12.0	1.4	0.26	0.02	0.10
BP13	52.4	38.5	10.7	19.9	1.7	0.44	0.6	0.96
Mean ±SD:	72.5 ±27.6	48.9 ±18.9	8.6 ±2.7	12.6 ±7.9	2.6 ±2.2	1.7 ±1.5	0.21 ±0.21	0.20 ±0.23

its grounds as belonging to the C group (industry lands). Mean concentrations of Cu and Cd are below those fixed by the Environmental Minister's Decree (Cu – 600mg/kg, Cd – 15mg/kg).

The results of the determination of metal content in soil from the Upper Silesia area obtained during this research, in comparison to the literature data, indicate a similar level of assays. For example Rostański [26] determined the following concentration range of metals in the soils from the area of Upper Silesia [mg/kg]: Zn: 181-10000; Pb: 32-1400 and Cd: 1.2–99.7.

The metal concentration range in the leaves and root of dandelion is proposed in literature [5] as the so-called background. The range of the proposed background values for the element content in leaves amounts to [mg/kg]: for Zn 20-110, Cu 5-20, Pb 1.6-6.5 and Cd 0.3-1; while in the root of dandelion it is as follows [mg/kg]: for Zn 10-60, Cu 5-25, Pb 0.2-5,0 and Cd 0.1-1.0. While comparing the obtained results (tables 3 and 4) with the above given values, one shall notice that in Biała Podlaska the mean content of heavy metals both in dandelion leaves and roots corresponded to the values proposed as background. However, the content of all the investigated metals in the plants collected in the area of Ruda Śląska and Bytom exceeded significantly the background values. The content of some elements found in the tissues of dandelion from the contaminated region is regarded as noxious according to the data included in literature. Thus, for example, Kabata-Pendias [27] recognises the copper content of only 20 mg/kg as high, while higher than 100 mg/kg as noxious. Hemphill [28] and Jones [29] (after Sawicka-Kapusta [30]) assume Zn content of 400 mg/kg as the test of toxicity, although, as the above-mentioned authors report, most plants show disorders as early as values slightly above 100 mg/kg. Relatively high Zn values, at the level approx. 200 mg/kg and Cu – above 20 mg/kg, were recorded in the samples from the Upper Silesia region.

There are limited possibilities of phytoextraction of some elements by dandelion in strong soil contamination conditions. Out of the investigated elements this concerns especially Zn and Cu (Table 5). The mean cumulation factor of Zn in dandelion root in relation to soil was 1.62 for the samples of Biała Podlaska area, and 0.19 for the samples of Ruda Śląska and Bytom area. In leaves it amounted to: 2.4 and 0.22 respectively. Cu cumulation factor in the configuration of root/soil was: 3.40 and 0.37, and in the configuration of dandelion leaves/soil - 2.3 and 0.94 respectively for the samples of uncontaminated and contaminated areas. As can be seen in the data shown in illustrations 1A-1D, a distinct decrease of the cumulation factor (FC) value of these metals in the leaves and root of dandelion is accompanied by the increase of Zn and Cu concentration in soil. It is also confirmed by the values of cumulation factor calculated in the configuration: element concentration in soil/element cumulation factor in dandelion root. Statistically significant negative correlation were found between Zn and Cu concentrations in soil and cumulation factor (FC) in dandelion roots as well as between Zn concentration in soil and cumulation factor in dandelion leaves (Table 6). Yet, no statistically significant correlations were found in the above-mentioned con-

Table 4 . The concentrations of heavy metals in *Taraxacum officinale* (Web.) [mg/kg] in the areas of Ruda Śląska (R) and Bytom (B).

Area	Zn		Cu		Pb		Cd	
	leaf	root	leaf	root	leaf	root	leaf	root
R1	388.1	309.8	31.0	41.4	30.8	327.6	0.7	4.7
R2	265.7	148.2	51.0	40.6	26.5	20.2	1.0	0.39
R3	576.8	802.6	36.2	52.4	159.6	251.1	3.8	7.0
R4	332.0	108.8	35.3	19.3	64.5	23.9	3.3	1.2
R5	197.5	228.4	29.0	39.2	28.9	699.7	0.93	9.7
R6	133.9	59.5	36.3	31.3	20.5	5.2	0.79	0.27
R7	625.9	408.0	626.0	38.6	41.4	104.1	4.4	6.1
R8	268.0	207.6	39.4	45.4	56.8	40.0	2.3	2.3
R9	217.1	172.5	217.1	28.5	165.0	34.1	2.8	6.6
R10	149.6	49.5	11.2	4.7	4.7	0.44	2.4	0.48
R11	103.6	109.5	13.0	20.5	2.14	9.9	0.68	0.92
R12	92.3	90.1	3.3	4.0	12.9	7.1	0.81	0.92
B1	151.5	187.4	8.5	13.2	10.9	39.4	1.4	2.1
B2	148.6	164.9	15.8	32.0	20.4	189.6	2.2	4.3
B3	124.6	57.6	21.5	13.1	2.4	5.5	0.75	0.4
B4	90.0	125.4	25.1	37.1	33.4	191.6	0.79	2.7
B5	278.4	324.5	26.4	42.1	84.1	84.8	1.0	0.84
B6	101.9	109.7	63.0	17.9	16.9	105.9	1.1	2.8
B7	107.8	53.6	15.7	14.5	5.9	3.7	0.53	0.43
B8	99.6	122.6	10.5	15.9	8.8	241.8	1.6	5.0
B9	160.3	220.9	8.5	12.4	20.9	30.8	2.7	3.4
B10	102.0	36.6	102.0	6.5	3.3	7.2	1.9	0.69
Mean ±SD	213.9 ±150.6	186.3 ±168.3	64.8 ±133.4	25.9 ±14.6	37.3 ±45.7	110.2 ±163.3	1.72 ±1.12	2.9 ±2.6

Table 5. The cumulation factor of heavy metals (FC) in relation: root of dandelion/soil, leaf of dandelion/soil in the areas of Biała Podlaska (1) and Upper Silesia (2).

FC in relation	Cu		Zn		Cd		Pb	
	1	2	1	2	1	2	1	2
root/soil	3.4	0.37	1.62	0.19	1.33	0.57	0.07	0.22
leaf/soil	2.3	0.94	2.4	0.22	1.40	0.33	0.11	0.07

figurations for Pb and Cd. The values of Pb cumulation factor in the configuration of root/soil were: 0.07 (Biała Podlaska) and 0.22 (Upper Silesia), and in the configuration of plant leaves/soil were 0.11 (Biała Podlaska) and 0.07 (Upper Silesia). The values of cumulation factor for Cd in the configuration of root/soil were as follows: 1.33 and 0.57, while in the configuration of leaves/soil they were 1.4 and 0.33, respectively for the samples collected in Biała Podlaska area and in the Upper Silesia region (Table 5). The values of Cu, Zn and Cd cumulation factors for samples collected in uncontaminated areas (Biała Podlaska) exceeded the value of 1 while the value of Pb cumulation factor was distinctly lower than the value of 1. Kabata – Pendias and Pendias [17] indicate that the

Table 6. The correlation coefficient (r) of heavy metals in relation soil/leaf, soil/root soil/cumulation factor: leaf/soil, soil/cumulation factor: root/soil.

r in relation:	Cu	Zn	Pb	Cd
soil-leaf	0.88	ns	0.51	0.77
soil-root	0.85	0.60	ns	0.49
soil- FC leaf/soil	ns	-0.39	ns	ns
soil - FC root/soil	-0.47	-0.48	ns	ns

ns – was not stated

cumulation factor of Pb in plants is lower than the value of 1 while Cd is highly phytoassimilable. Kabata – Pendias [27] states also that the value of Cu cumulation factor in plants in relation to its concentration in soil is 1,7. In plants collected in the uncontaminated area of Polesie Lubelskie the value of Zn cumulation factor exceeded the value of 1 [31].

Literature [32,33] indicates a high mobility of zinc in plants and the ease of its absorption by the plant roots. The results obtained during this research demonstrate that after exceeding a certain value of Zn concentration in soil (about 200 mg/kg and above) the inhibition of its absorption by plants occurs. Also Gambuś et al. [34], who investigated the content of Zn in purple clover growing in the region of Krakow in soils contaminated to a various degree, noticed this fact. Moreover, Mikos - Bielak and Marczuk [31] in their investigations concerning determining the effectiveness of plants from Polesie Lubelskie forests to accumulate Zn observed the negative relation between soil contamination and the cumulation factor of Zn in plants. Such relations, however, are not found for Cd and Pb.

Literature [35] also indicates the ease of Cd absorption by the plants via root system. Wacławek and Moćko [36] also indicated the high mobility of Cd in soil and the related passage into the over-ground plant parts. The results of this work show that Cd is well absorbed by dandelion even from the soils heavily polluted with this element (corresponding to IV degree of contamination). Pb is also in soils heavily polluted with this element well absorbed by dandelion. It is confirmed by the values of Pb cumulation factor studied in the configuration of dandelion root/soil which for samples collected in the area of Biała Podlaska are 0,07 and 0,22 for samples collected in the Upper Silesia region. The data is confirmed by literature, according to which [17, 37] there is a relation between Pb concentration in plants and its concentration in soil. Excessive Pb accumulation is explained by attenuation of the biological barrier leading to unselective absorption of the element. With the increase of Pb concentration in a soil solution its amount in plant increases, especially in dandelion root and, to a lesser extent, in its above – ground parts. The literature [17] indicates also that this excessive amount of Pb makes that the absorption of Cu and Zn by plants decreases while the absorption of Cd may increase. This additional influence of Pb on Cd absorption may be the result of cell – membrane damage.

The fact that the value of Cu cumulation factor in dandelion root is about ten times lower in the contaminated area than in the uncontaminated one is evidence that Cu phitoextraction is limited in contaminated soils. Kiepas – Kokot and Zabłocki [38] indicate that in soils contaminated with Cu the development of plant root system is restrained. Restriction of root development may cause a significant decrease in absorption of this element.

Pb is relatively poorly absorbed by dandelion out of the investigated elements. This is also indicated by literature data ([18] and therein included literature). The cumulation factor of this element for the samples collected in environments differing with regard to purity in the configuration of root/soil as well as leaves/soil were distinctly below the value of 1.

The accumulation of metals in plants depends on various environmental factors. Apart from their general content in soil, also their content in the form available for plants is very important, and it depends, among other things, on soil reaction. In both environments, the investigated soils have been characterized by almost neutral reaction. Undoubtedly the research should broaden with the analysis of forms in which metals occur in soil. According to the investigations carried out by Angelova and Iwanov [39] in soils contaminated by a non-ferrous smelter, a relatively big fraction of Cd (53.2%) and Pb (4.13%) occured in mobile and assimilable by plants forms while percentages of these forms for Cu and Zn were considerably lower (less than 1%). Niesiobędzka [40], however, who studied speciation of metals in soils of northeastern Poland found small participation of Pb, Cu and Zn in the ion-exchange form (about 2%).

The conducted research proved that the inhibition of Cu and Zn absorption by dandelion takes place when soils are heavily contaminated with metals (II and III degree of contamination). No such distinct dependencies were noticed for Pb and Cd. Dandelion seems to be a good bioindicator of Cd level in the environment. It is indicated by the correlation coefficients in the configuration of dandelion leaves/soil ($r=0.77$, $n=35$, $p<0.01$) and dandelion root/soil ($r=0.49$, $n=35$, $p<0.01$) (Table 6). It is confirmend also by literature [41]. The root and leaves of this plant are good bioaccumulators of Cd. For this reason, the analysis of this element content in the case of phytotherapeutical use of dandelion seems indispensable.

Conclusions

1. The mean content of Zn, Cu, Pb and Cd in the soils of Biała Podlaska region corresponded to their natural contents, while the soils from Ruda Śląska and Bytom region have been classified as**:** slightly contaminated with Cu, to medium extent contaminated with Zn and Pb and heavily contaminated with Cd. The mean concentrations of metals in the soils of Biała Podlaska

region classified these soils as suitable for ecological crops. The mean concentrations of metals in the soils of the Upper Silesia region were characteristic of industrialized areas.
2. The mean metal content in the leaves and root of dandelion in Biała Podlaska area was within the range of concentrations assumed as background, while in the Upper Silesia region it significantly exceeded background values.
3. The accumulation of Zn and Cu by dandelion decreases with the increase of the soil concentration; such relations are not pronounced so clearly in the case of Pb and Cd.
4. Dandelion accumulates Cd in concentrations proportional to its content in soil in an environment highly contaminated with this element (IV degree of contamination).
5. The analysis of Cd content in plants is necessary in the case of dandelion use for phytotherapeutical purposes.

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