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## OCCURRENCE OF CADMIUM IN HERBS GROWING ON GRASSLAND LOCATED NEAR THE HIGHWAY

### WYSTĘPOWANIE KADMU W ZIOLACH ROSNĄCYCH NA UŻYTKACH ZIELONYCH ZLOKALIZOWANYCH W POBLIŻU DROGI SZYBKIEGO RUCHU

**Abstract:** The aim of this work is to determine the level of impurity by cadmium selected species of dicotyledonous plants to which belong the herbs collected from permanent grassland located near a highway. Chosen herbs were collected from the grasslands located near the international rout E-30 near Siedlce. Such herbs as common dandelion (*Taraxacum officinale* L.), greater plantain (*Plantago maior* L.) and garden sorrel (*Rumex acetosa* L.) were picked up.

The plant material was taken from the distance 2; 10; 30 and 50 m from the wayside ditch. Shoots of plants (stems and leaves) were separated from underground parts (roots and rhizome) and then they were dried them and grinded. Crumbled material in 5 g samples was put through mineralization at a temp. 450 °C. Samples prepared like that were put in to the solution with 10 cm<sup>3</sup> of 10 % HCl and added distilled water to the volume 50 cm<sup>3</sup>. The content of cadmium in received solutions was determined using the AAS method.

The concentration of the cadmium content in shoots and in underground parts systematically decreased in the measure of dismissing from the source of pollution in all studied plants.

Independently from the place of the gathering of the plant material, the most cadmium was accumulated by the common dandelion in the shoots (0.24 mg · kg<sup>-1</sup> d.m.), however the smallest concentration of cadmium in studied herbs was in the underground parts of garden sorrel (0.09 mg · kg<sup>-1</sup> d.m.) independently from the place of gathering.

**Keywords:** cadmium, common dandelion, greater plantain, garden sorrel

Microelements in plants are important elements with regard to their functioning in some biological processes and because of animals nutritional needs [1]. Common feature of microelements is that after exceeding the admissible level, they affect toxically life forms [2]. Both their shortage as well as the excess cause negative results.

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Recently very big interest in elements has been focused on heavy metals. Cadmium is ranked to the most toxic and threatening the health of people and animals [3].

Cadmium is absorbed by plants extremely easily, both by their root system and by their leaves mostly proportionally to its concentration in the environment [4]. The transportation of cadmium in a plant is easy, but with increased absorption it is accumulated mainly in roots, even in the case of absorption by leaf blades. In the case of exceeding the critical point heavy metals, including cadmium, affect the crop quality becoming simultaneously a threat for animals and people's health.

Cadmium is not an indispensable component for life forms. However, even its comparatively small quantities can be already toxic for animals. Toxicity of high concentrations of cadmium manifests itself in kidneys function disorders, neoplastic diseases and in reproductive system disorders.

In a human organism cadmium accumulates first of all in a liver and kidneys, where it combines extremely hard and for quite a long time, as for about 10 years time, with a low molecular protein. Moreover cadmium blocks phosphates and some enzymes and causes anemia. The most often it causes chronic poisonings which for 1-year period can run without any symptoms. Particularly dangerous is the excess of cadmium especially in plants which are consumed both by animals and people. To these plants among others belong herbs [5].

Therefore, the aim of this work is to determine the level of impurity by cadmium selected species of dicotyledonous plants to which belong the herbs collected from permanent grassland located near a highway.

## Material and methods

Chosen herbs were collected from the grasslands located near the international route E-30 near Siedlce. Such herbs as common dandelion (*Taraxacum officinale* L.), greater plantain (*Plantago maior* L.) and garden sorrel (*Rumex acetosa* L.) were picked up. The plant material was taken from the distance 2; 10; 30 and 50 m from the wayside ditch. Shoots of plants (stems and leaves) were separated from underground parts (roots and rhizome) and then they were dried and ground. Crumbled material in 5 g samples was put through mineralization at a temp. 450 °C. Samples prepared like that were put in the solution with 10 cm<sup>3</sup> of 10 % HCl and added distilled water to the volume of 50 cm<sup>3</sup>. The content of cadmium in received solutions was determined using the AAS method.

Obtained results were subjected to a statistical method of the variation one factor analysis using the Statistica programme – for Windows and module Anova/Manova. The significance of the differentiation of results was verified by the Tukey test for the level of significance  $p \leq 0.05$ .

## Results

The content of cadmium in studied herbs has changed depending on distance from the source of pollution and on plant species.

Kabata-Pendias [1] claims critical cadmium content in plants in relation to their usefulness for consumptive aims should not exceed the value of  $0.15 \text{ mg} \cdot \text{kg}^{-1} \text{ d.m.}$ , but for fodder aims should come to  $\leq 0.5 \text{ mg} \cdot \text{kg}^{-1} \text{ d.m.}$  The largest concentration of this metal was in shoots of common dandelion ( $0.32 \text{ mg} \cdot \text{kg}^{-1} \text{ d.m.}$ ) growing nearest the highway, that is in the distance of 2 m (Table 1). According to the investigation, with the increase of the distance from the source of pollution, the content of cadmium decreased in the considered plant material in common dandelion and in the other herbs as well.

Table 1

The cadmium content in the shoots of investigated plants [ $\text{mg} \cdot \text{kg}^{-1} \text{ d.m.}$ ]

Plants	Distance from the road [m]			
	2	10	30	50
Common dandelion	0.32 Aa	0.24 Ab	0.23 Ab	0.18 Ac
Greater plantian	0.18 Ba	0.13 Bb	0.10 Bc	0.07 Bd
Garden sorrel	0.20 Ca	0.17 Cb	0.16 Cb	0.10 Cc

Means in lines appointed various letters differ significantly; means in columns appointed various letters differ significantly.

The smallest quantities of this element were affirmed in the shoots of greater plantian ( $0.07 \text{ mg} \cdot \text{kg}^{-1} \text{ d.m.}$ ) gathered from the distance of 50 m from the source of pollution. The largest fall of the cadmium concentration with the distance from the source of pollution was in the shoots of greater plantian. This decrease was over 61 % for measurements at the distance of 2 m and 50 m. The smallest decrease of cadmium content coming to about 44 % was observed in shoots of the common dandelion for measurements on the same distances. The statistical analysis showed significant differences in the cadmium content in the shoots of greater plantian in all points of the experiment. However it was not found significant differences between the cadmium concentration in the shoots of common dandelion and garden sorrel growing at the distance of 10 and 30 m.

The comparison with literature data concerning the contamination levels of heavy metals in plants near highways is very difficult [6]. The ranges of cadmium extracted from the herbs, were lower than those observed in *Graminaceae* by many authors eg [7] and [8] who studied *Chenchrus echinatus*, *Sorghum halopense*, *Paspalum paniculatum* and *Stipia ichu*. Nevertheless, they are similar to the values obtained in recent studies on tobacco leaves [9] or herbs leaves and vegetables [10]. Levels of cadmium were lower than those found in earlier studies [8] although they were comparable to those recently observed [11, 12] and [9, 13]. In comparison to the values owning to subchronical toxicity for cattle through forages ( $0.5 \text{ Cd mg} \cdot \text{kg}^{-1} \text{ d.m.}$ , [11] the concentrations of this metal was less.

Independently from the species of the studied dicotyledonous plants the most cadmium ( $0.23 \text{ mg} \cdot \text{kg}^{-1} \text{ d.m.}$ ) had the plants growing in the distance of 2 m from the wayside ditch. This content systematically decreased with the distance from the source

of pollution achieving the lowest average content ( $0.12 \text{ mg} \cdot \text{kg}^{-1} \text{ d.m.}$ ) for the distance of 50 m.

Roadside contamination was obvious by the significant negative correlations between concentrations of metals in plant samples and distance from road edge [14, 15]. Metals in roadside plant samples were within normal levels although plants from control sites were found to have slightly less metals [16]. Different parts of a plant (roots, stem & leaves) were found to accumulate metals in different concentrations.

The average cadmium contents in underground parts also decreased with the distance from the source of pollution. The largest concentration of this element had the plants gathered in the distance of 2 m ( $0.17 \text{ mg} \cdot \text{kg}^{-1} \text{ d.m.}$ ). Although, levels of Cd obtained in plant were lower than the EU limit and the background value given by [1], detection of the metal in plant cells for sustained monitoring. Ruminants that wander and graze along roadsides feed on these grasses while birds and domestic fowls feed on insects and earthworms [17, 18]. Transfer of metals through the food chain and accumulation are most probable the cause of health problems especially in animals that occupy the upper echelons of food chain. Thus, concerning of accumulation and toxicity ability of this metal in ruminants grazing on vegetation along these roads is very important.

The smallest quantities of cadmium had the plants gathered in the distance of 50 m ( $0.11 \text{ mg} \cdot \text{kg}^{-1} \text{ d.m.}$ ). The cadmium contents independently from the species of the studied plant did not show significant differences between measurements performed on the distance of 10 and 30 m. In the other cases the measurements showed significant differences between themselves.

It was reported that direct uptake of Cd into leaves can occur [5]. In particular, in the case of a high intrinsic level of Cd (usually resulting from root uptake), foliar Cd uptake increases due to increased permeability of the leaf cuticle [19]. Although Cd concentrations are usually low in plants grown in uncontaminated sites, Cd concentrations in leaves can be as high as, for example  $45 \mu\text{g/g}$ , when plants are grown on contaminated sites.

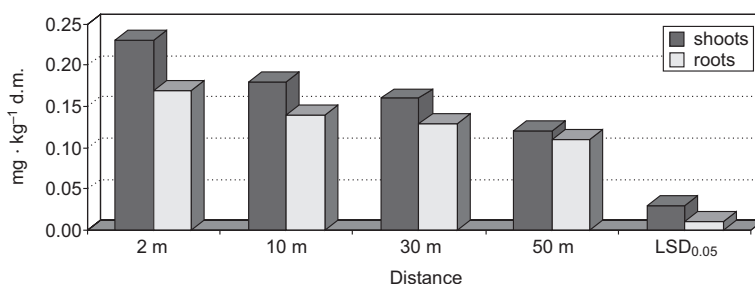


Fig. 1. The average contents of cadmium in the shoots and in underground parts of studied species of plants on the estimated distances

The accumulation of heavy metals is not only in the shoots of herbaceous plants. Their underground parts also show ability to the accumulation of heavy metals. Conducted investigations (Table 2) showed, that the largest concentration of cadmium was in underground parts of the common dandelion ( $0.19 \text{ mg} \cdot \text{kg}^{-1} \text{ d.m.}$ ) growing in the

distance of 2 m from the wayside ditch, but the least cadmium in this distance was taken by garden sorrel ( $0.13 \text{ mg} \cdot \text{kg}^{-1} \text{ d.m.}$ ).

Table 2

The cadmium content in underground parts of plants [ $\text{mg} \cdot \text{kg}^{-1} \text{ d.m.}$ ]

Plants	Distance from the road [m]			
	2	10	30	50
Common dandelion	0.19 Aa	0.16 Ab	0.16 Ab	0.15 Ab
Greater plantain	0.18 Ba	0.17 Bb	0.15 Bc	0.12 Bd
Garden sorrel	0.13 Ca	0.09 Cb	0.08 Cb	0.07 Cb

Means in lines appointed various letters differ significantly; means in columns appointed various letters differ significantly.

As was reported [15], average metal concentrations in scabwort leaves were clearly below the range of metal concentrations in plant leaves that are considered phytotoxic. However, concentrations of Pb, Cd, and Zn in roadside samples of scabwort leaves were higher than those reported in leaves of the same plant from the control site [20]. The ability of different plant species to accumulate metals and reflect environmental contamination has been investigated by a number of researchers [6, 15, 20, 21].

The cadmium content decreased with the distance from the source of pollution in underground parts (Table 2) of greater plantain and garden sorrel. In the case of common dandelion at the distance of 10 and 30 m the same quantities of cadmium were affirmed ( $0.16 \text{ mg} \cdot \text{kg}^{-1} \text{ d.m.}$ ).

The largest decrease the cadmium content with the distance from highway was in the plants of garden sorrel. The content of this metal in this plant at the distance of 50 m decreased about 46 % in the relation to the measurement performed at the distance of 2 m. The smallest decrease coming to about 21 % was observed in underground parts of the common dandelion.

The results of the conducted statistical analysis show significant differences in the content of cadmium in underground parts in the studied herbs. Significant differences cadmium content were also between all points of greater plantain. In the case of two other plants there were no significant differences in the content of this element between measurements performed at the distance of 10 m, 30 m and 50 m.

Taking into account studied plants it was showed, that the common dandelion had the most cadmium content in shoots independently to distance from the road ( $0.24 \text{ mg} \cdot \text{kg}^{-1} \text{ d.m.}$ ), and the least one greater plantain ( $0.12 \text{ mg} \cdot \text{kg}^{-1} \text{ d.m.}$ ) (Fig. 2). The similar tendency was also in underground parts of herbs, where the largest concentration of this element had the common dandelion ( $0.165 \text{ mg} \cdot \text{kg}^{-1} \text{ d.m.}$ ), and the smallest one, garden sorrel ( $0.09 \text{ mg} \cdot \text{kg}^{-1} \text{ d.m.}$ ).

Plants used in therapeutics should be picked in areas free of any contamination sources [22]. However, as can be seen from the literature [23, 24] medical raw plant materials differ significantly with respect to the content of metals.

The concentration of heavy metals is one of the criteria according to which raw plants can be used for the production of medicines. Due to the importance of the

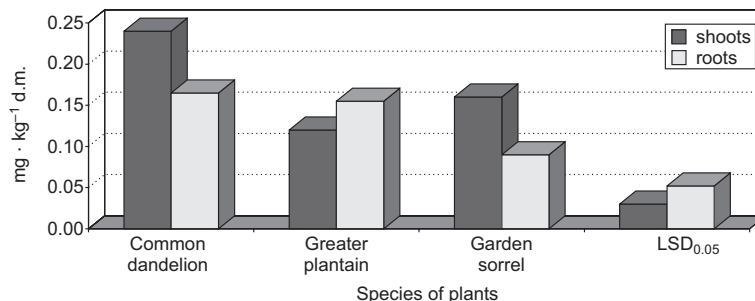


Fig. 2. The average content of cadmium in shoots and underground parts of studied species of plants

mineral and trace elements present in medicinal herbs, several studies have been carried out to determine their levels [16, 18, 23, 25–27].

Elevated Cd concentrations [22] were determined in birch which is one of the most popular herbs in Poland and common dandelion (concentrations higher than the WHO permissible level of  $0.3 \text{ mg} \cdot \text{kg}^{-1} \text{ d.m.}$ ).

Independently from the place of the gathering of the plant material (Fig. 2), the average content of cadmium in underground parts of the garden sorrel ( $0.09 \text{ mg} \cdot \text{kg}^{-1} \text{ d.m.}$ ) differed significantly from the content of this metal in common dandelion ( $0.165 \text{ mg} \cdot \text{kg}^{-1} \text{ d.m.}$ ) and greater plantain ( $0.155 \text{ mg} \cdot \text{kg}^{-1} \text{ d.m.}$ ).

Significant differences were not confirmed between common dandelion, and greater plantain independently from the distance of the gathering of the investigative material.

Medicinal plants are used for tea preparation, only the extractable component of heavy metals is available to humans [22]. Due to low extraction efficiency from raw materials to water, only a small fraction of the total content of Ba, Cd, Cr, Ni, Pb and Zn in the raw material can be found in infusions prepared from common dandelion, birch and hawthorn in comparison with levels of these metals in raw materials themselves.

## Conclusions

From among of studied herbs, the best coefficient of pollution with cadmium had common dandelion, which had the largest quantity of this metal at the distance of 2 m from highway in shoots ( $0.32 \text{ mg} \cdot \text{kg}^{-1} \text{ d.m.}$ ) as well as in underground parts ( $0.19 \text{ mg} \cdot \text{kg}^{-1} \text{ d.m.}$ ).

The concentration of the cadmium content in shoots and in underground parts systematically decreased in the measure of dismissing from the source of pollution in all studied plants.

Independently from the place of the gathering of the plant material, the most cadmium accumulates had the common dandelion in the shoots ( $0.24 \text{ mg} \cdot \text{kg}^{-1} \text{ d.m.}$ ), however the smallest concentration of cadmium in studied herbs was in the underground parts of garden sorrel ( $0.09 \text{ mg} \cdot \text{kg}^{-1} \text{ d.m.}$ ) independently from the place of gathering.

The admissible contents of cadmium for consumptive aims ( $0.15 \text{ mg} \cdot \text{kg}^{-1} \text{ d.m.}$ ) were exceeded in the shoots and in underground parts especially in common dandelion at all distances from the source of pollution.

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### WYSTĘPOWANIE KADMU W ZIOŁACH ROSNĄCYCH NA UŻYTKACH ZIELONYCH ZLOKALIZOWANYCH W POBLIŻU DROGI SZYBKIEGO RUCHU

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**Abstrakt:** Celem pracy jest określenie stopnia zanieczyszczenia kadmem wybranych gatunków roślin dwuliściennych, do których należą m.in. zioła zbierane z trwałych użytków zielonych znajdujących się przy trasie szybkiego ruchu. Wybrane zioła zbierano z użytków zielonych przy międzynarodowej trasie E-30 w pobliżu Siedlec. Zbierano takie zioła, jak: mniszek pospolity (*Taraxacum officinale* L.), babkę zwyczajną (*Plantago major* L.) i szczaw zwyczajny (*Rumex acetosa* L.). Materiał roślinny pobrano z odległości 2; 10; 30 i 50 m od przydrożnego rowu. Następnie oddzielono części nadziemne roślin (łodygi i liście) od części podziemnych (korzeni i kłączy), po czym wysuszono je i zmielono. Rozdrobniony materiał w 5 g próbkach poddano mineralizacji w temp. 450 °C. Tak przygotowane próbki przeprowadzono w roztwór z 10 cm<sup>3</sup> 10 % HCl i uzupełniono wodą destylowaną do objętości 50 cm<sup>3</sup>. W otrzymanych roztworach oznaczono zawartość kadmu za pomocą metody AAS.

Stężenie zawartości kadmu zarówno w częściach nadziemnych, jak i podziemnych systematycznie zmniejszało się w miarę oddalania od źródła zanieczyszczenia we wszystkich badanych roślinach. Niezależnie od miejsca poboru materiału roślinnego najwięcej kadmu kumuluje mniszek pospolity w częściach nadziemnych (0,24 mg · kg<sup>-1</sup> s.m.), natomiast najmniejsze stężenie kadmu w badanych ziołach niezależnie od miejsca pobierania było w częściach podziemnych szczawiu zwyczajnego (0,09 mg · kg<sup>-1</sup> s.m.).

**Słowa kluczowe:** kadm, trasa szybkiego ruchu, mniszek pospolity, szczaw zwyczajny, babka lancetowata