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CADMIUM CONTENTS IN THE SOILS AND PLANTS CULTIVATED IN THE ECOLOGICALLY HAZARDOUS REGIONS

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A b s t r a c t. The studies comprised 20 points localised in four communities of the Silesian province. The aim of the investigations was to assess cadmium contents in soils, grain and straw of spring barley cultivated in the ecologically hazardous region and to describe relations between this metal contents in the soils and indicative parts of barley.

It was found out that 27 of the examined soils were characterised by an increased cadmium contents, 69 of the soils were slightly contaminated and 8 of them showed medium contamination. In 42 grain samples of barley the permissible dose was exceed in the plants appropriated for consumption. A significant relationship was found between cadmium contents in the soils and their granulometric composition. Significant relationships were also registered between cadmium concentration in the soil and its contents in barley. Cadmium contents in grain was significantly correlated with organic carbon and clay fraction. However for straw, significant relations were found between cadmium contents and granulometric composition, reaction and organic matter contents.

K e y w o r d s: barley, grain, straw, soil, cadmium.

INTRODUCTION

Parent rocks are natural sources of heavy metals in soils. These are the rocks from which the soil were derived [1,2]. The amount of heavy metals coming from that source is generally diversified. However, it does not threaten soil fertility and so does not create any worse conditions for plant growth and quality. On the other hand when a soil is enriched with heavy metals that come from industrial and economic human activities in the amounts exceeding their natural contents by far, it may become harmful to soil biological properties and toxic to plants. This in turn pollutes the food chain and ground waters [5,8].

Cadmium is especially interesting for the researchers studying environmental protection as it is exceptionally toxic [5,8,11]. Cadmium pollution of soils is a very undesirable occurrence, both from the biological and ecological points of view. A major amount of cadmium with anthropogenic genesis is accumulated in the soil surface layer [1,11]. Cadmium forms relatively well soluble combinations when compared to the other heavy metals. That why it is easily absorbed from the soil by plants, both by root systems and overground parts. It was characterised as a highly efficient coefficient in the soil - plant transfer [4]. Cadmium absorption by plants is determined by the soil physico-chemical properties, mainly its reaction and organic matter content [2,6,9]. Cadmium accumulation in plants does not always increased proportionally to its contents in the soil. It often depends on the species properties of a given plant [7,8,11].

The aim of the present studies was to assess cadmium content in soils, grain and straw of spring barley cultivated in an ecologically hazardous region and to describe relations between its contents in the soils and indicative parts of barley.

MATERIALS AND METHODS

Soil and spring barley samples from 104 points spread out in the north-east part of the Silesian province were collected for the present studies. After air drying, soil samples were ground in a porcelain mortar and screened with a 1-mm mesh plastic sieve. Granulometric composition was determined using an areometric method after Bouyoucos-Cassagrande with Prószyński's modification, soil reaction (pH) with a potentiometric method, hydrolytic acidity and sorption complex capacity according to Kappen's method and organic matter contents after Tiurin's method. Cadmium contents both in the soil and plant material (after previous dry mineralization) were determine with a Philips PU 9100X atomic absorption spectrophotometer [15].

RESULTS AND DISCUSSION

Basing on the grain size analysis, it was found that 20 from 104 studied soils were classified as very light and 84 as light. Reaction of those soils ranged from 4.25 to 6.85 (Table 1). Their acidity level required liming in about 2% of the studied soils, for 20% it is necessary, for 51% it is desirable and for 27% ought to be limited. Organic C contents ranged from 0.1 to 2.26% and an average value was 1.40% (Table 1). Cadmium contents in the studied soils was diversified and fluctuated

Table 1. Physico-chemical properties of investigated soils and content of Cd in soils and barley

Statistical characterization	Particles ϕ<0.02 mm (%)	pH_{KCl}	Org. C (%)	Hh cmol H^+ kg^{-1}	T CEC cmol(+) kg^{-1}	Cd mg kg^{-1} d.m.		
						Soil	Grain	Straw
Mean	12.92	6.07	1.4	1.31	14.73	1.38	0.17	0.62
Minimum	5	4.25	0.1	0.48	5.87	0.72	0.01	0.22
Maximum	19	6.85	2.3	2.85	33.19	2.38	0.76	2.29
V(%)*	24	10	31	52	45	27.59	96.35	69.23

*V - coefficient of variation (%); Hh - hydrolytic acidity; T - sorption complex capacity.

in the range 0.72-2.38 mg Cd kg^{-1} d.m.; at average 1.38 mg Cd kg^{-1} d.m. and coefficient of variation was 27.6% (Table 1). According to Terelak *et al.* [16], cadmium contents in the soils of Poland ranged from 0.01 to 24.75 Cd kg^{-1} d.m., with the average level of 0.22 Cd kg^{-1} d.m. However, cadmium concentration in the soils of Silesia, the average level was 1.14 mg Cd kg^{-1} d.m. Our results showed that the contents of studied element in the examined soils was six times higher than the country average (0.22 mg Cd kg^{-1} d.m.). Undoubtedly, it resulted from metalliferous dust pollution from steel industry. According to Terelak *et al.* [16], cadmium concentration in the most polluted soils of Silesia amounts to 6.71 mg Cd kg^{-1} d.m. Very high cadmium concentrations of 24.75 Cd kg^{-1} d.m. are not characteristic of large areas and they have very local character. However, in these soils such a high cadmium concentration was not observed and the maximum was about 2.28 mg Cd kg^{-1} d.m.

Cadmium pollution of soils classified according to suggestions of the Institute of Soil Science and Plant Cultivation [12] revealed its increased contents in the 27 of the examined soils (I^{st} degree), slight contamination in 69 soils (II^{nd} degree) and medium contamination in 8 soils (3^{rd} degree). The studies [14] pointed out that those areas ought to be re-cultivated and taken under control to monitor chemical composition of agricultural crops, to exclude highly polluted areas form agricultural production.

Common knowledge is that the above-ground parts contain more heavy metals, such as cadmium, since they come not only from the soil but also from air pollution [7,11]. Low amounts of these elements were found in corn grain and fruit but the highest amounts were observed in roots [9-11].

Cadmium concentration in spring barley was, on the average 0.17 mg in grain. It ranged from 0.01 to 0.76 mg Cd kg^{-1} d.m. Its content is straw was 0.62 with a range from 0.22 to 2.29 mg Cd kg^{-1} d.m. Cadmium contents in grain was very

diversified which was clearly visible in the coefficient of variation V = 96.35%. Slightly lower diversification was observed in straw V = 69.23% (Table 1). The results showed that the straw of spring barley contained considerably more cadmium than grain. The range of variation was wider in straw than in grain (Table 2) According to Dudka [3], cadmium concentration in Polish cereals is lower than in the examined spring barley. In the case of straw, it ranged from 0.05 to 1.50 mg Cd, with an average of 0.22 mg Cd kg^{-1} d.m. In the case of grain, it ranged from 0.03 to 1.30 mg Cd, with 0.11 mg Cd kg^{-1} d.m on the average.

Table 2. Simple correlation coefficient (r) between the Cd content in plants and soils and some of its properties

Cd in	% fraction (mm)				pH_{KCl}	C-organic	Cd		
	1.0-0.1	0.1-0.02	<0.02	<0.002			Soil	Grain	Straw
Soil	0.318 ***	-0.311 **	-0.142	0250 **	-0.056	0.186	X	-0.253 **	0.603 ***
Grain	0.167	0.083	-0.276 **	-0.248 *	0.119	-0.428 ***	X	X	0.028
Straw	0.542 ***	-0.493 ***	-0.314 **	0.173	-0.341 ***	-0.230 *	X	X	X

r - significant at: *P=0.05; **P=0.01; ***P=0.001.

The examined samples of barley were estimated in relation with their value for consumption, fodder and industrial processing. Their classification was carried out according to the critical contents of trace metals for plants suggested by Kabata-Pendias *et al.* [12]. The critical cadmium content assumed to evaluate plants from the point of view of their suitability for consumption was 0.15 mg Cd kg^{-1} d.m., for fodder it was <0.5 mg Cd kg^{-1} d.m. and for industrial processing >0.5 mg Cd kg^{-1} d.m. Barley evaluated according to this criterion revealed 60% of grain samples suitable for consumption, 37% for fodder and only 3% threshold values concerning industrial usefulness were exceeded.

A significant relationship between the selected properties and cadmium contents in the soil and plant was detected by calculating coefficients of simple correlation. The values shown in Table 2 showed a significant relation between cadmium contents in the soil and soil granulometric composition, i.e. sand fraction (r=0.318), silt (r=-0.311) and colloidal clay (r=0.2510). Significant relations were registered also between Cd concentration in the soil and its contents in barley (for grain r = -0.253 and for straw 0.603). Cadmium contents in grain was strongly influenced by organic carbon r= -0.438, clay fractions r= -0.276. For straw, the most

significant relations were found between cadmium contents and granulometric composition (sand, silt and clay fractions) and soil reaction.

CONCLUSIONS

1. Cadmium contents in the studied soils ranged from 0.72-2.38 mg Cd, with an average of 1.38 mg Cd kg^{-1} d.m. Estimation of cadmium pollution in soils according to a classification suggested by the Institute of Soil Science and Plant Cultivation revealed its increased contents in 27 of the examined soils, a slight contamination of 69 soils and medium contamination in 8 soils.

2. Cadmium concentration in the grain of spring barley was on the average 0.17 (0.01-0.76 mg Cd kg^{-1} d.m.) and it was higher in straw 0.62 (0.22-2.29 mg Cd kg^{-1} d.m.). Barley evaluated according to the consumption criterion gave 60% of grain samples suitable for consumption, 37% for fodder and only 3% of the threshold values for industrial usefulness were exceeded.

3. An accurate relationship between cadmium contents in the soil and soil granulometric composition of the investigated soils was examined together with cadmium content in grain and straw. Among the studied soil properties, organic carbon and clay influenced cadmium contents most in grain, whereas granulometric composition and soil reaction in the case of straw.

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