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Evaluation of the total concentration of iron, manganese, cadmium and nickel and their DTPA extractable forms in the common dandelion rhizospheric and non-rhizospheric soil of the lower Vistula river floodplain grasslands[1]

Ocena całkowitej zawartości żelaza, manganu, kadmu i niklu oraz ich form ekstrahowanych DTPA w glebie ryzosferowej mniszka lekarskiego oraz glebie pozaryzosferowej użytków zielonych z terenów zalewowych Doliny Dolnej Wisły

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Słowa kluczowe: gleba ryzosferowa, dolina zalewowa, mniszek lekarski, metale ciężkie

Abstract

Rhizospheric and non-rhizospheric soils were collected from six topsoils of grasslands in the Lower Vistula River Valley. The research covered the areas of the floodplains between the stream channel of the Vistula River and the flood embankment within the mesoregions of the Fordon Valley and the Grudziądz Basin. The research area, found in the Chełmiński and Nadwiślański Complex of Landscape Parks, is exposed to annual floods. The fluvial sediments are deposited during short-term and, most frequently spring, high discharges of the Vistula River. The amount of the material deposited in the floodplain valleys depends on the range of the flood and landscape-specific local conditions. In the rhizospheric soil of the common dandelion, a higher content of the clay fraction and organic matter was found, as compared with the non-rhizospheric soil material. The total content of Fe, Mn, Cd and Ni and their forms extractable with the DTPA solution differed between the rhizospheric and non-rhizospheric soil. A lower total concentration of the metals was noted in the rhizospheric soil at all the sampling sites. The concentrations of Fe_{DTPA} and Mn_{DTPA} forms in Fluvisols were much higher than the concentration defined as the deficit one. A relatively high content of organic matter and the clay fraction in rhizospheric soil makes the metals bound by the sorption complex, thus limiting their bioavailability. Under Regulation of Minister of the Environment of 9 September 2002, concerning soil quality standards for protected areas compliant with nature protection laws, the total concentration of Cd and Ni in non-rhizospheric soil was slightly higher than the admissible value (1.0 and 35.0 mg•kg^{-1}, respectively). Since no unfavourable effect of trace elements on the environment was demonstrated and as the floodplain areas are under agricultural use, to evaluate the pollution, the standards applicable for agricultural land were assumed. According to those criteria, the soils are not classified as polluted with cadmium and nickel.

Streszczenie

Próbki gleby ryzosferowej oraz pozaryzosferowej pobrano z 6 powierzchni użytków zielonych w obrębie Doliny Dolnej Wisły. Badaniom poddano tereny dolin zalewowych pomiędzy korytem Wisły a wałem przeciwpowodziowym w obrębie mezoregionów Doliny Fordońskiej i Kotliny Grudziądzkiej. Teren badań, znajdujący się w obrębie Chełmińskiego i Nadwiślańskiego Zespołu Parków Krajobrazowych, podlega corocznym zdarzeniom powodziowym. Osady fluwialane są deponowane w trakcie krótkotrwałych i najczęściej wiosennych wezbrań Wisły. Ilość deponowanego materiału w dolinach zalewowych zależy od zasięgu powodzi oraz lokalnych uwarunkowań związanych z rzeźbą terenu. W glebie ryzosferowej mniszka lekarskiego stwierdzono wyższą zawartość frakcji iłowej oraz materii organicznej w porównaniu do materiału glebowego strefy pozaryzosferowej. Całkowita zawartość Fe, Mn, Cd i Ni oraz ich form ekstrahowanych roztworem DTPA wykazywały zróżnicowanie w glebie ryzosferowej oraz pozaryzosferowej. Niższą całkowitą zawartość badanych metali stwierdzono w glebie ryzosferowej we wszystkich miejscach poboru próbek. Zawartość form Fe_{DTPA} i Mn_{DTPA} w badanych glebach była znacząco wyższa od zawartości, poniżej której rośliny odczuwają niedobór tych metali. Relatywnie wysoka zawartość materii organicznej oraz frakcji iłowej w glebie ryzosferowej powoduje, że metale zostają związane przez kompleks sorpcyjny, przez co ograniczona zostaje ich biodostępność. Zgodnie z Rozporządzeniem Ministra Środowiska z dnia 9 września 2002 r. określającym standardy jakości gleby dla obszarów poddanych ochronie na podstawie przepisów o ochronie przyrody – całkowita zawartość Cd i Ni w glebie pozaryzosferowej nieznacznie wyższa była od dopuszczalnej (odpowiednio 1.0, i 35.0 mg•kg^{-1}). Z uwagi, że nie wykazano niekorzystnego oddziaływania pierwiastków śladowych na środowisko oraz że tereny dolin zalewowych są użytkowane rolniczo – do oceny zanieczyszczenia przyjęto standardy dla użytków rolnych. Według tych kryteriów badane gleby nie kwalifikują się do zanieczyszczonych kadmem i niklem.

1 . INTRODUCTION

An excessive concentration of heavy metals, both indispensable for plants and those without any metabolic functions, has an unfavourable effect on plants growth and yielding due to the metals capacity for bioaccumulation [Kabata-Pendias, Pendias 1999]. In rhizospheric soil, contaminants show specific behaviour as a result of trace elements distribution, mobilisation and bioavailability [Lu et al. 2005]. The mobility of metals in soil is mostly affected by the content of organic matter, texture, mineral composition, sorption capacity, pH and oxydoreduction potential [Harmsen 2007, Van Gestel 2008].

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Processes associated with root growth, the production of mucilaginous substances and the uptake of elements create a specific physicochemical environment in the rhizospheric soil where roots interact with organic matter and with microbial components as well as with clay minerals, unlike in the non-rhizospheric soil [Curl, Truelove 1986, Lombi et al. 2001]. The bioavailability of metals gets considerably limited with an increase in the content of clay fraction, humus substances in soil as well as the soil environment alkalisation [Dube et al. 2001, Van Gestel 2008]. The formation of metaloorganic bonds limits a free transfer of the heavy metals to the plant roots, decreasing the content in the food chain [Kwiatkowska-Malina, Maciejewska 2011]. Humus substances show a few-fold higher sorption capacity, as compared with clay minerals and they constitute the most essential component of the soil sorption complex. The stability of metaloorganic bonds and the degree of their solubility depend mostly on the reaction and oxydo-reduction potential [Semple et al. 2004]. The mobility and the availability of trace elements to plants are also defined by the form of their occurrence as well as by the microbial activity in rhizosphere [Singh et al. 2003, Bielińska 2009]. Soil microbes have a variety of properties that can effect changes in metal mobility and toxicity, as well as mineral dissolution. Such mechanisms are important components of biogeochemical cycles for metals as well as associated elements in biomass, sediments, soil and minerals [Gadd 2010].

While Fe, Mn and Ni have essential metabolic functions in plant, animal and human nutrition, the biological functions of Cd are not known; however, all metals can exert toxicity when present above a certain threshold concentration [Adriano et al. 2004]. Cadmium demonstrates one of the highest values of bioaccumulation in soil and plants [Kabata-Pendias 2000].

In the Fluvisols of the flood areas, the content of trace elements is usually increased, when compared with the geochemical background [Czarnowska, Bontruk 1995, Czarnowska et al. 1995, Czarnowska, Turemka 1997, Kobierski et al. 2008, Kobierski, Piotrowska 2010]. The sediments deposited during the annual floods can contain more mobile forms of metals, posing a real threat to plants and animals [Namieśnik, Rabajczyk 2011]. Common dandelion shows a high capacity for the accumulation of trace elements, so it is used as a soil environment pollution bioindicator [Kabata, Dudka 1991, Gworek et al. 2011, Ligocki et al. 2011].

The aim of this paper was to evaluate the content of iron, manganese, cadmium and nickel in the soil of permanent grasslands located in the floodplains of the Vistula River. The total content of metals and their DTPA extractable forms in the rhizospheric soil of common dandelion and in the non-rhizospheric soil were compared.

2. MATERIAL AND METHODS

The common dandelion (*Taraxacum officinale*) rhizospheric and non-rhizospheric samples of soil were collected from grasslands between the Vistula River stream channel and the flood embankment within the mesoregions of the Fordon Valley and the Grudziądz Basin.

Sampling sites: F1 – 53° 07' 55.6" N, 18° 09' 27.1" E; F2 – 53° 08' 08.6" N, 18° 10' 48.9" E; F3 – 53° 08' 6.2" N, 18° 09' 38.2" E; F4 – 53° 20' 27.3" N, 18° 22' 10.3" E; F5 – 53° 20' 48.4" N, 18° 22' 39.4" E; F6 – 53° 22' 08.9" N; 18° 26' 11.2" E.

The rhizospheric soil (<4 mm) adjacent to the common dandelion roots was carefully separated from the roots and then minor root fragments were removed. The non-rhizospheric soil was sampled 1 m away from the place of common dandelion occurrence (0–20 cm deep). Each sample was taken in three replicates and all the results were exposed to the statistical analysis. After drying, the soil samples were sieved through the sieve with the mesh 2.0 mm in diameter. In the soil material, the following were assayed: the grain size composition following the areometric method (without organic matter removal); the content of organic carbon with the TOCN Primacs apparatus provided by Skalar; the reaction – with the potentiometric method in distilled H_2O (pH_w) and the 1 M KCl solution (pH_{KCl}); the hydrolytic acidity according to the Kappen method; electrolytic conductivity (EC; at the ratio of 1:5 soil/distilled H_2O); the content of exchangeable cations following the barium chloride method [PN-EN ISO 11260, 2011]; the total content of metals after digestion in the mixture of HF and $HClO_4$ [Crock, Severson 1980]; the content of the forms of metals extracted with the DTPA solution [Lindsay, Norvell 1978]. The content of exchangeable cations of Ca, Mg, K, Na and the concentration of Fe, Mn, Ni and Cd in extracts were determined using the Philips PU 9100X atomic absorption spectrometer.

The tables provide mean values from three replicates. The standard deviation (SD) for the total content of Fe, Mn, Ni, Cd as well as their forms extractable with DTPA ranged from 0.01 to 6.4. The values of the coefficient of variation for respective metals did not exceed 12.5%.

3. RESULTS AND DISCUSSION

The rhizospheric soil demonstrated a higher content of the clay fraction and a lower content of the silt fraction than the non-rhizospheric soil (Table 1). The clay fraction content ranged from 14% to 25% in rhizospheric soil as well as from 11% to 20% in the non-rhizospheric soil. In the rhizospheric soil, the content of the organic carbon fell within 23.6 to 36.3 $g \cdot kg^{-1}$ and it was higher than the content in the non-rhizospheric soil, ranging from 21.3 to 29.8 $g \cdot kg^{-1}$ (Table 2). The pH_w and pH_{KCl} varied both in rhizospheric and non-rhizospheric soil. Most samples showed neutral reaction, except for samples F2r and F2n the reactions of which being slightly acid. The EC value in the rhizospheric soil ranged from 0.51 to 0.76 $mS \cdot cm^{-1}$, whereas in the non-rhizospheric soil it was slightly lower and fell within 0.23 to 0.52 $mS \cdot cm^{-1}$. All the soils demonstrated a relatively high cation exchange capacity (CEC) from 19.3 to 33.8 $cmol(+) \cdot kg^{-1}$ in the rhizospheric soil as well as from 16.9 to 31.6 $cmol(+) \cdot kg^{-1}$ in the non-rhizospheric soil. The base saturation was very high and ranged from 94.3% to 99.0% in the rhizospheric soil as well as from 90.6% to 98.5% in the non-rhizospheric soil (Table 3).

Table 1. Grain size composition

No.	Percentage of fraction in diameter		
	2.0–0.05 mm	0.05–0.002 mm	<0.002 mm
Rhizospheric soil			
F1r	59	22	19
F2r	72	14	14
F3r	67	18	15
F4r	37	38	25
F5r	39	40	21
F6r	54	27	19
Non-rhizospheric soil			
F1n	45	41	14
F2n	72	16	12
F3n	58	31	11
F4n	38	42	20
F5n	39	46	15
F6n	43	40	17

Table 2. Selected properties of soils

No.	C_{org} ($g \cdot kg^{-1}$)	pH		EC ($mS \cdot cm^{-1}$)
		H_2O	1 M KCl	
Rhizospheric soil				
F1r	36.3	6.70	6.64	0.68
F2r	26.8	6.65	6.42	0.56
F3r	26.2	6.80	6.60	0.76
F4r	23.6	7.31	7.17	0.62
F5r	32.7	7.02	6.56	0.51
F6r	28.2	7.04	6.92	0.55
Non-rhizospheric soil				
F1n	29.8	6.90	6.72	0.52
F2n	22.0	6.49	5.71	0.30
F3n	24.4	6.71	6.27	0.27
F4n	21.3	7.12	7.06	0.38
F5n	28.4	6.94	6.68	0.23
F6n	26.1	7.05	6.74	0.25

EC, electrolytic conductivity.

Table 3. Sorption properties of soils

No.	Hh	(S)	CEC	(V)
	cmol(+)$\cdot kg^{-1}$			%
Rhizospheric soil				
F1r	0.8	33.0	33.8	97.7
F2r	1.1	18.2	19.3	94.3
F3r	0.7	23.9	24.6	97.2
F4r	0.3	29.6	29.9	99.0
F5r	1.0	28.1	29.1	96.6
F6r	0.4	29.2	29.6	98.7
Non-rhizospheric soil				
F1n	1.0	30.6	31.6	96.9
F2n	1.6	15.3	16.9	90.6
F3n	1.6	19.1	20.7	92.3
F4n	0.4	26.3	26.7	98.5
F5n	1.0	25.8	26.8	96.3
F6n	1.0	26.8	27.8	96.4

Hh, hydrolytic acidity; (S), sum of base cations; CEC, cation exchange capacity; (V), base saturation.

The total iron content ranged from 13.9 to 29.2 $g \cdot kg^{-1}$ in rhizospheric soil and from 21.6 to 35.9 $g \cdot kg^{-1}$ in non-rhizospheric soil (Tables 4 and 5). The amount of iron extracted with the DTPA solution in the rhizospheric soil fell within the range from 123 to 259 $mg \cdot kg^{-1}$, whereas the content of Fe_{DTPA} in the non-rhizospheric soil was slightly lower and it ranged from 101 to 223 $mg \cdot kg^{-1}$. Dąbkowska-Naskręt et al. [2000] report on the content of Fe_{DTPA} in the Fluvisols of the Lower Vistula Valley from 17.3 to 173.7 $mg \cdot kg^{-1}$. At all the non-rhizospheric soil sampling sites, the total manganese content was clearly higher than the one noted in the common dandelion rhizosphere; in the non-rhizospheric soil it was from 0.70 to 1.24 $g \cdot kg^{-1}$ and from 0.47 to 0.88 $g \cdot kg^{-1}$ in the rhizospheric soil. The content of phytoavailable forms of manganese in the rhizospheric soil ranged from 25.3 to 50.4 $mg \cdot kg^{-1}$ and it was slightly higher than the content of Mn_{DTPA} in the non-rhizospheric soil. In the soils of the floodplain of the Unisław Basin located a few kilometres down the Vistula River, a similar total content of iron and manganese was recorded [Kobierski, Piotrowska 2010]. The acid reaction of the soil is favourable to the plants for the uptake of greater amounts of manganese [Sapek 2009]. The manganese mobility in soil is also affected by the oxydoreduction conditions and the content of organic matter. The concentration of bioavailable Fe and Mn forms in the Fluvisols was considerably higher than the content referred to as the deficit one for plants, namely 4.5 $mg \cdot kg^{-1}$ for iron and 1.0 $mg \cdot kg^{-1}$ for manganese [Lindsay, Norvell 1978].

The common dandelion rhizospheric soil contained a slightly lower total content of nickel than the non-rhizospheric soil with 23.9 to 44.3 $mg \cdot kg^{-1}$ (Tables 6 and 7). The content of cadmium extracted with the DTPA solution in the total content of that metal was high both in the rhizospheric and non-rhizospheric soil. Cadmium extracted with the DTPA solution accounted for 25.0% to 81.8% of the total content of cadmium in the rhizospheric soil as well as 18.2% to 58.8% in the non-rhizospheric soil. Much higher contents of Cd_{DTPA} were recorded in the Fluvisols of the Lubuskie Province Oder River gorge; to 2.23 $mg \cdot kg^{-1}$ [Ibragimow et al. 2010]. Czarnowska and Turemka [1997] report on the Fluvisols of the Vistula River Valley and Żuławy Region contained from 0.06 to 14.24 mg $Cd \cdot kg^{-1}$, and most of that metal was noted in the soils before the flood embankment. In the Fluvisols of the middle and lower part of the Vistula River, the total Cd content was, on average, 0.82 $mg \cdot kg^{-1}$. In the surface horizon of the soils under agricultural use in Poland, the mean content of cadmium is defined as 0.22 $mg \cdot kg^{-1}$ [Terelak et al. 1997]. An increased total content of cadmium, when compared with the geochemical background, points to a clear effect of the annual floods on the accumulation of that metal in the soils of the floodplains of the Lower Vistula River Valley. Under Regulation of Minister of the Environment of 9 September 2002 concerning soil quality standards (*Dz. U.* No 165, item 1359), the admissible content of cadmium in the soils in the protected areas under the nature protection regulations may not exceed 1.0 $mg \cdot kg^{-1}$. For that reason, non-rhizospheric soil F2n is the only one that is not polluted with cadmium. In the non-rhizospheric soil sampled from sites F1n, F4n, F5n and F6n, the total content of nickel was higher than 35 $mg \cdot kg^{-1}$, which qualifies the soils researched as polluted with that metal. The Regulation provides that in the case of protected areas the standards applicable for respective metals apply whenever their unfavourable effect on the environment is demonstrated. Assuming, at the same time, that the areas of the Vistula River floodplains are under agricultural use, the Cd and Ni concentration recorded in the soils do not classify them as polluted with those metals.

According to Kabata-Pendias and Pendias [1999], the mean nickel content in the topsoil of Fluvisols ranges from 20 to 30 $mg \cdot kg^{-1}$.

Table 4. Mean content of iron and manganese in rhizospheric soil

No.	Fe_t ($g \cdot kg^{-1}$)	SD	Mn_t ($g \cdot kg^{-1}$)	SD	Fe_{DTPA} ($mg \cdot kg^{-1}$)	SD	Mn_{DTPA} ($mg \cdot kg^{-1}$)	SD	Fe_{DTPA}/Fe_t (%)	Mn_{DTPA}/Mn_t (%)
F1r	19.7	0.1	0.59	0.02	135	3.1	29.1	0.5	0.7	4.9
F2r	14.5	0.2	0.49	0.04	123	2.9	50.4	2.9	0.8	10.3
F3r	13.9	0.4	0.47	0.02	258	4.5	25.3	0.9	1.9	5.4
F4r	28.3	0.3	0.88	0.05	142	4.0	42.9	1.2	0.5	4.9
F5r	29.2	0.2	0.83	0.03	259	0.6	37.9	0.5	0.9	4.6
F6r	22.4	0.3	0.58	0.01	188	1.5	32.0	1.5	0.8	5.5

Fe_t, total content of Fe; Mn_t, total content of Mn; SD, standard deviation (n = 3).

Table 5. Mean content of iron and manganese in non-rhizospheric soil

No.	Fe_t (g•kg^{-1})	SD	Mn_t (g•kg^{-1})	SD	Fe_{DTPA} (mg•kg^{-1})	SD	Mn_{DTPA} (mg•kg^{-1})	SD	Fe_{DTPA}/Fe_t (%)	Mn_{DTPA}/Mn_t (%)
F1n	29.3	0.5	1.08	0.04	114	3.8	23.0	1.2	0.4	2.1
F2n	23.1	0.7	0.78	0.03	209	3.8	22.2	1.0	0.9	2.8
F3n	21.6	1.3	0.70	0.04	223	5.3	29.5	1.0	1.0	4.2
F4n	35.6	1.0	1.12	0.10	101	2.1	21.5	1.0	0.3	1.9
F5n	35.9	1.2	1.24	0.04	147	3.6	13.6	0.4	0.4	1.1
F6n	30.8	1.7	0.98	0.08	163	6.4	27.8	0.8	0.5	2.8

Fe_t, total content of Fe; Mn_t, total content of Mn; SD, standard deviation (n = 3).

Table 6. Mean content of cadmium in rhizospheric soil

No.	Ni_t (g•kg^{-1})	SD	Ni_{DTPA} (g•kg^{-1})	SD	Cd_t (mg•kg^{-1})	SD	Cd_{DTPA} (mg•kg^{-1})	SD	Ni_{DTPA}/Ni_t (%)	Cd_{DTPA}/Cd_t (%)
F1r	20.6	0.5	1.3	0.11	0.4	0.05	0.3	0.03	6.3	75.0
F2r	18.1	0.5	1.2	0.15	0.5	0.03	0.2	0.01	6.6	40.0
F3r	16.3	0.8	1.4	0.06	0.7	0.03	0.3	0.02	8.6	42.9
F4r	37.7	0.5	1.2	0.11	1.0	0.06	0.3	0.02	3.2	30.0
F5r	36.3	0.9	1.8	0.15	1.2	0.11	0.3	0.03	5.0	25.0
F6r	31.4	2.1	1.9	0.13	1.1	0.09	0.9	0.04	6.1	81.8

Ni_t, total content of Ni; Cd_t, total content of Cd; SD, standard deviation (n = 3).

Table 7. Mean content of nickel and cadmium in non-rhizospheric soil

No.	Ni_t (g•kg^{-1})	SD	Ni_{DTPA} (g•kg^{-1})	SD	Cd_t (mg•kg^{-1})	SD	Cd_{DTPA} (mg•kg^{-1})	SD	Ni_{DTPA}/Ni_t (%)	Cd_{DTPA}/Cd_t (%)
F1n	35.2	0.9	1.4	0.05	1.6	0.14	0.8	0.03	4.0	50.0
F2n	25.2	1.0	1.5	0.09	0.9	0.05	0.4	0.05	6.0	44.4
F3n	23.9	0.4	1.6	0.14	1.1	0.08	0.5	0.04	6.7	45.5
F4n	42.5	1.2	1.7	0.12	1.6	0.12	0.4	0.02	4.0	25.0
F5n	44.3	0.7	2.2	0.12	2.2	0.11	0.4	0.03	5.0	18.2
F6n	38.8	1.9	2.1	0.14	1.7	0.13	1.0	0.09	5.4	58.8

Ni_t, total content of Ni; Cd_t, total content of Cd; SD, standard deviation (n = 3).

Kobierski et al. [2008] in the research of Fluvisols of the Unisław Basin recorded the concentration of Ni ranging from 12.5 to 43.9 mg•kg^{-1}. The mobility of nickel in soil is affected by the reaction, sorption capacity and the number and the quality of organic-and-mineral complexes [Smolińska, Król 2011]. A negative effect of a high content of nickel in soil on the physiological processes of plants can be decreased by soil liming [Kuziemska, Kalembasa 2010].

The Vistula River Valley Fluvisols investigated by Czarnowska et al. [1995] in the middle part of the Valley contained slightly lower mean contents of heavy metals: Mn – 400 mg•kg^{-1}, Ni – 19.2 mg•kg^{-1}, as well as Fe – 13.9 g•kg^{-1}. The mean content of Mn in the Fluvisols of Żuławy Region was, however, 615.0 mg•kg^{-1}, Ni – 35.6 mg•kg^{-1} and Fe – 26.5 g•kg^{-1} [Czarnowska, Bontruk 1995]. A varied total content of metals in Fluvisols of the floodplains of respective sections of the Vistula River is a result of a different grain size composition of Fluvisol sediments and their local deposition conditions. In the Fluvisols of the Vistula River and Żuławy Region, the mean concentration of the soluble Mn forms was 30.00 mg•kg^{-1} as well as Cd – 0.29 mg•kg^{-1} [Czarnowska, Szymańczak-Sieńczewska 1999].

A lower total content of the metals was found in the rhizospheric soil at all the soil sampling sites analysed. The rhizospheric soil of common dandelion growing on grasslands of the Vistula River floodplains demonstrated a higher content of the clay fraction as well as organic matter, when compared with non-rhizospheric soil material. A relatively high content of organic matter and clay fraction in rhizospheric soil make metals bonded to sorption complex, thus decreasing their mobility, especially if it refers to the soils exposed to strong anthropogenic impact on the environment. The rhizospheric soil contains more clay fraction since together with water it is sucked by the roots and accumulated in the root zone, which most probably refers to fine clay fraction rich in clay minerals which, in turn, can be an important adsorbent for metals in soil solution [Bhattacharyya, Gupta 2008].

The annual floods are a source of fluvial sediments to be deposited in the Lower Vistula floodplain. They contain pollutants, including metals that can be accumulated in the rhizospheric soil. The solubility of the trace elements depends on the metal loading over soil sorbents, pH and the concentration of dissolved organic matter in the soil solution. The complexation of heavy metals with dissolved organic matter influences the solubility and mobility of those metals [Weng et al. 2002].

Root exudates in the rhizospheric soil of common dandelion can trigger phytostabilisation of nickel and cadmium due to their transformation into hardly soluble compounds. As a result of the effect of the plant roots on the soil environment, bioavailable metal forms can get immobilised [Salt et al. 1995, Ruttens et al. 2006]. Root exudates can affect the Cd bioavailability and toxicity; e.g. modifying the rhizosphere pH, chelating and depositing with Cd ions as well as changing rhizospheric soil microorganisms [Dong et al. 2007].

4. CONCLUSIONS

1. Soil samples collected from dandelion rhizosphere contained higher amounts of organic matter as well as the clay fraction, when compared with the non-rhizospheric soil of grasslands in the Vistula River floodplain.
2. The total concentration of Fe, Mn, Cd and Ni as well as the concentration of Cd and Ni phytoavailable forms were lower in the rhizospheric soil, when compared with the non-rhizospheric soil.
3. The concentration of Fe and Mn forms extracted with the DTPA solution in the Fluvisols under study was considerably higher than the concentration referred to as the deficit level for plants.
4. A relatively high content of organic matter and the clay fraction in rhizospheric soil makes metals bound to the sorption complex, thus limiting their availability to plants. The rhizospheric soil forms a specific natural filter against an excessive pollution with heavy metals.

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