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SELECTED TRACE ELEMENTS IN SOIL AND PLANTS FROM MARSHY MEADOWS OF THE SAN RIVER VALLEY

WYBRANE MIKROELEMENTY W GLEBACH I ROŚLINACH ŁĄK ŁĘGOWYCH DOLINY SANU

Abstract: The research was conducted out on meadows located on floodplain terrains in the San River valley. The subject of the study was Ni, Mn and Co content in soils and plants marshy ecosystems. The total content of analyzed elements and the contents their soluble forms in 1 mol HCl · dm^{-3} were estimated in collected soils.

Alluvial soils and turf layer were characterized by natural content of these elements. Fresh alluvial were rich in $CaCO_3$ and other studied elements.

Keywords: alluvial soils, fresh alluvial, nickel, manganese, cobalt, the San River valley

Terrains of marshy meadows are extremely valuable ecosystems which depend on seasonal floods. Green grasslands localized on marshy meadows of the San River valley were subjects of presented studies. There were described selected trace elements in ecosystems of grasslands located in alluvial soils of the San River valley.

Material and methods

The researches were conducted in all the San River valley. Soil samples were picked up from grasslands at two layers – ie at 0–10 cm and 10–30 cm depth. From the places where the soil was picked up there were prior removed meadows sward and the fresh alluvial were collected after floods run away. The collected soil material was analyzed according to the commonly used methods using in agrochemical laboratories [1]. In order to analyze Ni, Mn and Co content the soil samples were mineralized in $HClO_4$, the

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determination was made by means of atomic absorption spectrophotometry. Because of low Ni and Co concentration in basic solution these two elements were condensed in organic phase. The total contents of analyzed elements and the contents of their soluble forms in 1 mol HCl · dm^{-3} were estimated in studied soils.

After drying to absolutely dry mass, the plant material was mineralized in mixture of acids – HNO_3, $HClO_4$ and H_2SO_4 in proportion 20 : 5 : 1. The content of Ni, Mn and Co was also determined in soil material.

The samples were collected at the same time when the first crop of the grass is harvested. The contents of Ni, Mn and Co in fresh alluvial, plants and soils in the San River valley was the purpose of researches. In researches it decide to demonstrate the argument that the fresh alluvial have positive influence on meadows soils.

Results

The basic characteristics of alluvial soils from the San River valley were presented in Table 1.

Table 1

The basic parameters of fresh alluvial and studied alluvial soils from the San River valley

Parameter	Arithmetic mean	Geometric mean	Median	Scope	
				Minimum	Maximum
Fresh alluvial (n = 53)					
Granulometric composition [%]					
Particles diameter:					
1.0–0.1 mm	45.40	36.08	44	2	98
0.1–0.02 mm	32.66	27.20	33	1	56
< 0.02 mm	21.94	16.51	20	1	67
< 0.002 mm	4.53	3.48	4	1	18
pH in H_2O	7.47	7.53	7.51	7.09	8.21
pH in KCl	7.17	7.25	7.24	6.66	7.99
$CaCO_3$ [g · kg^{-1} d.m.]	49.21	42.03	52.62	9.37	98.24
C_{org} [g · kg^{-1} d.m.]	18.4	14.0	19.0	0.42	79.8
Layer 0–10 cm (n = 48)					
Granulometric composition [%]					
Particles diameter:					
1.0–0.1 mm	28.9	24.2	26.0	4	80
0.1–0.02 mm	38.7	37.1	37.5	13	57
< 0.02 mm	32.4	28.4	30.5	7	73
< 0.002 mm	8.3	6.3	7.0	1	21
pH in H_2O	6.63	7.14	7.36	5.50	7.91
pH in KCl	5.22	6.21	6.55	3.88	7.07
$CaCO_3$ [g · kg^{-1} d.m.]	20.86	12.83	13.98	0.80	72.99
C_{org} [g · kg^{-1} d.m.]	19.7	17.6	19.4	1.2	54.0

Table 1 cont.

Parameter	Arithmetic mean	Geometric mean	Median	Scope	
				Minimum	Maximum
Layer 10–30 cm (n = 48)					
Granulometric composition [%]					
Particles diameter:					
1.0–0.1 mm	24.6	20.9	22.0	5	52
0.1–0.02 mm	39.8	38.8	40.5	24	58
< 0.02 mm	35.6	32.8	33.5	13	68
< 0.002 mm	10.5	9.0	8.5	2	22
pH in H_2O	6.68	7.34	7.65	5.54	8.10
pH in KCl	5.33	6.30	6.65	4.21	7.07
$CaCO_3$ [$g \cdot kg^{-1}$ d.m.]	22.14	14.29	16.92	0.80	57.71
C_{org} [$g \cdot kg^{-1}$ d.m.]	11.3	9.3	11.2	0.5	19.6

The studied soils possessed generally neutral or alkaline reaction. Fresh alluvial were rich in $CaCO_3$, geometric mean equaled 42.03 $g \cdot kg^{-1}$ of d.m.

In places where floods appeared the deposited carbonate of calcium prevented soil acidification. In situations when floodbanks cut-off the floods the soil profiles have gradually acidified themselves and there have started the process of transformation from alluvial soils into brown alluvial soils.

In Table 2 there were presented: a range, median, arithmetic and geometric mean for Ni, Mn and Co in alluvial soils, fresh alluvial and grassland vegetation.

Table 2

Content of studied elements [$mg \cdot kg^{-1}$] in alluvial soils, grassland vegetation and fresh alluvial from the San River valley

Metal content	Arithmetic mean	Geometric mean	Median	Scope	
				Minimum	Maximum
Alluvial soils, layer 0–10 cm (n = 48)					
Total Ni	31.05	29.56	30.04	11.18	54.76
Soluble Ni	7.69	6.87	7.85	1.40	15.30
Total Mn	617.0	584.0	575.0	256.0	1166.0
Soluble Mn	463.0	427.0	429.0	151.0	995.0
Total Co	8.34	7.84	7.95	3.30	17.20
Soluble Co	3.22	3.00	3.10	0.90	5.60
Alluvial soils, layer 10–30 cm (n = 48)					
Total Ni	30.77	29.66	28.92	17.78	50.40
Soluble Ni	7.56	6.54	8.05	0.30	19.40
Total Mn	611.0	580.0	564.0	261.0	1059.0
Soluble Mn	416.0	375.0	391.0	104.0	901.0
Total Co	8.54	8.10	7.92	5.00	17.81
Soluble Co	3.00	2.75	2.90	0.80	5.10

Table 2 cont.

Metal content	Arithmetic mean	Geometric mean	Median	Scope	
				Minimum	Maximum
Grassland vegetation (n = 48)					
Ni	1.31	1.17	1.20	0.39	3.71
Mn	58.31	46.82	43.50	16.80	228.80
Co	0.13	0.09	0.09	0.02	0.52
Fresh alluvial (n = 53)					
Total Ni	23.69	21.24	22.52	5.90	45.69
Soluble Ni	6.00	4.68	6.20	0.10	12.80
Total Mn	752.7	623.6	554.0	270.0	3437.0
Soluble Mn	637.2	514.6	450.0	188.0	2284.0
Total Co	6.62	6.04	5.73	1.88	12.31
Soluble Co	2.57	2.22	2.40	0.30	5.20

In Figures from 1 to 5 there were presented the studied elements in a range of: 25 % – lower quartile, 50 % median and 75 % upper quartile.

Mean content of total Ni in turf and under-turf layer of alluvial soils from the San River valley was very similar (Table 2). However there was observed a less interquartile range and variability (Fig. 1).

Content of soluble in 1 mol HCl · dm^{-3} forms of Ni did not revealed any differences between studied layers; a broader range was visible in deeper layer.

Nickel content in grassland vegetation ranged in 0.39–3.71 mg · kg^{-1} d.m. It is worth to add that lower quartile was 0.83 and upper one 1.59 mg · kg^{-1} d.m. (Fig. 1).

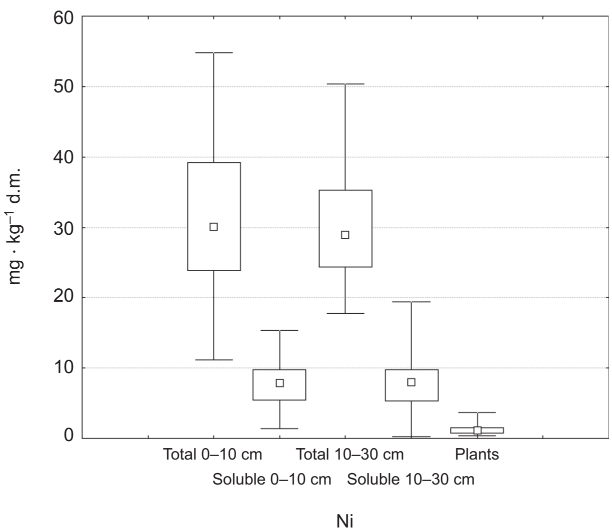

Fig. 1. Nickel content in alluvial soils in 0–10 cm and 10–30 cm layer and in plants

Manganese content was similar in both layers of studied soils ie total and soluble forms of this element (Fig. 2).

The Mn content in grassland vegetation ranged from 16.8 to 228.8 mg · kg^{-1} d.m. (Table 2), however in Fig. 2 there was presented a range between quartiles which was 29.0–71.45 mg · kg^{-1} d.m., it means that 75 % of observations were not over 72 mg · kg^{-1} d.m.

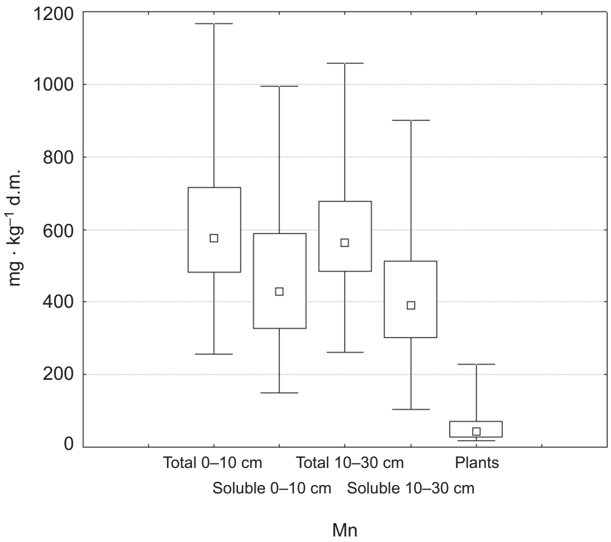

Fig. 2. Manganese content in alluvial soils in 0–10 cm and 10–30 cm layer and in plants

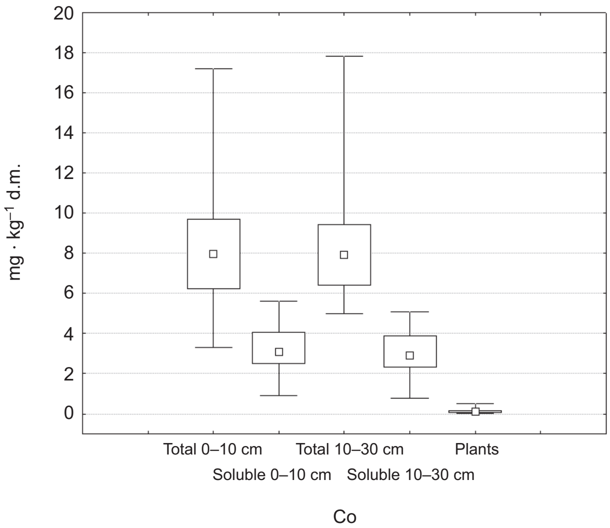

Fig. 3. Cobalt content in alluvial soils in 0–10 cm and 10–30 cm layer and in plants

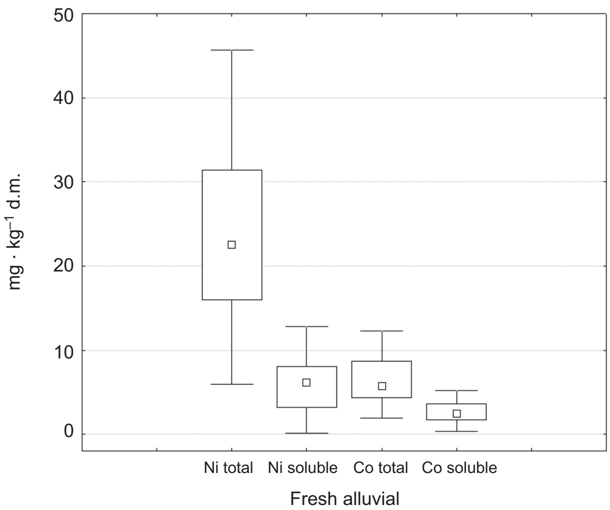

Fig. 4. Nickel and cobalt content in fresh alluvial

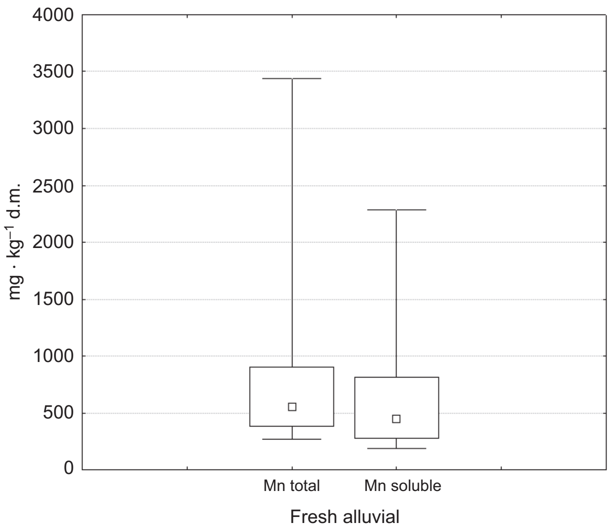

Fig. 5. Manganese content in fresh alluvial

Differences in content of total cobalt within single layers were meager. Geometric mean for turf layer was 7.84 mg · kg^{-1} d.m. and for under-turf equaled 8.1 mg · kg^{-1} d.m. (Table 2). Despite that the maximal values were about 18 mg · kg^{-1} d.m., so however upper quartiles in both layers laid under 10 mg · kg^{-1} d.m. (Fig. 3).

Geometric mean content of cobalt in grassland vegetation was 0.09 mg · kg^{-1} d.m. while upper quartile equaled 0.16 mg · kg^{-1} d.m. and was significantly lower than other maximal values (0.52 mg · kg^{-1} d.m.) (Fig. 3).

Geometric mean of total nickel content in fresh alluvial was 21.24 mg · kg^{-1} d.m. However, the content of soluble forms was significantly lower (Fig. 4). It can result from neutral reaction in studied soils.

Content of total cobalt in fresh alluvial was a little bit lower than in studied soils. Geometric mean equaled 6.04 mg · kg^{-1} d.m. of soil (Fig. 4).

Total Mn content in fresh alluvial ranged in broad scope of 270–3437 mg · kg^{-1} d.m. It should be underlined that upper quartile was 904 mg · kg^{-1} d.m. (Fig. 5). Because of very broad range within results there was calculated a quantile 97.5 which separated 2.5 % the upper values from 5 % which could lay outside a border of error. This value was 1818 mg · kg^{-1} d.m. The content which equaled three thousand was rare.

Discussion

Nickel is bound geochemically with iron and cobalt and its content in soils depends on loam minerals as well as organic matter content.

Nickel solubility increases along with acidification of soils. Mean content of this element in Polish soils is according to Kabata-Pendias and Pendias [2] 4–50 mg · kg^{-1} d.m., so the content of this element in studied soils ranged within the quoted scope.

Mean manganese content for different soils types in Poland are 100–1300 mg · kg^{-1} d.m. according to Kabata-Pendias and Pendias [2]. In conducted studies, the alluvial soils in the San River valley did not diverge from the mentioned scope.

Even determined maximum (1059 mg · kg^{-1} d.m.) was lower than upper mean values quoted by mentioned authors. Only the maximum values in fresh alluvial were higher.

As a minimal manganese content in grassland vegetation Falkowski et al [3] point out 10–20 mg · kg^{-1} d.m., while Borowiec and Urban [4] claim that optimal value is significantly higher ie 50–100 mg · kg^{-1} d.m. The variability of manganese content in studied grassland vegetation from the San River valley ranged from 16.8 to 228.8 mg · kg^{-1} d.m. and geometric mean equaled 46.82 mg · kg^{-1} d.m. The studied vegetation reached minimum values but quite often manganese content was in minus against optimal ones.

Kabata-Pendias and Pendias [2] say that in alluvial soils of Poland total cobalt content ranged from 5.5 to 19.0 mg · kg^{-1} d.m. Borowiec and Urban [4] in studied grassland soils from Lubelszczyzna, including alluvial soils, determined cobalt content in range from trace values to 3.3 mg · kg^{-1} d.m. In own research total cobalt amount was near to the values pointed out by the first authors. The scope of this content for both layers ranged from 3.3 to 17.81 mg · kg^{-1} d.m. Content of cobalt in its soluble fraction ranged from 0.8 to 5.6 mg · kg^{-1} d.m.

In good quality fodder according to Falkowski et al. [3] there should be minimum 0.08 mg Co · kg^{-1} d.m. whereas Borowiec and Urban [4] claim that the good content is when a value exceeds 0.1 mg Co · kg^{-1} d.m., and when the values reach less than 0.05 mg · kg^{-1} d.m. the content is too low. Grassland vegetation from the San River valley had usually a sufficient content of this element.

The content of the mentioned elements in fresh alluvial was similar to content in alluvial soils, so the fresh alluvial may be treated as a source of these elements however this enrichment is non-toxic.

The calcium carbonate is basic compound in carbonate buffer with especially big buffer capacity, so the mobility of some elements may be limited. The content of studied elements in plants was present in admissible amount if about animals feeding and sometimes diverged slightly in minus as in case of manganese.

Conclusions

1. Nickel, manganese and cobalt content in alluvial soils from the San River valley did not diverge from the background amount for soils in Poland.
2. Grassland vegetation from marshy meadows did not exceed admissible standards if about animals feeding and in some cases eg manganese there was possible to point out slight shortages.
3. Fresh alluvial were rich in studied elements and can be treated as a source of biogenic elements especially such as calcium.
4. The farming on terrains under floods must be fit to natural river functioning which features a seasonal floods resulting in creation on the surface a valuable fresh alluvial.

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**WYBRANE MIKROELEMENTY W GLEBACH
I ROŚLINACH ŁĄK ŁĘGOWYCH DOLINY SANU**

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Abstrakt: Badania prowadzono na terenie użytków zielonych zlokalizowanych na obszarach zalewowych doliny Sanu. Badano zawartość Ni, Mn i Co w glebach oraz roślinności ekosystemów łęgowych. W badanych glebach oznaczono całkowitą zawartość badanych pierwiastków oraz zawartość ich form rozpuszczalnych w 1 mol $HCl \cdot dm^{-3}$.

Gleby aluwialne i ruń łąkowa charakteryzowały się naturalną zawartością badanych pierwiastków. Świeże namuły były zasobne w badane pierwiastki oraz węglan wapnia.

Słowa kluczowe: gleby aluwialne, nikiel, mangan, kobalt, dolina Sanu