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CONTENT OF MACRO- AND MICROELEMENTS IN ROADSIDES' TOP LAYER OF FOREST AREAS AND CHARACTERISTICS OF PLANT SPECIES SETTLED

ZAWARTOŚĆ MAKRO- I MIKROSKŁADNIKÓW W WIERZCHNIEJ WARSTWIE POBOCZA DRÓG TERENÓW LEŚNYCH ORAZ CHARAKTERYSTYKA GATUNKÓW ROŚLIN JE ZASIEDLAJĄCYCH

Abstract: The paper presents research results concerning the content of micro- and macroelements in soils of roadsides along forest areas, salinity indicators and spatial distribution of roadside flora on the basis of trophic index. Study area with the total shoulder width of 8 m, along hardened surface in Szczecin Lowlands. The research has indicated that the content of macro- and microelements: P, K, Mg, Ca and Na was decreasing as the distance from the roadway was growing. Indeed, most of macroelements were found in the edge zone (edge of shoulder), with a width of 20–30 cm, adjacent directly to the edge of roadway. In all researched areas soil richness for phosphorus was low, for magnesium low (A and B zone) and very low (C and D zone), high in potassium in the edge area and medium in the proper shoulder. Content of soluble microelements in 0.5 mol · dm⁻³ HCl was the greatest in the edge area and was decreasing if further from the edge of the roadway. Rating abundance of species observed on the edge of the shoulder (A), on the proper shoulder (B), in roadside ditches (C), on slopes of mid-forest (D) showed a similar number of species found in roadside ditches and on slopes (on average 23 and 22 taxons). On the basis of soil salinity indicators (*Z* and *SAR*) they were not specified in any of the analyzed shoulder zones.

Keywords: forest soils, the content of macro- and microelements in the soil, flora, forest, soil salinity indicators.

Soil salinity, which is caused by ice-removing chemicals used on streets in urban areas, is formed along traffic routes, where sodium chloride has been used in order to improve transport during Winter since 1986. These actions, which we are not able to avoid, cause cyclic accumulation of large amount of soluble salts, mainly NaCl and

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NaHCO_3 , especially in early Spring, which increases salt concentration and pH of the soil to the level which may be toxic for plants. Hence, a solution is sought, which would assure both smoothness of traffic and would be less harmful to the environment, as well as to road users. In Finland in the late 90's potassium formate (HCOOK) and potassium acetate (CH_3COOK) were used. In the USA are used as follows: magnesium acetate $[(\text{CH}_3\text{COO}_2)\text{Mg}]$, calcium acetate $[(\text{CH}_3\text{COO}_2)\text{Ca}]$, sugar-rich solutions produced during partial hydrolysis of waste products from processing of sugar beet and maize, urea $\text{CO}(\text{NH}_2)_2$ and alcohols [1].

Ice-removing chemicals used on streets have an impact on chemical nature of roadsides' top layers, and thus roadside flora. Their influence is connected to properties of substrate material, as well as the distance from the roadway.

The aim of this paper is to assess changes in content and richness category of forms acknowledged as assimilable macro- and microelements in roadside soil along forest areas in Szczecin Lowlands during Spring time, changes in indicators of soil salinity and participation of plant species with different trophic index.

Material and methods

In Spring 2005, research was carried out in order to study roadsides with hardened surface (asphalt) and with comparable capacity, located along forest areas of Szczecin Lowlands.

For the purpose of observation four sample collection points were chosen, located outside build-up areas along forest roads: Modrzewie $53^\circ34'26''\text{N}$, $014^\circ47'09''\text{E}$, Lozienica $53^\circ33'03''\text{N}$, $014^\circ36'32''\text{E}$, Kliniska $53^\circ27'44''\text{N}$, $014^\circ47'36''\text{E}$ and Strumiany $53^\circ27'08''\text{N}$, $014^\circ52'12''\text{E}$.

Sampling from the top layer of humus 0–10 cm of roadside was performed in Spring (March) in each sample collection point. Four characteristic roadside zones were researched, situated as follows:

- A – road shoulder edge adjoining the road surface (0.2–0.3 m width),
- B – proper road shoulder (1.0–1.2 m width),
- C – ditch (1.0–1.5 m width, 0.5–0.8 m depth),
- D – slope (1.0–2.5 m height, inclination 30°).

Using methods generally accepted in soil science, determinations were done as follows: granulation, soil pH reaction measured in KCl solution of $1 \text{ mol} \cdot \text{dm}^{-3}$ (pH_{KCl}) concentration and loss on ignition at 550°C . Content of forms regarded as available to plants, after extraction with HCl at a concentration of $0.5 \text{ mol} \cdot \text{dm}^{-3}$ [2], was determined by AAS: K, Ca Mg, Na, Cu, Fe, Mn and Zn while P colorimetrically.

Soil salinity was calculated on the basis of degree of changes in soil sodium (Z) relative to the amount of sodium ions of calcium and magnesium ions expressed in equivalent amounts [3], and SAR (*Sodium Adsorption Ratio*) [4]:

$$Z = \frac{\text{Na}}{\text{Ca} + \text{Mg}},$$

$$\text{SAR} = \frac{\text{Na}}{\sqrt{\frac{\text{Ca} + \text{Mg}}{2}}}$$

The significance of differences in element content between zones was determined by using Tukey's HSD test, while the SD value at 0.05 significance level test of Newman-Keuluss, using the program Statistica 9.

The assessment of soil was carried out according to the classification of Sapek and Sapek [2], which is applied to agricultural grasslands. Because the tested samples contained less than 20 % of organic matter, classification of the nutrient content was made, which divided soil richness into three grades: low, medium and high. The exceptions was magnesium, which content was valued for five grades of abundance.

Results and discussion

Data included in Table 1, characterizing researched soil, were already presented in earlier publications [5, 6]. Re-presentation was necessary to assess soil fertility.

Researched soil had granulation of loose sand according to PTG classification [7]. pH_{KCl} values allowed to determine that in A and B zones the reaction was neutral and in C and D zones it was acid. Salinity as well as loss on ignition were decreasing as the distance from the edge of the road was further [5].

Table 1

The mean value of chosen properties in the 0–10 cm layer of mid-forest sideroads in Spring

Roadside zone	Loss on ignition [%]	pH_{KCl}	Salinity [g NaCl · kg ⁻¹ of soil]	Percentage content of fractions with diameter [mm]			
				> 2	2–0.5	0.5–0.002	< 0.002
A	2.96	7.03	0.202	17.2	93.3	5.3	1.4
B	2.15	6.70	0.183	4.8	93.3	4.8	1.9
C	2.20	5.20	0.131	1.7	92.6	5.1	2.2
D	1.80	5.20	0.096	1.1	93.6	4.7	1.7

The content of all researched macroelements (P, K, Mg, Ca and Na), was decreasing as the distance from the edge of the road was further. Significant changes were found between soils of different zones (Table 2). The highest content of phosphorus soluble in 0.5 mol · dm⁻³ HCl was in the shoulder area (3.30 mg · 100 g⁻¹ soil) and as one moves from the edge of the road it was significantly decreasing in the zone of the ditch and embankment. That same relation appeared in the case of soluble potassium in soil.

Phosphorus content was established low. Potassium content in A zone was high, in B zone medium, and in zones C and D it was low. Magnesium in A and B zones is low, and in C and D zones very low. According to Bieniek [8], almost 1/3 of magnesium in total is present in mineral compounds in soluble forms. In studies of muck soil conducted by the authors, the content of magnesium according to boundary numbers reached very low level, which is a proof for the strong need of fertilizing soils researched.

Table 2

The average content of macro- and microelements soluble in $0.5 \text{ mol} \cdot \text{dm}^{-3} \text{ HCl}$ in 0–10 cm layer of soil from the roadsides and homogenous groups

Shoulder zone	P	K	Mg	Ca	Na	Cu	Fe	Mn	Zn	Soil salinity indicator	
	[mg · 100 g ⁻¹ of soil]						[mg · kg ⁻¹ of soil]				Z
A	3.30a	43.9a	39.9a	5.80a	0.358a	14.80a	14.71a	115.0	68.1a	0.0078a	0.071
B	2.59ab	26.5ab	25.4ab	5.05ab	0.229ab	6.90	12.04ab	76.9	55.1ab	0.0075	0.054
C	1.98bc	16.2b	11.8b	2.08ab	0.068b	4.23	6.51ab	55.5	36.7b	0.0049	0.024
D	1.49c	10.9b	9.2b	1.32b	0.043b	1.32	5.20b	46.7	31.2b	0.0041	0.018
NIR _(0.05)	1.08	24.4	18.8	3.94	0.214	n.i.	8.59	n.i.	28.7	—	—

Among other microelements, copper content showed no relevant diversity, despite the fact that in A and D zones the content was high, in B zone medium, and in D zone low. Moreover, manganese also showed no important variety, even though A zone had medium content and the rest had low. In case of iron there was a significant difference between zones A and D, although the content of zinc was high, there was an essential difference between the soils of zone A and soils of zones C and D (Table 2).

Soil salinity indicators Z and SAR are not equivalent. Both allow for assessment of environmental risks associated with soil environment connected to content of soluble salts of sodium [3]. In the study, the Z rate was less than 1, which indicates a lack of signs of salinity. The value of this index ranged from 0.0078 to 0.0041. Also the SAR index was less than 10, so the soil has appropriate conditions for the development of plants (Table 2). It was observed that the further from the roadway, the lower was the value of indexes researched.

Rating the number of species observed on the edge of the road shoulder (A), on the proper road shoulder (B), in ditches (C), and on slopes (D), it showed a similar number of species found in roadside ditches and on slopes (on average 23 and 22 taxons).

In further zones of the road shoulder, which were situated next to road surface, the most species were recorded on the proper road shoulder (on average 19 taxons), while the road shoulder edge stood a small number of observed taxons (on average 7). Analysis of *trophism index* (Tr) based on ecological index numbers [9] showed a domination of species preferring mesotrophic soils (Tr = 3) and oligotrophic (Tr = 2) throughout the whole profile of vertical formation of mid-forest roadsides in the researched area. In this respect, two became distinguished – a roadside ditch and embankment, where the species accounted for more than 83 % and 86 % of all plants observed there. Among them *Rumex acetosella*, *Festuca ovina*, *Helichrysum arenarium*, *Hieracium pilosella*, *Corynephorus canescens*, *Trifolium campestre*, *Jasione motana*, *Calluna vulgaris*, *Vaccinium myrtillus*, *Artemisia campestris* and *Calamagrostis epigejos* were most often reported (Fig. 1). In both of these zones single plant species

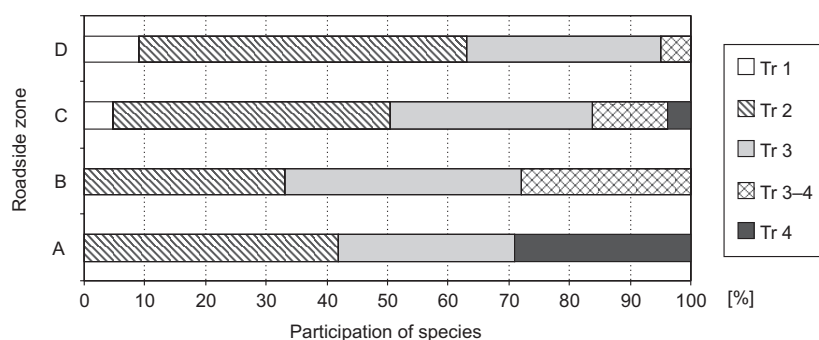


Fig. 1. The percentage of species at different trophic index by Zarzycki [9], in particular zones of mid-forest roadsides. Key: A – edge of shoulder; B – proper shoulder; C – roadside ditch; D – roadside slope; Tr 1 – extremely oligotrophic soils; Tr 2 – oligotrophic soils; Tr 3 – mesotrophic soils; Tr 3–4 – meso- to eutrophic soils; Tr 4 – eutrophic soils

associated with extremely oligotrophic habitats ($Tr = 1$) were observed, such as *Trifolium arvense*, *Sedum acre* or *Vaccinium vitis-idea*.

While in proper road shoulder of mid-forest roads and its edge presence of species associated with mesotrophic and oligotrophic soils was of a lesser degree and amounted to 73 % and 71 %, the most frequently observed taxons were as follows: *Carex arenaria*, *Carex hirta*, *Agrostis vulgaris*, *Trifolium campestre*, *Cerastium arvense*, *Holcus mollis*, *Veronica officinalis* and *Festuca rubra*. Presence of intolerant species to extremely oligotrophic habitats was not stated, whereas observed were the species which indicated on eutrophic nature of substrate, such as *Plantago major* or *Poa annua*.

Conclusions

1. The content of forms regarded available for plant macroelements P, K, Mg, Ca and Na in soil was decreasing as the distance was further from the edge of the roadway. Indeed, most macroelements was in the edge zone (edge of shoulder), with a width of 20–30 cm, adjacent directly to the edge of the roadway.

2. In all researched areas soil richness for phosphorus was low, for magnesium low (A and B zone) and very low (C and D zone), high in potassium in the edge area and medium in the proper shoulder.

3. Content of soluble microelements in $0.5 \text{ mol} \cdot \text{dm}^{-3}$ HCL was the greatest in the edge area and was decreasing if further from the edge of the roadway.

4. Analysis of trophic index leads to the conclusion that in the whole profile of vertical formation of roadsides species preferring mesotrophic soils ($Tr = 3$) and oligotrophic soils ($Tr = 2$) were clearly dominating. However, at a distance of 2 m from the road (edge of shoulder and proper shoulder) species preferring eutrophic soils and in more distant soils (ditch and slope), plants preferring extreme oligotrophic habitats were observed.

5. Shoulder zones differed in abundance of species observed. The largest – with similar taxons number was found in roadside ditches (C) and on slopes of mid-forest roads (D) (on average 23 and 22), on the proper shoulder (B) were slightly less species (19), while on the edge of the shoulder (A) the number of taxons decreased to 7.

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ZAWARTOŚĆ MAKRO- I MIKROSKŁADNIKÓW W WIERZCHNIEJ WARSTWIE POBOCZA DRÓG TERENÓW LEŚNYCH ORAZ CHARAKTERYSTYKA GATUNKÓW ROŚLIN JE ZASIEDLAJĄCYCH

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Abstrakt: Przedstawiono wyniki badań dotyczące zawartości makro- i mikroskładników w glebach poboczy dróg biegnących przez tereny zadrzewione, wskaźników ich zasolenia oraz przestrzennego rozmieszczenia flory przydrożnej na podstawie wskaźnika trofizmu. Badaniem objęto strefy pobocza o łącznej szerokości 8 m, wzdłuż dróg o nawierzchni utwardzonej na Nizinie Szczecińskiej. Przeprowadzone badania wskazują, że zawartość makroskładników: P, K, Mg, Ca oraz Na zmniejszała się w glebie w miarę oddalania się od krawędzi jezdni. Istotnie najwięcej makroskładników było w strefie brzegowej (skraj pobocza), o szerokości 20–30 cm, przylegającej bezpośrednio do krawędzi jezdni. Analizując zasobność gleby w przyswajalny fosfor, stwierdzono, że była ona niska we wszystkich badanych strefach, magnezu niska (strefa A i B) i bardzo niska (strefa C i D), a potasu wysoka w strefie brzegowej i średnia w strefie pobocza właściwego. Zawartość mikroskładników rozpuszczalnych w $0,5 \text{ mol} \cdot \text{dm}^{-3} \text{ HCl}$ największa była w strefie brzegowej i zmniejszała się w miarę oddalania od krawędzi jezdni. Ocena liczebności gatunków obserwowanych na skraju pobocza (A), na poboczu właściwym (B), w przydrożnych rowach (C) i na skarpach dróg śródleśnych (D) wykazała podobną liczbę gatunków występujących w przydrożnych rowach i na skarpach (średnio 23 i 22 taksony). Na podstawie wskaźników zasolenia gleby (Z i SAR) nie określono ich w żadnej z analizowanych stref pobocza.

Słowa kluczowe: gleby leśne, zawartość makro- i mikroskładników w glebie, flora leśna, wskaźniki zasolenia gleby