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CONTENT OF SELECTED ELEMENTS IN THE LEAVES GROWING IN AN URBAN AGGLOMERATION

ZAWARTOŚĆ WYBRANYCH PIERWIASTKÓW W LIŚCIACH DRZEW ROSNĄCYCH W AGLOMERACJI MIEJSKIEJ

Abstract: In the study the content of K, Ca, Mg and Na in the leaves of *Acer platanoides* L., growing in the agglomeration of Gdynia and Gdansk, was shown and the mean ion equivalent ratios between these elements were determined. The obtained results showed large differentiation in the amount of the elements in the leaves of maple growing on particular sites in the urban environment. Correlation relationships between the concentration of heavy metals in the leaves of maple show a significant influence, particularly in the case of of Cd and Pb, on the content of determined elements in the assimilation apparatus. The results of the studies on the trees also showed changes in mutual ion ratios of the elements in the leaves.

Keywords: elements, *Acer platanoides* L.

Functioning of an urban agglomeration makes the conditions of trees vegetation in this area get worse and worse. An excessive concentration of heavy metals and impurities in urban environment leads, among other things, to disturbances in the element uptake by plants [1–3] and also in the ion balance [4–7]. As a result, there are considerable changes in the content of macro- and microelements in the assimilation apparatus [8, 9] causing mainly deficiency in elements indispensable for appropriate course of physiological processes. [10–15]. Maple (*Acer platanoides* L.), a characteristic feature of which is a wide ecological niche, belongs to the group of plants commonly used in urban agglomerations.

The studies aimed to determine the bioaccumulation of selected macroelements (K, Na, Ca and Mg) in the assimilation apparatus of maple (*Acer platanoides* L.) growing in the urban agglomeration of Gdansk and Gdynia and the average ion equivalent ratios between these elements. The obtained results will make it possible to determine if the studied physiological parameters can be used as the indicator reflecting the influence of the urban environment on the growth of maple.

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Material and methods

The studies were carried out in the area of urban agglomeration of Gdańsk and Gdynia in 2004. In each town seven research sites were set up in the centre of the city along the streets of high traffic volume, two in the housing estate, two in the park and the control point at a distance of about 25 km from the city. On each research site four representative trees of an approximate diameter at breast height (d.b.h.) of about 20 cm were selected. From each tree two one-year shoots were selected.

Material for the analysis consisted of fully formed leaves of the first and the second pair of a year's gain of *Acer platanoides* L. Leaves for chemical determination were collected in September at the height of about 2 metres from the southern side of the tree. After the leaves had been washed, dried and then subjected to wet mineralization, the content of K, Na, Ca and Mg in the leaves was determined using the atomic absorption spectrophotometry (AAS). Their mutual ion ratios were also calculated. The obtained results were worked out statistically, by calculating the correlation coefficient between the amount of macro- and microelements in the tree leaves. The analysis of variance was carried out and the significance of factors, was assessed by Tukey test at a significance level of $\alpha = 0.05$.

Results and discussion

The obtained results showed large diversity in the content of the determined elements in the leaves of maple growing both in the agglomeration of Gdansk and in that of Gdynia.

The statistical analysis showed a significant effect of the site location on the content of macroelements in the tree leaves. Lowered amounts of potassium were obtained in the leaves of maple trees growing along the streets, both in Gdansk and Gdynia. The leaves of trees from these research sites contained within 70 % less of potassium than the leaves from the control trees and about 60 % less of this element than the leaves of park trees (Tables 1, 2). The uptake of potassium from the soil by the leaves of trees growing in Szczecin is also insufficient [15]. The negative significant correlation relationships for this macroelement were observed between the concentration of Pb, Cd, Ni and Zn in the tree leaves from Gdynia and the amount of Pb, Cd, Ni, Zn, Cu and Fe in the tree leaves from Gdansk (Table 3). A slight increase in the content of magnesium was observed in the leaves of trees growing in Gdansk as compared with the control maple trees (Tables 1, 2). There were also correlation relationships between the amount of this macroelement in the leaves and the concentration of Pb, Cd and Zn in the leaves of trees growing in Gdynia and Cd and Mn in the leaves of maple trees from Gdansk (Table 3).

The amount of Cd was 46 times, Ni – 12 times, Pb and Zn – 4 times, Fe and Cu it was 3 times higher in the leaves of maple trees growing in the centre of Gdansk than in those from the control site [16]. Whereas the amounts of Cd and Pb recorded in the leaves of trees growing in Gdynia on the sites along the streets with heavy traffic exceed the upper range presented for these metals by Kabata-Pendias and Pendias [7] and

Markert [17]. The concentration of heavy metals in the tree leaves was increased on the sites located along the streets but their values did not exceed the upper limits for these metals [18].

The course of variability of Ca and Na in the leaves of trees from Gdansk was differentiated. It was shown that the content of calcium in the leaves of investigated trees from the centre of Gdansk was lower by 7.7 g · kg^{-1} of dry matter than that in the control leaves (Table 1).

Table 1

The average content of elements [g · kg^{-1} d.m.] in the leaves of maple in the area of Gdansk

Stand		Elements [g · kg^{-1} d.m.]			
		K	Na	Ca	Mg
ul. Kartuska	City centre	7.3	0.18	21.8	6.4
ul. Jabłoniowa		9.4	0.32	19.4	5.5
ul. Bieganskiego	Housing estates	14.5	0.29	27.3	3.8
ul. Dragana		13.0	0.35	20.3	4.2
Park MOSiR	Park	22.3	0.24	25.7	4.1
Park Orunski		24.1	0.22	26.9	3.7
Control stand		29.8	0.15	28.3	5.2
$LSD_{0.05}$		2.24	0.17	2.61	2.04

In Gdynia an approximate amount of calcium was observed in the leaves of the control, park and housing estate trees (average about 23 g · kg^{-1} d.m.). The content of Ca in the leaves of maple trees was lower than the content determined (35 g · kg^{-1} d.m.) by Insley et al in the leaves of lime tree [19]. However, a slight increase in this macro-element content was recorded in the tree leaves from the centre of the city (Table 2).

Table 2

The average content of elements [g · kg^{-1} d.m.] in the leaves of maple in the area of Gdynia

Stand		Elements [g · kg^{-1} d.m.]			
		K	Na	Ca	Mg
ul. Morska	City centre	9.7	0.49	25.9	5.8
ul. Kwiatkowskiego		11.3	0.23	24.4	6.1
ul. Swarzewska	Housing estates	12.9	0.53	26.3	5.3
ul. Bosmanska		14.3	0.41	19.7	4.9
Park Rady Europy	Park	25.5	0.34	22.3	4.3
Park na Kamiennej Gorze		23.1	0.40	24.0	3.9
Control stand		33.8	0.51	23.9	4.7
$LSD_{0.05}$		1.00	0.10	1.51	0.29

On the basis of the correlation coefficient a negative significant correlation relationship was observed between the concentration of Pb, Ni, Zn, Cu and Fe and the content of this element in the leaves of trees from Gdansk. The content of Ca in the leaves of trees from Gdansk is in significantly correlated with the concentration of heavy metals (Table 3).

Table 3

Relationships (r) between the content of macro- and microelements in the leaves of maple from Gdansk and Gdynia

	Gdansk				Gdynia			
	Potassium	Sodium	Calcium	Magnesium	Potassium	Sodium	Calcium	Magnesium
Lead	–0.84*	–0.07	–0.79*	0.56	–0.86*	–0.30	0.17	0.78*
Cadmium	–0.82*	–0.17	–0.68	0.79*	–0.89*	–0.27	0.25	0.82*
Nickel	–0.93*	0.09	–0.77*	0.61	–0.84*	–0.04	0.16	0.30
Manganese	–0.74	–0.22	–0.61	0.87*	–0.40	–0.44	0.17	0.37
Zinc	–0.78*	–0.21	–0.94*	0.44	–0.87*	–0.12	0.04	0.77*
Copper	–0.81*	–0.11	–0.89*	0.38	–0.85	0.24	0.38	0.71
Iron	–0.83*	–0.20	–0.96*	0.54	–0.38	–0.15	0.06	0.45
Magnesium	–0.44	–0.38	–0.46		–0.73	–0.11	0.38	
Calcium	0.81*	0.36			–0.21	0.32		
Sodium	–0.16				0.21			

* Significant for: $\alpha = 0.05$.

The leaves of the trees growing in the housing estate were marked by a higher amount of sodium in comparison with the leaves of the remaining research sites. An average content of this element in these leaves amounted to 0.32 g · kg^{-1} d.m. in Gdansk and on average 0.47 g · kg^{-1} d.m. in Gdynia (Tables 1, 2). The level of sodium content (ranging from 0.34 to 0.63 g · kg^{-1} d.m.) was similar in the leaves of small-leaved lime growing in the centre of Szczecin [15]. The value of correlation coefficient showed a negative insignificant relationship between the concentration of heavy metals and the content of this element in the leaves of studied trees from the agglomeration of Gdansk and Gdynia (Table 3).

Correlation relationships between the content of macro- and microelements in the leaves of maple show a significant effect of trace metals, particularly those unused in the plant metabolism (Cd, Pb), on the chemical composition of the assimilation apparatus. These relationships are probably connected with phenomena of synergism and antagonism, the processes of which are slightly different in polluted soils than in typical arable soils. The phenomenon of interaction plays a significant role because it causes disturbances of chemical balance in plants. In the studied leaves of trees, changes in mutual ion ratios of the defined elements were observed. In the trees growing in the city centre these relations were considerably narrowed as compared with the control trees (Tables 4, 5). The changes in mutual relations may cause the acceleration of some processes and simultaneously the delay the other [7].

Table 4

Mean ion equivalent proportions in the leaves of maple growing in Gdansk

Stand	Ion proportions				
	K : (Ca + Mg)	K : Ca	K : Mg	K : Na	Ca : Mg
ul. Kartuska	0.12	0.17	0.36	23.75	2.06
ul. Jabloniowa	0.17	0.25	0.52	17.14	2.11
ul. Bieganskiego	0.17	0.27	0.49	21.76	1.80
ul. Dragana	0.25	0.32	0.94	22.01	2.91
Park MOSiR	0.35	0.44	1.68	57.00	3.79
Park Orunski	0.37	0.46	2.00	68.89	4.35
Control stand	0.41	0.54	1.77	108.57	3.30

Table 5

Mean ion equivalent proportions in the leaves of maple growing in Gdynia

Stand	Ion proportions				
	K : (Ca + Mg)	K : Ca	K : Mg	K : Na	Ca : Mg
ul. Morska	0.14	0.19	0.52	9.26	2.69
ul. Kwiatkowskiego	0.17	0.24	0.57	29.01	2.39
ul. Swarzewska	0.19	0.25	0.75	14.35	3.00
ul. Bosmanska	0.27	0.38	0.30	20.55	2.39
Park Rady Europy	0.45	0.58	1.91	43.33	3.29
Park na Kamiennej Gorze	0.39	0.49	1.84	34.71	3.75
Control stand	0.55	0.73	2.23	39.54	3.05

Conclusions

1. A significant impact of the site location on the amount of K, Na, Ca and Mg was observed in the leaves of maple.

2. Ion ratios were remarkably narrowed in the trees from the city centre as compared with the control trees.

3. A significant correlation relationship was shown between the concentration of cadmium and lead and the content of potassium and magnesium in the leaves of the trees investigated.

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ZAWARTOŚĆ WYBRANYCH PIERWIASTKÓW MINERALNYCH W LIŚCIACH DRZEW ROSNĄCYCH W AGLOMERACJI MIEJSKIEJ

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Abstrakt: W pracy przedstawiono zawartość K, Ca, Mg i Na w liściach *Acer platanoides* L., rosnącego w aglomeracji miejskiej Gdyni i Gdańska oraz określono średnie równoważnikowe proporcje jonowe między tymi pierwiastkami. Uzyskane wyniki wykazały duże zróżnicowanie w zawartości oznaczanych pierwiastków w liściach klonu rosnącego na poszczególnych stanowiskach w środowisku miejskim. Zależności korelacyjne między koncentracją metali ciężkich w liściach klonu wskazują na znaczący wpływ szczególnie Cd i Pb na zawartość oznaczanych pierwiastków w aparacie asymilacyjnym. U badanych drzew uzyskane wyniki wykazały również zmiany we wzajemnych proporcjach jonowych pierwiastków w liściach.

Słowa kluczowe: pierwiastki, *Acer platanoides* L.