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Reaction of lime trees (*Tilia* sp.) growing along the Żwirki i Wigury Street in Warsaw on soil salinity caused by chemical technology of snow removal

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Summary. The studies were focused on the influence of sodium chloride application in the chemical technology of snow removal from streets on the conditions of lime trees (*Tilia* sp.) growing along the Żwirki i Wigury Street in Warsaw and the determination of the degree of salinity on soils under street vegetation. The analyses show that chemical technology of soil removal causes changes in the soil environment. They include ionic imbalance of the soil solution and change of soil reaction. Electrical conductivity of the saturated soil extract also increases, as well as content of soluble salts in soils under street vegetation. Sodium chloride significantly influences the lime trees growing along the Żwirki i Wigury Street. Leaves growing directly near the street show severe effects of paralysis by sodium chloride in form of necrosis, discoloration (browning), and in consequence drying and premature leaf-fall.

Key words: soil salinity, sodium chloride, lime tree.

1. Introduction

Intense development of municipal transportation requires correct maintenance of streets in all climatic conditions throughout the year. The most commonly applied method of road slipperiness removal is chemical technology based mainly on the application of sodium chloride. This method has negative influence of the physicochemical properties of soils as well as direct and indirect influence on street vegetation.

The study is focused on the analysis of the influence of chemical technology of snow removal on the condition of lime trees (*Tilia* sp.) in the Żwirki i Wigury Street in Warsaw and evaluation of the salinity conditions of soils.

2. Study area

Based on the observation of the condition of lime trees carried out from early spring, four measurement points were established. They were situated along the main crossways of the street. The trees growing along the crossways showed distinct signs of growth disorders, such as leaf necrosis, premature fall and drying up of particular branches and trunks. Each selected point was located 2 m from the street margin and ca. 2 m from the nearest tree. The control point that was not subject to the salination processes was localized in a nearby park.

3. Study method

Soil profiles were drilled with an auger in measurement points (profiles nos. 1–4) and a control point (profile no. 0); soil samples were collected from each profile from the following depth intervals: 0–30; 30–60; 60–90 and 90–120 cm. The soil samples were dried and disintegrated in a mortar. The grain size composition was determined using the Casagrande metod in the modification of Prószyński, pH was tested in 1M KCl, electrical conductivity of the soil saturated extract was measured conductometrically. Water extracts from soils were made in a 1:5 proportion of soil to water. Ions of soluble salts of Ca, Mg, K and Na were determined in the extracts using the AAS method, chlorides were determined argentometrically; sulphates – nephelometrically and bicarbonates – acidimetrically. The total content of soluble salts was calculated as the sum of particular ions in the water extract.

Table 1. Characteristics of soil salinity

Profile No.	Depth [cm]	pH [in 1M KCl]	EC_e [$dS \cdot m^{-1}$]	Cl^-	Soluble salts
				[$mg \cdot 100\ g^{-1}$ of soil]	
1	0–30	7.1	2.7	36.2	172
	30–60	7.2	3.3	39.1	171
	60–90	6.8	3.8	51.8	206
	90–120	6.9	2.9	40.5	189
2	0–30	6.9	2.4	27.7	124
	30–60	7.3	4.1	55.3	209
	60–90	6.8	2.9	55.4	184
	90–120	6.9	2.1	33.4	143
3	0–30	6.9	3.0	38.0	154
	30–60	7.1	4.6	58.9	224
	60–90	7.3	5.4	68.9	257
	90–120	7.2	5.9	66.0	256
4	0–30	6.9	2.0	36.4	133
	30–60	7.0	3.8	42.6	180
	60–90	7.0	4.6	65.3	235
	90–120	7.2	5.4	68.9	249
0	0–30	6.6	0.7	2.1	65.4
	30–60	6.7	0.8	2.1	70.2
	60–90	6.7	0.7	1.4	54.3
	90–120	6.7	0.7	1.4	45.8

Five samples of leaves from each tree were collected from the lime trees growing near the profiles; they were dried in air temperature, later at 60ºC, and then ground. Finally, four collective samples were obtained from leaves of lime trees growing near profiles 1–4; an additional collective sample represented the control point. The content of ash particles: Ca, Mg, Na and K was established in the leaf material using the AAS method; chlorides were determined argentometrically.

4. Results and discussion

The surface horizons of the studied soils were developed from loamy sands, whereas deeper in the profiles occurred clayey silt or slightly clayey silt. The reaction of the studied soils was neutral or alkaline and varied within 6.7 to 7.3 (Tab. 1).

Soil salinity can be characterized based on electrical conductivity of saturated soil extracts, the quantity of the chloride anion and the sum of soluble soils in the soil solution. Many authors (Pokojska et al. 1998; Pracz & Kwasowski 2005; Hulisz 2007) suggest that the boundary value of electrical conductivity of saturated soil extracts, above which the soils are considered as salinated should be 2 $dS \cdot m^{-1}$. This means that all studied soils are salinated, which is also confirmed by the content of soluble soils usually exceeding 0.2%.

In non-saline soils, the content of the chloride ion is low and most commonly does not exceed 3 $mg \cdot 100\ g^{-1}$ of soil. The content of this ion exceeding 10 $mg \cdot 100\ g^{-1}$ of soil may unfavourably influence plant growth (Czerwiński et al. 1984; Kwasowski 1996). In soils under the analyzed street vegetation, the content of the chloride ion was elevated and several times exceeded the contents typical of non-saline soils.

The ionic composition of soluble salts in the soils under street vegetation varied from the ionic composition typical of soils. Application of sodium chloride in the winter season caused significant changes in the quantitative series of ions in the soil solutions. In non-saline soils, the decreasing series of ion content in chemically comparable quantities are:

– for cations: $Ca^{2+} > Mg^{2+} > K^+ > Na^+$,
– for anions: $HCO_3^- > SO_4^{2-} > Cl^-$.

Such series were also determined in the soil of the control point (profile 0), whereas in soils collected along the Żwirki i Wigury Street (profiles 1–4) the ion series were:

– for cations: $Na^+ > Ca^{2+} > Mg^{2+} > K^+$, or $Ca^{2+} > Na^+ > Mg^{2+} > K^+$
– for anions: $Cl^- > HCO_3^- > SO_4^{2-}$. These results are similar to those from other reports (Czerwiński et al. 1984; Dużyński & Kusza 1999; Pracz 2001) and indicate salination of the studied soils by sodium chloride.

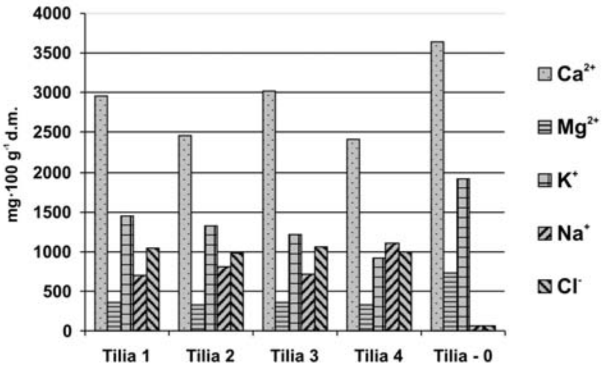

Figure 1. Content of ions in the lime tree leaves

The first observed symptom indicating leaf paralysis by sodium chloride was the appearance of yellowing of the leaf tip by the end of May. Increase of the content of chloride ions in the leaves caused browning of the leaves, followed by drying that covered successively larger parts of the leaf blade. A characteristic feature of paralysis symptoms was a yellow zone located between the external part of the blade covered by necrosis and the internal, healthy part of the leaf. In mid-July most leaves were completely dry, and in August light-green, young leaves appeared on some branches. Similar symptoms, as a reaction of trees to salination, were noted by other authors (Dużyński & Kusza 1999; Brogowski et al. 2000).

The analyzed leaves of lime trees were characterized by a disordered ionic composition, particularly in relation to the content of Na^+ and Cl^- ions in relation to the lime trees from the control point (Fig. 1).

The content of chlorine varied from 988 to 1058 mg·100 g^{-1} d.m. of leaves, which over a dozen times exceeded the content of this ion in lime leaves growing in the park. The ratio of bivalent to univalent cations was much lower; this is linked with the accumulation of excessive amounts of sodium ions in the leaves. Brogowski et al. [2000] noted exceeded contents of sodium and chlorine ions in lime leaves growing along the streets in Łódź, as well as the narrow ratio of bi- to univalent cations, a fact that is considered an important cause of pathological changes in leaves.

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