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ANTHROPOGENIC INDUSTRISOLS WITHIN EWA PENINSULA IN SZCZECIN PORT PART I. STRATYGRAPHY AND CHEMICAL PROPERTIES

ANTROPOGENICZNE GLEBY INDUSTRIOZIEMNE W OBRĘBIE PÓŁWYSPU EWA W PORCIE SZCZECIN CZĘŚĆ I. BUDOWA STRATYGRAFICZNA I WŁAŚCIWOŚCI CHEMICZNE

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Streszczenie. Badaniami objęto gleby industrioziemne inicjalne (przykryte) oraz idustrioziemne próchniczne występujące na półwyspie Ewa w porcie szczecińskim. Materiał do badań gleb inicjalnych (przykrytych) pozyskano z głębokich odwiertów (do 13 m p.p.t.), a do badań gleb próchnicznych z powierzchniowej 0–25(30 cm) warstwy sporadycznie występujących na półwyspie zieleńców. Pobranie materiału glebowego tych gleb z większych głębokości utrudniała infrastruktura portu. W budowie stratygraficznej gleb przykrytych-inicjalnych wyodrębniono powierzchniową warstwę o miąższości 2,7–4,4 m (średnio 3,20 m) piaszczystego materiału glebowego nawiezionego w celu uzdatnienia bagnistego terenu pod planowaną zabudowę. Nawieziony materiał, pochodzący m.in. z pogłębiania pobliskich akwenów, przyczynił się do kompakcji utworów holoceńskich (namułów organicznych i torfów niskich), które aktualnie ujawniają się na głębokości 3,20–9,00 m. Występująca pod płytami żelbetowymi piaszczysta warstwa nasypowa zawierająca 2–5% frakcji <0,002 mm i tylko w górnej części wykazywała frakcje szkieletowe pochodzenia antropogenicznego. Wyróżniał ją odczyn (pH_{KCl} 5,7–8,0), niewielka do 1% zawartość $CaCO_3$ i węgla organicznego średnio 7,0 g · kg^{-1} oraz szeroki stosunek C : N 17,5 : 1. Natomiast dominująca w badanych odwiertach warstwa organiczna charakteryzowała się pH_{KCl} 4,9–6,7, zawartością węgla organicznego w granicach 174,1–183,7 g · kg^{-1} i stosunkiem C : N od 13,5 : 1 do 16,7 : 1. Porównanie właściwości wierzchniej warstwy gleb przykrytych o miąższości 0,25–1,50 m z glebami próchnicznymi skwerów potwierdza wspólną genezę tych piaszczystych materiałów glebowych. Gleby próchniczne zawierały bowiem także 3–6% frakcji <0,002 mm, podobny odczyn i zawartość $CaCO_3$. Zwiększona w nich zawartość węgla organicznego do 28,6 g · kg^{-1} a w niektórych przypadkach nawet do 86,6 g · kg^{-1}, oraz azotu ogólnego od 2,2 do 8,9 g · kg^{-1} spowodowały bardziej korzystny stosunek C : N od 9,7 : 1 do 13,0 : 1. Wysokie nagromadzenie węgla organicznego oraz przyswajalnego fosforu, potasu i magnezu są przede wszystkim wynikiem stosowanych zabiegów nawożeniowych i pielęgnacyjnych. Z porównań tych właściwości wynika jak ważną rolę w ekosystemie gleb miejskich i przemysłowo-miejskich odgrywa sposób ich użytkowania, który staje się ważnym czynnikiem glebotwórczym.

Key words: industrisols, properties, stratigraphic structures.
Słowa kluczowe: budowa stratygraficzna, gleby industrioziemne, właściwości.

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INTRODUCTION

The modern port of Szczecin is located in the marshy and peaty estuary of the Odra within the northern part of Międzyodrze. This segment of the Odra valley, according to Mikołajski (1960, 1966), Dziedziul (1975), Białecki and Turek-Kwiatkowska (1991) is underlaid with alluvial formations (sand, river mud and gravel) to the depth of 25 m, and about 7 m thick surface layer consists of peat. The present studies of Dobracki and Piotrowski (2002) support those findings. In the opinion of Mikołajski (1960) and Dziedziul (1975) locating port in such a difficult terrain hampered building port facilities, which required the use of 13 m piles. However, detailed analysis of topographical conditions of Szczecin and its surroundings shows that the selected place was the best option. Despite the fact that the port is separated from Szczecin agglomeration by the West Odra, its construction contributed to the development of the city since as. Hilchen (1936) and Lesiński (1975) think the port and city complement each other, and according to Wachowiak (1957), the history of Szczecin is closely connected with the port from immemorial times.

Peninsula Ewa originates (Fig. 1) from digging, in 1931, the Dębicki and Grabowski canals and their later filling in by Danes. Earlier, it constituted an integral part of the island Ostrów Grabowski. It owes its name to a grain elevator, built before the Second World War, on its northern top. After 1945 the elevator was named ‘Ewa’ and the whole peninsula started to be called the same.

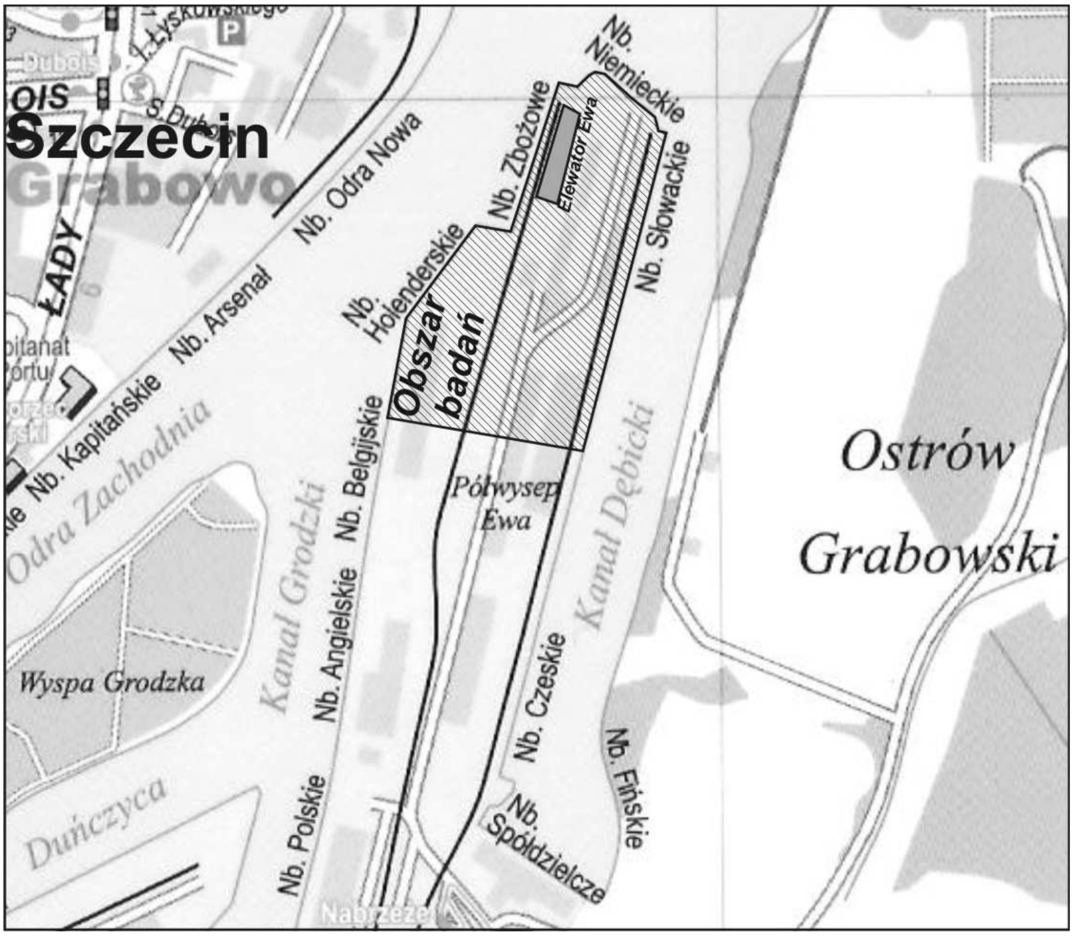

Fig. 1. Location of peninsula Ewa
Rys. 1. Lokalizacja półwyspu Ewa

The construction of grain elevator of storing capacity of 43 000 tonnes with complete infrastructure (220 m quay made of reinforced concrete, railroad and railroad facilities, power transformer, administration building), required the improvement of waterlogged ground. Białecki and Turek-Kwiatkowska (1991) report that 7 mln m^3 of sand, extracted as a result of deepening adjacent waterways, were used for covering that area. The paper of Schulze and Cantz (1937) on geological studies, conducted before the beginning of building the current Elevator 'Ewa', shows that numerous exploratory boreholes were made to find the ground bearing layer. Next, each square metre of peaty area was covered with 4 m^3 of sand, and on certain parts, additionally, with 60 cm layer of slag.

After completion of construction works, the ground was covered with brick slabs resistant to great mechanical pressure. During World War II, however, as a result of carpet air raids by Allies and subversive actions of Germans, Szczecin port, including the area around the elevator, was seriously destroyed, in some parts to 80–90% (Świokło and Moskalewicz 1945; Czapliński 1975). In the case of elevator, the damaged or destroyed surface was replaced with reinforced concrete slabs.

In 2007 there was the concept of building, in the vicinity of functioning at the Grain Quay elevator 'Ewa', a new storing warehouse, of similar capacity ca. 40 000 tonnes, for reloading grain and feed. In order to determine geological-engineering conditions of the ground for prospective investment, 18 boreholes to the depth of 10–13 m were made within the area under reinforced concrete slabs, at the Slovakian Quay. The description of these boreholes in the form of 'Card of geological-engineering borehole' was carried out by Kołodziej and Tarnawski (2008). The study was undertaken to determine: the texture, reaction, the content of $CaCO_3$, organic matter, available and total macroelements in anthropogenic, industrisols of peninsula Ewa in Szczecin port, and the impact of soil use on their properties.

MATERIAL AND METHODS

The soil material from the peninsula 'Ewa' (Fig. 1) was collected (in 2008 year) in the form of composite samples from:

- 12 deep boreholes (10–13 m) within the area covered with reinforced slabs at Slovakian Quay.
- uncovered areas occurring sporadically on the examined peninsula, from the depth 0–20 (30) cm.

Boreholes were 20–35 m apart from each other and the soil material was similar at particular depths, which made it possible, by taking into account the granulometric composition, organic matter content and depth, to separate 57 composite samples – 31 of mineral origin and 26 of organic. Composite samples from uncovered areas, mostly lawns, were taken by means of Egner's soil auger, 15 altogether, 10 mineral and 5 organic. Collecting samples from deeper parts of soil profile was impossible because of port infrastructure. Laboratory analyses included 72 soil samples representive of anthropogenic industrisols. After sifting the material through a 2 mm mesh sieve, in soil skeleton, anthropogenic substrates were separated from natural and their share was expressed as weight percentages. In mineral fine earth, the share of soil fraction was determined by the method of Cassagrande, modified by Prószyński.

In all samples, reaction was determined potentiometrically, content of $CaCO_3$ – by the method of Scheibler, organic carbon – by the Tiurin method, total nitrogen by the Kieldahl method, available phosphorus and potassium by the method of Egner-Riehm and available magnesium according to Schachtschabel. The application of uniform above mentioned methods for finding the contents of available P, K, Mg, both in mineral and organic soils, was forced by the terrain structure in which mineral and organic strata occurred at different depths. Content of macroelements (P, K, Mg, Na), soluble in the mixture of concentrated acids HNO_3 + $HClO_4$ was determined by soil mineralisation in this mixture, using atomic absorption spectrophotometer Unicam Solaar 929. Phosphorus was obtained colorometrically.

The division of soils and mineral formations in the description of soil horizons is based on the classification of Polish Society of Soil Science (2009), whereas their soil group according to Systematics of Polish Soils (Komisja Genezy... 2011) and WRB (FAO et al. 2006), Soil color was determined according to Oyama and Takehera (2003).

RESULTS AND DISCUSSION

In the light of information (Mikołajski 1960; Lesiński 1975, Białecki and Turek-Kwiatkowska 1991) on the construction conditions, functioning and infrastructure of Szczecin port, the soils covering its area, according to Systematics of Polish Soils (Komisja Genezy... 2011), belong to the order of anthropogenic soils (A), type industrisols (AI) subtypes initial (ecranic) (AIin) and humus (Aipr). This is also supported by industrial-service character of port operations. On the basis of present WRB (FAO… 2006) criteria they are classified as Technic Regosols and Mollic Technosols. It should be noted that there are attempts at improving WRB classification as regards Technosols (Charzyński et al. 2013).

Within Szczecin port, the majority of initial industrisols are sealed (Ekranic) and such an alternative has not been included in the latest Systematics of Polish Soils (2011). The examined soil from deep boreholes belonged to such initial industrisols (ecranic). Their stratigraphic structure is shown in borehole 11.

Borehole 11.	Depth to 11.2 m, water table in transported cover layer
0.0–0.25 m –	Reinforced concrete slabs (airport), sealed;
0.25–1.3 m –	anthropogenic, uniform material in the form of fine sand, slightly loamy sand (5% fraction <0.002 mm), slight amounts of slag and tiny metal elements, colour 10 YR 5/6 yellow-dark brown, grey in places 7.5YR2/1, traces of humus, loss on ignition 2.5%, weak reaction to HCl (1.9% $CaCO_3$);
1.3–3.4 m –	anthropogenic, uniform loose sand (4% fraction <0.002 mm), sporadic addition of slag, moist, grey, loss on ignition 0.5%, slight reaction to HCl;
3.4–4.0 m –	anthropogenic, fine loose sand (4% fraction <0.002 mm), moist, grey 7.5YR2/1, transitioning into Holocene formations like silt and peat, no reaction to HCl;
4.0–5.4 m –	fen alder peat without anthropogenic artefacts, strongly dense, moist, dark brown-grey, loss on ignition 76.8%, pH_{KCl} – 4.9;
5.4–9.5 m –	fen peat transitioning into silt, similar to gyttja, strongly moist , grey to dark grey 7.5YR3/1, with patches of fine sand, loss on ignition 19.7%, pH_{KCl} – 5.5;
9.5–11.2 m –	fine river sand with depth transitioning into medium slightly loamy, at places with organic silt, gleyed, grey 10Y2/1, excessively moist, loss on ignition 2.1%, content of $CaCO_3$ – 0.51%, pH_{KCl} – 7.1.

Analysis of soil material from 12 boreholes confirmed that the area designated for the construction of grain elevator, had been covered with 4.0 m layer of mound, mostly fine, loose and slightly loamy, with a small amount of skeleton soil of anthropogenic origin, in particular. A relatively high content of skeleton soil was found only in the upper part of this sand cover, in 3 boreholes, at the depth 0.0–1.50 (3.00) m, e.g. in borehole 16 they made up 43.3% and 89.5% were anthropogenic: slag crumbles, construction rubble such as large amounts of brick, glass, ceramics and metal segments. Small amounts of those artifacts were detected in organic material (2 cases at the depth 1.00–1.50 m, Table 1). The lower part of that layer consisted of fine loose sand without anthropogenic additions, extracted probably during deepening nearby water bodies. It is characterised by a small amount of skeleton soil and sporadic occurrence of shell crumbles, which slightly react to 10% HCl. Within the Odra estuary such dredged material was used for reconstructing river embankments and levees as well as remediation of water-logged land Borowiec and Kwarta (1959), Osiecimski (1966), Białecki and Turek-Kwiatkowska (1991), Niedźwiecki et al (2001).

At the depth ca. 3.20 m, Holocene formations occur in the form of organic silt (of small thickness) from 2–3 m layer of fen peat, predominantly sedge or alder, compacted by the load of cover material. Evaluating the conditions of waterlogged area, designated for the construction of the elevator, Mikołajski (1960) states that 6–9 m layer of peat was 'compressed by 2.5 m' after covering it with 4 m of earth. The lower part of organic layer was the material with clay fraction, soft plastic, similar to gyttja, dark to olive-black, at places with patches of fine sand.

Below 8.50 (9.00) m dominated gley, fine or medium, loose sand, with sporadic presence of gravel, organic-clay matter and shells.

On the basis of cited literature, it may be assumed that presented stratigraphy of the peninsula Ewa, to a great extent is representative of the area of whole port of Szczecin.

Transported cover layer was not only observed on the area of port grounds. Examining the soils of oldest part of Szczecin Chudecka (2009) found the anthropogenic stratum of the thickness of 1.6 m on average and maximum 4.2 m.

The examined mineral cover of peninsula Ewa, generally, 3.2 m thick, had slightly acid to alkaline reaction (pH_{KCl} 5.7–8.0) due to the quality of the material from different periods of city development and varying content of debris. Hence, there was only a slight amount of $CaCO_3$, mostly not exceeding 1% (Table 1). Similar pH values and $CaCO_3$ content were reported by Charzyński et al. (2011) in ekranic urbisols of Toruń and Kluż-Napoka.

Apart from that, the sand cover was characterised by a low content of organic matter. Mean content of organic carbon, in the layer 0.25–1.50 m, was 7.0 $g \cdot kg^{-1}$ and decreased with the depth to 2.2 $g \cdot kg^{-1}$, while the amount of total nitrogen was low but relatively stable (mean 0.3–0.4 $g \cdot kg^{-1}$). As a result, C : N ratio was also differentiated form 17.5 : 1, in the surface part of mineral layer to 7.3 : 1 in its deeper part. Comparable C : N ratios were obtained for the soils covered with bitumen (ekranosols) by Sammel et al. (2013) within the street Obrońców Stalingradu in Szczecin.

In the analysed boreholes, predominant with regard to thickness, compacted organic layer, had pH_{KCl} 4.9–6.7, mean total content of organic carbon in the range 174.1–83.7 $g \cdot kg^{-1}$ and total nitrogen 11.5–12.9 $g \cdot kg^{-1}$, which resulted in C : N ration from 13.5 : 1 to 16.7 : 1 (Table 1). More detailed information on the stratigraphy of natural gyttja-peat deposit on nearby island – Wyspa Pucka is presented by Niedźwiecki et al. (2000).

Table 1. Subsoil structure, reaction, content of $CaCO_3$, organic matter and total nitrogen in anthropogenic industrisols (initial-ekranic) on Slovakian Quay within Ewa peninsula in Szczecin port

Tabela 1. Budowa podłoża glebowego, odczyn oraz zawartość $CaCO_3$, materii organicznej i azotu ogólnego w antropogenicznych industrioziemach (inicjalnych–przykrytych) glebach na Nabrzeżu Słowackim w obrębie półwyspu Ewa w porcie Szczecin

Kind of soil Samales Rodzaj próbek glebowych	Depth of sampling Głębokość pobrania [m]	Number of samples Ilość próbek	Texture group percentage of fraction <0.002 mm Grupa granulo-metryczna procentowa zawartość frakcji <0,002 mm	Skeleton soil Części szkieletowe [%]	Anthropogenic admixtures in skeleton soil Domieszki antropogeniczne w częściach szkieletowych [%]	Loss on ignition Straty na wyżarzaniu [g · kg^{-1}]	$C_{org.}$ [g · kg^{-1}]	$N_{tot.}$	C : N	pH_{KCl}	$CaCO_3$ [%]
Mineral Mineralne	0.25–1.50	11	pl, ps (sporad. pg) 2–5	11.7* 0.1–43.3**	41.0 5.0–89.6	18.0 5.0–55.0	7.0 2.9–14.1	0.4 0.2–0.9	17.5	5.7–8.0	0.9 0.0–3.2
Organic Organiczne	1.00–1.50	2	n.d.	0.0–6.3	n.s.	228 223–233	148.3 132.0–164.6	10.8 10.4–11.2	13.7	5.7–6.7	n.s.
Mineral (no organic material) Mineralne (organiczne nie występują)	1.50–3.20	7	pl,pl 2–5	0.2 0.0–6.3	n.s.	5.0 2.0–8.0	2.2 0.4–4.1	0.3 0.2–0.4	7.3	7.8–8.0	0.3 0.0–0.8
Mineral Mineralne	3.20–4.50	2	pl, ps; 3–5	0.4–1.0	n.s.	3.0 2.0–4.0	n.o.	n.o.	n.o.	7.6–7.7	0.3 0.0–0.6
Organic Organiczne		8	n.d.	n.s.	n.s.	39.5 21.0–62.2	174.1 103.6–247.1	12.9 7.5–18.7	13.5	5.2–5.6	n.s.
Organic (no mineral material) Mineralne (organiczne nie występują)	4.50–8.50 (9.00)	16	n.d.	n.s.	n.s.	335 203–768	183.7 83.1–367.9	11.5 5.0–18.3	16.7	4.9–6.7	n.s.
Mineral (no organic material) Mineralne (organiczne nie występują)	8.50 (9.00)– –13.0	11	pl, ps; 2–5	0.0–34.9	n.s.	15.0 3.0–38.0	n.o.	n.o.	n.o.	6.8–7.7	0.6 0.3–2.6

n.s. – not found – nie stwierdzono; n.d. – N/A – nie dotyczy; n.o. – not determined – nie oznaczono; * – mean values – wartości średnie; ** – extreme values – wartości ekstremalne.

Differentiation of soil material, in terms of quality and origin, affected the content of macroelements. The surface, mineral, 0.25–1.50 m layer of ekranosols contained 54.5 mg · kg^{-1} of available phosphorus, 71.3 mg·kg^{-1} of available potassium and 33.8 mg · kg^{-1} of available magnesium (Table 2). According to IUNG (1990) standards, phosphorus resources may be considered medium, whereas those of potassium and magnesium – low. On the other hand, the anthropogenic material of organic origin, occurring at this depth, was richer in the above mentioned macroelements (Table 2) since mean content of available phosphorus amounted to 159.1 mg · kg^{-1} and potassium to 141.1 mg · kg^{-1} and twice exceeded the content of these elements revealed in the natural organic-peat layer at the depth 3.20–8.50 (9.00) m.

Similar variations were found in soluble in HNO_3 + $HClO_4$, total content of phosphorus, potassium, magnesium and sodium. In comparison with mineral layers with low macroelement content, the organic material, both of anthropogenic and natural origin was characterised by 5.1-fold higher amount of phosphorus, 6.8-fold of potassium, 5.4-fold of magnesium and 4.4-fold of sodium (Table 2).

As it had been mentioned above, the analyses included also the soil material from the depth of 0–20(30) cm of uncovered adjacent area, mostly lawns and squares. Organoleptic and granulometric assessment showed that the material was also introduced while preparing the ground for construction and is of similar stratigraphic structur. Hence, the content of fraction <0,002 mm in the range 3–6%, similar content of $CaCO_3$ – 1.1% on average and pH_{KCl} 6.8–7.4. Increased amount of organic carbon to 28.6 g · kg^{-1} and in some cases even to 86.6 g · kg^{-1} and total nitrogen from 2.2 to 8.9 g · kg^{-1} (Table 3A) is related to the area use and management as lawn cultivation and shrub planting require soil improvement by application of garden substrate, biohumus, peat composts and other ‘soil ammendments’, containing high amount of organic matter and essential nutrients (Niedźwiecki et al. 1996, 2009; Greinert 2009). In this layer the ratio of C : N, ranging from 9.7 : 1 to 13.0 : 1, was more favourable, whereas in the surface layer of ekranosols it was wider, from 13.7 : 1 to 17.5 : 1. A significant role in humus industrisols was played by water circulation, gas exchange and more favourable microbiological activity. These functions, in the soils sealed with impermeable materials, are limited or inhibited in the opinion of Scalenghe and Marsan (2009).

Fertilisation and cultivation practices contributed also to high accumulation of available phosphorus, potassium and magnesium in the humus industrisols. Compared to ekranosols, there was 4.6-fold higher content of available phosphorus, 3.9-fold of potassium and 3.6-fold of magnesium. Total amount of the above elements, phosphorus in particular, turned out to be more beneficial (Table 2, 3B). The studies of Kollender-Szych et al. (2008), Niedźwiecki et al. (2009), Chudecka (2009) show that in urban and industrial-urban soils there is sufficient or even excessive amount of phosphorus.

Presented comparisons prove that land utilisation, both in urban and industrial-urban ecosystem, affects the processes leading to the development of definite types of soils. In this environment, according to Pietsch and Kamieth (1991), Burghardt (1996), Kollender-Szych et al. (2008), not only parent rock but also other soil-forming factors, undergo changes, due to the main factor, namely, utilisation.

Table 2. Content of available macroelements, soluble in concentrated HNO_3 + $HClO_4$ in anthropogenic industrisols (initial-ekranic) on Slovakian Quay within Ewa peninsula in Szczecin port (mean and extreme values)
Tabela 2. Zawartość makroskładników przyswajalnych oraz rozpuszczalnych w mieszaninie stężonych kwasów HNO_3 + $HClO_4$ w antropogenicznych industrioziemnych (inicjalnych–przykrytych) glebach na Nabrzeżu Słowackim w obrębie półwyspu Ewa w porcie Szczecin (wartości średnie i ekstremalne)

Kind of soil samples Rodzaj próbek glebowych	Depth of sampling Głębokość pobrania [m]	Available elements Składniki przyswajalne [mg · kg^{-1}]			Macroelements soluble in concentrated mixture of HNO_3 + $HClO_4$ [g · kg^{-1} DM soil] Składniki rozpuszczalne w mieszaninie stężonych kwasów HNO_3 + $HClO_4$ [g · kg^{-1} s.m. gleby]			
		P	K	Mg	P	K	Mg	Na
Mineral Mineralne	0.25–1.50	54.5* 25.6–101.2**	71.3 24.7–241.7	33.8 5.5–82.5	0.18 0.09–0.32	0.91 0.32–1.77	0.89 0.35–2.35	0.13 0.05–0.45
Organic Organiczne	1.00–1.50	159.1 119.3–198.9	141.1 44.0–238.2	126.6 112.9–140.3	0.84 0.70–0.99	4.01 2.78–5.25	2.75 2.29–3.21	0.32 0.23–0.41
Mineral (no organic material) Mineralne (organiczne nie występują)	1.50–3.20	22.9 10.8–33.4	25.5 17.9–42.8	29.4 13.8–50.0	0.08 0.07–0.09	0.66 0.26–2.85	0.41 0.25–0.90	0.05 0.04-0.06
Mineral Mineralne	3.20–4.50	21.3 9.3–33.4	27.7 27.5–27.9	14.3 14.1–14.5	0.05 0.07–0.09	0.3 0.22–0.38	0.35 0.25–0.45	0.05 0.04–0.06
Organic Organiczne		69.9 13.6–120.6	67.7 34.5–102.8	176.3 103.1–256.2	0.53 0.26–0.82	4.67 2.54–6.65	3.51 2.32–4.74	0.37 0.21–0.88
Organic (no mineral material) Mineralne (organiczne nie występują)	4.50–8.50(9.00)	86.0 10.8–176.0	54.6 22.2–109.2	173.5 63.8–275.4	0.46 0.20–0.70	3.62 1.44–6.62	2.62 0.35–4.79	0.30 0.16–0.57
Mineral (no organic material) Mineralne (organiczne nie występują)	8.50(9.00)–13.0	87.3 15.5–172.5	22.6 7.6–41.1	43.2 10.1–185.1	0.19 0.09–0.41	0.55 0.19–0.88	0.55 0.34–0.69	0.07 0.04–0.10

* mean values – wartości średnie; ** extreme values – wartości ekstremalne.

Table 3. Topsoil properties of humus industrisols under lawns and neglected greens within Ewa peninsula in Szczecin port
A – soil characteristics; **B** – macroelement content
Tabela 3. Właściwości powierzchniowej warstwy gleb industrioziemnych próchnicznych stanowiących fragmenty trawników i nieużytków zielonych w obrębie półwyspu Ewa w porcie Szczecin
A – ogólna charakterystyka materiału glebowego; **B** – zawartość makroskładników

A

Kind of soil samples Rodzaj próbek glebowych	Depth of sampling Głębokość pobrania [m]	Number of samples [p.c.s.] Ilość próbek [szt.]	Texture group. Percentage of fraction <0,002 mm Grupa granulometryczna procentowa zawartość frakcji <0,002 mm	Skeleton soil Części szkieletowe [%]	pH_{KCl}	Loss on ignition Straty na wyżarzaniu [g · kg^{-1}]	C [g · kg^{-1}]	N [g · kg^{-1}]	C : N	$CaCO_3$ [%]
Mineral Mineralne	0.0–0.20(30)	10	pl (ps) 3–6	30 16–42	6.8–7.4	50.0 7.1–80.0	28.6 19.8-48.1	2.2 1.1–3.9	13.0	1.1 0.5–1.8
Organic Organiczne	0.0–0.20(30)	5	n.d.	n.s.	6.6–7.1	233 146–331	86.6 47.0–107.4	8.9 4.4–14.5	9.7	1.8 0.0–2.5

B

Kind of soil samples Rodzaj próbek glebowych	Depth of sampling Głębokość pobrania [m]	Number of samples [p.c.s.] Ilość próbek [szt.]	Available elements Składniki przyswajalne [mg · kg^{-1}]			Elements soluble in concentrated $HNO_3 + HClO_4$ [g · kg^{-1} DM. soil] Składniki rozpuszczalne w mieszaninie stężonych kwasów $HNO_3 + HClO_4$ [g · kg^{-1} s.m. gleby]			
			P	K	Mg	P	K	Mg	Na
Mineral Mineralne	0.0–0.20(0.30)	10	229.1 115.3–321.2	219.4 94.7–380.3	84.6 29.1–146.1	1.17 0.57–1.76	1.12 0.82–1.42	2.24 1.73–3.24	0.27 0.18–0.58
Organic Organiczne	0.0–0.20(0.30)	5	271.0 221.8–323.8	335.2 252.2–429.7	158.5 104.1–212.0	2.90 2.05–4.24	2.0 1.38–3.05	5.80 2.89–7.96	0.60 0.29–0.82

n.s. – not found – nie stwierdzono; * – mean values – wartości średnie; ** – extreme values – wartości ekstremalne.

CONCLUSIONS

The studies on anthropogenic industrisols on peninsula Ewa in Szczecin port showed that:

1. Initial industrisols (ecranic) had a complex stratigraphic structure. Under reinforced concrete slabs they were covered with 2.7–4.5 m (mean 3.2 m) layer of sand, fine or medium, loose or slightly loamy (2–5% fraction <0.002 mm) with anthropogenic additions in upper layer and low organic matter content. There was also sporadic occurrence of peat. The sand layer was underlaid with bog formations ca. 4.0–9.0 m thick, in the form of organic sediments and peat (alder and sedge), on the bottom with gyttja-like material. At the depth of about 9.0 m, driftsand of varying grain size was found.
2. Adjacent to ekranosols, on small parts of the area, humus industrisols, also developed from the sand, containing 3–6% <0.002 mm fraction, had a similar stratigraphic structure. In the studies, they were represented by 0–20(30) cm layer because port infrastructure did not allow to sample deeper material.
3. The comparison of ekranic and humus topsoil properties of similar origin showed the differences in; the content of: organic carbon, total nitrogen, C : N ratio, and the accumulation of available and total macroelements. Initial industrisols (ecranic) had low amounts of organic carbon 7.0 g $\cdot$ kg^{-1} and total nitrogen 0.4 g $\cdot$ kg^{-1}, on average, C : N ratio 17.5 : 1, low resources of available potassium and magnesium and medium of phosphorus. In humus soils there was the increase in the content of organic carbon to 28.6 g $\cdot$ kg^{-1}, and in some cases even to 86.6 g $\cdot$ kg^{-1}, total nitrogen ranged from 2.2 to 8.9 g $\cdot$ kg^{-1} and C : N ratio from 9.7 : 1 to 13.0 : 1, whereas the content of available phosphorus was 4.6-fold, available nitrogen 3.9-fold and magnesium 3.6-fold higher.

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Abstract. The studies included initial industrisols (ecranic) on the peninsula Ewa in Szczecin port. Samples of these soils were collected from deep boreholes (to 13 m below ground level), whereas those of humus soils from the topsoil 0–25(30 cm) of sporadically occurring lawns. Port infrastructure did not allow sampling deeper strata. In stratigraphic structure of initial ekranosols, the surface layer, 2.7–4.4 m thick (mean 3.20 m) of sand, transported to improve the swampy terrain under construction, was distinguished. Transported material, obtained from dredging the nearby water bodies contributed to the compaction of Holocene formations (organic deposits and fen peat), visible at the depth 3.20–9.00 m. This sandy cover layer, under reinforced concrete slabs, contained 2–5% fraction <0.002 mm and only in its upper part, skeleton fractions of anthropogenic origin. It was characterised by pH_{KCl} 5.7–8.0), a slight to 1% $CaCO_3$ content, mean 7.0 g · kg^{-1} content of organic carbon and wide C : N 17.5 : 1 ratio, whereas the predominant organic layer of examined boreholes had pH_{KCl} 4.9–6.7, organic carbon in the range 174.1–183.7 g · kg^{-1} and the ratio of C : N from 13.5 : 1 to 16.7 : 1. Comparison of topsoil properties of initial industrisols (ekranic) of thickness 0.25–1.50 m, with humus soils under squares, confirms the common origin of these sandy soil materials. Humus soils also contained 3–6% fraction <0.002 mm, similar reaction and $CaCO_3$ content. Increased, in these soils, content of organic carbon to 28.6 g · kg^{-1} and in some cases even to 86.6 g · kg^{-1}, and total nitrogen from 2.2 to 8.9 g · kg^{-1} resulted in a more beneficial ratio of C : N from 9.7 : 1 to 13.0 : 1. High accumulation of organic carbon and available phosphorus, potassium, and magnesium is, first of all, the effect of fertilisation and cultivation practices. The analysis of these properties shows how important role, in the ecosystem of urban and industrial-urban soils, is played by land utilisation, which is becoming a vital soil-forming factor.