10

EKRANOSOLS OF TORUŃ AIRFIELD

PRZEMYSŁAW CHARZYŃSKI
RENATA BEDNAREK
ŁUKASZ MENDYK
MARCIN ŚWITONIAK
ALEKSANDRA POKOJSKA-BURDZIEJ
ANDRZEJ NOWAK

Introduction

According to the Thematic Strategy for Soil Protection (2006) defined by the Commission of the European Communities, the major threats leading to soil degradation include: erosion, decline in organic matter, local and diffuse contamination, compaction, decline in biodiversity, salinisation, floods, landslides and sealing. Further in the document: 'In order to achieve a more rational use of soil, Member States will be required to take appropriate measures to limit soil sealing by rehabilitating brownfield sites and to mitigate its effects by using construction techniques that allow maintaining as many soil functions as possible'.

When studying the ecological situation in the cities, extensive covering of the earth's surface should be taken into account, as this causes the soil degradation. The examples include aerial photographs of Moscow, which revealed that covered soils represent 90 – 95% of the total area in the city centre, 80% in industrial districts, and 60% in residential districts (Stroganova et al. 1998).

According to Stroganova et al. (1998), the soil surface can be covered (isolated from the impact of the atmosphere) by:

- buildings,
- permeable road surfaces (pavement, gravel),
- impermeable road surfaces (asphalt, concrete).

The problem of soil covering has been extensively studied by the team of researchers from the Lomonosov State University of Moscow who analysed technogenic and anthropogenic soils of the city (Stroganova et al. 1998; Prokofieva, Gubankov 2000; Stroganova, Prokofieva 2000, 2001, 2003; Gerasimova et al. 2003). Soils covered with asphalt were called *Ekranosols*. The name comes from French: *écran* – screen and from Russian: *zemla* – soil, earth. The systematics of urban surface deposits developed by the aforementioned research team defines Ekranosols as one of the urban soil types under the road foundation, asphalt, concrete and others. Burghardt (2001) classifies the covered soils from the group of lithosols as ekranolits and defines them as young urban soils where diagnostic horizons have not developed yet.

In the latest edition of WRB classification (IUSS Working Group WRB 2006), sealed soils were included in the new Reference Soil Group – Technosols. They are identified on the lower level of classification, with the qualifier Ekranic (ek). This qualifier is applied when technic hard rock starts within 5 cm of the soil surface, covering at least 95% of the horizontal extent of the pedon.

The authors of this chapter previously undertook the research on the covered soils in the city of Toruń and Romanian Cluj-Napoca (Charzyński et al. 2011).

The study area and soil profile documentation

Soil pits were located in the Toruń airfield (Fig. 1), which is situated on terrace IV of the Vistula River with an altitude of 50–52 m a.s.l. The terrace is built of sands with gravel interbeddings of 7–10 m thickness mostly (Niewiarowski, Weckwerth 2006). The Toruń airfield located in the western part of the city, covers an area of 297 ha, and includes a homogeneous land of Ekranic Technosols with an area of over 15 ha. It consists of two runways with the length of 1.270 m and the width of 60 m, arranged in the shape of the letter 'T'.

A balloon and airship (dirigible) airport, as well as the airfield were built in Toruń already in the first decade of the 20th century by the then German authorities. When Pomerania was regained by the Republic of Poland (18 January, 1920), Toruń military facilities were planted with vegetation by the Polish army. Soon after that, the Aviation Observers Officers School was opened (including the Aeronautical Officers' School). Since 1924, the airfield hosted Air Force Regiment 4. In 1935, sport aviation enthusiasts set up a local flying club, which was the first association of this kind in the Pomeranian Province and was called the Pomeranian Flying Club (in Polish: Aeroklub Pomorski). During World War II, the German Luftwaffe was stationed in the Toruń airfield, and at that time the aforementioned runways were built (Słowiński 1983). At present, the Pomeranian Flying Club operates in the airfield.

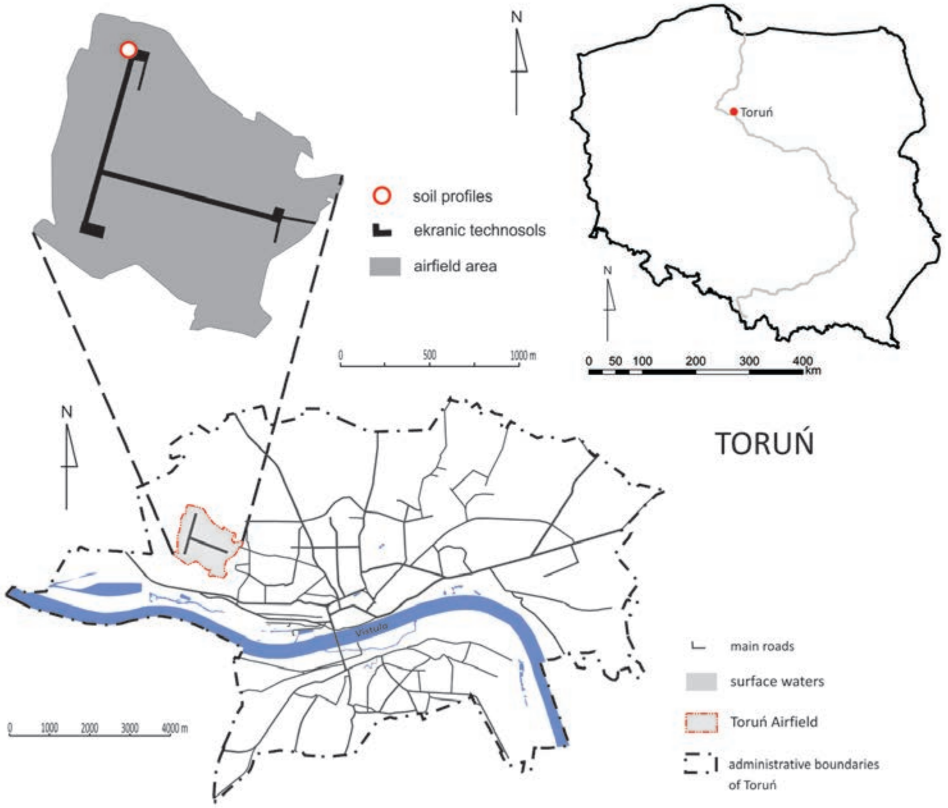


Fig. 1. Location of soil profiles within Toruń urban areas.

Three soil pits were made in the airfield area:

- profile 1 – the reference, Arenosol (Parathaptobrunic), 2 m from the edge of the concrete apron,
- profile 2 – Ekranic Technosol, soil covered with concrete, 1 m from the edge of the concrete apron,
- profile 3 – Ekranic Technosol, soil covered with concrete, 3 m from the edge of the concrete apron (Fig. 2).

Samples with undisturbed and disturbed structure were collected for laboratory analysis from profiles 1 and 2, from all identified horizons. Analyses of soil samples collected from horizons and layers were performed according to international standards (van Reeuwijk 2006). The following additional analyses were performed in samples collected from selected horizons:

- total phosphorus (P_t) by Bleck's method, modified by Gebhardt (1982),
- the content of heavy metals dissolved in 2M HNO_3 (Fe, Mn, Zn, Pb, Cd, Cu, Cr, Ni, Co)

by atomic absorbance spectroscopy (AAS) after Desaules et al. 2001; and magnetic susceptibility (κ) was determined at the Institute of Environmental Engineering of the Polish Academy of Sciences in Zabrze.

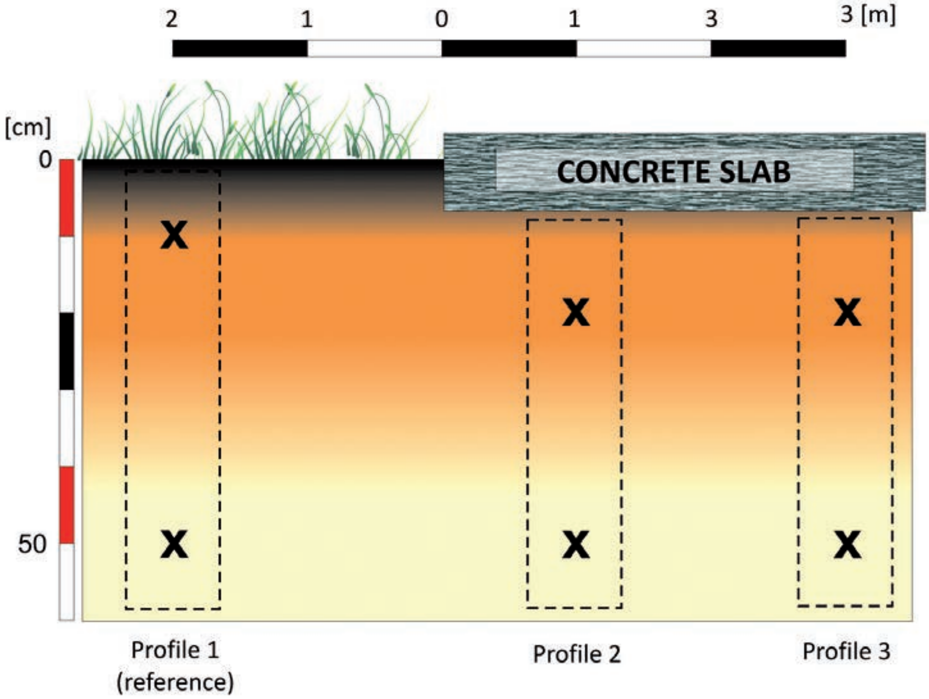


Fig. 2. Sampling diagram for microbiological analysis (X – soil sampling sites)

The following samples were collected for microbiological analysis:

- profile 1 – from a depth of 10 and 50 cm,
- profile 2 – from a depth of 20 and 50 cm,
- profile 3 – from a depth of 20 and 50 cm.

Samples from profile 3 were collected using a drill. The number of bacteria and fungi was determined with the Koch plate method. The method of the most probable numbers was used to determine the number of the following groups of microorganisms:

a) amonifiers,
b) denitrifiers,
c) methylene blue reducers,
d) glucose acidifiers.

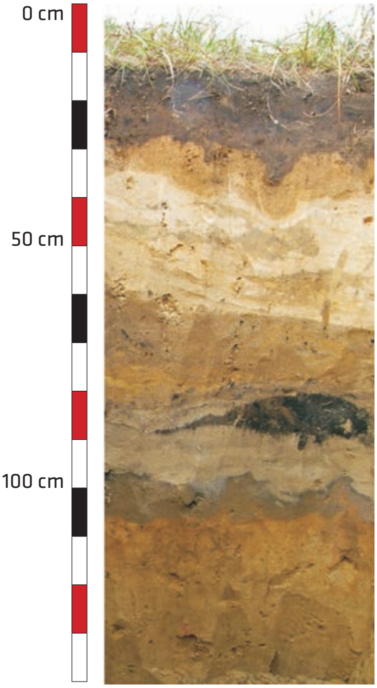
The total number of microorganisms able to generate colonies (cfu – colony forming units) was calculated per 1 g of dry soil matter.

Profile 1

Location:
Toruń Airfield,
Toruń, Northern Poland

Coordinates:
53˚02’14” N
18˚32’27” E

Soil classification (WRB 2007):
Arenosol (Parathaptobrunic)



Ap – 0–18 cm: human-disturbed, sand, dark greyish brown, weak granular structure, slightly moist, clear boundary.
B/Cp – 18–55 cm: human-disturbed, sand, very pale brown, single grain structure, slightly moist, clear boundary.
A/Bp – 55–74 cm: human-disturbed, sand, pale brown, weak granular/single grain structure, slightly moist, clear boundary,
A/Cp – 74–94 cm: human-disturbed, sand, pale brown, weak granular/single grain structure, slightly moist, insertion of organic matter enriched material, clear boundary.
Ab – 94–103 cm: sand, greyish brown, single grain structure, slightly moist, clear boundary.
Bwb – 104–130 cm: sand, light yellowish brown, single grain structure, slightly moist, gradual boundary.
C – below 130 cm: sand, very pale brown, single grain structure, slightly moist.

Table 1. Selected soil properties – profile 1

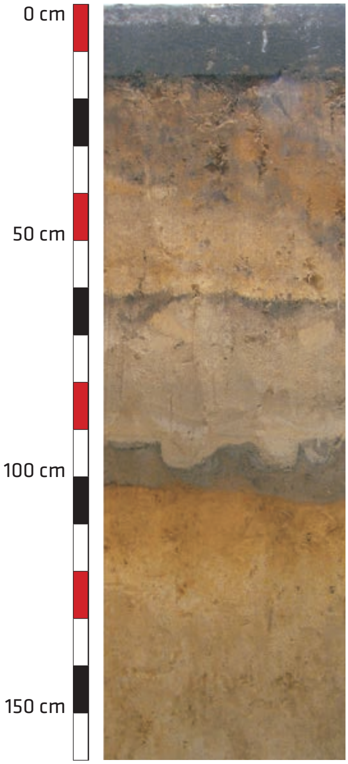
HORIZON		Ap	B/Cp	A/Bp	A/Cp	Ab	Bwb	C
DEPTH [cm]		0–18	18–55	55–74	74–94	94–103	104–130	<130
PARTICLE SIZE DISTRIBUTION [%]								
>2 mm		1	<1	<1	<1	2	2	<1
2 mm–50 µm		97	97	98	99	97	98	98
50–2 µm		3	3	2	1	2	2	2
<2 µm		0	0	0	0	1	0	0
TEXTURE CLASS (USDA)		sand	sand	sand	sand	sand	sand	sand
SOIL MATRIX COLOUR	dry	10YR 4/2	10YR 7/3	10YR 6/3	10YR 6/3	10YR 5/2	10YR 6/4	10YR 7/4
	moist	10YR 3/1	10YR 5/4	10YR 4/3	10YR 4/3	10YR 4/2	10YR 4/4	10YR 5/4
BULK DENSITY [g·cm^{-3}]		1.68	1.69	1.62	1.69	1.68	1.74	1.69
ACTUAL MOISTURE by volume [%]		11.8	2.2	8.6	3.0	3.5	5.0	4.9
OC [%]		0.86	–	0.24	–	–	0.09	–
N$_t$ [%]		0.055	–	0.009	–	–	0.007	–
C:N		16	–	25	–	–	12	–
pH	**in H$_2$O**	7.5	7.6	7.5	7.5	7.6	7.5	6.1
	in 1M KCl	6.5	6.8	6.5	6.8	6.5	6.5	5.1
CaCO$_3$ [%]		0.1	0.0	0.1	0.1	0.0	0.0	0.0
P$_t$ [mg·kg^{-1}]		110	65	135	90	163	93	100

Profile 2

Location:
Toruń Airfield,
Toruń,Northern Poland

Coordinates:
53˚02’14’’ N
18˚32’27’’ E

Soil classification (WRB 2007):
Ekranic Technosol
(Arenic, Parathaptobrunic)



Concrete slab – 0–15 cm.

Ap1 – 15–20 cm: sand, pale brown, weak granular structure, slightly moist, clear boundary.

B/Cp – 20–60 cm: sand, very pale brown, weak granular structure, slightly moist, clear boundary.

Ap2 – 60–63 cm: sand, very dark grey, weak granular structure, slightly moist, clear boundary.

C – 63–95 cm: sand, pale brown, single grain structure, slightly moist, clear boundary.

Ab – 95–102 cm: sand, light brownish grey, single grain structure, slightly moist, clear boundary.

Bwb – 102–120 cm: sand, light yellowish brown, single grain structure, slightly moist, clear boundary.

C – below 120 cm: sand, very pale brown, single grain structure, slightly moist.

Table 2. Selected soil properties – profile 2

HORIZON		Ap1	B/C	Ap2	C	Ab	Bwb	C
DEPTH [cm]		15–20	20–60	60–63	63–95	95–102	102–120	<120
PARTICLE SIZE DISTRIBUTION [%]								
>2 mm		<1	<1	<1	<1	2	5	1
2 mm–50 µm		98	96	95	98	98	99	98
50–2 µm		2	4	4	2	2	1	2
<2 µm		0	0	1	0	0	0	0
TEXTURE CLASS (USDA)		sand	sand	sand	sand	sand	sand	sand
SOIL MATRIX COLOUR	**dry**	10YR 6/3	10YR 7/3	10YR 3/1	10YR 6/3	10YR 6/2	10YR 6/4	10YR 7/4
	moist	10YR 4/2	10YR 5/4	10YR 2/1	10YR 5/3	10YR 4/2	10YR 4/4	10YR 5/4
BULK DENSITY [g·cm^{-3}]		1.56	1.46	–	1.63	1.71	1.66	1.79
ACTUAL MOISTURE by volume [%]		3.6	3.8	–	3.6	5.3	5.1	4.5
OC [%]		0.13	0.14	2.39	–	0.13	0.11	–
N_t [%]		0.006	0.007	0.138	–	0.008	0.010	–
C:N		23	20	17	–	16	11	–
pH	**in H_2O**	8.8	5.3	7.4	6.2	4.7	4.9	5.4
	in 1M KCl	8.0	5.0	6.7	5.1	4.7	4.9	5.0
$CaCO_3$ [%]		0.2	0.0	0.2	0.0	0.0	0.0	0.0
P_t [mg·kg^{-1}]		139	139	118	93	91	162	104

General soil properties

Morphology and physical properties

Morphology, as well as physical and chemical properties of the analysed airfield soils were significantly changed compared to natural soils in the vicinity. Also the research conducted in Pushchino revealed that not only Ekranosols, but also adjacent soils are characterised by modified morphology and compaction (Reshotkin 2003).

Distorted, unnatural configuration of horizons (buried A horizons mixed with Brunic B horizons) as well as sharp, irregular boundaries between horizons were a consequence of previous levelling treatments, which were carried out during the construction of the concrete apron. Originally, dune forms occurred in this area, which is typical of natural terrace areas of the Toruń Basin. In both presented profiles, the primary area was located much deeper, ca 95 cm (Ab horizon). Based on the arrangement of horizons in the buried soils, it seems likely that Brunic Arenosols occurred here before levelling. This is also confirmed by the abundant occurrence of such soils in the forests surrounding the airfield (Bednarek, Jankowski 2006).

Particle size distribution in the studied soils was very similar to that of the natural soils occurring in the terraces of the Toruń Basin. It was mostly sandy material of fluvial origin, deposited during the formation of Pleistocene terraces and remodelled by the aeolian process in later periods. The content of the silt and clay fraction was negligible. There were not significant differences in the particle size distribution between the reference soil and the soil under the concrete. In both profiles, the soil skeleton occurred mostly in the buried soil – below the depth of 95 cm. It consists of coarser mineral material – gravel. The lack of skeleton in overlying horizons and their highly monofractional character may prove that the deposited material came from dune forms previously occurring in the airfield. Similar relations were proved by studies of other covered soils in Toruń and Cluj-Napoca (Charzyński et al. 2011).

The highest moisture content was recorded in the Ap horizon in profile 1, which is related to retention properties of the humus. The moisture content irregularly decreased below this horizon, which reflected mixing of the soil material with a varying humus content. In the covered soil (profile 2), a layer situated directly beneath the concrete was over-desiccated, which is typical of Ekranic Technosols (Stroganova et al. 1998). On the other hand, the moisture content of lower horizons was similar to values recorded in profile 1 (the reference). This was a consequence of impeded rainwater infiltration by impermeable road surfaces. Craul (1992) proved that a high percentage of sealed lands alters the balance between infiltration and evaporation. Already after two or three days after covering the ground, the soil moisture drops to permanent wilting moisture.

The humus horizon in the studied Ekranic Technosols was destroyed and replaced by concrete slabs of the runway. Because soil sealing reduces the growth of plants, this horizon is not able to develop again. The lack or initial stages of humus horizons in Ekranosols was also reported by Greinert (2003).

Reaction and carbonates

Soils occurring within the airfield were poor in $CaCO_3$ (0.1–0.2%) and less abundant in this component compared to other technogenic soils in Toruń (Charzyński et al. 2011). This is probably related to the airfield location in the area with no previous building development (no artefacts found in the profiles, e.g. fragments of brick or mortar).

The analysed soils were characterised by increased pH values compared to natural soils in the Toruń Basin (Bednarek, Jankowski 2006). Values of pH in the material above the buried Brunic Arenosol (Profile 2) ranged from 8.8 to 5.3 (in H_2O) and from 8.0 to 5.1 (in KCl); whereas reaction of the buried soil was acid.

According to Greinert (2003), strongly alkaline reaction of layers directly beneath the technic hard rock (pH 8.8–9.6) and a small content of calcium cations may be related to low buffer capacity of road construction materials (washed sand). This phenomenon can be accounted for high values of pH in the reference soil from the airfield (profile 1 – 7.5), which was located in the vicinity of concrete slabs cleared of snow with the use of i.a. salt.

Organic matter properties and total phosphorus content

The content of organic carbon (OC) highly varied in the analysed soils – from 0.09 to 2.39%. The highest values occurred in the humus horizon of profile 1 (0.86%) and in the humus horizon Ap2 of profile 2 (2.39%). The total content of nitrogen (N_t) has a similar pattern – from 0.006% in the horizon directly beneath the concrete in profile 2 to 0.138% in the humus horizon Ap2 of the same profile. The studied technogenic soils had a wide ratio of organic carbon to total nitrogen (18–25). The C:N ratio in the upper layers of Ekranic Technosols is wider in the covered soil (23) compared to reference soil (16). This could indicate a generally lower biological activity in the covered soils.

The total phosphorus content (P_t) in the studied soils of the airfield ranged from 65 to 163 $mg \cdot kg^{-1}$. Small amounts of P_t corresponded to geochemical background values of sandy soils occurring on terrace IV of the Vistula River (Geochemical Atlas of Poland 1995). This indicated the absence of anthropogenic/technogenic enrichment with this element in the area. As in the case of calcium carbonate content, the total phosphorus content in the studied soils was much lower compared to Ekranosols in the centre of Toruń, where it ranged from 46 to even 2 599 $mg \cdot kg^{-1}$ (Charzyński et al. 2011).

Heavy metal content and magnetic susceptibility

Samples from horizons Ap and A/Bp of unsealed soil and samples from horizons Ap1, B/C and Ap2 from soil under the runway (Table 3) were analysed in terms of heavy metal (HM) content and magnetic susceptibility (κ).

The content of heavy metals was several times lower in the covered soil from the airfield compared to reference soil next to the runway. This could be attributed to the protective effect of impermeable road surfaces, reducing the impact of industrial and traffic emission.

Table 3. Content of heavy metals soluble in 2M HNO_3 (HM), magnetic susceptibility (κ) in the examined profiles and Pearson's correlation coefficient (κ:HM)

Depth [cm]	κ [10^{-8} $m^3 \cdot kg^{-1}$]	Fe	Mn	Zn	Pb	Cd	Cu	Cr	Ni	Co
		HM [$mg \cdot kg^{-1}$]								
Profile 1										
0–18	5.6	862	63.2	5.3	4.7	<0.01	1.4	0.4	0.6	0.4
55–74	3.3	725	56.8	0.9	2.5	<0.01	0.3	<0.1	0.8	<0.1
Profile 2										
15–20	2.7	714	36.2	1.0	2.5	<0.01	0.1	0.3	0.6	0.3
20–60	2.1	720	15.3	0.9	1.2	<0.01	0.2	<0.1	0.9	<0.1
60–63	5.1	1248	13.0	2.1	4.7	<0.01	3.7	0.6	1.7	<0.1
MEAN		853	36.9	2.04	3.12	<0.01	1.14	0.43	0.92	0.35
SD		228	23.1	1.89	1.54	<0.01	1.52	0.15	0.49	0.07
κ:HM		0.98	0.88	0.94	1.00	0.98	0.87	0.96	0.20	0.98

According to Kocher and Wessolek (2003), soils in the direct vicinity of the road surface are characterised by strong sorption of certain metals (Cd, Cu, Ni, Zn). Their content decreases with a distance from a roadway. Also Nehls et al. (2008) observed that the material filling the gaps between pavement slabs is characterised by a high content of heavy metals, particularly lead. Contrary to loamy material, sandy soil material does not absorb lead, which may explain a small content of this element in sandy soils near the roads (Bouvet et al. 2003). According to Imperato et al. (2003), exhaust gases are the source of Pb, Zn and Cu content in soils, whereas Tijhuis et al. (2000) reported from Norway that car tyres carry large amounts of road dust in winter, which contains an elevated amount of Cd, Cr, Cu, Pb and Zn. The main cause of the increased Pb content was leaded petrol, currently not in use. Abrasion of tyres is partly responsible for the content of Zn and Cd in the soil, because different parts of the braking system, e.g. braking blocks, contain Cu and Zn. Other sources of heavy metals include i.a. industrial emissions and garbage.

As evidenced by the presented research, the content of heavy metals in the soil of the Toruń airfield was low compared to the background represented by reference unsealed soils adjacent to profiles of Ekranosols. This was associated with a small traffic of vehicles limited to aircraft taxiing and rare passages of cars. Therefore, the above-mentioned sources of pollution had no significant effect on the soil properties.

Soil microbiological properties

The total number of bacteria and fungi, as well as the abundance of selected physiological groups of microorganisms was determined in the selected samples collected from all the profiles in the Toruń airfield.

The largest number of bacteria was found in the Ap horizon of the reference soil – $6.61 \cdot 10^{-6}$ cfu·g^{-1}. Much fewer bacteria occurred in layers immediately beneath the concrete and at a depth of 50 cm in the reference and sealed soil: from $8.4 \cdot 10^{-4}$ to $4.18 \cdot 10^{-5}$ cfu·g^{-1} (Fig. 3). The concrete cover contributed to the fact that the number of bacteria directly under the slabs was comparable to the number of bacteria at a depth of 50 cm, both in sealed and reference, unsealed soil. The distance from the edge of the airfield apron was irrelevant.

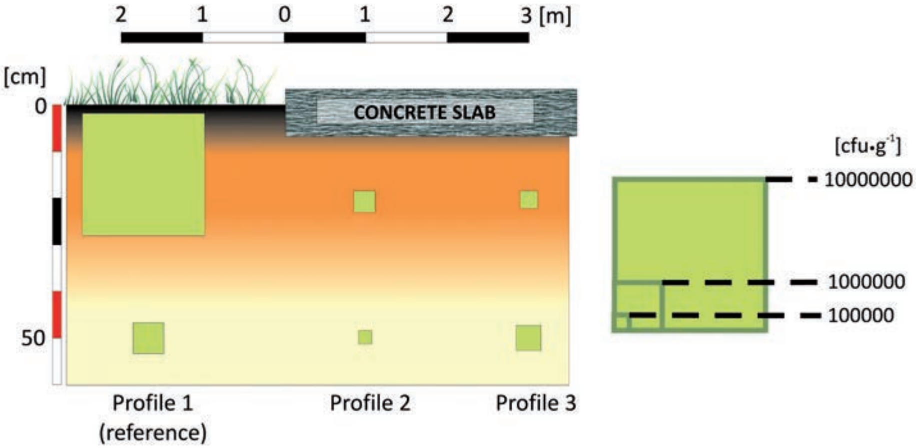


Fig. 3. The number of bacteria (cfu – colony forming units)

A similar situation was observed with fungi. The largest number of fungi was found in the Ap horizon of the reference soil – $9.0 \cdot 10^{-4}$ cfu·g^{-1}, and a much smaller number in the horizons immediately beneath the concrete slabs and at a depth of 50 cm both in the reference and sealed soil: from $9.5 \cdot 10^{-2}$ to $2.06 \cdot 10^{-3}$ cfu·g^{-1} (Fig. 4). As in the case of bacteria, the number of fungi in the horizon immediately beneath the concrete was comparable with their number at a depth of 50 cm of the sealed and unsealed soil. The distance from the edge of the airfield apron was irrelevant.

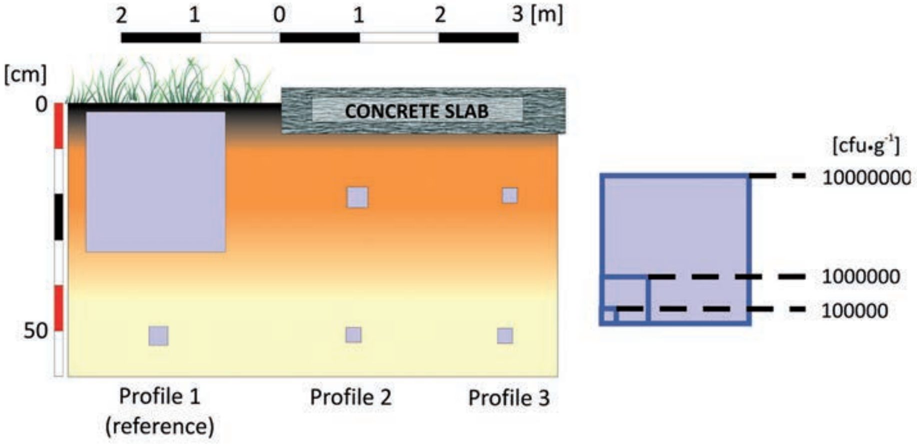


Fig. 4. The number of fungi (cfu – colony forming units)

The comparison between the reference and sealed soil revealed only an increase in the number of amonifiers in Ekranic Technosol situated within a distance of 1 m from the edge of the airfield apron (profile 2). Their number was similar in profile 3, situated 3 m from the edge of the apron, and in the reference soil. The number of denitrifiers was reduced in the profiles under the concrete. The number of bacteria reducing methylene blue was similar in profile 1 (the reference) and profile 2 (under the concrete). Whereas in profile 3 under the concrete at a depth of 20 cm, their number was two times lower compared to the reference soil at a depth of 10 cm. In the horizon situated at a depth of 50 cm of the sealed soil in profile 3, the number of these bacteria was two times higher compared to profile 1. The number of glucose acidifying bacteria significantly decreased in horizons at a depth of 20 cm in profiles 2 and 3 compared to horizon Ap of the reference soil. As in the case of methylene-blue reducing bacteria, this increase may be explained by a higher content of organic matter in the buried humus horizon (Table 4).

The studied Ekranosols contain a reduced number of microorganisms in the topsoil, which contributed to anaerobic conditions and a low content of organic matter. 'New microbiological conditions prevailing under the covered surface determine the development of anaerobic microorganisms and the reduction processes. Furthermore, lower and more stable temperatures in Ekranosols are conducive to the development of specific psychrotrophic microorganisms' (Bednarek, Jankowski 2006).

Also Wessolek (2008) emphasizes that soil sealing destroys the habitat of soil fauna and flora by disturbing the circulation of matter and energy in the soil.

Table 4. The number of microorganisms with specific physiological properties per 1 g dry weight

Depth [cm]	amonifiers	denitrifiers	methylene blue reducers	glucose acidifiers
Profile 1 (reference)				
10	15 900	47 800	122 200	122 200
50	4 600	20 600	46 400	4 600
Profile 2 (1 m of the concrete slab edge)				
20	258 000	150	154 800	3 100
50	770	46 000	25 500	4 600
Profile 3 (3 m of the concrete slab edge)				
20	20 400	1 500	45 900	11 700
50	4 700	2 600	113 800	25 900

The British researchers were comparing different urban soils: from under the trees surrounded by pavement slabs, near busy streets, as well as in allotment gardens and urban parks, and they proved that the former had the lowest microbial activity (Bullock, Gregory 1991).

According to Machulla et al. (2003), the surface soil layers (0–5 cm), which are rich in organic matter and relatively well aerated, are characterised by the highest biomass and microbial activity. As evidenced by Quantin et al. (2003), who studied soils in New Caledonia, the availability of organic matter is the main parameter controlling the activity of bacteria in the soil. The biological activity is reduced in sealed soils with no or fragmentary humus horizons. Lower and more stable temperature under the asphalt favours the development of specific microorganisms while reducing the growth of microorganisms decomposing the organic debris (Stroganova et al. 1998).

Summary

One of the distinguishing features of urban soils is no exchange of components between the environmental elements as a result of compact cover (Burghardt 1996). Road and other covered surfaces modify the ecosystem structure and indirectly affect the uncovered urban soils, which are open for exchange processes (Stroganova, Prokofieva 2001).

Although Ekranosols are not capable of fulfilling several biocenological functions, there is still a poor exchange of gases between the atmosphere and the microorganisms. Roots of plants may penetrate through artificial surface, which leads to its destruction, while grass and shrubs may grow in crevices (Stroganova et al. 1998). It is assumed that areas of Ekranic Technosols, abandoned as a result of physical and biological weathering (plants taking root in crevices and cracking), are again exposed after a certain time. According to Stroganova et al. (1998), soil fauna may transform the soil structure even under the cover. Whereas Burghardt et al. (2003) and Nelhs et. al. (2006) believe that substances in the soil under pavement slabs accumulate in gaps between the slabs. A similar phenomenon is observed in the Toruń airfield where grass covered gaps between slabs and cracking. The above-mentioned processes are inhibited and their effects are mitigated by regular removal of vegetation growing on the airfield apron and sealing up of new crevices. It can be assumed that carbon enriching the material within crevices of the Toruń airfield slabs is of natural origin, and admixtures from combustion gases (Nehls et al. 2006) are negligible.

According to Stroganova et al. (1998), the artificial surface directly and indirectly affects the components of urban ecosystems, and therefore, road surfacing technology should be improved. They should be more water and air permeable. On the other hand, soil sealing should be reduced. Compared to unsealed soils, Ekranosols exert much lesser impact on the functioning of ecosystems in urban areas. They are not involved in a number of soil-forming processes. The sealed soils, however, can be treated the same way as the nearby, unsealed soils since they are also a component of urban soil cover. They should be reclaimed for green areas (Stroganova et al. 2003). Other authors, i.a. Prokofieva and Gubankov (2000), observed that Ekranosols may be useful after removal of a sealing cover. According to Burghardt et al. (2003), they should be regarded as soils, not grounds, even though they do not serve a productive function and they are not involved in the processes of soil-environment exchange. Due to the lack of fresh organic matter supply, the circulation of chemical elements is very limited in Ekranic Technosols (Tobiasova 2004).

The sealed soils are an essential component of a city. They should be researched and charted, because their characteristics affect the ecological situation in a city (Stroganova, Prokofieva 2000). Ekranosols are also important because they store information about the history of the urban ecosystem. Their boundaries are sharp and easy to identify. Profiles of Ekranosols have both natural and technogenic horizons. One could say that they are in hibernation and they are ready to be exposed and restored to their original functions.

Sealed soils differ to a large extent from not covered soils in terms of morphology and several physical, chemical and microbiological properties. Ekranic Technosols of the Toruń airfield were characterised by a destroyed upper part of the soil profile as a result of land levelling. They had higher bulk density in the horizon immediately below the concrete or asphalt as a consequence of compaction during the construction and/or compaction caused by vibrations resulting from taxiing down the runway. Isolation of the soil from the rainwater caused desiccation of the upper layer of the sealed soil compared to surface horizons of the reference soil without a technic hard rock. They were also characterised by elevated pH values in the layer directly below the concrete, e.g. due to leaching of carbonates from the concrete slab or their penetration through cracking caused by salt used for snow removal. Other characteristics included a small content of heavy metals compared to adjacent unsealed soil, which resulted from a protective effect of the artificial surface (pavement).

A wide range of the C:N ratio in the soil beneath the concrete may prove its low biological activity. Microbiological analysis has repeatedly revealed a reduced number of microorganisms in the upper layer of the covered soil. The abundance of bacteria and fungi colonies under the concrete slabs was much smaller compared to the surface horizon of unsealed soil. This was caused by anaerobic conditions and destruction of the humus horizon.

This study was financed by Polish Ministry of Science and Higher Education (grant No. N N306 463738).

References:

1. Bednarek R., Jankowski M. 2006. Soils. [In:] L. Andrzejewski, P. Weckwerth, S. Burak (Eds.). *Toruń and its surroundings – Environmental Monograph*. Wyd. UMK, Toruń: 153–176 (in Polish with English Summary).
2. Bouvet M., Francois D., Schwartz Ch. 2003. Road soil retention of heavy metals leached from Municipal Solid Waste Incinerator bottom ash used in road construction. *SUITMA 2003 Abstracts*. Nancy, France: 121–123.
3. Bullock P., Gregory P. 1991. *Soils in the Urban Environment*. Blackwell Scientific Publications, Oxford: 148.
4. Burghardt W. 1996. *Urbaner Bodenschut*. Springer Verlag, Berlin.
5. Burghardt W. 2001. Soils of Low Age as Specific Features of Urban Ecosystem. [In:] J. Sobocká (Ed.) *Soil Anthropization VI*. Bratislava, Slovakia: 11–18.
6. Burghardt W., Hagedorn A., Komossa M., Wenikajtys M. 2003. Characteristics and Types of Street Soils. *SUITMA 2003 Abstracts*. Nancy, France: 55–57.
7. Charzyński P., Bednarek R., Błaszkiewicz J. 2011. Morphology and properties of Ekranic Technosols in Toruń and Cluj-Napoca. *Rocz. Glebozn.* 62(2): 1–6 (in Polish with English Summary).
8. Commission of the European Communities (CEC). 2006. *Thematic Strategy for Soil Protection – COM* (*2006*)/231. http://ec.europa.eu/environment/soil/pdf/com_2006_0231_en.pdf.
9. Craul P. G. 1992. *Urban Soils in Landscape Design*. Wiley, New York.
10. Desaules A., Hämmann M., Weisskopf M. 2001. *Commentary on the Ordinance of 1st July 1998 relating to impacts on the soil* (*OIS*). Swiss Agency for the Environment, Forest and Landscape, Berne.

11. Gebhardt H. 1982. Phosphatkartierung und bodenkundliche Gelände untersuchungen zur Eingrenzung historischer Siedlungs – und Wirtschaftsflächen der Geestinsel Flögeln, Kreis Cuxhaven. *Probleme der Küstenforschung im Südlichen Nordseegebiet*, Band 14: 1–10.
12. *Geochemical Atlas of Poland*. 1995. J. Lis, A. Pasieczna (Eds.). 1: 2 500000, Państwowy Instytut Geologiczny, Warsaw.
13. Gerasimova M. I., Stroganova M. N., Możarova K. W., Prokofieva T. W. 2003. *Anthropogenic soils* (*genesis, geography, recultivation*). Moscow (in Russian).
14. Greinert A. 2003. *Studies on soils of Zielona Góra urban area*. Oficyna Wydawnicza Uniwersytetu Zielonogórskiego, Zielona Góra (in Polish).
15. Imperato M., Adamo P., Naimo D., Arienzo M., Stanzione D., Violante P. 2003. Spatial Distribution of Heavy Metals in Urban Soils of Napoli. *SUITMA 2003 Abstracts*, Nancy. France: 101–103.
16. IUSS Working Group WRB. 2007. *World References Base for Soil Resources 2006*. Update 2007, World Soil Resources Reports, 103, FAO, Rome.
17. Kocher B., Wessolek G. 2003. Road Runoff Changes Sorption Characteristics of Sandy Roadside Soils. *SUITMA 2003 Abstracts*, Nancy. France: 97–99.
18. Machulla G., Franzke F., Besch-Frotscher W., Felinks B. 2003. How different are the microbial properties of anthropogenic soils from those in undisturbed soils. *SUITMA 2003 Abstracts*. Nancy, France: 67–69.
19. Nehls T., Józefaciuk G., Sokołowska Z., Hajnos M., Wessolek G. 2006. Pore-system characteristics of pavement seam materials of urban sites. *J. Plant Nutr. Soil Sci.* 169: 16–24.
20. Nehls T., Józefaciuk G., Sokołowska Z., Hajnos M., Wessolek G. 2008. Filter properties of seam material from paved urban soils. *Hydrol. Earth Syst. Sc.* 12: 691–702.
21. Niewiarowski W., Weckwerth P. 2006. Genesis and relief development. [In:] L. Andrzejewski, P. Weckwerth, S. Burak (Eds.). *Toruń and its surroundings – Environmental monograph*. Wyd. UMK, Toruń: 65–98 (in Polish with English Summary).
22. Prokofieva T., Gubankov A. 2000. Sealed Soils in Urban Cover. [In]: W. Burghardt, Ch. Dornauf (Eds.) *First International Conference on Soils of Urban, Industrial, Traffic and Mining areas, Proceedings*, 1. Essen, Germany: 270.
23. Quantin C., Becquer T., Rouiller J., Berthelin J. 2003. Impact of Bacterial Activity on Metal Mobilisation and Redistribution in a New Caledonia Soils. *SUITMA 2003 Abstracts*. Nancy, France: 73–75.
24. Reshotkin O. 2003. *Properties of Soils in Urban Areas* (*Exemplified by the Soils of Pushchino*). *SUITMA 2003 Abstracts*. Nancy, France: 191–195.
25. Słowiński K. 1983. *Toruń airfield 1920–1945*. WKiŁ, Warsaw (in Polish).
26. Stroganova M., Myagkova A., Prokofieva T., Skvortsova I. 1998. *Soils of Moscow and urban environment*. Moscow.
27. Stroganova M., Prokofieva T. 2000. Urban Soils – concept, definitions, classification. [In]: W. Burghardt, Ch. Dornauf (Eds.) *First International Conference on Soils of Urban, Industrial, Traffic and Mining Area, Proceedings*, 1. Essen, Germany: 235–239.

28. Stroganova M., Prokofieva T. 2001. Urban Soils – a Particular Specific Group of Anthrosols [In:] J. Sobocká (Ed.) *Soil Anthropization VI*. Bratislava, Slovakia: 23– 28.
29. Stroganova M., Prokofieva T. 2003. Soil Survey and Ecological Status Estimation of Urban Areas. *SUITMA 2003 Abstracts*. Nancy, France: 233–235.
30. Tijhuis L., Brattli B., Sether O. M. 2000. A Geochemical survey of topsoil in the city of Oslo. Norway, *Environ. Geochem. Health* 24: 67–94.
31. Tobiasova M. 2004. Specific Problems of Urban Soils Research in the area of Prešov. [In:] J. Sobocká (Ed.) *Soil Anthropization VIII*. Bratislava, Slovakia: 123.
32. van Reeuwijk. L.P. 2006. *Procedures for soil analysis*. 7th Edition. Technical Report 9, ISRIC – World Soil Information, Wageningen, Netherlands.
33. Wessolek G. 2008. Sealing of Soils. [In:] J. M. Marzluff, E. Shulenberger, W. Endlicher, M. Alberti, G. Bradley, C. Ryan, U. Simon, C. Zumbrunnen (Eds.). *Urban Ecology. An International Perspective on the Interaction Between Humans and Nature*. Springer, Berlin: 161–179.