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Filtration Properties of Anthropogenic Soils in Kozłówka Manor Park

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ABSTRACT

A study of the filter properties of soils in relation to water and air in the manor park in Kozłówka in the Lublin Province was carried out. The natural soils of the area are represented mainly by black soils formed from loamy sand. The soils of the park show significant differences from the natural soil cover, as they have been subjected to radical anthropogenic impacts as a result of various works associated with the construction and redevelopment of the palace buildings and the change of land use. As a result, there are now soils within the park that are classified as Anthrosols or Technosols. In all the studied pedons, the natural genetic horizons were obliterated, in some layers there was a change in the texture. The positive effect of anthropogenisation was mainly manifested in the high organic carbon content of the surface layer of all pedons. To analyse the filter properties of the soils, samples of preserved structure were taken from layers 0–10 cm, 20–30 cm and 40–50 cm into standard cylinders. The following properties were determined: the water filtration coefficient in the saturated zone (Ks); the water permeability; the air permeability at water potential states in the range -0.98 kPa to -49.00 kPa; the full water capacity and the air capacity. Considering the area of the entire park, it must be said that the filtration properties showed high levels in relation to both water and air. The water permeability was characterised by very high values. Also for air permeability in the field water capacity condition, very high and high values predominated. Particularly high values of this trait were found in the surface layer, rich in organic carbon. The presence of construction debris in large quantities in Urbic Technosols had the effect of reducing air permeability. The results obtained from the study of the filtering properties of the soils of the manor park in Kozłówka can provide an essential source of information which is the basis for undertaking possible recultivation and care works, which are necessary for the conscious shaping of the park establishment.

Keywords: manor park, Kozłówka, filter properties, anthropogenic soils.

INTRODUCTION

Soils in parks and gardens play a significant role in regulating microclimate by allowing the flow and evaporation of water. Additionally, they counteract floods by controlling the runoff of surface water and store a substantial amount of organic carbon in the soil [Tresch et al. 2018]. In the case of park and garden settings, the correct arrangement of the physical properties of the soil ensures not only the proper functioning of the ecosystem but, very importantly, a spectacular visual effect [Setälä et al. 2016]. Bringing plants, which are sometimes very demanding, to their optimum condition involves providing their root systems with the necessary amounts of water and air. A significant threat to the vegetation of parks and gardens is posed by water scarcity, related to climatic conditions [Wagner et al. 2013]. Under the influence of water scarcity, plant vitality decreases, mainly in trees [Jim 2019, Rahman et al. 2019]. Excessive soil moisture caused by heavy rainfall and flooding can pose an equally high risk [Orzepowski et al. 2017]. Moisture has a significant impact on the physical properties of soil, especially in the context of water dynamics influenced by external factors, such as rainfall. This is most evident in the surface layers of the soil, where water flow is observed in two directions: descending (infiltration) and ascending (evaporation) [Simůnek et al. 2013]. Research on the physicochemical properties of soils in parks and gardens are often described in world literature [Yang and Zhang 2015; Charzyński et.al 2018; Lindén et al. 2020,]. However, there are still too few analyzes regarding filtration properties. This issue is particularly important because it allows for a better understanding of the soils ability to transmit water, which is important for water balance, flood avoidance, and overall ecosystem health. Additionally, the filtration properties of the soil influence the retention of groundwater and are crucial for maintaining the appropriate level of humidity, which is of fundamental importance for vegetation and the functions of the ecosystem of parks and gardens.

Bakhmatova et al. [2022] reviewed the results of studies of urban park soils located in cities on different continents. This review shows that the properties of soils and the ways in which they function are determined by the action of natural and anthropogenic factors such as the history of parks, the length of time they have been in operation, the ways in which soils have been transformed and the nature of the vegetation cover. The soil cover in urban parks is therefore heterogeneous and a combination of natural and anthropogenic components. Chupina (2020) concluded from a study of botanical garden soils that the diversity of anthropogenic influences determines the diversity of their structure. As a result, these soils combine the characteristics of agricultural soils (due to their loosening and use of fertilizers), urban soils (due to the use of various materials containing anthropogenic inclusions) and natural soils.

This paper contains the results of a study, which is a continuation of an earlier research of the physical condition of soils in the manor park in Kozłówka (Lubelskie Voivodeship, Lubartów County) [Słowińska-Jurkiewicz and Jaroszuk-Sierocińska 2015]. It presents material on the filtration properties of soils in relation to water and air. This is a very important issue, as soil irrigation and aeration are carried out, as required, in the park in Kozłówka as part of reclamation and maintenance works [Zamoyski Museum in Kozłówka 2022].

MATERIAL AND METHOD

The palace and garden complex in Kozłówka is located on the terrace of the Parysówka river, in the Lubartowska Upland mesoregion. The soils of this area are represented mainly by Phaeoziems formed from loamy sand. Under natural conditions, these soils were included in the weak cereal-pasture agricultural suitability complex (9). They were characterised by periodic heavy waterlogging, so drainage was carried out in the 1970s. As a consequence of drainage in years of low rainfall, there is most often a shortage of water in soils of complex 9.

The soils of the park show significant differences from the natural soil cover; they have been radically anthropogenically impacted as a result of the various works associated with the construction and redevelopment of the palace buildings and the change of land use. As a result, there are currently soils within the park that are classified as Anthrosols or Technosols according to IUSS Working Group WRB [2014].

The research was conducted on five pedons: I Plaggic Anthrosol, II Terric Anthrosol, III Urbic Technosol, IV Urbic Technosol, and V Terric Anthrosol. In Anthrosols there is a diagnostic level of plaggic or terric, and in Urbic Technosols (by volume) artefacts in the amount of $\geq 20\%$, i.e. manmade or transformed substances, for example building rubble. The plaggic horizon is a mineral surface horizon, black or brown in colour, produced as a result of the fertilisation of agricultural fields with a mixture of turf and other bedding materials and animal droppings. The terric horizon is a mineral surface horizon that is formed by the addition of earthy fertilisers, compost, loess or silt to the soil over an extended period of time.

For the analysis of the filtration properties of the soils, samples of preserved structure were taken from the 0–10 cm, 20–30 cm, 40–50 cm layers in 10 replicates into standard cylinders with a volume of 100 cm^3. Half of the samples were used for saturated water permeability testing and half for air permeability and soil air capacity (pore volume) testing.

The water filtration coefficient in the saturated zone (Ks) was determined with the Wita ICW apparatus (Eijkelkamp Agrisearch Equipment, The Netherlands) using the constant water level method. Based on the value of the filtration coefficient, the water permeability (water conductivity in the saturated zone) per $m \cdot d^{-1}$ was determined.

Air permeability measurements ($10^{-8} \cdot m^2 \cdot Pa^{-1} \cdot s^{-1}$) at water potential states in the range -0.98 kPa to -49.00 kPa were carried out with an LPiR-2e type apparatus (Multiserw-Morek, Poland). Measurements were carried out at a constant ambient temperature (20±0.5°C), so it was not necessary to take into account the dynamic viscosity of the air.

The air capacity at each potential state between -0.98 kPa and -49.00 kPa was calculated based on the difference between the full volumetric water capacity of the soil and the water content of the soil at each potential state. The full water capacity was determined when the soil was completely saturated with water. Soil water potential-moisture characteristics were prepared from determinations made in low-pressure chambers on porous ceramic plates (Eijkelkamp Agrisearch Equipment, The Netherlands, Soil Moisture Equipment Co. USA). The following soil pore equivalent diameters corresponded to the subsequent soil water potential values: -0.98 kPa – 300 µm; -3.10 kPa – 100 µm; -9.81 kPa – 30 µm; -15.54 kPa – 20 µm; -31.00 kPa – 10 µm; -49.00 kPa – 6 µm.

The texture of the soil was determined using the Bouyoucos-Casagrande areometric method modified by Prószynski. The content of the coarse texture was determined as a percentage of soil volume during field work. The soil were classified into texture groups according to the criteria of PTG [2009]. The organic carbon content ($g\cdot100^{-1}g^{-1}$) was determined using the Tiurin method with Simakov modification.

As the distribution of filtration property values does not have the character of a normal distribution [Kołodziej 2020], a statistical analysis was abandoned. For each layer in each pedon, the values of water permeability (saturated water conductivity) and air permeability and air capacity in the field water capacity state were classified into the appropriate class. According to Paluszek [2011], the limit numbers for water permeability are: ≤ 0.100 $m\cdot d^{-1}$ – 'very low', 0.101–0.500 $m\cdot d^{-1}$ – 'low', 0.501–2.000 $m\cdot d^{-1}$ – 'medium', 2.001–10.00 $m\cdot d^{-1}$ – 'large', >10.00 $m\cdot d^{-1}$ – 'very large'. For air permeability at field water capacity (-15.54 kPa), the limit numbers are: $1.8\cdot10^{-8}$–$5.0\cdot10^{-8}\cdot m^2\cdot Pa^{-1}\cdot s^{-1}$– 'very small', $5.1\cdot10^{-8}$–$20.0\cdot10^{-8}\cdot m^2\cdot Pa^{-1}\cdot s^{-1}$ – 'small', $20.1\cdot10^{-8}$–$50.0\cdot10^{-8}\cdot m^2\cdot Pa^{-1}\cdot s^{-1}$ – 'medium', $50.1\cdot10^{-8}$–$100.0\cdot10^{-8}\cdot m^2\cdot Pa^{-1}\cdot s^{-1}$ – 'large', $>100.0\cdot10^{-8}\cdot m^2\cdot Pa^{-1}\cdot s^{-1}$– 'very large'. The limiting numbers proposed for total porosity were used to evaluate the volume water capacity.

RESULTS AND DISCUSSION

In all of the pedons studied, natural genetic horizons have been obliterated as a result of construction work and mechanical cultivation and years of intensive introduction of organic and mineral materials. In pedon I Plaggic Anthrosol occurs in the 0–50 cm layer of the diagnostic horizon of plaggic (Figure 1). In pedon II Terric Anthrosol occurs in the 0–60 cm layer of the diagnostic horizon of terric (Figure 2). In pedon III of the Urbic Technosol, there is a layer from 0 to below 60 cm containing an average of approximately 20% (v/v) of artefacts in the form of construction debris (Figure 3). In pedon IV of Urbic Technosol there was a similar layer with an average of approximately 25% (v/v) construction rubble content (Figure 4). Pedon V Terric Anthrosol contained a two-part terric diagnostic horizon, consisting of a 0–20 cm layer, formed by organic

Figure 1. Pedon I Plaggic Anthrosol, a site of soil excavation (the lawn at the end of the French garden) (Photo: M. Jaroszuk-Sierocińska)

Figure 2. Pedon II Terric Anthrosol, a site of soil excavation (the lawn next to the chateau in the French garden) (Photo: M. Jaroszuk-Sierocińska)

Figure 3. Pedon III Urbic Technosol, a site of soil excavation (the front lawn of the palace) (Photo: M. Jaroszuk-Sierocińska)

Figure 4. Pedon IV Urbic Technosol, a site of soil excavation (the lawn on the side of the entrance gate) (Photo: M. Jaroszuk-Sierocińska)

matter enrichment, and a 20–60 cm layer, formed by the addition of large amounts of clay to the clayey-sandy material (Figure 5). Considering the texture of the investigated soils, it should be noted that the majority of pedons were dominated by loamy sand or sandy loam (Tables 1–5). The most dramatic change in soil particle size occurred in pedon V, where clay material was used as a drainage substance in the layer below 20 cm. Similary in pedons III and IV (Urbic Technosols) significant amounts of building rubble were found in all the layers tested. The positive effect

Figure 5. Pedon V Terric Anthrosol, a site of soil excavation (the lawn next to the rose garden) (Photo: M. Jaroszuk-Sierocińska)

of anthropogenisation was mainly manifested in the high organic carbon content of the surface layer of all pedons, especially pedon V.

Water permeability (water conductivity in the saturated zone) showed very high values in most of the layers, allowing this feature to be included in the ‘very high’ class (Table 6). Only in the 40–50 cm layer in pedon II was the water permeability rated as ‘high’ and in the same layer in pedon III as ‘medium’. Extremely high values of water permeability were found in the 0–10 cm layer of pedon V. It should be considered that the very high water filtration in the surface layer of pedon V was conditioned by the high organic carbon content, favouring the formation of soil aggregate structure. Equally important was the presence of numerous earthworms (Lumbricus terrestris) forming a network of channels. In effect, the network of interconnected macropores allowed water to drain very quickly. Particular attention should be paid to the 20–30 cm and 40–50 cm layers in the same pedon, with a texture of sandy loam. The enrichment of the soil material in the clay fraction resulted in a dramatic reduction in the full volumetric water capacity. However, the water permeability in these layers was ‘very high’. This was due to the presence of zoogenic channels in the compacted sandy silty material, filled with loose humus material displaced from the surface layer. Although these channels

Table 1. Basic properties of I Plaggic Anthrosol

Pedon	Layer [cm]	Diameter of fraction content in [mm] [g·100^{-1}g^{-1}]			Granulometric group	$C_{org.}$ [g·100^{-1}g^{-1}]	Features
		2–0.05	0.05–0.002	≤ 0.002			
I Plaggic Anthrosol	0–10	69	30	1	Sandy loam	1.50	No anthropogenic admixtures, numerous earthworms
	20–30	67	32	1	Sandy loam	0.61	No anthropogenic admixtures, numerous earthworms
	40–50	77	20	3	Loamy sand	0.25	No anthropogenic admixtures, numerous earthworms

Table 2. Basic properties of II Terric Anthrosol

Pedon	Layer [cm]	Diameter of fraction content in [mm] [g·100^{-1}g^{-1}]			Granulometric group	C org. [g·100^{-1}g^{-1}]	Features
		2–0.05	0.05–0.002	≤ 0.002			
II Terric Anthrosol	0–10	73	25	2	Loamy sand very poorly skeletal	3.13	Pieces of bricks measuring 20–40 mm, very abundant earthworms
	20–30	62	33	5	Sandy loam very poorly skeletal	0.97	Few pieces of bricks measuring 20–40 mm
	40–50	70	27	2	Sandy loam very poorly skeletal	0.61	20–40 mm pieces of brick

Table 3. Basic properties of III Urbic Technosol

Pedon	Layer [cm]	Diameter of fraction content in [mm] [g·100^{-1}g^{-1}]			Granulometric group	C org. [g·100^{-1}g^{-1}]	Features
		2–0.05	0.05–0.002	≤ 0.002			
III Urbic Technosol	0–10	77	22	1	Loamy sand poorly skeletal	2.98	Few pieces of bricks and building limestone measuring 5–50 mm, few earthworms
	20–30	78	18	4	Loamy sand medium skeletal	0.67	Numerous pieces of bricks and building limestone measuring 5–50 mm
	40–50	60	36	4	Sandy loam poorly skeletal	0.61	Few pieces of bricks and building limestone measuring 5–50 mm

Table 4. Basic properties of IV Urbic Technosol

Pedon	Layer [cm]	Diameter of fraction content in [mm] [g·100^{-1}g^{-1}]			Granulometric group	C org. [g·100^{-1}g^{-1}]	Features
		2–0.05	0.05–0.002	≤ 0.002			
IV Urbic Technoso	0–10	75	21	4	Loamy sand medium skeletal	2.94	Numerous pieces of brick and building limestone measuring 2–50 mm
	20–30	73	18	9	Sandy loam medium skeletal	0.92	Numerous pieces of brick and building limestone measuring 2–50 mm, traces of vole and mole activity
	40–50	71	21	8	Sandy loam medium skeletal	0.12	Pieces of brick and building limestone measuring 2–50 mm, traces of vole and mole activity

Table 5. Basic properties of Pedon V Terric Anthrosol

Pedon	Layer [cm]	Diameter of fraction content in [mm] [g·100^{-1}g^{-1}]			Granulometric group	C org. [g·100^{-1}g^{-1}]	Features
		2–0.05	0.05-0.002	≤ 0.002			
V Terric Anthrosol	0–10	57	37	6	Sandy loam	6.03	Few pieces of bricks measuring 5–10 mm, numerous earthworms
	20–30	48	24	28	Sandy clay loam	0.32	No anthropogenic admixtures, few earthworms, few vertical zoogenic channels
	40–50	46	23	31	Sandy clay loam	0.25	No anthropogenic admixtures, few earthworms, few vertical zoogenic channels

Table 6. Full water capacity (v/v) and water permeability in the saturated zone (K*s*)

Pedon	Layer [cm]	Full water capacity (*v/v*) $[m^3 \cdot m^{-3}]$	Full water capacity class (*v/v*)	Water permeability in the saturated zone (K*s*) $[m \cdot d^{-1}]$	Water permeability class in the saturated zone (K*s*)
I Plaggic Anthrosol	0–10	0.528	Very high	24.96	Very high
	20–30	0.455	High	26.84	Very high
	40–50	0.411	Medium	11.76	Very high
II Terric Anthrosol	0–10	0.545	Very high	14.23	Very high
	20–30	0.422	Medium	22.60	Very high
	40–50	0.385	Low	4.26	High
III Urbic Technosol	0–10	0.494	High	19.06	Very high
	20–30	0.391	Low	13.94	Very high
	40–50	0.408	Medium	0.75	Medium
IV Urbic Technosol	0–10	0.478	High	41.54	Very high
	20–30	0.393	Low	77.24	Very high
	40–50	0.397	Low	120.81	Very high
V Terric Anthrosol	0–10	0.698	Very high	195.35	Very high
	20–30	0.348	Very low	45.26	Very high
	40–50	0.340	Very low	28.61	Very high

were sparse, the vertical direction of the channels may have played an important role in water filtration. Further very high water permeability values were found in the 20–30 cm and 40–50 cm layers in pedon IV, where zoogenic channels 40–60 mm in diameter were present, indicative of vole and mole activity. The lowest water permeability was found in the 40–50 cm layer of pedon III. It was attributable to the lack of activity of the soil macrofauna and the blocking effect of construction debris. It should be emphasised that the predominant 'very high' water permeability in the investigated soils occurred regardless of the size of the full water capacity. 'Very high' water permeability was found at all classes of full water capacity, i.e. both 'very high' and 'very low'.

The air capacity of the soil, which shapes to a large extent the filtering properties in relation to air, increased as water potential and gravitational runoff decreased (Table 7). In most pedons, air capacity showed the highest values in the surface layer, regardless of water potential status. In the state of field water capacity (-15.54 kPa), when air occupies pores > 20 µm in diameter after gravity drainage, the air capacity corresponded to the 'very high' class in the whole of pedon I and in the 0–10 cm layer of pedon V. The 'high' class was noticed in the 0–10 and 40–50 cm layers of pedon II, in layers 0–10 and 20–30 cm of pedons III and IV. Air capacity in the "medium" class was found in the following layers: 20–30 cm of pedon II and 40–50 cm of pedon IV. The "small" class included layers of 40-50 cm of pedon III and 20-30 cm of pedon V, and the "very small" clasyficated a 40-50 cm layer of pedon V. The most active pores with diameters > 300 µm (-0.98 kPa) and > 100 µm (-3.10 kPa) occurred predominantly in pedons I, II and III in the surface layer, in pedons III and IV such a large variation between layers did not occur.

Air permeability in the studied soils showed greater variation than water permeability. (Table 8). In the field water capacity condition (-15.54 kPa), air permeability was determined to be 'very high' in six layers, four of these layers were surface layers of 0–10 cm (pedons I, II, III and V). 'High' air permeability was found twice, 'medium' three times, 'low' twice and 'very low' twice. The highest air permeability in the field water capacity condition was shown by the surface layer in pedon II. Another high value was in 0–10 cm layer of pedon I. Both of these layers had numerous earthworms forming hollows to facilitate air movement. The lowest air permeability in the field water capacity condition, classified as 'very low', was found in the clay-enriched layers 20–30 cm and 40–50 cm in pedon V respectively. Unlike in the case of water permeability, there was no positive effect of zoogenic zones filled with material displaced from the surface layer in these layers. Considering water potential states greater than the field water capacity (-0.98; -3.10; -9.81 kPa), when air moves only in the largest pores, it should be noted that air permeability developed in a very different way. In pedon

Table 7. Air capacity at different states of soil water potential

Pedon	Layer [cm]	Air capacity at water potential (kPa) [m³·m⁻³]						Field air capacity class at -15.54 kPa
		-0.98	-3.10	-9.81	-15.54	-31.00	-49.00	
I Plaggic Anthrosol	0–10	0.138	0.156	0.194	0.207	0.219	0.236	Very high
	20–30	0.082	0.105	0.168	0.199	0.228	0.248	Very high
	40–50	0.097	0.134	0.194	0.217	0.229	0.253	Very high
II Terric Anthrosol	0–10	0.125	0.136	0.161	0.174	0.189	0.203	High
	20–30	0.078	0.086	0.104	0.119	0.133	0.19	Medium
	40–50	0.094	0.105	0.132	0.148	0.159	0.174	High
III Urbic Technosol	0–10	0.084	0.107	0.153	0.171	0.188	0.210	High
	20–30	0.081	0.103	0.141	0.167	0.186	0.201	High
	40–50	0.066	0.072	0.081	0.092	0.098	0.104	Low
IV Urbic Technosol	0–10	0.080	0.110	0.136	0.149	0.160	0.170	High
	20–30	0.087	0.111	0.128	0.144	0.154	0.161	High
	40–50	0.071	0.086	0.104	0.120	0.128	0.138	Medium
V Terric Anthrosol	0–10	0.126	0.152	0.174	0.188	0.200	0.212	Very high
	20–30	0.054	0.058	0.063	0.072	0.076	0.081	Low
	40–50	0.039	0.043	0.045	0.052	0.054	0.057	Very low

Table 8. Air permeability at different states of soil water potential

Pedon	Layer [cm]	Air permeability at water potential (kPa) [$\times 10^{-8}$ m^2 Pa^{-1} s^{-1}]						Air permeability class in the field water capacity condition at -15.54 kPa
		-0.98	-3.10	-9.81	-15.54	-31.00	-49.00	
I Plaggic Anthrosol	0–10	267.20	306.60	588.00	847.70	1321.70	1391.88	Very high
	20–30	29.50	89.10	92.80	95.50	130.70	116.00	High
	40–50	185.90	166.00	3.5	5.30	4.50	5.40	Low
II Terric Anthrosol	0–10	1206.62	1236.80	1279.70	1314.94	1355.52	1390.64	Very high
	20–30	3.94	5.56	6.84	9.54	11.26	16.80	Low
	40–50	23.02	43.78	605.62	380.56	580.16	1038.22	Very high
III Urbic Technosol	0–10	51.52	152.58	7.36	137.98	206.94	380.96	Very high
	20–30	23.76	30.78	13.72	56.62	71.54	35.88	High
	40–50	16.02	18.60	92.30	24.70	35.88	46.84	Medium
IV Urbic Technosol	0–10	3.28	12.66	18.92	24.26	24.56	25.44	Medium
	20–30	7.76	24.70	31.78	34.74	36.82	39.26	Medium
	40–50	101.74	74.28	119.96	145.48	131.34	89.56	Very high
V Terric Anthrosol	0–10	34.24	48.38	72.14	133.00	308.14	531.94	Very high
	20–30	2.52	3.82	3.96	4.48	4.76	5.08	Very low
	40–50	2.42	3.26	2.94	4.58	4.14	4.18	Very low

II in the 0–10 cm layer already at a potential condition of -0.98 kPa, when air movement took place in pores >300 µm in diameter, the air permeability was extremely high. As the soil water potential decreased, the air permeability increased. However, in an analogous layer in pedon V, where the macroporosity content was similar, air permeability was many times lower.

Quite often, as the water potential decreased, there was a decrease in the air permeability value and then an increase again. Quite often, as the water potential decreased, there was a phenomenon of air permeability values decreasing and then increasing again. In Pedon I in the 40–50 cm layer, the characteristic in question reached a maximum value at a potential state of -0.98 kPa when air occupied pores >300 µm. Subsequently, after the removal of water from increasingly smaller pores, there was a decrease in air permeability to a minimum value at a potential of -9.81 kPa. At a field water capacity of -15.54 kPa, there was a slight increase in the value of the trait. Despite further drainage, its value remained at a similar level. This type of reduction in air permeability, despite an increase in air volume, was encountered in all pedons, most commonly in the deeper layers at potential values of -9.81 kPa or -15.54 kPa. This is related to the phenomenon of water meniscus closing of soil pores, occurring during soil wetting and drying processes. These pores only begin to take part in air exchange when the meniscuses are eliminated during the drainage of soil in a water potential state below the field water capacity. Undoubtedly, the value of air permeability is determined not only by the volume of pores in which air is contained, but also by the nature of the pores. The increase in air permeability is favoured by the presence of biogenic hollows running in different directions, especially when they connect with each other. The dominance of horizontal crack-type pores that are not networked is the reason for the very low air permeability [Słowińska-Jurkiewicz 1989]. The role of the channels and fissures created by tree roots in the soil of the palace park is highlighted by Greinert and Drab [2000]. According to these authors, the presence of such pores, despite their low air capacity, facilitates air movement in dehydrated soils.

Considering the area of the entire park, it must be said that the filtering properties, both in relation to water and air, showed high levels. Very high values were characterised by water permeability. In situations of heavy precipitation or rapid snow melt, this facilitates the drainage of excess water. However, during dry periods when irrigation is used, too much water filtration should be assessed as unfavourable. Also for air permeability in the field water capacity condition, 'very high' and 'high' values predominated. Particularly high values of this trait were found in the surface layer 0–10 cm, rich in organic carbon. This phenomenon results from the accumulation of organic matter delivered to the surface layer of soil as a result of the decomposition of plant residues and organic fertilization. This process occurs under the influence of microorganisms and biological factors that contribute to the accumulation of organic carbon in this layer. Additionally, the 0-10 cm layer is often the most biologically active and dynamically changing part of the soil, which may affect the accumulation of organic carbon. The presence of construction debris in large quantities in the Urbic Technosols (pedons III and IV) had the effect of reducing air permeability. This was found in the 40–50 cm layers of pedon III and the 0–10 cm and 20–30 cm layers of pedon IV. As a result, the air permeability at field water capacity in these layers was classified as 'medium'.

The results obtained in the study of pedons classified as Technosols correspond with the findings of Yilmaza et al. [2019]. The authors find it very difficult to determine the filtration properties of Technosols due to the presence of coarse-grained materials, including large pieces of brick. Pranagal et al. [2023] concluded that adding mineral waste (not crushed Carboniferous rock) to sandy soils should be avoided. The effect of adding this waste in thea studies was a long-term deterioration of the soil's filtration properties. The tested soils were clearly different from the natural soils and drained much faster than sandy soil. It is the use of construction debris and earthy materials that is considered to be the main cause of the transformation of park soils [Kabała et al. 2010]. Also Charzyński i inni [2018] and Kabała et al. [2020] emphasise that technogenic soils are significantly different in their morphology and physico-chemical properties, depending on the type of human influence or the type of anthropogenic parent material. Some technogenic soils can create highly productive garden or park habitats. It should therefore be concluded that the pedon diversity present in the Kozłówka park is typical of the soils of parks and gardens, both manorial and urban.

According to Zubala and Patro [2015], one of the significant measures aimed at improving water conditions in the soil is to increase the share of biologically active surfaces. It brings good results in the form of increased retention in the entire water system. Xie et al. [2020] showed that soil compaction often significantly reduces soil filtration and increases runoff and flooding during the rainy season. This does not allow for normal and sufficient water replenishment, causing water shortages during droughts. The authors emphasize that improving the soil filtration rate is particularly important for water circulation in parks. Halecki and Stachura [2021] in their research also emphasize that in compacted soil, where excess water cannot move from the root zone, soil filtration should be improved. The revitalization of green areas, including parks, is supported by improving the water balance by increasing water retention in the soil.

CONCLUSIONS

The obtained results of the research on filtration properties of soils in the manor park in Kozłówka can be a necessary source of information for the management and employees of the Zamoyski Museum in Kozłówka. They should be the basis for undertaking possible recultivation and cultivation works, which are necessary for conscious shaping of the park establishment.

As a result of construction work and mechanical cultivation and years of intensive introduction of organic as well as mineral materials, the park's soil cover has been radically transformed and the natural genetic horizons have been obliterated. As a result, anthropogenic soils have been created, representing Plaggic and Terric Anthrosols and Urbic Technosols.

The filter properties of the soils, in relation to both water and air, were characterised by high levels. Water permeability (water conductivity in the saturated zone) mostly represented the 'very high' class. The air permeability in the field water capacity condition (-15.54 kPa) was more variable. The air permeability class 'very high' mostly included the surface layers. Air permeability was reduced by the residue of building rubble (Urbic Technosols) and, above all, the introduction of clay material (Terric Anthrosol) into the soil. The factors increasing the water and air filtration values were mainly the presence of zoogenic vertical pores of the hollow type, as well as the aggregate structure of the soil resulting from the regular introduction of organic materials.

When assessing the filtering properties of the park's soil cover, it is important to note that the very high water permeability undoubtedly facilitates the drainage of excess water. However, under conditions where soil irrigation is required, it can result in too rapid drainage and water loss. In the case of air permeability, the addition of clay to natural sandy material should be assessed negatively.

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