SOIL SCIENCE ANNUAL
2020, 71(4), 352–358

https://doi.org/10.37501/soilsa/127165

The influence of Technosol characteristics on the lady's-slipper orchid population (*Cypripedium calceolus* L.) in a forest area – the case study

Jarosław Lasota, Tomasz Wanic, Ewa Błońska*

Department of Ecology and Silviculture, Faculty of Forestry, University of Agriculture in Krakow, al. 29 Listopada 46, 31-425 Krakow, Poland

* dr hab. inż. E. Błońska prof. UR, eblonska@ar.krakow.pl, ORCID iD: https://orcid.org/0000-0001-7731-1673

Received: 12.06.2020
Accepted: 02.09.2020
Associated editor: P. Sewerniak

Keywords

Enzyme activity
Forest ecosystems
Galio odorati-Fagetum communities
Soil properties

Abstract

The aim of this study was to show the detailed properties of Technosol formed from the remains of an old lime kiln in Western Pomerania as a habitat of a rare protected plant - the lady's-slipper orchid (*Cypripedium calceolous*). Additionally, an attempt was made to establish the relationship between soil properties and the occurrence of the lady's slipper orchid. The study was conducted in the area of the Polanów Forest District in the Żydowo forestry, near Lake Kwiecko (northern Poland). In the middle of the patch of the lady's-slipper orchid (*Cypripedium calceolous*), a soil pit was dug, in which numerous artifacts in the form of brick rubble and enamel were found, which testify to the anthropogenic material from which the studied soil developed. Soil samples were taken from each soil horizon and basic physicochemical properties were determined. Additionally, a grid of points from which samples were taken from the humus horizon was established in the lady's-slipper orchid occurrence patch. The grid was used to check the surface properties of Technosol horizons in the whole range of the examined species occurrence. The occurrence of Humic Technosol was found in the patch of lady's-slipper orchid. The conducted study confirms that in forest areas of the remains of lime kilns, fertile Technosols are formed by as a result of natural succession of forest vegetation. As a result of these processes, in a short period of time (400 years) a soil profile of Humic Technosols with a deep, structural, biologically active humus horizon developed. Statistical analyzes showed that pH, high abundance of organic carbon and high biochemical activity of the soil studied are conducive to the development of the lady's-slipper orchid.

1. Introduction

Technosols are the soils strongly transformed as a result of non-agricultural human activity resulting from urbanization and industrialization processes (Charzyński et al., 2013). In the Polish Soil Classification (2019), together with culturozems, they are included in the order of anthropogenic soils. The diagnostic feature of Technosols is the presence of significant amounts of artifacts that have been placed in or on the soil as a result of human activity. These can be mining waste (collected on dumping grounds), industrial waste (sludge, ashes, slag), municipal waste and residues associated with the demolition of buildings and structures (rubble, asphalt, glass, ceramics, etc.) (Polish Soil Classification, 2019). In forest areas, the occurrence of Technosols is mainly limited to post-industrial areas that have been reclaimed in the forest direction or covered with vegetation as a result of natural succession (Pająk et al., 2018). Technosols in forests may also be associated with the occurrence of old buildings (fortified settlements, settlements, etc.), small waste dumps or landfills after the exploitation of ores called warp, or old barrows and cemeteries, but these are usually small areas (Banaszek and Rączkowski, 2010; Wysocki, 2011; Woch et al., 2017).

The vegetation that inhabits Technosols surfaces can have very different characteristics. If reclamation is carried out in the forest direction, the species composition of the regenerating vegetation can be regulated (Pająk et al., 2016; Stępniewska et al., 2020). Where the development of vegetation occurs spontaneously as a result of natural succession, the species composition of the resulting communities will depend on the properties of the substrate from which they are formed. Important factors determining the development of vegetation are microbiological processes, water availability and microclimatic conditions (Woch et al., 2017; Pająk et al., 2018). In the species composition of vegetation entering the Technosols surface, pioneer species with a wide amplitude of ecological requirements play a major role. They are often ruderal, non-native taxa resistant to stress that inhabit a wide range of habitats (Woch et al., 2016; Woch, 2017 and 2018). There are also known cases when Technosols become a habitat for rare protected plants. An example can be the so-called calamine violets (*Viola questphalica, Viola calaminaria*) occurring on Technosols formed from zinc-rich waste

and heaps, which are remnants of former metallurgical activity (Jędrzejczyk et al., 2003). Examples of other rare plants with metallophilic characteristics or species of dry grasses and shrubbery include *Biscutella laevigata, Erysimum odoratum, Gentiana cruciata, Gentianella germanica, Prunella grandiflora, Pulsatilla patens*, *Thesium alpinum* or plants from Orchidaceae family (*Malaxis monophyllos, Cephalanthera damasonium*, *Cephalanthera rubra, Epipactis atrorubens*) (Urbisz et al., 2014; Woch et al., 2017).

Cypripedium calceolus is mainly a boreal species which occurs in shady deciduous and mixed woodland (rarely in full sunlight), predominantly on calcareous soils (Brzosko et al., 2002). Its largest populations are situated in the Biebrza National Park (northeast Poland), which is the biggest protected complex of swamps in the Central and Western Europe. According to the current state of knowledge, the lady's-slipper orchid in Poland is found in about 200 localizations (Kucharczyk, 2010). Lady's slipper orchid has been strictly protected in Poland since 1946.

The aim of this study was to show the detailed properties of Technosol formed from the remains of an old lime kiln in Western Pomerania as a habitat of a rare protected plant – the lady's-slipper orchid (*Cypripedium calceolous*). Additionally, an attempt was made to establish the relationship between soil properties and the occurrence of the lady's slipper orchid. The study described the soil profile of Humic Technosol and characterized in detail the properties of the humus accumulation horizon in the patch of lady's-slipper orchid occurrence.

2. Material and methods

The study was conducted in the area of the Polanów Forest District in the Żydowo forestry, near Lake Kwiecko (northern Poland). Research plots were established in areas dominated by *Galio odorati-Fagetum* communities. The study determined the habitat conditions in which the population of lady's-slipper orchid (*Cypripedium calceolus*), rare in this area, developed. According to the study by Korczyński and Krasicka-Korczyńska (2014), the population size in this area was 150–350 specimens. In the middle of the patch, a soil pit was dug, in which numerous artifacts in the form of brick rubble and enamel were found, which testify to the anthropogenic material from which the studied soil developed. Later, the analysis of archival documents confirmed that lime kilns were located in the area of Western Pomerania, already in the early period of Roman influence (Michałowski and Teska, 2015). Soil samples were collected from each soil horizon. Basic physicochemical properties were determined in samples taken from the profile (Ostrowska et al., 1991). After drying the samples and sieving through a 2 mm mesh sieve, the texture was determined using a laser diffractometer (Analysette 22, Fritsch, Idar-Oberstein, Germany), pH in water and 1M KCl by potentiometric method. Calcium carbonate content was determined by Scheibler method, hydrolytic acidity (Hh) by Kappen method and exchangeable acidity (Hw) by Sokolow method. The content of organic carbon (OC) and total nitrogen (Nt) was determined using the LECO CNS 2000 True Mac Analyzer (Leco, St. Joseph, MI, USA), while the content of exchangeable cations (Ca^{2+}, Mg^{2+}, K^{+}, and Na^{+}) using ICP (ICP-OES Thermo iCAP 6500 DUO, Thermo Fisher Scientific, Cambridge, U.K.). Based on the obtained contents of exchangeable cations, the base saturation (BS) was calculated for each horizon.

Additionally, a grid of points from which samples were taken from the humus horizon was established in the lady's-slipper orchid occurrence patch. The grid was used to check the surface properties of Technosol levels in the whole range of the examined species occurrence. In order to examine the variability of the properties of humus accumulation horizon around the soil cover, 36 samples were taken in the lady's-slipper orchid occurrence patch at the nodes of the regular 2x2 m grid. To determine the properties, samples with natural moisture content were taken from the grid nodes and stored at 4°C. Dehydrogenase activity was determined by Lenhard method (Alef and Nannipieri, 1995). The pH, organic carbon and total nitrogen content and hydrolytic acidity were determined in the samples from the surface horizon.

A general linear model (GLM) was used to investigate the effect of soil properties on the occurrence of the lady's slipper orchid. Principal component analysis (PCA) was used to evaluate the relationships between the soil properties and occurrence of the lady's slipper orchid. Differences with $p<0.05$ were considered statistically significant. Analyses were performed using Statistica 12 software (StatSoft 2012).

3. Results

The occurrence of Humic Technosol was found in the patch of lady's-slipper orchid. Three genetic horizons were identified in the soil profile, differing in organic matter content, share of skeletal parts as well as structure and rooting (Table 1, Fig. 1). In the upper part of the analyzed profile, a deep (0–30 cm) horizon of humus accumulation was developed, characterized by a small share of skeletal parts (single rocks and brick crumbs) and a well-developed fine solid granular structure. At the same time, the soil was characterized by an alkaline reaction (pH in H_2O 7.43) and the presence of calcium carbonate (3.9%) (Table 2). At a deeper horizon of enrichment up to 80 cm, a high content of skeletal parts (60%) in the form of brick crumbs and rocks was found. That horizon was characterized by an aggregate structure and a compact arrangement with a relatively high degree of rooting (Table 1, Fig. 1). The enrichment horizon was characterized by alkaline reaction (pH in H_2O 8.0), presence of calcium carbonate (9.0%), high content of exchangeable alkaline cations (14.18 cmol(+)·kg^{-1}) and low content of organic carbon and nitrogen (5.4 and 0.33 g·kg^{-1} respectively) (Table 2). In the deepest horizon of Technosol (80–100 cm), a stone-loam formation with a high share of skeletal parts (80%) was found, among which brick crumbs with rocks and dark clay sinter resembling enamel dominated (Fig. 2). In terms of chemical characteristics, the deepest horizon was characterized by high calcium carbonate content (20%), alkaline reaction (pH in H_2O 8.0) and very low organic carbon content (1.7 g·kg^{-1}) (Table 2).

The analysis of the spatial variability of the organic carbon content in the examined patch showed the diversity of this

Table 1
Characteristic of Humic Technosol horizons

Horizon	Depth	Color	Texture	Soil skeleton	Structure	Rooting	Consistence
Aa	0–30	10R 4/2	ls	singly	gr-3-d	3	F
BwCa	30–80	10R 5/6	assl	60% brick crumbs, rocks	oa-2-s	2	VF
Ca	80–100	10R 6/4	sl	80% brick crumbs	mc	–	VF

color determined according to Munsell soil-color-charts, ls- loamy sand, gassl– anthropogenic stony sandy loam, sl – stony loam, gr-3-d – fine solid granular structure, oa-2-s – medium persistent angular structure, mc – massive structure, F – friable , VF – very firm

Fig. 1. Soil profile of Humic Technosol

Fig. 2. Clay silt sinter from dipper horizon of Humic Technosol

feature. On the surface of the examined patch, the carbon content varied from 22.8 to 143.0 g·kg^{-1} and was the highest at the southern end of the patch (Fig. 3). Nitrogen content ranged from 1.29 to 4.83 g·kg^{-1}, C/N ratio 13.0–33.1, hydrolytic acidity 0.35–6.05 cmol(+)·kg^{-1} in the examined patch (Table 3). The activity of dehydrogenases also showed strong variability in the humus accumulation horizon in the analyzed Technosol (30.5–270.6, mean 114.1 µmol·kg^{-1}·h^{-1}) (Table 3) and was strongly related to the organic carbon content. The highest activity was observed at the points located in the southern part of the patch, where the activity exceeded 200 µmol·kg^{-1}·h^{-1} (Fig. 4). Soil with higher biological activity and higher organic carbon content was covered by the lady's-slipper orchid – southern end of the patch (Fig. 3 and 4).

Table 2
Physico-chemical properties of Humic Technosol

Horizon	pH H_2O	pH KCl	OC	Nt	C/N	Hh	Hw	S	BS	$CaCO_3$
			g·kg^{-1}			cmol(+)·kg^{-1}			%	%
Aa	7.43	7.23	38.5	2.38	16.2	1.10	0.09	15.88	93.5	3.9
BwCa	8.02	7.68	5.4	0.33	16.3	0.41	0.00	14.18	97.2	9.0
Ca	7.99	7.68	1.7	0.13	13.0	0.66	0.00	19.08	96.7	20.0

OC – organic carbon, Nt – total nitrogen, Hh – hydrolytic acidity, Hw – exchangeable acidity, S – base cation, BS – base saturation

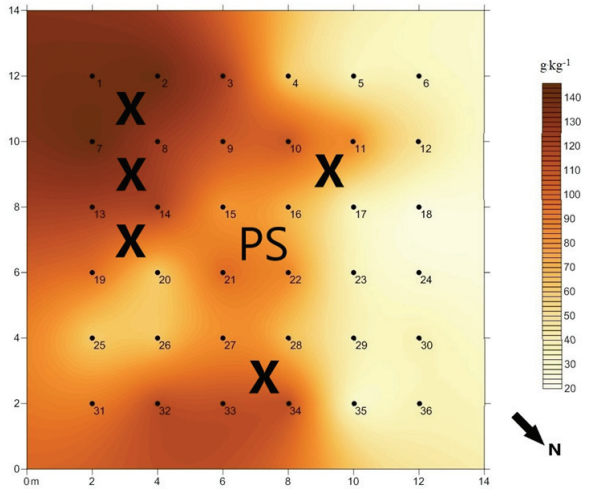

Fig. 3. Spatial distribution of organic carbon in humus horizon of investigated HumicTechnosol (X – occurrence of the lady's-slipper orchid; PS – location of a soil pit)

Table 3
Properties of humus horizon of Humic Technosol

	mean	min	max	SD
pH H_2O	7.44	5.81	7.83	0.47
pH KCl	7.07	4.95	7.45	0.60
Hh (cmol(+)·kg^{-1})	1.05	0.35	6.05	1.10
OC (g·kg^{-1})	79.42	22.77	143.00	37.65
Nt (g·kg^{-1})	3.07	1.29	4.83	1.04
C/N	24.84	12.95	33.14	5.90
DH (µmol TFF·kg^{-1}·h^{-1})	114.06	30.46	270.60	64.64

Hh – hydrolytic acidity, OC – organic carbon, Nt – total nitrogen, DH – dehydrogenase activity

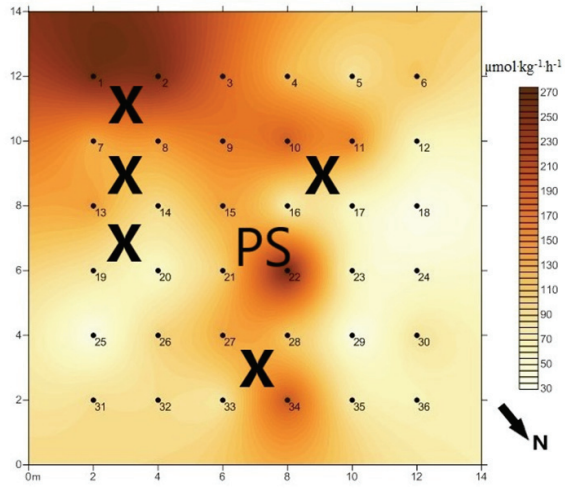

Fig. 4. Spatial distribution of dehydrogenase activity in humus horizon of investigated Humic Technosol (X – occurrence of the lady's-slipper orchid; PS – location of a soil pit)

The PCA confirmed the positive effect of pH, carbon content and biochemical activity on the occurrence of the lady's slipper orchid (Fig. 5). The two main factors had a significant impact (74.4%) on the variance of the variables. Factor 1 relates to the carbon content and dehydrogenase activity mainly, and factor 2 can be linked to acidity of soils. Specifically, the lady's slipper orchid was associated with the highest pH, high carbon content and dehydrogenase activity (Fig. 5). The relations were also confirmed by the GLM analysis, which showed a strong relationship between the carbon content, pH and the occurrence of the lady's slipper orchid (Table 4).

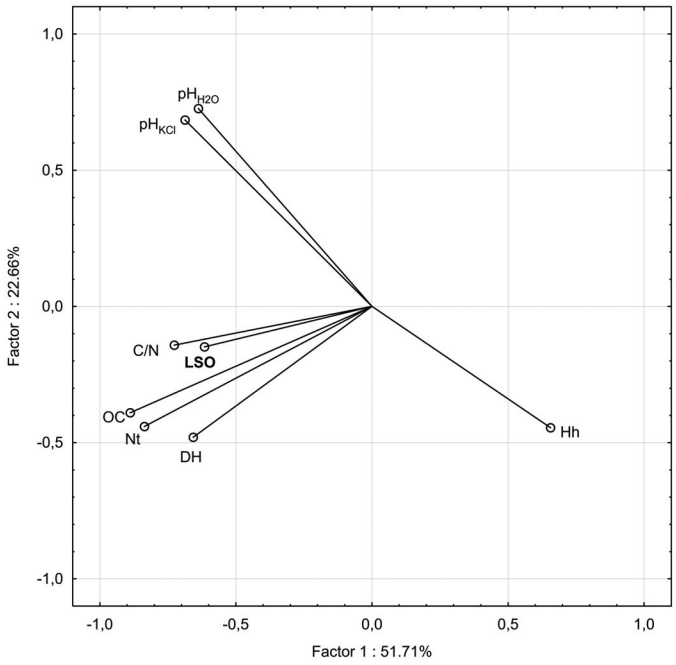

Fig. 5. PCA diagram showing the relationship between the lady's slipper orchid occurrence (LSO) and soil properties in the studied site (OC – organic carbon, Nt – total nitrogen, DH – dehydrogenase activity, Hh – hydrolytic acidity)

Table 4
Summary of GLM analysis of the effect of the soil properties on the occurrence of the lady's slipper orchid

	LSO	
	F	*p*
pH H_2O	2.07	0.161
OC	**4.97**	**0.034**
DH	0.18	0.673
pH H_2O*OC	**4.79**	**0.037**
pH H_2O*DH	0.23	0.638
OC*DH	1.82	0.188

OC – organic carbon, DH – dehydrogenase activity; Significance effect ($p < 0.05$) are show in bold

4. Discussion

According to the criteria presented in the Polish Soil Classification (SGP6) (Kabała et al., 2019), the discussed Technosol can be classified as Humic Technosol but this classification assumes that the humus horizon of such soils was artificially deepened or shaped as a result of reclamation activities. In the analyzed case, there is no evidence of purposeful actions aimed at restoring the humus horizon and it can be assumed that the current state of humus accumulation horizon is a consequence of slow weathering of materials from the former structure and restoration of the humus horizon as a result of the impact of forest vegetation.

The lady's-slipper orchid in terms of soil requirements is seen as a species preferring medium-humid soils, poor in nitrogen but rich in exchangeable cations and calcium carbonate (Terschuren, 1999). In Poland, it is most abundant in the Roztocze, Lublin Upland and Małopolska Upland, where on the carbonate substrate it mainly inhabits soils with rendzinas characteristics (Kucharczyk et al., 2014). The analyzed Technosol has chemical characteristics similar to those of carbonate soils. In the described soil, calcium carbonate was found in the whole profile, soil humus saturated with calcium with high enzymatic activity and low acidity. These features determine the high fertility of the discussed Humic Technosol, comparable to richer in humus rendzinas. According to Czerepko et al. (2014), soil moisture is an important habitat factor influencing the conservation status of the lady's-slipper orchid population. These authors, when examining the conservation status of the *Cypripedium calceolus* population in the Miechów and Chełm forest districts, showed that the area occupied by the population of this rare orchid and the number of generative shoots are positively correlated with the soil moisture index. The analyzed Humic Technosol did not show features of gleyic processes, however, the location conditions (vicinity of the lake) certainly influence the water infiltration at deeper levels and determine the more humid microclimate. A thorough analysis of the development conditions and the dynamics of changes in the lady's-slipper orchid population in the Kwiecko Lake area (Korczyński and Krasicka-Korczyńska, 2014) shows that in recent decades the lady's-slipper orchid population occupies an area that is located about 1 m above the lake level. The current water level in the lake was raised by 3.1 m in 1971 after the construction of a hydroelectric power plant. Humic Technosol analyzed in the study is characterized by its young age. The period of its formation can be estimated at about 400 years. In such a short period of time, a relatively deep soil profile with separate horizons, differing in structure, share of skeletal parts and content of organic matter was formed as a result of natural processes, under the influence of forest vegetation.

The high enzymatic activity found in the soil confirms the degree of advancement of the soil-forming process and the formation of a sufficiently rich community of soil microorganisms. In the humus accumulation horizons of fertile forest soils, the dehydrogenase activity is in the range 30–70 $\mu mol \cdot kg^{-1} \cdot h^{-1}$ (Januszek, 1999; Lasota, 2006). In the patch of the analyzed Technosol occurrence, even the activity exceeding 250 $\mu mol \cdot kg^{-1} \cdot h^{-1}$ was found, which indicates a much higher overall activity of microorganisms in the studied Humic Technosol. The lady's-slipper orchid was associated with places with higher biological activity and higher organic carbon content (Fig. 3 and 4). High biological activity of the analyzed soil is also evidenced by the intensity of soil profile overgrowth by roots (intensive overgrowth by roots was found up to 80 cm from the surface). Intense development of root systems is a source of soil organic matter. The roots are a key element of the underground system shaping soil properties and rhizosphere processes are important in the carbon cycle (Cheng and Kuzyakov, 2005).

The conducted analyzes indicate the relationship between the occurrence of lady's slipper orchid and soils rich in organic matter with high pH. The soils with the presence of lady's slipper orchid were characterized by high biochemical activity expressed by the dehydogenase activity. Previous studies showed that the occurrence of this species was related to the content of calcium carbonate (Kucharczyk et al., 2014). So far, no relationship between the occurrence of lady's slipper orchid and soils characterized by a high content of organic matter and high biochemical activity has been demonstrated.

Conclusions

The conducted study confirms that in forest areas of the remains of lime kilns, fertile Technosols are formed by as a result of natural succession of forest vegetation. As a result of these processes, in a short period of time (400 years) a soil profile of Humic Technosols with a deep, structural, biologically active humus level developed. Soils with the characteristics of Humic Technosol create suitable conditions for the growth of the lady's-slipper orchid. Statistical analyzes confirmed that pH, high abundance of organic carbon and high biochemical activity of the soil studied were crucial for the development of the lady's-slipper orchid in the studied site.

Acknowledgement

This work was supported by the Ministry of Science and Higher Education of the Republic of Poland (SUB/040012/D019).

References

Alef, K., Nannipieri, P., 1995. Enzyme activities. [In:] Alef, K., Nannipieri, P. (Eds.), Methods in applied, Soil Microbiology and Biochemistry. Academic Press, London-New York- San Francisco.

Banaszek, Ł., Rączkowski, W., 2010. Archeologia w lesie. O identyfikacji stanowisk archeologicznych w gminie Polanów (i nie tylko) (Arche-

ology in the forest. On the identification of archaeological sites in the Polanów commune (and not only)). [In:] Rączkowski, J., Sroka, J. (Eds.), Historia i kultura ziemi Sławieńskiej. Tom X. Miasto i Gmina Polanów. Fundacja „Dziedzictwo", 117–131 (in Polish).

Brzosko, E., Wróblewska, A., Ratkiewicz, M., 2002. Spatial genetic structure and clonal diversity of Island populations of lady's slipper (*Cypripedium calceolus*) from the Biebrza National Park (northeast Poland). Molecular Ecology 11, 2499–2509. https://doi.org/10.1046/j.1365-294X.2002.01630.x

Charzyński, P., Bednarek, R., Greinert, A., Hulisz, P., Uzarowicz, Ł., 2013. Classification of technogenic soils according to WRB system. Soil Science Annual 64(4), 145–150. https://doi.org/10.2478/ssa-2013-0023

Cheng, W., Kuzyakov, Y., 2005. Root effects on soil organic matter decomposition. [In:] Wright, S., Zobel, R. (Eds.), Roots and soil management: interactions between roots and the soil. Agronomy Monograph No. 48, American Society of Agronomy, Madison, Wisconsin, 119–143. https://doi.org/10.2134/agronmonogr48.c7

Czerepko, J., Gawryś, R., Cieśla, A., Sokołowski, K., 2014. Environment conditions influence on protection status of lady's slipper orchid *Cypripedium calceolus* L. in managed forests. Sylwan 158(11), 867–874.

Januszek, K., 1999. Aktywność enzymatyczna wybranych gleb leśnych Polski południowej w świetle badań polowych i laboratoryjnych (Enzyme activity of selected forest soils on Southern Poland in the field and laboratory experiments). Scientific Papers of the Agricultural University of Krakow, 250 (in Polish).

Jędrzejczyk, M., Bzdęga, K., Rostański, A., 2003. Current resource status of the calamine Violets Viola guestphalicaNauenb. and Viola calaminaria (Ging.) Lej. on the zinc spoil heap in Katowice-Wełnowiec. Archives of Environmental Protection 29(2), 21–30.

Kabała C., et al., 2019. Polish Soil Classification, 6th edition – principles, classification scheme and correlations. Soil Science Annual 70(2), 71–97. https://doi.org/10.2478/ssa-2019-0009

Korczyński, M., Krasicka-Korczyńska, E., 2014. Dynamics of Lady's slipper orchid (*Cypripedium calceolus* L.) population at Lake Kwiecko (West Pomerania). Biodiversity Research and Conservation 36, 53–60. https://doi.org/10.2478/biorc-2014-0026

Kucharczyk, M., 2010. 1902 Obuwik pospolity *Cypripedium calceolus* L. (Lady's slipper orchid *Cypripedium calceolus* L.) [In:] Monitoring gatunków roślin. Przewodnik metodyczny. Część I. (Plan species monitoring. Methodical guide. Part I) Perzanowska J. (Eds.). GIOŚ, Warszawa, 83–98. (in Polish).

Kucharczyk, M., Bąba, W., Kucharczyk, H., 2014. Cypripedium calceolus L. Obuwik pospolity. [In:] Kazimierczakowa, R., Zarzycki, K., Mirek, Z. (Eds.) Polska Czerwona Księga Roślin (Polish Red Book of Plants). Instytut Ochrony Przyrody PAN, 739–741 (in Polish)

Lasota, J., 2006. Enzymatic Activity of Soils in Forest Sites of the Western Beskid Mountains. Polish Journal of Soil Science 39(1), 43–53.

Michałowski, A., Teska, M., 2015. Piece wapiennicze z południowo-zachodniej strefy osadnictwa Kultury Wielbarskiej w fazie lubowidzkiej na tle porównawczym – przegląd źródeł (Lime kilns from the south-western part of the Wielbark Culture settlement in the Lubowidz Phase against a comparative background – an overview of evidence) Folia Prehistorica Posnaniensia 20, 317–337. (in Polish). http://doi.org/10.14746/fpp.2015.20.18

Ostrowska, A., Gawliński, S., Szczubiałka, Z., 1991. Metody analizy i oceny właściwosìci gleb i rosìlin (Methods of analysis and assessment of soil and plant properties). Environmental Protection Institute, Warszawa, 333 pp. (in Polish).

Pająk, M., Krzaklewski, W., Pietrzykowski, M., Likus, J., Kowalczewski, W., 2016. Rekultywacja leśna realizowana na terenach pogórniczych kopalni siarki „Osiek" (Reclamation to forest conducted on post-mining areas lands of the "Osiek" sulfur mine). Environmental Egineering 41, 87–95 (in Polish).

Pająk, M., Błońska, E., Szostak, M., Gąsiorek, M., Pietrzykowski, M., Urban, O., Derbis, P., 2018. Restoration of Vegetation in Relation to Soil Properties of Spoil Heap Heavily Contaminated with Heavy Metals. Water Air Soil Pollution 229, 392. http://doi.org/10.1007/s11270-018-4040-6

Stępniewska, H., Uzarowicz, Ł., Błońska, E., Kwasowski, W., Słodczyk, Z., Gałka, D., Hebda, A., 2020. Fungal abundance and diversity as influenced by properties of Technosols developed from mine wastes containing iron sulphides: a case study from abandoned iron sulphide and uranium mine in Rudki, south-central Poland. Applied Soil Ecology 145, 103349. http://doi.org/10.1016/j.apsoil.2019.08.011

Polish Soil Classification, 2019 (6th edition). Polskie Towarzystwo Gleboznawcze, Komisja Genezy Klasyfikacji i Kartografii Gleb. Wydawnictwo Uniwersytetu Przyrodniczego we Wrocławiu, Polskie Towarzystwo Gleboznawcze, Wrocław-Warszawa (in Polish).

Terschuren, J., 1999. Action Plan for Cyprypedium Calceolus in Europe. Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention). Nature and Environment 100, 65.

Urbisz, A., Nowak, T., Rostański, A., Jędrzejczyk-Korycińska, M., Bzdęga, K., Urbisz, A., Folcik, Ł., Węgrzynek, B., Gucwa-Przepióra, E., Woźnica, P., Tokarska-Guzik, B., 2014. Floristic values of heavy metal contaminated areas in the Silesia-Cracow Uplands. Acta Biologica Cracoviensis. Series Botanica. Abstracts 56(2), 80.

Woch, M.W., Kapusta, P., Stefanowicz, A.M., 2016. Variation in dry grassland communities along a heavy metal gradient. Ecotoxicology 25(1), 80–90. http://doi.org/10.1007/s10646-015-1569-7

Woch, M.W., 2017. Species trait-environment relationships in semi-dry *Brachypodium pinnatum grasslands* on old waste heaps left by Zn-Pb mining in the western Małopolska region (S Poland). Tuexenia 37(1), 247–270. http://doi.org/10.14471/2017.37.015

Woch, M.W., Stefanowicz, A.M., Stanek, M., 2017. Waste heaps left by historical Zn-Pb ore mining are hotspots of species diversity of beech forest understory vegetation. Science of The Total Environment 599–600, 32–41. http://doi.org/10.1016/j.scitotenv.2017.04.197

Woch, M.W., 2018. Factors of variation in beech forest under story communities on waste heaps left by historical Zn-Pb ore mining. Ecotoxicology and Environmental Safety 164, 681–689. http://doi.org/10.1016/j.ecoenv.2018.08.067

Wysocki, J., 2011. Stanowiska archeologiczne w krajobrazie kulturowym Mazowsza. Problemy zarządzania i eksploatacji (Archaeological sites in the cultural landscape of Mazovia. Problems of management and exposition). Mazovia Regional Studies 7, 103–115. (in Polish).

Wpływ właściwości gleby technogenicznej na populację obuwika pospolitego (*Cypripedium calceolus* L.) w terenie leśnym – studium przypadku

Słowa kluczowe

Aktywność enzymatyczna
Ekosystem leśny
Zespół *Galio odorati-Fagetum*
Właściwości gleb

Streszczenie

Celem niniejszej pracy było ukazanie szczegółowych właściwości gleby technogenicznej powstałej z pozostałości dawnego pieca do wypalania wapna na terenie Pomorza Zachodniego, jako siedliska rzadkiej, chronionej rośliny – obuwika pospolitego (*Cypripedium calceolus*). Dodatkowo podjęto próbę ustalenia zależności między właściwościami gleby a występowaniem obuwika pospolitego. Badania przeprowadzono na terenie Nadleśnictwa Polanów w leśnictwie Żydowo, w pobliżu jeziora Kwiecko (północna Polska). W środku płatu obuwika, wykopano głęboką odkrywkę, w której stwierdzono liczne artefakty w formie gruzu ceglanego oraz szkliwa świadczące o antropogenicznym materiale, z którego wykształciła się badana gleba. Z każdego wydzielonego poziomu gleby pobrano próbkę do analiz fizyko-chemicznych. Dodatkowo, w płacie występowania obuwika pospolitego założono siatkę punktów, z których pobrano próbki z poziomu próchnicznego. Siatka posłużyła do sprawdzenia właściwości powierzchniowych poziomów badanej gleby technogenicznej w całym zasięgu występowania badanego gatunku. W płacie występowania obuwika pospolitego stwierdzono glebę technogeniczną próchniczną. Przeprowadzone badania potwierdzają, że w terenach leśnych pozostałości po wapiennikach w efekcie naturalnej sukcesji roślinności leśnej kształtują żyzne gleby technogeniczne. W wyniku tych procesów, w relatywnie krótkim czasie (400 lat) wykształcił się profil gleby technogenicznej próchnicznej, z głębokim, strukturalnym, aktywnym biologicznie poziomem próchnicznym. Analizy statystyczne potwierdziły, że pH, wysoka zasobność w węgiel organiczny oraz wysoka aktywność biochemiczna badanej gleby sprzyjają rozwojowi obuwika.