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EFFECT OF SPONTANEOUS SUCCESSION ON PHYSICAL STATE OF POST-MINE TECHNOSOL

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Abstract. The aim of this study was to examine the impact of spontaneous succession in comparison with black fallow on selected physical properties of soil damaged by mining in the area of internal dumping ground Pątnów near Konin. To evaluate the soil physical status, basic physical and chemical parameters (total organic carbon, bulk and particle density, pH), water characteristic curves, and water and air permeability were measured. The observed water retention data with the saturated hydraulic conductivity value were fitted to obtain soil water characteristic curves, differential porosity plots, and hydraulic conductivity function in the vadose zone. Over 30 years of spontaneous succession treatment of the post-mining grounds enriched the resulting Technosol in organic carbon 4 times more than the black fallow treatment. Vegetation caused a high belowground input of organic material, which was apparent by very low bulk density and very high porosity values. Spontaneous succession changed the typical differential porosity of a sandy soil mostly in the mesopore region. Soils under both treatments were characterised by excessive field air capacity, but the soil under spontaneous vegetation revealed higher volume of water available for plants in comparison to the black fallow soil, despite its coarser texture. The black fallow soil had lower and more variable air and water permeabilities than the soil under spontaneous succession. Vegetation including plants with extensive root systems positively influenced soil physical state, thereby improving soil ecosystem stability.

Keywords: technosol, physical properties, black fallow, spontaneous succession

INTRODUCTION

Mining is an anthropogenic activity which causes considerable degradation of the environment. Open-cast excavation of lignite leads to drastic disturbances, causing changes in the morphology of the area, reduction of flora and fauna diversity, decline in soil productivity and organic carbon concentration, modification of soil structure and of water and air relations (Wick *et al.* 2014, Quadros *et al.* 2016).

Post mining grounds are usually unfavourable for agricultural use and vulnerable to erosion or subsidence, therefore they need to be reclaimed (Shrestha and Lal 2011, Raizada and Juyal 2012). Providing functional and stable soil is important for successful ecosystem rehabilitation. Mine soil quality relies on vegetation which improves soil physical, chemical and biological conditions of disturbed sites (Zhao *et al.* 2013, Zhen *et al.* 2015). Different families of plants influence soil functions in diverse ways. Legumes, which have an ability to fix atmospheric nitrogen, increase soil organic matter, improve soil porosity and structure, recycle nutrients and decrease soil pH (Li *et al.*, 2016). Grasses, characterised by fast growth, quickly cover the land, and consequently stabilise the soil (Fullen *et al.* 2006). Asteraceae, typical mycorrhizal symbionts, increase N content, affect metabolism of phosphorus and lower pH in soil (Chen *et al.* 2015). Post-mining sites can be successfully covered by spontaneous succession as an advantageous natural process that stimulates developing of soil substrate (Mudrák *et al.* 2010, Tropek *et al.* 2010).

One of the lignite mining centres in Poland, with estimated reserves of 466.4 million tonnes, is located near Konin. This area shows a high textural heterogeneity, since the soil substrate found on dumping grounds is made up, to a considerable extent, from diverse rocks (Quaternary sands, grey and yellow boulder loams, Miocene sands, Pliocene clays) mixed at various amounts and proportions (Gilewska and Otremba 2011). Moreover, as in other open pit mines, the land in Konin Lignite Mine has undergone substantial transformation. It entailed significant changes in the soil environment, i.e. unfavourable soil physical, chemical, and biological condition, and required complex reclamation. Knowledge of physical properties which govern practically all processes in soil is important for assessing rehabilitation progress. Consequently, the aim of this study was to examine the impact of spontaneous succession (SS_{NPK}) as a reclamation technique, in comparison with black fallow (BF_{NPK}), on selected physical properties of the soil degraded by mining in the area of internal dumping ground Pątnów near Konin. To evaluate the soil physical status, basic physicochemical parameters, water characteristic curves, and water and air permeability were measured.

MATERIALS AND METHODS

The samples came from the experimental field established in 1978 by the Department of Soil Science and Reclamation of the Poznań University of Life Sciences on the internal dumping ground Pątnów (52°18′46″N, 18°15′32″E) near

Konin. The reclamation was carried from 1978 in accordance with the principles of the target species concept developed by Bender (1995). After reclamation the soil is classified as Spolic Technosol, TC-sp (IUSS Working Group WRB, 2015).

The soil samples were collected in spring 2009 from the following fields (12×50 m in size): (1) black fallow (BF_{NPK}) where plants were eliminated continuously with mechanical cultivation: ploughing was applied once a year in the autumn; basic treatments like harrowing and disking were done in the autumn and in the spring, with the frequency depending on the weather conditions; sampling was done over a month after the last cultivation; (2) spontaneous succession (SS_{NPK}) with predominating species: alfalfa (*Medicago sativa* L.), orchard grass (*Dactylis glomerata* L.), sorrel (*Rumex acetosa* L.), wormwood (*Artemisia absinthium* L.), common yarrow (*Achillea millefolium* L.) and wood small-reed (*Calamagrostis epigejos* (L.) Roth). The productivity of the mine soil was low, thus in both cases mineral fertilisers were applied at the rates of 160 kg N ha^{-1}, 40 kg P_2O_5 ha^{-1} and 80 kg K_2O ha^{-1}. Nitrogen was provided in the form of ammonium nitrate, phosphorus in the form of superphosphate, and potassium in the form of chloride.

For the study of the physical properties of the soil, samples with undisturbed structure were taken in 12 replicates per treatment, into metal cylinders with 100 cm^3 volume, from the layer of 0-10 cm. Six soil cores were used for soil water characteristic determination. The soil samples were brought to the state of full saturation with water, 0 kPa. Next, measurements of soil water content were performed, at the potentials: –0.98, –3.10, –9.81, –15.54, –30.99, and –49.03, –155.4, –490.3, and –1554 kPa in pressure chambers on porous ceramic plates (Eijkelkamp, The Netherlands; SoilMoisture Equipment Co., USA), following the Richards' method. The volumetric soil water content (*WC*, m^3 m^{-3}) was determined by a standard thermogravimetric method. Water retentions were calculated as follows: gravitational water $GW = WC_0 - WC_{-15.54}$, water available for plants $AW = WC_{-15.54} - WC_{-1554}$, water unavailable for plants $UW = WC_{-1554}$, where WC_0 – maximum water capacity, $WC_{-15.54}$ – field water capacity for a soil with a deep groundwater table (FC), WC_{-1554} – permanent wilting point (PWP). The available water content values, *AW*, were categorised according to Paluszek (2011) into 5 classes: ≤ 0.080 – very low; 0.081-0.120 – low; 0.121-0.170 – medium; 0.171-0.210 – high; > 0.210 m^3 m^{-3} – very high.

At the field water capacity, air permeability, $AP_{-15.54}$ (10^{-8} m^2 Pa^{-1} s^{-1}), was also measured for the samples in the metal cylinders in the device designed to test the permeability of moulding sands (type LPiR-2e, Multiserw-Morek, Poland) at constant ambient temperature (20±0.5°C). The values of $AP_{-15.54}$ were categorised into 5 classes: 1.8-10.0 – very low; 10.1-100 – low; 100.1-1000 – medium; > $1000 \cdot 10^{-8}$ m^2 Pa^{-1} s^{-1} – high (Kołodziej *et al*. 2016).

Utilising the other 6 soil cores collected into the metal cylinders, saturated hydraulic conductivity, K_S (m d^{-1}), was measured with the ICW laboratory permeameter (Eijkelkamp, The Netherlands) by a constant head method. The values of saturated hydraulic conductivity, K_S, were categorised into 5 classes: 0.100 – very low; 0.101-0.500 – low; 0.501-2.000 – medium; 2.001-10 – high; > 10 m d^{-1} –very high (Paluszek, 2011). The RETC computer program was then used to fit soil water characteristic curves to the observed water retention data and, along with the saturated hydraulic conductivity value (K_S), to predict the unsaturated hydraulic conductivity function (RETC 6.02, www.hydrus3d.com; van Genuchten *et al.* 1991) with single-porosity - van Genuchten-Mualem (van Genuchten 1980) or dual-porosity – Durner-Mualem (Durner 1994) models. RETC was run with the fitting parameters WC_S (saturated water content), α, and *n*. WC_R (residual water content) and w_2 were chosen to maximise R^2 and minimise α and *n* standard deviations. The obtained fitted values of water capacity were used to plot the water retention curves in the coordinates of water content vs. modulus of soil water potential, *WC* vs. |Ψ|, respectively. Differential porosity in m^3 m^{-3} was resolved on the basis of the fitted volumetric water retention curve. Pore volume (m^3 m^{-3}) was plotted as the function of equivalent pore diameter, d_E (μm), estimated from $d_E = 294/|\Psi|$, where |Ψ| was the modulus of soil water potential expressed in kPa. Hydraulic conductivity, *K* (m d^{-1}), was presented as the function of effective degree of saturation, $WC_E = (WC - WC_R)/(WC_S - WC_R)$.

6-kg composite bulk samples with disturbed structure were taken from each treatment at the same depth and point as the cylinders. They were used to determine soil texture (sand 0.05–2 mm, silt 0.002–0.05 mm, and clay < 0.002 mm fraction content, kg kg^{-1}) by a combination of the hydrometer and the wet-sieve methods (Polish Society of Soil Science 2009), particle density, ρ_S (Mg m^{-3}, by pycnometer method), total organic carbon (*TOC*, g kg^{-1}, by wet oxidation with dichromate(VI) in sulphuric(VI) acid), pH (by the potentiometric method with a glass electrode in 1:5 (V/V) suspension of soil in a 1 mol dm^{-3} solution of KCl). Bulk density of the soil, ρ (Mg m^{-3}), was determined with the thermogravimetric method, on the basis of the ratio of the mass of soil dried at 105°C to the initial volume of the soil (100 cm^3) in the 6 metal cylinders, after the soil water characteristics had been assessed. Total porosity of the soil, P_O, was calculated on the basis of the results of particle and bulk densities and expressed in m^3 m^{-3}. The ρ and P_O values were categorised according to Paluszek's (2011) classifications for sandy and loamy arable topsoil. The values of ρ were grouped into 5 classes: ≤ 1.4 – very low; 1.41-1.50 – low; 1.51-1.60 – medium; 1.61-1.70 – high; > 1.70 Mg m^{-3} – very high. The values of P_O were classified as follows: ≤ 0.360 – very low; 0.361-0.390 – low; 0.391-0.420 – medium; 0.421-0.450 – high; >0.450 m^3 m^{-3} – very high.

Air capacity of the soil, *AC* (m^3 m^{-3}), at the saturation state corresponding to each soil water potential was calculated as the maximum water capacity minus water content at the relevant state of saturation with water. The air capacity values at –15.54 kPa

($AC_{-15.54}$, field air capacity, $m^3 m^{-3}$) were categorised according to Paluszek (2011) into 6 classes: ≤ 0.070 – very low; 0.071-0.110 – low; 0.111-0.140 – medium; 0.141-0.180 – high; 0.181-0.220 – very high; > 0.220 $m^3 m^{-3}$ excessive field air capacity.

Soil physicochemical variables were tested for normality of variance using the Kolmogorov-Smirnov test. The permeability parameters (*AP* and K_S) were not normally distributed, thus data log transformations were done prior to statistical analyses. Nevertheless, in Tab. 5 non-logarithmic K_S and *AP* values are presented. Mean values (*X*) and coefficients of variation (the ratios of the standard deviation to the mean, V_X, %) were calculated for the measured parameters. The coefficients of variation V_X were classified as small (0-10%), medium (10.1-50%), large (50.1-100%) or very large (> 100%). The means for both treatments were compared by Student's or Satterwhite's (in the case of unequal variances) t-test.

RESULTS AND DISCUSSION

The studied fields located in the inner dumping ground had coarse texture. Soil under the black fallow treatment (BF_{NPK}) was sandy loam with 0.58, 0.24, and 0.18 kg kg^{-1} of sand, silt, and clay, respectively. Soil under spontaneous succession (SS_{NPK}), on the other hand, was sandy with 0.83, 0.10, and 0.07 kg kg^{-1} of respective particle fractions. The soils were characterised by alkaline reaction, 7.2, related with the presence of carbonate minerals. Soil under SS_{NPK} revealed much higher total organic carbon values, *TOC*, 9.60, in contrast to 2.16 g kg^{-1} detected in BF_{NPK} soil.

Particle density, ρ_S, of both soils was equal to 2.67 Mg m^{-3} due to the similar mineral composition of both fields. Bulk density values, ρ, varied considerably between the treatments; lower values in SS_{NPK} could be related to the action of a diverse vegetation with both fibrous and taproot root systems. Consequently, BF_{NPK} soil had medium, and SS_{NPK} soil – very low bulk density, taking into account the loamy or sandy texture of these soils. In analysed soils, the values of total porosity, P_O, were high in BF_{NPK} and very high in SS_{NPK}, reversely to bulk density values (Tab. 1).

Table 1. Bulk density, particle density and porosity of black fallow (BFNPK) and spontaneous succession (SSNPK) treatments

Parameter	BF_{NPK}		SS_{NPK}		Signif.
	X	V_X (%)	*X*	V_X (%)	
Bulk density, ρ (Mg m^{-3})	1.52	4.6	0.64	7.8	***
Particle density, ρ_S (Mg m^{-3})	2.67		2.67		
Total porosity, P_O ($m^3 m^{-3}$)	0.430	5.8	0.760	2.5	***

X – mean; V_X – coefficient of variation; Signif. – significant differences between means according to the t-test at $P < 0.001$ (***)

Figure 1a shows interpolated soil water characteristic (SWC) curves. Water retention parameters obtained from measured data are presented in Table 2. In view of the fact that the R^2 values were very close to 1, the applied models generated very good fits of measured data, allowing accurate prediction of soil hydraulic properties.

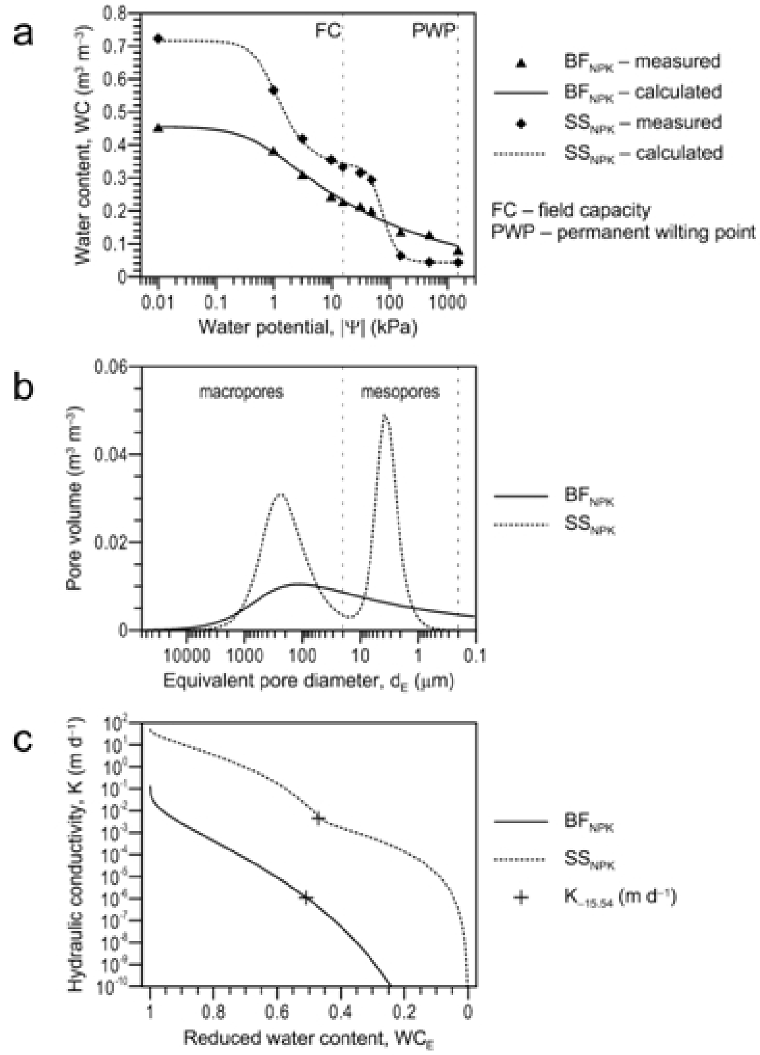

Fig. 1. (a) Soil-water characteristic curves; (b) Differential porosity vs. equivalent pore diameter, d_E (μm); (c) Hydraulic conductivity, K (m d^{-1}) vs. effective degree of saturation, W_{CE}. BF_{NPK} – black fallow; SS_{NPK} – spontaneous succession

From the agronomic (practical) point of view, it is more convenient to use the volumetric water content. When the volume of water is related to the volume of soil (frequently penetrated by roots), the current soil structure state, described via soil bulk density and porosity, could be respected (Turski and Witkowska-Walczak 2004). SWC curves plotted for the BF_{NPK} and SS_{NPK} soils were very different, revealing the influence of vegetation on retention capabilities and air properties of the soils (Tab. 3, Fig. 1a). The gravitational water retention for SS_{NPK} was 1.7 times higher than for BF_{NPK} soil (Tab. 4), by ca. –90 kPa. The water capacity for both soils reached ca. 0.15 $m^3 m^{-3}$. As a result, available water content in SS_{NPK} doubled the respective value in BF_{NPK} soil, and, on the contrary, unavailable water retention in BF_{NPK} almost doubled the corresponding value in SS_{NPK} soil.

Table 2. Parameters of soil water characteristic curves of black fallow (BF_{NPK}) and spontaneous succession (SS_{NPK}) treatments

Parameter	BF_{NPK}	SS_{NPK}
Residual water content, WC_R ($m^3 m^{-3}$)	0.000	0.043
Saturated water content, WC_S ($m^3 m^{-3}$)	0.456±0.027[a]	0.716±0.022[a]
α_1 (m^{-1})	18.857±12.362[a]	11.795±2.628[a]
n_1	1.20±0.03[a]	2.18±0.33[a]
α_2 (m^{-1})	n/a[b]	0.142±0.022[a]
n_2	n/a[b]	4.05±1.14[a]
w_2	n/a[b]	0.43
R^2	0.992	0.999

[a]mean ± 95% confidence limits; [b]not applicable

Table 3. Water, *WC*, and air capacity, *AC*, at given soil water potential, Ψ, of black fallow (BF_{NPK}) and spontaneous succession (SS_{NPK}) treatments

Soil water potential, Ψ (kPa)	Water capacity, *WC* ($m^3 m^{-3}$)					Air capacity, *AC* ($m^3 m^{-3}$)				
	BF_{NPK}		SS_{NPK}		Signif.	BF_{NPK}		SS_{NPK}		Signif.
	X	V_X (%)	*X*	V_X (%)		*X*	V_X (%)	*X*	V_X (%)	
0	0.454	5.5	0.723	11.2	***					
–0.98	0.383	5.5	0.567	12.3	***	0.070	20.0	0.156	29.5	**
–3.10	0.310	4.2	0.419	16.7	**	0.144	11.1	0.304	16.4	***
–9.81	0.243	6.6	0.355	18.0	**	0.211	6.6	0.368	13.6	***
–15.54	0.228	7.0	0.333	18.6	**	0.226	6.6	0.389	13.1	***
–30.99	0.214	7.5	0.316	19.3	**	0.240	6.7	0.406	12.8	***
–49.03	0.201	9.0	0.295	19.0	**	0.253	6.3	0.427	12.4	***
–155.4	0.137	5.1	0.065	9.2	***	0.317	6.0	0.658	11.4	***
–490.3	0.128	34.4	0.045	8.9	**	0.326	10.1	0.677	11.5	***
–1554	0.081	6.2	0.044	11.4	***	0.373	5.4	0.679	11.3	***

X – mean; V_X – coefficient of variation; Signif. – significant differences between means according to the t-test at P < 0.01 (**) or 0.001 (***)

The specific features of SWC curves for each treatment were moreover apparent in the differential porosity plots (Fig. 1b). Pore-size distribution of BF_{NPK} soil was unimodal, with a maximum in the macropore range at ca. 100-200 µm. On the contrary, pore-size distribution of SS_{NPK} soil was bimodal, with peaks in the range of mesopores, ca. 3-4 µm, and macropores at ca. 200-300 µm. Dual-porosity characteristics of the SS_{NPK} soil could be associated with the presence of inter-aggregate biogenic channels developed by plant roots and mesopores in the porous aggregates which develop in the presence of vegetation and high *TOC*.

Table 4. Water retention categories of black fallow (BF_{NPK}) and spontaneous succession (SS_{NPK}) treatments

Parameter	BF_{NPK}		SS_{NPK}		Signif.
	X	V_X (%)	*X*	V_X (%)	
Gravitational water, *GW* (m^3 m^{-3})	0.226	6.6	0.389	13.1	***
Available water, *AW* (m^3 m^{-3})	0.146	7.5	0.290	20.3	***
Unavailable water, *UW* (m^3 m^{-3})	0.081	6.2	0.044	11.4	***

X – mean; V_X – coefficient of variation; Signif. – significant differences between means according to the t-test at P < 0.001 (***)

The field air capacity, $AC_{-15.54}$, according to Paluszek (2011), was excessive and it was more than 1.7 times higher for SS_{NPK} than for BF_{NPK} soil (Tab. 3). Consequently, the minimum air capacity required at the state of field water capacity for good plant condition, 0.10 m^3 m^{-3}, was exceeded at least two times in both treatments. Air capacity increased with decreasing soil water potential and emptying soil pores of water and the air capacity of SS_{NPK} soil in the entire range of soil water potentials was 1.7-2.2 times higher than the respective values for BF_{NPK} soil.

The BF_{NPK} soil retained medium, and, the SS_{NPK} soil – very high volume of water available for plants, *AW* (Tab. 4), however both soils had an excessive field air capacity, $AC_{-15.54}$ (Tab. 3). These results could not be straightforwardly attributed solely to the texture of both soils (sandy loam for BF_{NPK} and sand for SS_{NPK}) as demonstrated for unfertilised BF and SS fields of nearly identical texture (Kołodziej *et al*. 2016). Although high field air capacities are typical for coarse-textured soils, one could presume that in sandy loam the available water content should be higher than in the sand. The higher amount of water available for plants in SS_{NPK} soil is, however, justified by the higher *TOC* and vegetation cover which rebuilt soil structure mostly in mesopore region. Micropore volume, on the other hand, could be in fact related to the texture, and higher values of micropore volume could be explained by higher amount of silt and clay fraction in BF_{NPK} soil in comparison to SS_{NPK} soil.

BF_{NPK} soil had low, and SS_{NPK} soil – high air permeability value at the field water capacity, $AP_{-15.54}$ (Tab. 5). Hydraulic permeability for both soils followed similar trend as air permeability and resulted in low value for BF_{NPK} soil and very high value for SS_{NPK} soil. Similar sequence of values was detected also for hydraulic conductivity values at the field water capacity ($K_{-15.54}$). Hydraulic conductivity, K, decreased more rapidly with decreasing effective degree of saturation, WC_E, for BF_{NPK} soil, and slower for SS_{NPK} soil, however in the range of reduced water content from 1 to 0.47-0.51 (corresponding to the field water capacity) both curves were virtually parallel, indicating comparable drop of hydraulic conductivity with water loss. This part of K vs. WC_E curve is governed by the macropore structure. Despite the larger volume of macropores in SS_{NPK} soil, the reduction of K for both soils was similar (Fig. 1c).

Table 5. Air permeability, $AP_{-15.54}$, hydraulic conductivity, K_S and $K_{-15.54}$, of black fallow (BF_{NPK}) and spontaneous succession (SS_{NPK}) treatments

Parameter	BF_{NPK}		SS_{NPK}		Signif.
	X	V_X (%)	X	V_X (%)	
Air permeability at –15.54 kPa, $AP_{-15.54}$ (10^{-8} m^2 Pa^{-1} s^{-1})	50.5	21.4	2021.5	12.3	***
Saturated hydraulic conductivity, K_S (m d^{-1})	0.2	149.9	48.5	5.0	**
Hydraulic conductivity at –15.54 kPa, $K_{-15.54}$ (m d^{-1})	$1.1 \cdot 10^{-6}$		$4.6 \cdot 10^{-3}$		

X – geometric mean; V_X – coefficient of variation of log data; Signif. – significant differences between means according to the t-test at P < 0.01 (**) or 0.001 (***)

The analysis of the soil physical state created in the process of post-mining land rehabilitation in the region of Konin revealed a positive influence of plant root system on the physical state of soil. As described by Elmer *et al*. (2013), with high temporal and spatial resolution for the artificial catchment built in an opencast lignite mine, early stages of this ecosystem development were characterised by great dynamics. During the first 2 years, intensive water and wind erosion took place in the catchment, which is typical for bare soil (Brodowski and Rejman 2004). The processes were slowed down markedly by the biological colonisation (spontaneous succession) which started immediately and became obvious after 4 years of the study. Our study presents the physical state of the soil after 30 years since the technical reclamation was finished. A mature habitat of spontaneous succession (SS_{NPK}) was contrasted with a soil left bare (as a black fallow, BF_{NPK}) for the same time. Structure formed during tillage of BF_{NPK} soil practically disappeared due to sandy loam texture and low *TOC* content, before the samples were collected. As a result, this comparison gave the unique opportunity to study the influence of pioneer plants on the soil physical state. In our experiment the presence of vegetation (SS_{NPK} treatment) resulted in 4 times higher total organic carbon in comparison with the unvegetated soil (BF_{NPK}). Low bulk density and high porosity in SS_{NPK} soil revealed indirectly a high belowground input of organic material – the upper soil layer was vastly penetrated by roots. The SS_{NPK} soil attained the physical status similar to a meadow. For example, Sochorec *et al*. (2015), for a non-compacted grassland on a sandy loam, also reported very low bulk density (1.05-1.14 Mg m^{-3}), very high total porosity (0.560-0.601 m m^{-3}), and medium infiltration rate (38.9-56.0 m d^{-1}). The vegetation remodelled a typical for sand, S-shaped soil water characteristic curve, especially in the mesopore region, which resulted in higher available water content. The water and air permeabilities revealed less variability and higher values in the soil stabilised with plant roots. As stated by Canadell *et al*. (1996), roots in temperate grassland can reach as deep as to 1-5 m into the soil and the maximum rooting depth of herbaceous plants is ca. 2.5 m. It is then quite obvious that plant roots have a great potential to stabilise soil structure and thus – soil physical status (Gyssels and Poesen 2003).

CONCLUSIONS

1. Over 30 years of spontaneous succession treatment of the post mining grounds enriched the resulting Technosol in organic carbon 4 times more than the black fallow treatment.

2. Vegetation caused a high belowground input of organic material, which was apparent by the very low bulk density and the very high porosity values.

3. Spontaneous succession changed the typical differential porosity of a sandy soil in the meso- and macropore region.

4. Soils under both treatments were characterised by excessive field air capacity, but the soil under spontaneous vegetation revealed higher volume of water available for plants in comparison to the black fallow soil, despite its coarser texture.

5. The black fallow soil had lower and more variable air and water permeabilities than the soil under spontaneous succession.

6. Spontaneous succession including plants with extensive root systems positively influenced soil physical state, thereby improving soil ecosystem stability.

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WPŁYW SUKCESJI SPONTANICZNEJ NA STAN FIZYCZNY POGÓRNICZEJ GLEBY INDUSTRIOZIEMNEJ

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Streszczenie. Celem pracy była ocena wpływu sukcesji spontanicznej w porównaniu z czarnym ugorem, na stan fizyczny gleby zdegradowanej działalnością górniczą na obszarze zwałowiska wewnętrznego Pątnów koło Konina. Zmierzono podstawowe parametry fizyczne i chemiczne (węgiel organiczny, gęstość, pH), pojemności wodne oraz przewodnictwo wodne i powietrzne. Na podstawie pojemności wodnych i współczynnika filtracji wyznaczono krzywe potencjału wody glebowej – wilgotność, porowatości dyferencjalne i funkcję przewodnictwa wodnego w strefie nienasyconej. 30-letnia sukcesja spontaniczna znacznie bardziej niż czarny ugór wzbogaciła glebę industrioziemną w węgiel organiczny. Wierzchnie warstwy gleby przerośnięte korzeniami charakteryzowały się bardzo niskimi wartościami gęstości i bardzo wysokimi – porowatości. Roślinność zmieniła typowy dla gleby piaszczystej rozkład wielkości porów, szczególnie w zakresie mezoporów. Obie gleby charakteryzowały się nadmierną polową pojemnością powietrzną, ale gleba pod spontaniczną sukcesją wykazała większą zawartość wody dostępnej dla roślin, mimo lżejszego składu granulometrycznego. Czarny ugór miał niższe i bardziej zmienne wartości przepuszczalności wodnej i powietrznej niż gleba pod spontaniczną sukcesją. Rośliny o rozwiniętych systemach korzeniowych pozytywnie wpłynęły na stan fizyczny gleby, polepszając tym samym stabilność ekosystemu glebowego.

Słowa kluczowe: gleba industrioziemna, właściwości fizyczne, czarny ugór, sukcesja spontaniczna