Acta Agrophysica, 2001, 50, 197-205

THE PROPERTIES OF HUMUS IN SOME PROFILES OF THE BLACK EARTH - GLEYIC PHAEOZEMS - FROM THE MAŁOPOLSKA UPLAND

R. Mazurek, J. Niemyska-Łukaszuk

Department of Soil Science and Soil Protection, Agricultural University of Cracow
Al. Mickiewicza 21, 31-120 Kraków, Poland

A b s t r a c t. The aim of the present research work was to evaluate the influence of lithogenic conditions on the physico-chemical properties, quantity and quality of humus components in the black earths from the Małopolska Upland. Soil samples were collected from 5 soil profiles which represented proper black earth (profiles No. 1-4) and degraded black earth (profile No. 5). All the investigated soils were under sward.

The examined black earths were characterised by different physico-chemical properties strongly related to the parent rock type. Their pH level and sorption capability were decreasing with a decrease in the clay content of the soil texture. Humus resources were the lowest in sandy black earths (average 212 t ha^{-1}) and the highest in the black earh derived from clay (454 t ha ^{1}). In the humus composition of the examined black earths, humic acids dominated over fulvic acids. In the A horizons, the Ch:Cf ratio was close to 1, and lower in the upper parts of these horizons which is typical of turf soils. Humus horizons in some of the investigated black earths were classified as epipedon anthropoid according to phosphorus content soluble in 1% citric acid (109 P kg^{-1} soil).

K e y w o r d s: phaeozem, Małopolska Upland, humus, phosphorus.

INTRODUCTION

Black earths in Poland are concentrated in a few larger complexes [1,3]. They also occur in other places throughout the country but on smaller areas. They can also be found in medium size complexes in the area of the Małopolska Upland.

One of the significant factors that form the properties of black earths is moisture conditions as influenced by the depth of underground water deposits [8]. Water-air conditions are also of importance for soil formation that influences type of parent rock and decides, among others, on the accumulation processes and transformations of organic matter [6]. According to the Systematics of Polish Soils

[9] parent rocks of black earths are mainly silt and clay deposits, and less frequently sands.

The aim of the work was to determine the influence of lithogenic conditions on the quantity and quality of humus compounds of the black earths from the Małopolska Upland.

MATERIALS AND METHODS

Soil samples were taken from 5 profiles representing proper black earths (4 profiles) and degraded black earth (1 profile) (Fig. 1). Soil outcrops from the area of the Proszowice Plateau present black earths derived from loess and Holocene clay when the soils taken from the area of Cracow Gate were formed from Pleistocene sand. All the investigated soils came from greenland.

Basic physico-chemical soil properties were determined in the soils by the methods generally used in soil science, i.e.: pH potentiometrically in H_2O and 1 M KCl, soil texture after the modified Cassagrande's method, humus content according to the modified Tiurin's method with C organic oxidation using potassium dichromate (VI), total content of nitrogen according to the Kjeldahl's method using Kjeltec apparatus, hydrolytic acidity in 1 M sodium acetate, cation exchange capacity (CEC) by the determination of basic cations (Ca, Mg, K, Na) using ammonium chloride for extraction.

Fig. 1. Location of soil profiles.

Moreover, phosphorus content soluble in 1% citric acid was determined in the humus horizons. Analyses of fractional humus composition was carried out according to the Boratyński and Wilk methods. Humification degree was determined on the basis of the Duchaufour and Jacquin's method.

RESULTS AND DISCUSSION

Properties of the black earths are clearly differentiated due to their lithological diversity. Differences are visible especially in the case of soil reaction and sorption properties (Table 1). Calcium carbonate has not occurred in the sandy black earths. That resulted in lower pH values in these soils than in the soils derived from loess and clay. Similar pH values have been characteristic for the sandy black earths from the other areas of the country [7]. Among the investigated soils, pH in water amounted to 7.6 only in a one part of the sandy black earth profile (profile 4). It was caused by the occurrence of the Miocene clay, rich in calcite under glacifluvial sands. The highest amount of calcium carbonate was found in all the horizons of clayey black earth (Table 2). This profile was characterised by the highest pH values and the highest cation exchange capacity (CEC). The lowest sorption capacities characterised sandy black earths where the cation exchange capacity did not exceed 10 cmol(+) kg^{-1} of soil (Table 1). A sorption complex of the investigated soils was filled primarily with calcium and magnesium ions. Potassium exceeded the amount of 1 cmol(+) kg^{-1} of soil only in the deeper horizons of the profile 5. Degree of base saturation (V%) had the lowest level in the profiles of the soils derived from glacifluvial sands. In the remaining soils, it exceeded 95%, except for the upper horizon Aa of the profile 3, i.e. black earth derived from loess (Table 1).

Content and compositions of humus compounds was determined by the character of parent rock. The soil derived from clay had the humus A horizon with the depth of up to 88 cm and high humus content that formed the highest humus resources in the soil (454 t ha^{-1}) (Table 3, Fig. 2). Considerably lower, but still high humus resources occur in the black earths derived from loess (292 t ha^{-1}). Humification degree of the organic matter in the investigated black earths was similar but always lower in the upper parts of the humus horizons due the inflow of high amounts of fresh organic matter which in turn influenced an increase of the C:N ratio in this part of the profile.

In the stable turf soils a big mass of fresh organic matter which entered upper humus horizons, led to the formation of large amounts of humus com-

T a b l e 1. Reaction and sorption properties of the investigated soil profiles

Profile No.	Depth (cm)	Horizon	pH		Exchangeable cations (cmol(+) kg^{-1})				S	Kh	PWK	V (%)
			H_2O	KCl	Ca	Mg	K	Na	cmol(+) kg^{-1}			
Proper black earths												
1. Derived from clay	0-17	Ah	7.37	6.83	31.24	6.71	0.45	0.29	38.69	0.87	39.56	97.80
	17-53	Aa1	8.14	7.24	32.06	8.86	0.49	0.66	42.07	0.14	42.21	99.67
	43-88	Aa2	8.35	7.36	29.59	8.45	0.67	0.76	39.47	0.14	39.61	99.65
2. Derived from lo-ess	0-10	Aa	7.35	6.92	23.43	2.63	0.23	0.05	26.35	0.43	26.78	98.39
	10-49	Agg	7.59	7.05	22.20	2.11	0.16	0.10	24.56	0.29	24.85	98.83
	49-72	AG1	7.67	7.17	23.43	2.83	0.27	0.14	26.67	0.14	26.81	99.48
	72-80	AG2	7.80	7.16	24.25	3.44	0.47	0.19	28.34	0.14	28.48	99.51
3. Derived from lo-ess	0-15	Aa	6.10	5.44	13.56	2.86	0.12	0.18	16.72	2.9	19.62	85.22
	15-33	Agg	6.88	6.28	14.39	2.74	0.09	0.10	17.31	0.87	18.18	95.22
	33-57	ACG	7.29	6.43	11.10	2.54	0.08	0.10	13.82	0.58	14.40	95.97
4. Derived from sand	0-15	Ah1	5.95	5.19	4.11	0.83	0.12	0.01	5.07	2.46	7.53	67.31
	15-32	Ah2	6.42	5.64	4.11	0.30	0.03	0.03	4.47	1.30	5.77	77.46
	32-52	Aa1	6.73	5.89	3.70	0.29	0.01	0.01	4.01	1.16	5.17	77.57
	52-75	Aa2	6.79	5.96	3.70	0.30	0.02	0.01	4.03	0.16	5.19	77.64
	75-110	CG	7.62	6.58	1.64	0.33	0.03	0.01	2.01	0.22	2.23	90.13
Degraded black earths												
5. Derived from sand	0-24	Aa	6.24	5.67	6.58	1.32	0.07	0.04	8.01	1.88	9.89	80.99
	24-42	Agg	6.36	5.59	3.29	0.62	0.03	0.03	3.97	1.59	5.56	71.38
	42-78	CGox	6.44	5.50	1.23	0.27	0.02	0.01	1.52	0.87	2.39	63.63
	78-116	G	5.68	4.11	2.88	1.09	0.54	0.02	4.53	0.72	5.25	86.27
	116-140	IICG	6.04	4.65	2.88	1.76	1.40	0.09	6.12	1.30	7.42	82.49
	140-150	IIICG	5.72	6.43	2.47	1.75	1.06	0.09	5.36	1.45	6.81	78.71

Table 2. Soil texture of the investigated profiles

Profile No.	Depth (cm)	Horizon	Percent of particles with dia (mm)					$CaCO_3$ (%)
			1.0-0.1	0.1-0.05	0.05-0.02	<0.002	<0.02	
			Proper black earths					
1. Derived from clay	0-17	Ah	11	1	32	18	56	5.26
	17-53	Aa1	9	1	16	23	74	6.46
	43-88	Aa2	6	4	22	25	68	7.96
2. Derived from loess	0-10	Aa	4	6	44	6	46	4.38
	10-49	Agg	4	7	46	7	43	4.00
	49-72	AG1	4	7	45	8	44	4.90
	72-80	AG2	4	7	39	11	50	4.21
3. Derived from loess	0-15	Aa	1	7	47	12	45	2.90
	15-33	Agg	1	7	47	10	45	2.29
	33-57	ACG	2	10	46	10	42	2.13
4. Derived from sand	0-15	Ah1	81	3	6	2	10	0.00
	15-32	Ah2	81	3	3	4	13	0.00
	32-52	Aa1	84	3	3	4	10	0.00
	52-75	Aa2	84	5	1	5	10	0.00
	75-110	CG	86	6	3	1	5	0.00
			Degraded black earths					
5. Derived from sand	0-24	Aa	74	3	13	2	10	0.00
	24-42	Agg	81	5	5	4	9	0.00
	42-78	CGox	76	7	3	8	14	0.00
	78-116	G	77	6	3	8	14	0.00
	116-140	IICG	22	21	32	9	25	0.00
	140-150	IIICG	48	13	19	8	20	0.00

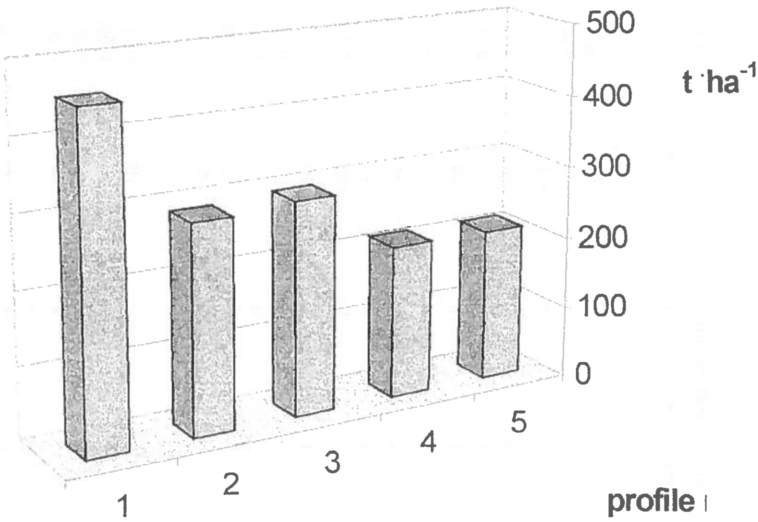

Fig. 2. Average resource of humus (t ha^{-1}) in investigated soil profiles.

Table 3. Humus content and its properties in the investigated soil profiles of black earths

Profile No.	Horizon	Depth (cm)	C org. (%)	Humus (%)	C:N	Degree of humification (%)	Average humus resources t ha^{-1}
1	Aaan	0-17	4.24	7.31	8.65	96	454.62
	Aa1	17-53	1.52	2.62	7.24	99	
	Aa2	53-88	1.40	2.41	7.33	100	
2	Aaan	0-10	2.37	4.09	11.31	98	289.27
	Aangg	0-49	1.39	2.40	7.69	99	
	AG1	49-72	1.11	1.91	6.53	99	
	AG2	72-80	0.87	1.50	5.44	-	
3	Aa	0-15	3.27	5.64	11.29	95	296.30
	Agg	15-33	2.25	3.88	8.67	98	
	ACG	33-57	0.98	1.69	7.00	100	
4	Ah1	0-15	2.03	3.50	12.69	92	211.58
	Ah2	15-32	0.85	1.47	6.07	99	
	Aa1	32-52	0.78	1.34	11.14	99	
	Aa2	52-72	0.79	1.36	11.29	100	
5	Aan	0-24	2.50	4.31	13.16	90	212.20
	Agg	24-42	1.05	1.81	9.55	98	

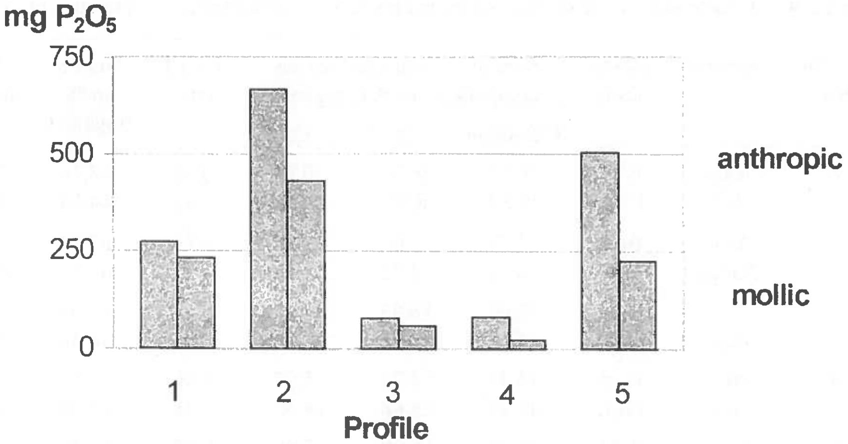

Fig. 3. Phosphorus content (mg kg^{-1}) in humus horizons of investigated profiles.

pounds with a relatively simple molecular structure [6,8,11]. It explains the fact that in the upper parts of humus horizons of the investigated soils, fulvic acids were the predominant humic acids. The Cf:Ch ratio was almost always lower in the upper than in the lower parts of these horizons, i.e., 1.06-2.00. It was already mentioned in the earlier research [2,10]. The influence of parent rock was also visible in the quantity of stable, organo-mineral compounds - humins. Black earth derived from clay and loess was characterised by the highest amount of humins while the black earth derived from sand, by considerably lower amount of these compounds.

Humus horizons of black earths belonged, as a rule, to mollic epipedon. It means that they were characterised by a strong spheroid texture, colour value under 3.5, degree of base saturation equal or higher than 50%, content of organic carbon of at least 0.6% and the minimum depth of over 18 cm. Mollic epipedon differ from anthropoid epipedon in the content of phosphorus soluble in 1% citric acid (Fig. 3). In the mollic pedon, it was lower than 109 mg P in kg of soil (under 250 mg P_2O_5). If the above amount was exceeded, the epipedon reached the criteria for the anthropoid epipedon [9]. In the three profiles of the investigated black earths, in the A horizons, the content of P_2O_5 exceeded the limit value of 250 mg kg^{-1} of soil. These were the soils derived from different parent rocks: from clay (profile 1), loess (profile 3) and sand (profile 5) (Table 3, Fig. 3). They were classed as anthropoid Aan on this basis their humus horizons (Table 1). A considerable decrease of the phosphorus content extracted with

T a b l e 4. Characteristics of the organic matter and phosphorus content in the investigated black earths

Profile No.	Horizon	Depth (cm)	Sum of the extracted humus components in % C organic			Ch:Cf ratio	Humins in % organic C	P_2O_5 (mg kg^{-1})
			C fraction	Ch	Cf			
1	Aaan	0-17	20.05	9.20	10.85	0.85	68.16	273.61
	Aal	17-53	13.82	8.55	5.26	1.63	44.74	232.05
2	Aaan	0-10	23.58	12.63	10.95	1.15	67.93	669.20
	Aangg	0-49	26.71	13.72	13.00	1.06	61.87	430.29
3	Aa	0-15	32.07	18.93	13.13	1.44	44.95	78.89
	Agg	15-33	14.64	9.76	4.88	2.00	40.44	57.71
4	Ah1	0-15	34.48	19.21	15.27	1.26	21.18	80.82
	Ah2	15-32	44.71	25.88	18.82	1.38	37.65	22.67
5	Aaan	0-24	34.40	16.80	17.60	0.95	22.40	503.02
	Agg	24-42	44.76	27.62	17.14	1.61	40.95	225.88

1% citric acid in the subhumous horizons, proved anthropogenic enrichment of the upper parts of the profile with this element (Table 4). Similarly high contents of phosphorus soluble in 1% citric acid were characteristic for intensively cultivated black earths from the Błonie-Sochaczew Plain [4].

CONCLUSIONS

1. The examined black earths were characterised by different physico-chemical properties, strongly related to the parent rock type. Their pH levels and sorption capability were decreasing with a decrease in the clay content of the soil texture.

2. Humus resources were the lowest in the sandy black earths (average 212 t ha^{-1}) and the highest in the black earh derived from clay (454 t ha ^{1}).

3. Humus compositions of the examined black earths showed the predominant presence of humic acids over fulvic acids. In the A horizons, the Ch:Cf ratio was close to 1, and lower in the upper parts of these horizons which is typical of turf soils.

4. Humus horizons in some of the investigated black earths were classified as epipedon anthropoid according to their phosphorus content soluble in 1% citric acid (109 P kg^{-1} soil).

REFERENCES

1. **Borkowski J.:** Grey and black soils from fine sand formation on Silesian territory. Roczn. Glebozn., 14, 1, 61-77, 1964.

2.**Borowiec S., Wybieralska A.:** Differetion of humus composition depending on type and utilization of soils. Rocz. Glebozn., 20,1, 67-97, 1969.

3.**Chojnicki J.:** Black earths developed from the cover silts of the Błonie-Sochaczew Plain. Roczn. Glebozn., 40, 3, 97-107, 1994.

4.**Chojnicki J., Czarnowska K.:** The changes of the contents of total and readily soluble phosphorus and Zn, Cu, Pb, Cd in agricultural soils under intensive cultivation. Roczn. Glebozn., 44, 3, 99-111, 1993.

5.**Ciarkowska K., Niemyska-Łukaszuk J.:** Influence of utilization mode on content and quality of humus compounds in gypsic rendzinas. Zesz. Probl. Post. Nauk Roln., 460, 113-120, 1998.

6.**Drozd J., Kowaliński S., Licznar M., Licznar S.E.:** Micromorphological interpretation of the physico-chemical processes in post-boog soil. Roczn. Glebozn., 38, 3, 121-137, 1987.

7.**Konecka-Betley K., Czępińska-Kamińska D., Janowska E.:** Black earths in alluvial landscape of the Kampinos Forest. Roczn. Glebozn., 47, 3, 145-158, 1996

8.**Licznar M., Drozd J.:** Influence of water relations on the productivity of black earths. Roczn. Glebozn., 47, 3, 9-22, 1996.

9.Systematics of Polish Soils. Roczn. Glebozn., 40, 3, 1989.

10.**Turski R.:** Characteristic of humus compositions in soils of Poland. Roczn. Nauk Roln., Seria D - Monografie, 212, 1988.

11.**Wachendorf C., Weber N., Blume H.P.:** Humuskörper unter landwirtschaftlicher Nutzung Vergleich eines Acker- und Grünland standortes. Mitteilgn. Dtsch. Bodenkundlichen Gesellsch., 80, 193-196, 1996.