Acta Agrophysica, 2001, 50, 139-146

HUMUS FRACTIONAL COMPOSITION OF THE SELECTED SOILS IN THE MAŁOPOLSKA PROVINCE

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A b s t r a c t. Twenty different soils were investigated. The soils varied in their acidification degree, granulometric composition and a carbon content. The investigated soils were collected from arable land, meadows and forests. Humic compounds were extracted from the soil according to the Konowowa and Bielczikova's method. Very high quantitative and qualitative differentiation was observed. It was related to the soil type and utilisation system. Low but differentiated quantities of humic compounds extracted by 0.05 M H_2SO_4 were found in the samples of the analysed soils. In the extract of pyrophosphate and sodium base as well as in the extract of sodium base, there were more fulvic acids than humic acids which was reflected in the narrow Ckh:Ckf ratio, particularly in the forest soils. In addition very high proportion of non-hydrolysing carbon was observed. Its content ranged from 52 to 84%. The highest proportion of this fraction was found in the soils agriculturally utilised.

K e y w o r d s: soil, composition of humus fraction, humic acids, fulvic acids.

INTRODUCTION

Without doubt, soil humus is one of the most important soil components which influences chemical, physical and also biological properties of the soil [20]. Humus in the soil improves its buffering and sorptive capacity. It influences formation a stable aggregate structure and improves water and air conditions. In addition, organic matter plays an important part in binding and translocating heavy metals that are harmful to the environment [17]. Organic-mineral links called chelate complexes are formed. They cause immobilisation of heavy metals [1-3]. Soil humus protects the soil against contamination. Fractional composition of humus and its content in the soil depend on many factors such as mineral [12] and organic fertilisation. Application of organic fertilisers, especially manure, beneficially affects humus content, particularly in the light soils [6-8]. It is assumed that organic fertilisation increases the level of soil organic matter while mineral fertilisation stabilises it [5]. The results of numerous experiments indicate that any interference, for example a long-term mineral or organic fertilisation, simplified crop rotation or introduction of heavy metals, influences the quality of humus compounds. Such changes in the soil are often unfavourable [4,6,9,11,14,19].

The paper presents a part of experiments concerning physico-chemical properties of acidic soils and their effect on plants (especially in the case of heavy metals). Considering a very important role that soil humus plays in soil fertility, we should endeavour to learn more about its quantity and quality. In the present paper we tried to present humus fractional composition of some selected soils in the Małopolska province.

MATERIAL AND METHODS

Samples collected from twenty different soils were investigated. The samples were collected from arable land, meadows, barren land and forests in the region of the Małopolska province (Table 1). The samples were collected from the upper soil horizons (Ap, Ah), (0-10 cm), taking into consideration mainly soil granulometric composition and reaction. Granulometric composition was determined by the Casagrande's method modified by Prószyński, pH was determined in the solution of 1 mol dm^{-3}, total nitrogen content by the Kjeldahl's method, total carbon content by the Tiurin's method and the humus fraction composition by the Kononowa and Bielczikova's method. Humus compounds were extracted from the soil with the use of the following solutions; 0.05 M dm^{-3} H_2SO_4, mixture of 0.1 M dm^{-3} $Na_4P_2O_7$ + 0.1 M dm^{-3} NaOH and 0.1 M dm^{-3} NaOH. In the obtained extracts, total carbon and carbon of humic acids were determined; whereas carbon of fulvic acids was calculated from the differences between the total amount of organic carbon in the extract and its amount in the humic acids.

RESULTS AND DISCUSSION

Considering the reaction of the soils used in the experiments, there were 16 acidic or very acidic soils, 3 light acidic soils and 1 neutral soil. Such a high proportion of acidic soils is typical of this region. Włodarczyk [22] also pointed out that the proportion quoted in his paper on the state of the soil acidification in Poland. The soils used in the experiments varied considerably in their granulometric composition (Table 1). The experiments revealed differences in the quantitative

Table 1. Selected properties of soils used in the experiment

No. of soil	Use	pH_{KCl}	Content of mechanical fractions (%)		
			1.0-0.1	0.1-0.02	<0.02
			mm		
I	ploughfield (Ap)	4.23	9	21	70
II	ploughfield (Ap)	5.69	36	33	31
III	ploughfield (Ap)	4.96	20	34	46
IV	ploughfield (Ap)	4.85	16	40	44
V	ploughfield (Ap)	6.23	9	58	33
VI	ploughfield (Ap)	6.51	4	7	89
Mean		5.41	16	32	52
VII	meadow (Ah)	4.34	7	46	47
VIII	meadow (Ah)	3.85	47	27	26
IX	meadow (Ah)	3.93	8	40	52
X	meadow (Ah)	4.02	40	37	23
XI	meadow (Ah)	3.88	27	41	32
XII	meadow (Ah)	4.28	12	18	70
XIII	meadow (Ah)	3.95	36	33	31
XIV	meadow (Ah)	3.71	20	34	46
Mean		4.00	25	35	41
XV	barrenland (Ah)	4.80	41	32	27
XVI	barrenland (Ah)	6.85	22	40	38
XVII	barrenland (Ah)	2.83	36	34	20
Mean		4.83	33	35	28
XVIII	forest (Ah)	5.18	26	35	39
XIX	forest (Ah)	3.32	9	21	70
XX	forest (Ah)	3.67	40	20	40
Mean		4.06	25	25	50

and qualitative composition of the humus compounds in the soils of this region (Table 2). The C-total content ranged from 1.02 to 3.59% and varied significantly (V=40%). The values show that the humus content in these soils exceeds its mean value found in Poland.

Similar results can be found in the paper written by Licznar *et al.* [12] on the experiments carried out on the humus fractional composition of the rendzina in the south-west part of Poland and in the paper by Pondel *et al.* [15] on the humus content in the soils of Poland.

Total nitrogen content varied in various soils and ranged from 0.097 to 0.443% (Table 2). It was found that this content in the soils increased together with the increase in the total carbon content (r=0.66). This fact supports the theory

T a b l e 2. Continuation

No. of soil	C organic	N total	C:N	C isolated									C non-hydro-lyzing
				0.05 M	0.1 M $Na_4P_2O_7$ + 0.1 M Na OH				0.1 M NaOH				
				H_2SO_4	C of the extract	Humic acids	Fulvic acids	C_{Kh}/C_{Kf}	C of the extract	Humic acids	Fulvic acids	C_{Kh}/C_{Kf}	
	%			in % of org. C					in % of org. C				in % of total C
XV	1.32	0.13	10.40	4.60	32.60	5.10	27.50	0.18	35.30	9.30	26.00	0.36	67.40
XVI	1.96	0.22	8.90	4.60	18.70	5.10	13.60	0.38	19.10	7.70	11.40	0.67	81.30
XVII	2.84	0.12	24.10	0.60	18.60	6.50	12.10	0.54	32.00	5.50	26.50	0.21	81.40
Mean	2.04	0.16	14.47	3.27	23.30	5.57	17.73	0.37	28.80	7.50	21.30	0.41	76.70
XVIII	1.33	0.11	12.20	2.60	23.60	3.80	19.80	0.19	31.70	7.10	24.60	0.29	76.40
XIX	1.40	0.13	10.90	9.70	40.80	8.30	32.60	0.25	32.10	9.50	22.60	0.42	59.20
XX	2.02	0.12	16.40	3.00	40.90	4.40	35.90	0.12	40.00	14.40	25.70	0.56	59.10
Mean	1.58	0.12	13.17	5.10	35.10	5.50	29.43	0.19	34.60	10.33	24.30	0.42	64.90
V%	40	49	38	57	36	34	43	96	27	31	33	77	17

* V% - variation coefficient (%).

Table 2. Fractional composition of humus compounds

No. of soil	C organic	N total	C:N	C isolated									C non-hydro-lyzing
				0.05 M H_2SO_4	0.1 M $Na4P_2O_7$ + 0.1 M Na OH				0.1 M NaOH				
					C of the extract	Humic acids	Fulvic acids	C_{Kh}/ C_{Kf}	C of the extract	Humic acids	Fulvic acids	C_{Kh}/ C_{Kf}	
	%			in % of org. C									in % of total C
I	1.02	0.14	7.30	9.40	48.00	6.20	41.90	0.15	31.90	9.70	22.20	0.43	52.00
II	1.15	0.10	11.80	2.50	19.80	12.10	7.70	1/57	20.00	12.80	7.20	1.77	80.20
III	1.65	0.11	11.00	1.50	30.70	4.10	26.70	0.15	22.20	6.80	15.40	0.44	69.30
IV	1.90	0.16	11.80	5.90	16.00	5.30	10.80	0.49	16.60	2.20	14.40	0.15	84.00
V	2.63	0.16	16.10	3.20	23.50	6.40	17.20	0.37	28.50	6.40	22.10	0.28	76.50
VI	3.59	0.35	10.10	0.80	20.10	5.90	14.20	0.42	19.20	6.70	12.50	0.53	79.90
Mean	1.99	0.17	12.02	3.88	26.35	6.67	19.75	0.53	23.07	7.43	15.63	0.60	73.65
VII	1.10	0.15	7.60	7.70	40.20	4.30	35.90	0.12	37.70	6.90	30.70	0.22	59.80
VIII	1.11	0.22	5.10	3.70	49.90	10.40	37.50	0.29	29.30	9.90	19.40	0.51	50.10
IX	1.15	0.13	9.00	4.60	41.30	8.70	32.60	0.26	45.00	9.50	35.50	0.27	58.70
X	1.45	0.15	9.50	8.60	19.80	5.40	24.30	0.22	39.60	7.20	26.50	0.27	80.20
XI	1.69	0.20	8.50	6.80	42.40	5.00	37.40	0.13	35.40	9.90	25.50	0.39	57.60
XII	1.76	0.14	12.70	8.00	43.10	6.00	37.20	0.16	27.70	8.50	19.20	0.44	56.90
XIII	1.81	0.19	9.50	9.10	23.00	8.70	14.20	0.61	40.90	11.40	29.50	0.39	77.00
XIV	3.07	0.44	6.90	5.60	46.50	5.90	39.30	0.17	41.90	7.80	34.00	0.23	53.50
Mean	1.64	0.20	8.60	6.76	38.28	6.80	32.30	0.25	37.19	8.89	27.54	0.34	61.73

that nitrogen is mainly collected in the humus compounds and in the upper soil layer, and it occurs mainly in the organic form [10]. Great differences in carbon and nitrogen contents influenced the C:N ratio, which varied and depended on the way of the soil utilisation. Borowiec and Wybieralska [2] pointed out that the level and fractional composition of the humus compounds depend mainly on the soil type and the way its is used. Fractional composition of humus compounds may indicate soil processes and let us also estimate soil usability and find the way it can be utilised. Humus that contains more humic than fulvic acids is most valuable. Such humus is found, for example, in chernozem [10]. In the soil samples under investigations, there were low but varied (V=57%) amounts of humus compounds extracted by 0.05 M H_2SO_4. This fraction ranged from 0. 6 to 9.7% of the total carbon content (Table 2). These results indicate low solubility of the soil organic matter in mineral acids, which is particularly characteristic of the podsol soils [10]. The compounds extracted with 0.05 M H_2SO_4 are considered similar to fulvic acids, which are found deeper in the soil in higher quantities.

Humus fractions soluble in the mixture of pyrophosphate and sodium base varied slightly less than the organic carbon content (Table 2). The carbon content determined in the extract after extraction with the mixture of 0.1 M $Na_4P_2O_7$ + 0.1 M NaOH ranged from 16.0 to 49.9% of the soil organic carbon.

The highest carbon amounts were extracted from the forest soils, the lowest - from the soils of arable land and barren land. In general, the amount of this fraction in the analysed soils varied considerably in relation to the type of soil, its use and humification processes in the soil. Among the compounds extracted with the mixture of pyrophosphate and sodium base, fulvic acids predominated markedly, with the one exception, when the content of humic acids was higher. The soils collected from forests had a very high proportion of Cf. Lower levels were found in the soils of arable land. As a result of a higher proportion of fulvic acids than humic acids, the ratio of Ch:Cf was, in general, lower than 1 in the accumulation horizons, particularly in the forest soils.

A great variety in the content of fulvic and humic acids resulted from the different ways of soil use. It was confirmed by many authors [2,5,6,16]. Humic and fulvic acid content in the soil and their inter-dependence was also investigated by Sokołowski [16] in the experiments on the effect of soil use on the accumulation and quality of the humus compounds. Sokołowski found out that the way of soil use influences the amount and transformation rate of organic matter in the humus layers and that the humus layers of arable land exert a considerable influence as compared to the humus of forest soils. The latter soils contain less of organic carbon, their organic matter is better bound with the mineral part of the soil and their humification level is higher. Wilk and Nowak [21] pointed out that soil utilisation is of great importance and has effect on the humus fractional composition of some arable soil types.

Humus fractions, strongly bound with the soil mineral part, were extracted from the soil with 0.01 M NaOH. Carbon content determined in the extract of 0.1 M NaOH varied in a similar way as after extraction with pyrophosphate and sodium base. It allowed for the approximation of the level of previous fractions. The amount determined was from 16.0 to 46.1% (Table 2). In the case of the C content extracted with 0.1 M NaOH, differences between the soils were less pronounced. The amount of carbon extracted from the humic acid increased in relation to carbon in the humic acid extracted with 0.1 $Na_4P_2O_7$ + 0.1 NaOH except in two soils in which the Ch content decreased. The proportion of carbon in fulvic acid decreased. It was reflected in the change of the Ch:Cf ratio. In general, this ratio changed in favour of humic acids. In the case of one soil it amounted to 1.77.

A lot of papers quote high levels of non-hydrolysing carbon found mainly in the agriculturally used soils that have been fertilised with organic fertilisers [3,18]; its share ranged from 52.0 to 84.0%. Such a high proportion of this fraction indicates the presence of permanent links between the soil mineral part and humic compounds which are not easily hydrolysed, as well as the presence of an organic remainder left behind after humification process.

CONCLUSIONS

1. In the extract of pyrophosphate and sodium base of the investigated soils, there was more fulvic than humic acids.

2. From the selected soils of the Małopolska province, 0.1 M NaOH extracted less fulvic acids which widened the Ch:Cf ratio.

3. The analysed soils had a great share of non-hydrolizing carbon.

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