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SORPTION PROPERTIES OF LITHOGENIC SOILS FROM NON-FOREST AREAS OF THE TATRA NATIONAL PARK

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A b s t r a c t: Investigations have been carried out on the soil material taken from 46 profiles representing lithogenic soils from non-forest areas of the Tatra National Park. When selecting soil material an altitude above sea level (over 1250 m a.s.l.), a rock parent type (non-calcareous and calcareous) were taken into account, in case of non calcerous soils, the weakly developed soils - rankers were selected.

On the basis of the investigetions the following conclusions have been drawn: sorption properties of ectohumus horizons in most of investigated lithogenic soils (rankers and rendzinas) are differenciated and formed under the influence of parent rocks. Ectohumus of Oh horizons of rankers sorbed exchangeable cations in following order $H^+>Ca^{2+}\geq Mg^{2+}>K^+>Na^+$. In composition of cations in Oh horizons of rendzinas dominated cations of calcium and the order was as follows: $Ca^{2+}>Mg^{2+}>H^+>K^+\geq Na^+$.

In ectohumus of Oh horizons of rendzinas occurring under bilberry heath and pine dwarf and rankers the composition of exchangeable ions as well as a degree of base saturation were close. In investigated soils sorption properties of mineral or organic-mineral horizons AC or ABC, occurring in direct contact with the parent rock, were formed under the influence of lithogenic factor.

K e y w o r d s: sorption, mountain soils, rendzinas, rankers, the Tatra Mts.

INTRODUCTION

The soils of the Tatra Mountain Range are characterised by the ectohumus horizons with a considerable depth [1,3,4,7]. These horizons, like those of poor forest habitats in the lowland, play a significant role in the ion exchange processes. They also determine buffer and resistance soil capacity. Additionally, they act as depots of biotic elements [3,5]. Their sorption properties are determined mainly by their organic matter content [8]. The above substance which characterises various degrees of humification processes, contains a large number of poorly co-ordinated functional groups, which are ionizable in the pH ranges of the soils [5].

Sorption properties of the Tatra soils, and especially of their ectohumus horizons, are formed as a result of supremacy of lithogenic or bioclimatic factors, according to their occurrence in various climatic-vegetation belts [1,3,4,7]. The properties of the well developed ectohumus horizons (with a depth over 20 cm) in the soils situated in the upper mountain belt and in the subalpine belt, under mountain forest and dwarf pine vegetation, are similar, independently of the type of the parent rock [1,3,4,7].

In literature, data regarding ectohumus properties in the overlying horizons that occur in the non-forest soils of the upper mountain belt and higher climatic-vegetation belts is rare. Hence, the aim of this work was to compare ion exchange capacities of the lithogenic, non-forest soils from the Tatra National Park, which belong to two orders: mineral non-carbonate soils weakly developed and derived from solid rocks and carbonate soils. The present investigations were carried out on the soils with ectohumus horizons. The soil material from the Oh horizons taken for analyses as it shows more distinct development than the Of horizons that did not always occur in these soils or were difficult to separate due to their small thickness (1-3 cm).

MATERIALS AND METHODS

The present investigations were carried out on the soil material taken from 46 profiles representing lithogenic soils from the non-forest areas of the Tatra National Park. When selecting soil material, an altitude above the sea level (over 1250 m a.s.l.), the rock parent type (non-calcareous and calcareous) were taken into account in the case of non-calcareous soils, and weakly developed soils rankers were selected.*

The lithogenic, non-calcareous, weakly developed soils were represented by 26 profiles of various rankers subtypes, situated in the upper mountain belt and above the upper forest limit, mainly under acidiphilic vegetation of grassland on the siliceous rocks (*Caricetalia curvulae*) and tall-grass communities (*Adenostyletalia*) (Table 1). The carbonate soils were represented by 20 soil profiles of humus rendzinas (17) and raw humus (3) situated at altitudes above the sea level such as rankers. Humus rendzinas occurred mainly under the vegetation of grassland on

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Table 1. General characteristic of investigated soils

Type and subtype of soil (number of profiles)	Horizons	Horizons depth "O" (cm)	Parent rock	Altitude m a.s.l.	Vegetation
		Rankers (26)*			
		-			*Nardetalia* (1)
Raw humous	O	4-24	granitoides, moraine	1250-1500	*Caricetalia fuscae*
(8)		x=9.9	(20)	(3)	(2)
	A1C				*Vaccinio-Piceetalia*
Slightly podzolized	A2C		metamorphic	1551-1880	(1)
(9)			(3)	(12)	*Caricetalia curvulae*
Podzolized					(15)
(8)	ABC		quartzites,		*Adenostyletalia*
Brown			sandstones	1801-2250	(5)
(1)	C		(3)	(11)	*Salicetalia herbaceae*
					(2)
		Rendzinas (20)			
	O	5-29 (52)		1260-1500	*Molinietalia* (3)
Humous			limestones	(10)	*Elyno-Seslerietalia*
(17)	A1C	$\bar{x} = 9.9$	(14)	1551-1800	(11)
Raw humous			dolomites	(6)	*Vaccinio-Piceetalia*
(3)	A2C		(6)	1801-2250	(4)
				(4)	*Adenostyletalia* (2)

()*number of profiles.

the carbonaceous rocks (*Elyno-Seslerietalia*) and tall-grass communities (*Adenostyletalia*), while the raw humus under the acidophilic vegetation of the pine dwarf and the bilberry heath of the subalpine belt (*Vaccinio-Piceetalia*) (Table 1). Location of investigated soil profiles (of non-forest areas of the Tatra National Park) is shown in the Fig. 1.

In order to estimate the influence of the lithogenic and bioclimatic factors on the sorption properties of the investigated soils, the selected results were limited to the properties of the following genetic horizons: Oh and AC or ABC. In the case of the AC and ABC horizons situated directly on solid rocks, their influence on properties of the soil substrate is obvious because of the close contact and presence of numerous rock fragments [2]. Whereas the Oh horizons, especially in case of the soils in the mountain woods, have a "climax" character [1,3,4,7].

In the soil samples representing isolated genetic horizons the following analyses were carried out: pH - potentiometrically in H_2O, in 0.01 M $CaCl_2$ and 1 M KCl, organic C content according to the modified Tiurin's method, cation exchange

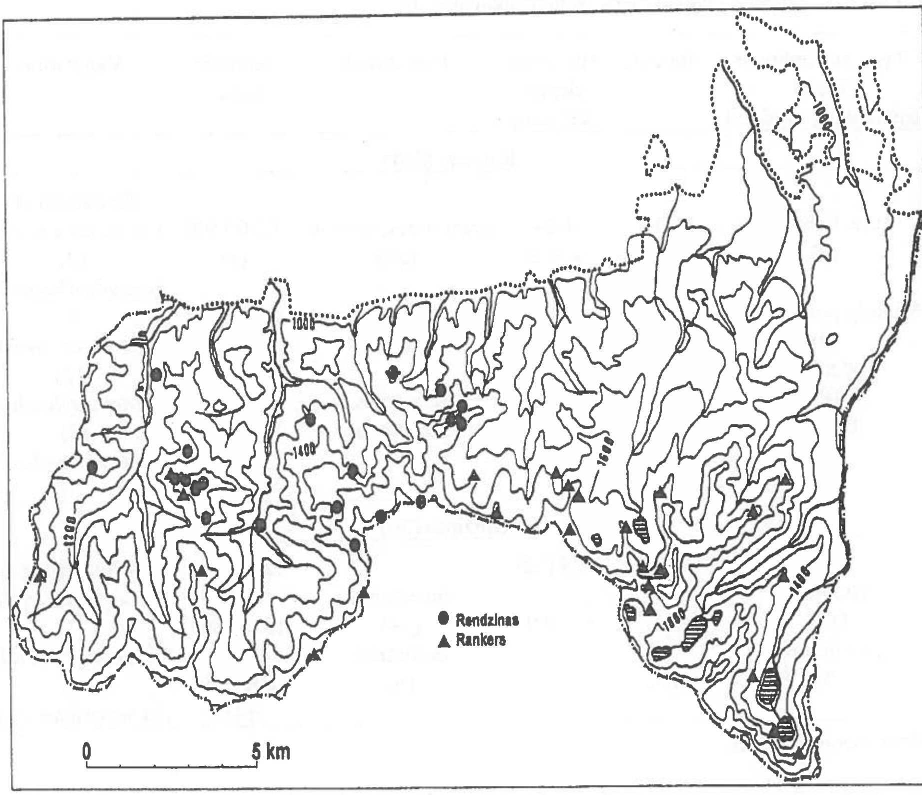

Fig. 1. Location of investigated profiles in the area of the Tatra National Park.

capacity (CEC) by determination of basic cations (Ca, Mg, K, Na), using ammonium chloride in two versions (for carbonate and non-carbonate soils) for their extraction, hydrolytic acidity in 1 M sodium acetate. The results obtained are shown in Tables 2-3 and their statistical description in Table 4.

RESULTS

The soil profiles selected for this investigation characterised different types of humus and its properties as well as differentiated depths of the ectohumus horizons. In the rankers, where humus of moderate-moor or moor type was most often found, depths of the Oh horizons ranged from 4 to 24 cm. In these horizons, the organic matter content ranged from 20.98 to 71.18%. In the humus and raw humus rendzinas, where humus of mull-moder type occurred most often, the depth of the

Table 2. Confrontation of properties of Oh horizons of rankers and rendzinas

Soil properties	Arithmetic mean		Mean standard		Minimum		Maximum	
	rankers	rendzinas	rankers	rendzinas	rankers	rendzinas	rankers	rendzinas
pH in H_2O	4.0	5.9	0.24	0.95	3.2	3.9	4.9	7.3
pH in $CaCl_2$	3.3	5.5	0.27	1.27	2.7	3.1	3.8	7.1
pH in KCl	3.2	5.4	0.28	1.16	2.6	2.9	4.2	7.1
%C org.	18.44	24.21	4.9	8.05	10.49	12.93	35.59	50.98
			(cmol(+)/kg)					
PWK	42.41	50.46	16.76	17.78	14.73	13.48	140.92	100.16
Ca^{2+}	0.93	28.05	0.86	14.57	0.30	1.62	5.82	65.23
Mg^{2+}	0.91	6.24	0.60	5.29	0.20	0.29	5.85	25.00
K^+	0.48	0.51	0.16	0.28	0.16	0.07	1.06	1.37
Na^+	0.10	0.37	0.04	0.27	0.04	0.01	0.18	1.3
S	2.42	35.18	1.51	13.88	0.55	7.38	10.24	77.49
Hh	43.77	15.28	16.23	13.42	13.65	0.64	132.89	51.30
V%	5.71	71.39	3.05	22.09	1.39	30.66	26.95	98.36

S - sum of basis; Hh - hydrolytic acidity; V - base saturation.

Table 3. Confrontation of properties of AC and ABC horizons of rankers and rendzinas

Soil properties	Arithmetic mean		Mean standard		Minimum		Maximum	
	rankers	rendzinas	rankers	rendzinas	rankers	rendzinas	rankers	rendzinas
pH in H_2O	4.7	7.4	0.27	0.29	3.9	6.6	5.9	8.1
pH in $CaCl_2$	4.3	6.8	0.32	0.49	3.8	5.9	5.2	7.4
pH in KCl	3.9	6.8	0.29	0.43	3.6	7.1	4.2	7.4
%C org.	4.48	1.96	3.02	0.99	0.15	0.33	11.5	3.89
			(cmol(+)/kg)					
PWK	18.99	18.73	8.58	7.84	5.96	7.16	55.56	40.09
Ca^{2+}	0.47	13.04	0.70	6.41	tr.	3.35	7.77	31.37
Mg^{2+}	0.16	4.67	0.14	2.85	0.01	0.76	0.69	11.52
K^+	0.09	0.13	0.04	0.09	0.02	0.01	0.17	0.65
Na^+	0.06	0.15	0.03	0.11	tr.	0.01	0.17	0.45
S	0.78	18.00	0.81	7.70	0.15	6.79	8.33	37.80
Hh	17.81	0.74	8.77	0.34	5.65	0.2	54.35	2.29
V%	4.83	95.38	4.72	2.12	0.86	89.03	48.07	99.26

humus horizons was 4-29 cm (occasionally 52 cm). In these horizons the amount of organic matter was 25.86-87.89%, and its greatest part was composed of strongly decomposed "pitch-black" humus (Tables 1 and 2).

T a b l e 4. Simple correlation coefficient between some chemical and sorption properties of investigated soils

	pH in KCl	pH in $CaCl_2$	Ca^{2+}	Mg^{2+}	S	Hh	PWK	V%	%C
pH in H_2O	0.9894***	0.9857***	0.5210***	0.42418***	0.4608***	-0.7175***	-0.0933	0.9152***	-0.1147
pH in KCl	1	0.9892***	0.5179***	0.4485***	0.6013***	-0.7119***	-0.0875	0.9183***	-0.1068
pH in $CaCl_2$		1	0.5694***	0.4559***	0.6406***	-0.7000***	-0.0767	0.9190***	-0.1675*
Ca^{2+}			1	0.1945**	0.9476***	-0.3063***	0.5766***	0.6709***	0.3479***
Mg^{2+}				1	0.4972***	-0.2779***	0.1881**	0.5244***	0.0442
S					1	-0.3568***	0.5790***	0.7660***	0.3350***
Hh						1	0.5551***	-0.6337***	0.3876***
CEC							1	0.1290	0.3836***
V%								1	0.0805

Significance level: *-0.05; **-0.01; ***-0.001.

Physico-chemical properties of the greater part of the ectohumus horizons (Oh) of the lithogenic soils derived from non-calcareous rocks (rankers) and calcareous (rendzinas) showed a clearly lithological character (Table 2). It was manifested as a composition of ions filling a sorption complex and its cation exchange capacity (CEC). The CEC of the ectohumus of the investigated soils was characterised by a wide range of the minimum and maximum values which influenced the value of the mean standard deviation. Such a large range values in the physico-chemical properties was found for the mountain soils in Nepal [6].

In the Oh horizons of the investigated soils, acid cations dominated. The order of these cations was as follows: $H^+>Ca^{2+}\geq Mg^{2+}>K^+>Na^+$. A parallel order was also found for the moor humus of the forest soils [1,5]. In the case of the Oh horizons of rendzinas, the sorption complex was filled mainly with the calcim cations and hydrogen (sum of acidic cations) and magnesium. Therefore, the content of exchangeable ions in the sorption complex of the rendzina Oh horizons was arranged in following order $Ca^{2+}>H^+>Mg^{2+}>K^+>Na^+$. Soil reaction and degree of base saturation (V%), with the mean value of 5.7% in the rankers and 71% in the rendzinas, were the consequence of such an order. The minimum pH values in the Oh horizons in the compared soils were similar, but always lower in the rankers. The maximum values of the degree of base saturation (V%) in the rankers were close to the minimum values for the rendzinas (Table 2). An approximation of the boundary values was carried out by the inclusion of the rendzina Oh horizons found under bilberry heath and pine dwarf. Such low values of V% in the O horizons of the rendzinas in the upper mountain belt was described by Adamczyk [1] and Skiba [7]. In these horizons, the content of the accumulated exchangeable ions was arranged in the same order as in the Oh horizons of the rankers, i.e.: $H^+>Ca^{2+}>Mg^{2+}>K^+>Na^+$.

In the AC and ABC horizons above the solid parent rock, often under Oh horizons, chemical and sorption properties did not depend on the bioclimatic conditions, but on the type of the parent rock and humus amount. The humus content, especially in the floor horizons, varied for the rankers and rendzinas (Table 3). Similar mean values of the cation exchangeable capacity (CEC) in both groups of the studied soils were influenced by the presence of ions, i.e. acid ions in the case of rankers (95.8%), and calcium and magnesium cations (94.5%) for the rendzinas. There is a statistically significant relation between the values of cation exchangeable capacity (CEC) and the sum of exchangeable basis (S) and hydrolytic acidity (Kh). This relation is expressed by the values of simple correlation coefficients (Table 4). The content of exchangeable ions in the above horizons of the rankers was arranged in the following order: $H^+ > Ca^{2+} > Mg^{2+} > K^+ > Na^+$; while in the rendzinas, where bivalent cations prevailed in the sorption complex, the order of exchangeable ions was as follows: $Ca^{2+} > Mg^{2+} > H^+ > K^+ \geq Na^+$.

The degree of base saturation (V%) was very even in the AC and ABC horizons of the studied rendzinas and amounted to 89-95%. A considerably wider range of variations was characteristic for the studied rankers with parent rocks of a non-calcareous parent character that differed in the contents of basic components (Table 3).

Humus content expressed by the percentage of organic C, influenced the sorption properties of the investigated soils most of all the studied chemical properties. It was much higher in the Oh horizons of the rendzinas than in analogous horizons of the rankers. In the in AC and ABC horizons of the rankers, it was more than 50% higher than in the rendzinas (Table 3). The relation between the CEC values and percentage of organic C was significant (r=0.3836***) (Table 4). The remaining relations between the composition of exchangeable cations in the sorption complex, its CEC, V and other selected properties of the soils were expressed by the values of simple correlation coefficients shown in Table 4.

CONCLUSIONS

1. Sorption properties of the ectohumus horizons in most of the investigated lithogenic soils (rankers and rendzinas) varied. They were formed under the influence of parent rocks.

2. The ectohumus of the rankers Oh horizons sorbed exchangeable cations in the following order: $H^+ > Ca^{2+} \geq Mg^{2+} > K^+ > Na^+$. Calcium cations were predominant in the cation composition in the Oh horizons of rendzinas. The order was as follows: $Ca^{2+} > Mg^{2+} > H^+ > K^+ \geq Na^+$.

3. In the ectohumus of the Oh horizons of rendzinas under bilberry heath and pine dwarf and rankers, the composition of exchangeable ions as well as a degree of base saturation were similar.

4. In the investigated soils, sorption properties of the mineral or organic-mineral horizons AC or ABC that are in the direct contact with the parent rock, were formed under the influence of lithogenic factors.

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