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SORPTION PROPERTIES OF GYPSIC RENDZINAS FROM THE NIECKA NIDZIAŃSKA AREA

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A b s t r a c t. In order to estimate sorption properties of gypsic rendzinas from the Niecka Nidziańska area as well as compare a composition of exchangeable cations in arable and turf soils 24 profiles have been investigated which represented following subtypes: initial, proper, chernozemic and brown ones, and derived from 3 types of miocene gypsum: selenite, shaly and compact gypsum. On the basis of the investigations it has been found that sorption properties of gypsic rendzinas were formed under influence of lithological factor and depend on the activity of the parent rock which is expressed by a content of the active calcium in the rock. Humous horizons of the arable soils characterised of a slightly lower complex exchange capacity and a higher contribution of potassium and magnesium in the composition of exchangeable ions in comparison with analogous horizons of the turf soils. A content of exchangeable cations permitted to count investigated soils among the soils with saturated complex of exchangeable cations. In their complex dominated calcium and the contribution of acid cations was small.

K e y w o r d s: gypsic rendzinas, sorption properties, arable soils, turf soils.

INTRODUCTION

The area of Niecka Nidziańska is a jurassic syncline filled with medium and upper cretaceous sediments, on which in tortone (miocene) a warm and shallow sea appeared leaving a series of gypsum deposits. Afterwards Niecka was enveloped only by cracovian glaciation. For that reason as well as for its higher location in comparison with Polish Lowland it has been uncovered from a glacial cover, therefore a characteristic feature of the configuration of the left-riversided Nida area is the occurrance of semispherical gypsic hills [6]. On their slopes and ridges there are outcrops of gypsic rocks, from which have derived soils called sulphate rendzinas. They occupy a surface of 3890 ha and are used as arable or turf soils [9].

Soil scientists have often worked on sorption properties of carbonate rendzinas determined by an organic matter influence and an active parent rock [1-3,5,8]. However, there are not in the literature data about the problems with reference to sulphate rendzinas. Therefore, the aim of the work was to characterise sorption properties of gypsic rendzinas from the Niecka Nidziańska area as well as study changes in the composition of exchangeable cations in the soils under the influence of the cultivation.

MATERIAL AND METHODS

Investigations were carried on the soil material taken out from 24 profiles representing gypsic rendzinas belonging to following subtypes: initial, proper, brown and chernozemic. The sois derived from 3 types of gypsum: selenite, shaly and compact, differ in the way of the use (arable and turf soils) (Table 1). The location of investigated profiles was shown in Fig. 1.

Table 1. General characteristics of soils

Type and subtype of soil	Horizon symbols	Ranges of horizons depth (cm)	Type of parent rock	Use and location
Initial rendzinas (3)*	ACca, AC	5-7	selenite	turf soils slopes (3)
Proper rendzinas (11)	Ap, Ah ACca, AC Cca, C	50-29 10-29 15-30	selenite (6) compact gypsum (2) shaly gypsum (3)	arable soils flat area (5) turf soils flat area (1) turf soils (5) slopes and ridges
Brown rendzinas (3)	Ap, Ah ABbrCca, ABbrC Cca, C	16-20 15-22 8-27	selenite (1) compact gypsum (1) shaly gypsum (2)	arable soils slopes and ridges (1) turf soils flat area (1) slopes and ridges (1)
Chernozemic rendzinas (7)	Ap, Ah A ACca, AC Cca, C	14-33 18-31 14-42 8-18	selenite (6) compact gypsum (2) shaly gypsum (3)	arable soils flat area (3) turf soils flat area (3) mild slopes (1)

()*number of profiles.

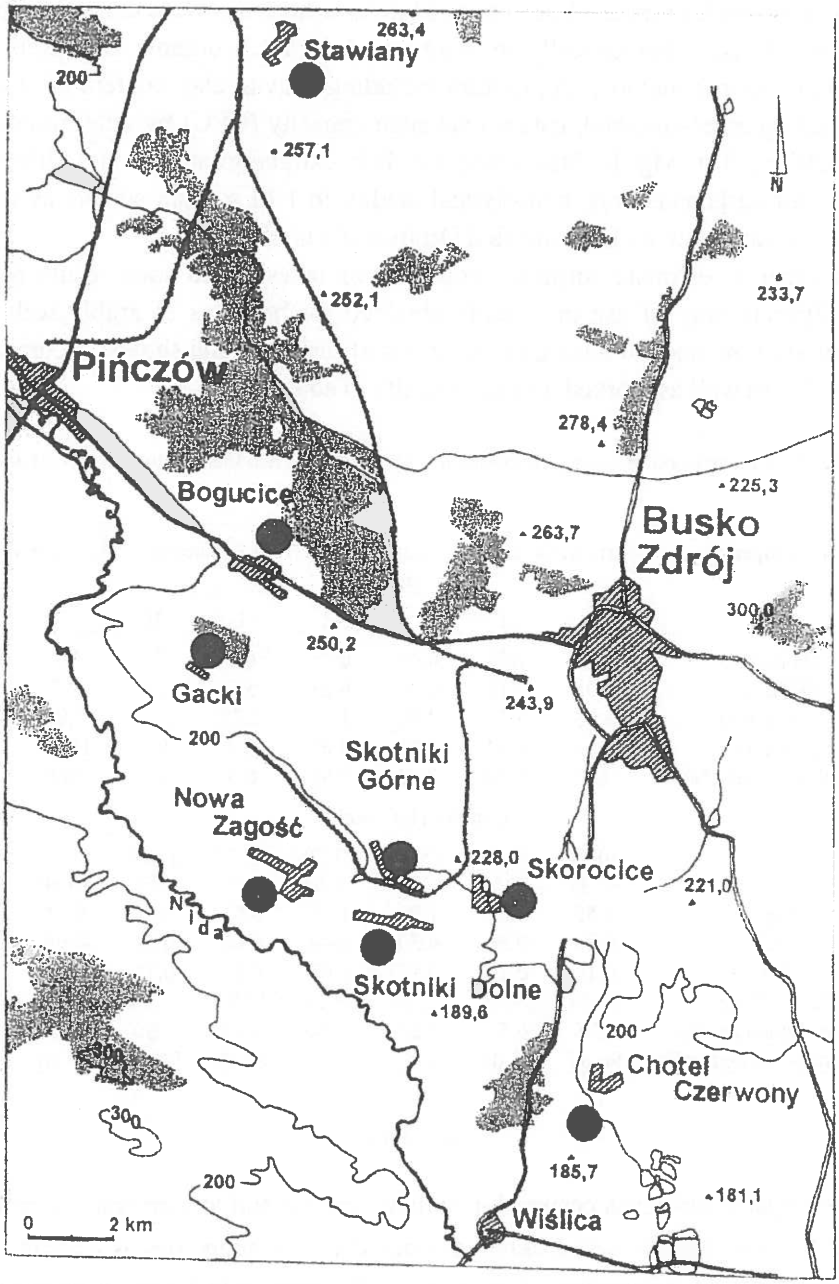

Fig. 1. Location of sites from which soil profiles were taken out.

In soil samples representing separated genetic horizons were carried following analysis: pH potentiometrically in H_2O and 1 M KCl, organic C content after modified Tiurin's method, soil texture including illuvial clay content after modified Cassagrande's method, cation exchange capacity (CEC) by determination of basic cations (Ca, Mg, K, Na), using for their extraction ammonium chloride in version for carbonate soils, hydrolytical acidity in 1 M sodium acetate as well as active calcium content after modified Druinerau's method.

In order to estimate sorption properties of investigated soils resulting from their different way of use the results obtained for horizons of arable soils were compared to the ones of analogical horizons of turf soils and shown in cumulative Tables 2-4 as well as worked out statistically (Table 5).

Table 2. A comparison of some physico-chemical properties of humous horizons of turf (I) and arable (II) soils

Soil properties	Arithmetic mean		Mean standard deviation		Minimum		Maximum	
	I	II	I	II	I	II	I	II
pH in H_2O	7.34	7.53	0.44	0.25	6.2	7.0	7.9	7.8
pH in KCl	7.08	7.16	0.48	0.28	5.8	6.6	7.5	7.6
C org. (%)	3.95	3.17	2.00	1.21	1.75	1.33	7.90	5.34
Ca act. (%)	5.54	3.44	6.21	3.67	0.2	0.1	16.08	10.65
Colloidal clay (%)	11.75	19.88	7.02	8.95	6.0	6.0	28.0	32.0
			(cmol(+) kg^{-1} soil)					
CEC	40.91	35.19	13.07	23.20	18.27	13.06	61.40	75.07
Ca^{2+}	37.35	27.69	13.33	17.05	14.50	8.50	60.80	63.50
Mg^{2+}	1.56	1.68	1.99	1.31	0.02	0.35	6.51	4.00
K^+	0.39	0.56	0.30	0.40	0.08	0.09	0.94	1.17
Na^+	0.16	0.17	0.05	0.07	0.11	0.11	0.28	0.33
Sum of basis	39.46	34.68	12.70	23.21	17.94	12.70	61.09	74.53
Hydrolytical acidity	1.28	0.51	2.53	0.28	0.27	0.30	9.28	1.17
Base saturation degreeV%	96.67	98.03	4.93	1.31	82.20	96.00	99.50	99.50

RESULTS

Investigated rendzinas occurred in similar climatic and topographical conditions. However, they characterised different physico-chemical properties as a result of differentited mineral composition of every type of gypsum, which was expressed by the granulation of investigated soils. From selenite, which generally features a lower content of clay than other types of gypsum, have formed comparatively shallow soils

Table 3. A comparison of some physico-chemical properties of transitional to parent rock horizons of turf (I) and arable (II) soils

Soil properties	Arithmetic mean		Mean standard deviation		Minimum		Maximum	
	I	II	I	II	I	II	I	II
pH in H_2O	7.43	7.8	0.53	0.23	5.8	7.5	7.9	8.2
pH in KCl	7.1	7.28	0.69	0.40	4.8	6.6	7.6	7.8
C org. (%)	2.83	1.69	2.90	1.15	0.23	0.60	12.53	3.70
Ca act. (%)	7.43	7.30	6.00	5.89	0.00	0.00	17.05	15.30
Colloidal clay (%)	12.72	20.6	9.08	10.85	2.0	8.0	33.0	41.0
			(cmol(+) kg^{-1} soil)					
CEC	47.66	33.66	18.31	20.07	18.20	12.26	74.89	69.68
Ca^{2+}	45.15	30.99	19.15	20.81	14.60	7.00	73.20	68.17
Mg^{2+}	1.05	1.15	1.53	1.35	0.00	0.00	4.71	4.00
K^+	0.18	0.20	0.09	0.12	0.09	0.09	0.48	0.45
Na^+	0.31	0.29	0.28	0.35	0.01	0.04	0.93	1.14
Sum of basis	46.68	33.33	18.58	20.11	17.88	11.90	73.84	69.54
Hydrolytical acidity	0.97	0.33	2.18	0.13	0.11	0.14	9.60	0.51
V (%)	97.71	98.62	5.21	0.89	77.10	97.10	99.70	99.80

Table 4. A comparison of some physico-chemical properties of soil parent rock horizons of turf (I) and arable (II) soils

Soil properties	Arithmetic mean		Mean standard deviation		Minimum		Maximum	
	I	II	I	II	I	II	I	II
pH in H_2O	7.6	7.93	0.20	0.28	7.4	7.6	8.0	8.4
pH in KCl	7.37	7.31	0.23	0.44	7.1	6.7	7.7	8.0
Ca act. (%)	9.96	8.17	2.65	5.50	3.96	2.76	13.43	15.43
Colloidal clay (%)	13.30	26.17	9.76	11.02	6.0	15.0	37.0	41.0
			(cmol(+) kg^{-1} soil)					
CEC	55.19	29.00	19.46	11.70	23.29	13.34	75.00	48.83
Ca^{2+}	53.97	26.28	19.45	12.70	21.60	11.25	73.20	47.20
Mg^{2+}	0.45	1.82	0.87	2.47	0.01	0.11	2.70	6.53
K^+	0.21	0.24	0.10	0.24	0.1	0.09	0.45	0.48
Na^+	0.25	0.32	0.28	0.14	0.03	0.08	0.98	0.68
Sum of basis	54.88	28.67	19.43	11.63	98.90	13.17	74.34	48.41
Hydrolytical acidity	0.31	0.33	0.16	0.09	3.96	0.17	0.66	0.42
V (%)	99.36	98.82	0.36	0.19	6.00	98.60	99.80	99.10

T a b l e 5. Simple correlation coefficients determining the correlation between some of chemical and physico-chemical properties of investigated soils

	pH	Ca^{2+}	Mg^{2+}	S	Hh	CEC	V (%)	C org. (%)	Ca act. (%)
pH in H_2O	0.8186***	-0.3370**	0.2521*	-0.3042*	-0.5920***	-0.3548**	0.5290***	-0.4437***	-0.0287***
pH in KCl	1	-0.0758	0.1686	-0.0631	-0.5080***	-0.1066	0.4789***	-0.3205**	0.0653
Ca^{2+}		1	-0.3258**	0.9642***	-0.0319	0.9609***	0.1862	-0.2296	0.5467***
Mg^{2+}			1	-0.2159	0.0509	-0.2123	-0.0541	0.3332**	-0.3187*
S				1	-0.0332	0.9965***	0.1956	-0.1820	0.5049***
Hh					1	0.0498	-0.9565***	0.6729***	-0.2702*
CEC						1	0.1136	-0.1263	0.4817***
V (%)							1	-0.6930***	0.3625***
C org. (%)								1	-0.5050***
Ca act. (%)									1

*significance level *-0.05; **-0.01; ***-0.001.

with lighter granulation and a lower contribution of colloidal clay than from other types of gypsum. The content of clay particles in soils derived from compact and shaly gypsum ranged in large limits. However, as a rule deeper soils and with heavier texture have occurred on these types of gypsum. Among investigated gypsic rendzinas most of arable soils constituted soils derived from shaly or compact gypsum, therefore these soils characterised decidedly higher content of colloidal clay in every horizon than turf soils (Tables 2-4).

Differences in mineral composition in every type of gypsum as well as a quality and quantity of accessory material have influenced a differentiation of composition of ions filling a sorption complex and its cation exchange capacity (CEC). Their determination characterised a large spread of minimum and maximum values, which affected the value of mean deviation (Tables 2-4). Similarly large range of determinations of physico-chemical properties was emphasised in reference to carbonate rendzinas derived from limestones from different geological formations [1,3,5].

In the sorption complex of gypsic rendzinas dominated basic cations. In Ap horizons of investigated arable soils the arrangement of cation contents was as follows: $Ca^{2+}>Mg^{2+}>K^{+}>H^{+}>Na^{+}$, and in deeper horizons, on account of a lower content of exchangeable sodium and potassium, the content of cations was arranged in a slightly different sequence: $Ca^{2+}>Mg^{2+}>H^{+}>Na^{+}>K^{+}$. The hydrolytical acidity in arable soils was low, in Ap horizons amounted meanly to 0.51 cmol(+) kg^{-1} soil and 0.33 cmol(+) kg^{-1}soil in bottom horizons. In every horizon of turf soils the arrangement of cation contents in the soil sorption complex was as follows: $Ca^{2+}>Mg^{2+}>H^{+}>Na^{+}>K^{+}$. A little higher content of hydrogen cations occurred in turf soils in comparison with arable soils. The hydrolytical acidity in top horizons of turf soils amounted meanly to 1.28 cmol(+) kg^{-1} soil and became lower together with the depth of profile, amounting to a mean value of 0.97 cmol(+) kg^{-1} soil in middle parts of profiles and 0.31 cmol(+) kg^{-1} soil in parent rock profiles (Tables 2-4).

Among basic cations dominated exchangeable calcium, which values ranged in large limits from 7 to 73.2 cmol(+) kg^{-1} soil. A content of the element in sorption complex ranged according to soil horizon and the way of the use. The highest mean contents of exchangeable calcium (53.97 cmol(+) kg^{-1} soil) characterised parent rock horizons of turf soils. It was connected with a strong activity of parent rocks of these soils, which was expressed by a high content of active calcium, meanly 9.96 cmol(+) kg^{-1} soil (Table 4).

Contents of exchangeable magnesium and potassium were the highest in top horizons and became lower together with the depth of soil profile which is related to the biological accumulation of these elements. Arable soils characterised a higher mean contents of discussed elements on account of their higher content in parent rocks (a lower contribution of soils derived from selenite especially poor in these elements). In sorption complex in investigated soils sodium occurred in amounts of 0.09 to 0.48 cmol(+) kg^{-1} soil and its content in arable as well as in turf soils inconsiderably increased together with the depth of the profile (Tables 2-4).

Investigated soils characterised high values of cation exchange capacity (CEC) and their large differentiation between horizons in profiles in soils of different ways of the use. In Ah horizons of turf soils a mean value of CEC was higher and amounted to 40.91 cmol(+) kg^{-1} soil, (ranging from 18.27 to 61.4 cmol(+) kg^{-1} soil) than in analogical horizons of arable soils, where a mean value of CEC amounted to 35.19 cmol(+) kg^{-1} soil, with a larger range of fluctuations (13.06 75.07 cmol(+) kg^{-1} soil). A higher value of the cation exchange capacity in accumulation horizons in turf soils has been influenced by a higher content of organic C in these horizons (meanly 3.95%) than in Ap horizons of arable soils (meanly 3.19%). Differences in values of CEC and contents of organic C between soils of different ways of use: arable and turf soils persist in deeper part of profiles amounting meanly 47.66 cmol(+) kg^{-1} soil in turf soils and 33.66 cmol(+) kg^{-1} soil in arable soils with a mean content of organic C - 2.83% in the middle part of profile of turf soils and 1.69% in analogical horizons of arable soils.

A result of the saturation of the sorption complex with basic cations was an alkaline soil reaction and a degree of base saturation (V%), whose main values in every profile of investigated gypsic rendzinas both arable and turf exceeded 95%, and pH was over 7, however, both of discussed soil properties have reached higher values in upper parts of profiles in arable soils than in turf ones (Tables 2-4).

Among chemical properties which influenced mostly sorption properties of investigated soils was, above all, a content of the active calcium. A relation between CEC values and % of active Ca was statistically significant ($r = 0.4817^{***}$) (Table 5). The remaining relations between the composition of exchangeable cations in the sorption complex, its CEC and V%, and other selected soil properties were expressed by a simple correlation coefficient shown in Table 5.

CONCLUSIONS

1. Sorption properties of investigated gypsic rendzinas have been formed under the influence of the lithogenic factor, and are strongly correlated with the content of the active calcium in the soil parent rock.

2. Humous horizons of arable soils characterised a little lower value of the cation exchange capacity and a higher contribution of potassium and magnesium in the composition of exchangeable cations in comparison with analogical horizons of turf soils.

3. Contents of exchangeable cations permitted to count investigated soils among soils with saturated sorption complex. In the sorption complex dominated calcium and the contribution of acid cations was inconsiderable.

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