Journal of Agricultural Sciences
Vol. 47, No 1, 2002
Pages 19-27

UDC: 631.425:631.445.44
Original scientific paper

SPECIFIC AREA OF SMONITZAS OF ALEKSINAC VALLEY

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Abstract: In the present paper an estimation was given of total specific area (S) of very clayey soils of smonitza type in Central Serbia on the basis of the data on their textural composition and maximal hygroscopic moisture. Total specific area (m^2g^{-1}) of the analysed very clayey smonitzas is, on average, equal to the product of maximal hygroscopic moisture (MH), expressed in percent ratio of the mass, and the coefficient 11.50, i.e. S = 11.50*MH (m^2g^{-1}).

Key words: smonitza, Aleksinac valley, Central Serbia, specific area, textural composition, maximal hygroscopic moisture.

Introduction

Specific soil area has become increasingly interesting recently because it is an extremely important factor both from agroproductive and pedogenetic/ecologic aspects. It is an important parameter that characterizes the energy of mutual action of solid soil phase and its other phases, and it reflects quantitative and qualitative compositions of elementary soil particles. It is related to many moisture, physico-textural, physico-chemical and temperature characteristics of soil, as well as to various processes taking place within the particles (Vitjazev and Schevtchenko, 1983; Ponizovskij, et al., 1993; Onishtchenko, 1994). In addition, the specific area correlates with the majority of physical and chemical soil characteristics, and first of all, with maximal hygroscopic moisture, textural and mineralogic composition. Therefore, knowing the data on textural composition and maximal hygroscopic moisture, it is possible to determine the

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value of total specific soil area and to estimate the precision of this determination by adsorption methods (P a k s c h i n a , 1997).

Each textural fraction of soil has certain mineralogic composition and certain specific area. Total specific soil area equals the sum of products of specific area and percent ratio of each soil fraction (V a d j u n i n a and K o r t c h a g i n a , 1973). The highest ratio in total specific area belongs to clay fraction (particles < 1 μm), composed primarily of highly dispersed secondary minerals. Adsorption methods are used for determination of specific areas of particular textural fractions, and also of soil as a whole. By this procedure, specific area is calculated from the moisture content in a textural fraction or soil as a whole, which occurs at such relative air moisture that causes the occurrence of tightly packed monomolecular water layer on the particles of solid phase.

Maximal hygroscopic moisture occurs at relative air moisture between 95 and 98%. According to the available data, at this moisture, on the surfaces of soil particles there appears a film of adsorbed water, the thickness of which is 9-10 monomolecular layers (M i t c h e r l i c h , 1957). For that reason, in this case, when calculating total specific area (S), the value of maximal hygroscopic moisture (MH) expressed as % per soil mass, is multiplied by coefficient 4 ($S = 4*MH$, m^2g^{-1}). Experimental data showed that the specific soil area, determined by this procedure, according to Mitcherlich's formula, has significantly lower values than the values obtained by other adsorption methods (V a d j u n i n a and K o r t c h a g i n a , 1973). However, there are authors who found the existence of only 4 monomolecular layers of water (P a k s c h i n a , 1997), which would indicate that in Mitcherlich's formula for specific area calculation, the coefficient does not equal 4.

It is well known that on a flat glass surface the thickness of water film at P/Po=1 amounts to 9-25 molecular layers. According to Rode's investigations, in the soils, especially loamy and clayey ones, the thickness of water film at P/Po=1 is significantly lower, because the size of pores and specific particle area do not allow the formation of thicker films (P a k s c h i n a , 1997).

Total specific soil area is also determined by other procedures and methods. All these methods may be divided into two main classes: 1) methods based on physical adsorption of water vapour and other gases by the soil, among which the most common are BET method, methods of Kutilek, Farrar, etc.; 2) methods based on theoretic calculation of areas of geometrically simplified particles (M i t c h u r i n , 1975; P o n i z o v s k i , et al., 1993). Each of these methods has its qualities, including rapidity, simplicity of performance, etc. However, the obtained values of the total specific area may differ significantly.

The procedure of specific area determination by maximal hygroscopic moisture is, compared to the others, more simple and thus more available to those more poorly equipped with laboratory facilities.

Precise determination of the coefficient that connects the value of maximal hygroscopic moisture with the value of total specific soil area enables utilization of the data on textural composition for previous estimation of the values of maximal hygroscopicity and soil specific area, and also an estimation of the precision of direct determination of these values (P a k s c h i n a , 1997).

There are no available data on the determination of specific areas of smonitzas in our country, and there also lack the data on determination of this very important physical feature in our soils, in general.

The aim of this study is to determine the value of the coefficient connecting the maximal hygroscopic moisture with total specific area in very clayey soils, of smonitza type in Central Serbia.

Material and Methods

To obtain more information on the connection between the two soil parameters, numerous analytical data on textural composition and maximal hygroscopic moisture of smonitzas of Aleksinac valley from various depth zones down to 2 meters of depth were studied. The total of 90 samples was analysed, which represent 12 profiles of highly clayey smonitzas.

Field investigations of smonitzas of Aleksinac valley, soil sample collection, as well as the determination of their most important physical (textural composition, maximal hygroscopic moisture etc.) and chemical properties were performed by M. Živković.

Maximal hygroscopic moisture was determined by Nikolaev method (V a d j u n i n a and K o r t c h a g i n a , 1973).

Total specific area of the investigated soils was determined mathematicaly on the basis of the analysis of their textural composition. For the calculation of specific areas of particular textural fractions, the data were used that had been presented in the paper by M i t c h u r i n (1975). According to these data, the specific area of textural fractions 0.25-0.05, 0.05-0.01, 0.01-0.005, 0.005-0.001, and < 0.001 mm amounts to 1.6, 4.5, 10.0, 18.0 nad 300.0 m^2g^{-1}, respectively.

The obtained results were statistically analysed.

Results and Discusion

Before discussing the obtained results on maximal hygroscopic moisture and specific area of the investigated smonitzas, we presented some of their most important physical and chemical properties. In Table 1 the data are presented on physical (particles < 0.01 mm) and colloidal (particles < 0.001 mm) clay, humus and $CaCO_3$ contents. More detailed characteristics of physical and chemical properties of these soils are presented in previous works of Ž i v k o v i ć et al. (1964) and G a j i ć and Ž i v k o v i ć (2001).

The results of textural analysis show that the analysed soil samples have heavy textural composition with the ratio of physical clay between 67.6 and

95.6%, and of colloidal clay between 44.0% and 68.5%. According to M. Živković, the analysed smonitzas belong, together with smonitzas of Kosovo and Metohija, to Serbian smonitzas richest in clay. Analyses of the clay fraction (<0.001 mm) revealed that in the analysed smonitzas there prevail minerals from a montmorilonite class (Živković et al., 1964).

Humus content in arable field profiles, at the depth of 0-20 cm (Ahp horizon) is, on average, about 1.5 times lower than in forest soils, and varies between 3.9 and 4.8%, while in the forest soils, at the same depth, it varies between 6.0 and 7.6%, and in all profiles it decreases in subsurface samples, mainly substantially.

Humus (Ahp) horizon in most analyzed profiles of smonitzas does not contain $CaCO_3$ or contains it only in traces. In profiles of carbonate smonitzas, $CaCO_3$ ratio varies from traces in surface sample (0-20 cm) to 17.69%.

The investigated smonitzas are characterised with high values of exchangeable cation capacity (S), on average, 51 me/100 g, and T = 56 me/100 g, according to the analyses of Živković et al. (1964).

The results on maximal hygroscopic moisture (MH) and calculated total specific area (S) of the analysed soils are presented in the Table 1.

Tab. 1. – Specific area (S), maximal hygroscopic moisture (MH) and some chemical and physical properties of smonitzas of Aleksinac valley

Prof. No	Depth, cm	Humus, %	$CaCO_3$, %	Particle content, % <0.01 mm	<0.001 mm	S, $m^2 g^{-1}$	MH, %	S/MH
1	2	3	4	5	6	7	8	9
2 forest	0-20	7.65	–	70.40	49.76	153	13.73	11.1
	20-40	5.63	–	71.40	52.80	162	13.77	11.8
	40-60	3.34	–	70.36	52.88	162	13.53	12.0
	60-80	2.89	–	69.82	49.52	152	13.31	11.5
	80-95	2.38	–	67.64	49.80	153	13.26	11.5
	95-120	1.44	12.32	69.56	46.20	143	12.47	11.5
	120-140	1.25	14.05	72.44	46.92	145	12.54	11.6
	140-160	1.18	10.48	73.56	50.72	156	13.19	11.8
								11.6*
9b forest	0-20	7.50	–	82.96	64.20	196	17.75	11.1
	20-40	3.98	–	87.12	65.72	201	16.64	12.1
	40-60	2.63	–	88.12	66.00	202	17.27	11.7
	60-80	2.54	t.p.	85.84	65.60	200	17.21	11.6
	80-100	2.14	t.p.	86.72	67.12	205	17.07	12.0
								11.7*
7 arable	0-20	7.92	–	83.00	56.44	174	15.12	11.5
	20-40	7.30	–	84.88	59.08	190	17.10	11.1
	40-60	7.01	–	84.65	59.72	183	19.05	9.6
	60-80	6.55	–	85.40	60.04	185	19.13	9.7

1	2	3	4	5	6	7	8	9
	90-110	3.05	14.66	86.32	53.48	166	18.28	9.1
	110-125	3.51	8.71	84.28	52.48	164	19.71	8.3
								9.9*
7a arable	0-20	5.71	4.77	87.28	58.76	181	15.14	11.9
	20-40	3.43	9.32	89.72	62.12	191	16.10	11.9
	40-60	1.88	16.46	90.64	60.56	187	16.54	11.3
	60-80	1.10	8.25	92.24	63.00	194	17.65	11.0
	80-100	0.64	2.61	95.56	68.36	210	18.57	11.3
								11.5*
10 arable	0-20	4.87	–	76.88	55.40	170	13.29	12.8
	20-40	4.04	–	77.40	57.00	175	14.75	11.9
	40-60	3.00	–	76.60	55.84	172	15.19	11.3
	60-80	2.13	–	76.76	57.32	176	14.84	11.8
	80-100	2.05	–	78.48	54.28	167	14.91	11.2
	110-130	0.87	18.85	75.88	48.08	149	13.05	11.4
	130-150	0.46	17.23	74.84	46.72	145	12.25	11.9
								11.8*
11 arable	0-20	5.03	3.91	78.24	55.04	170	14.94	11.3
	20-40	3.79	5.32	77.40	54.64	168	14.84	11.3
	40-60	3.04	9.94	77.08	54.80	169	15.26	11.1
	60-80	2.74	9.71	76.80	54.08	167	14.69	11.3
	80-100	1.97	13.81	75.56	50.64	157	13.78	11.4
	100-120	1.78	21.77	78.96	51.28	159	13.44	11.8
	120-140	1.60	27.65	77.64	48.36	151	13.18	11.4
	140-160	1.27	27.56	76.40	45.92	144	12.65	11.4
	170-190	0.81	27.13	75.92	46.28	144	12.29	11.7
								11.4*
12 arable	0-20	5.77	–	76.32	57.88	177	16.08	11.0
	20-40	3.40	–	75.72	59.40	181	15.84	11.5
	40-55	2.74	–	75.20	58.20	178	15.79	11.3
	55-70	1.89	7.59	75.60	53.20	164	14.85	11.0
	70-90	1.68	10.37	75.32	54.32	167	14.36	11.6
	90-110	1.63	13.82	75.08	50.72	156	14.07	11.1
	110-130	0.78	25.72	72.36	46.40	144	11.83	12.2
	130-150	0.45	25.28	70.28	44.04	137	11.89	11.5
	150-170	0.32	23.69	85.96	52.72	164	15.06	10.9
								11.3*
14 arable	0-20	4.81	t.p.	81.28	60.48	185	16.09	11.5
	20-40	4.64	t.p.	82.20	62.46	191	16.64	11.5
	40-60	3.44	–	81.28	62.88	192	17.12	11.2
	60-80	2.75	–	83.20	64.28	196	17.28	11.4
	80-100	2.32	–	81.76	62.56	191	17.38	11.0
	110-130	0.89	17.30	83.08	55.04	170	14.04	12.1

1	2	3	4	5	6	7	8	9
	130-150	0.79	17.76	81.80	55.52	171	14.83	11.6
	150-170	0.56	17.60	85.40	54.00	167	13.69	12.2
	170-190	0.38	14.26	92.32	66.32	204	15.95	12.8
								11.7*
15 arable	0-20	3.89	–	81.08	61.92	189	15.73	12.0
	20-40	2.62	t.p.	83.30	62.56	192	16.75	11.4
	40-60	2.01	t.p.	85.96	62.12	191	17.34	11.0
	60-80	1.39	5.91	84.52	57.72	178	16.50	10.8
	80-100	1.05	11.39	84.32	56.64	175	15.48	11.3
	100-120	0.73	18.51	86.28	49.84	156	13.78	11.4
	120-140	0.40	15.78	90.72	50.08	157	13.40	11.7
	140-160	0.30	15.55	92.20	54.60	171	14.77	11.6
	160-180	0.29	12.64	90.72	52.00	162	14.12	11.5
								11.4*
8 pasture	0-20	5.01	7.93	75.24	54.80	168	15.34	11.0
	20-40	2.42	15.12	83.28	56.72	175	15.08	11.6
	40-60	1.79	17.07	86.92	59.32	183	16.14	11.3
	60-80	1.21	17.69	88.80	61.20	189	16.87	11.2
	80-100	0.82	17.19	94.32	63.32	195	16.46	11.9
								11.4*
9 arable	0-15	4.05	t.p.	74.44	52.44	162	15.17	10.7
	15-30	3.18	1.45	78.96	56.12	173	14.54	11.9
	30-50	2.97	1.98	80.40	57.40	177	15.62	11.3
	50-65	2.54	5.21	81.88	59.52	183	15.88	11.5
	65-80	1.49	10.68	84.64	60.44	186	15.94	11.6
	80-100	0.94	13.66	85.16	58.12	179	15.64	11.4
	100-120	0.31	20.76	84.52	54.52	168	14.29	11.8
	120-140	0.18	12.07	83.56	58.08	178	14.83	12.0
								11.5*
17 arable	0-20	5.45	t.p.	75.10	54.04	166	14.62	11.4
	20-40	3.88	7.27	77.48	54.80	169	15.04	11.2
	40-60	3.07	11.55	76.04	54.96	169	14.62	11.6
	60-80	2.51	15.50	78.08	57.76	177	13.86	12.8
	80-100	1.70	19.12	78.04	57.50	176	13.68	12.9
	100-120	1.31	19.60	79.12	55.40	171	13.80	12.4
	120-140	0.48	26.17	85.14	55.92	173	13.78	12.5
	140-160	0.37	21.35	89.40	59.24	183	15.31	12.0
	160-180	0.27	12.53	88.16	65.80	202	15.73	12.8
	180-200	0.22	8.55	94.20	68.52	210	16.40	12.8
								12.2*

Note: *–mean value; t.p. –present in traces

From the data in Table 1, it can be seen that the values of maximal hygroscopic moisture in all investigated samples are fairly high and that they vary along the profile depth from 11.8 to 19.7. There were not significant differences between the values of maximal hygroscopic moisture of particular soil types, but there was found a significant and strong correlation both with total physical clay content, and with the ratio of clay fraction (Table 2).

T a b . 2. – Correlation matrix of the analysed parameters

	< 0.001 mm	< 0.01 mm	S, $m^2 g^{-1}$	MH, %	S/MH
< 0.001 mm	1.00				
< 0.01 mm	0.67*	1.00			
S, m^2g^{-1}	1.00*	0.70*	1.00		
MH, %	0.78*	0.60*	0.79*	1.00	
S/MH	–0.12	0.01	0.11	–0.52*	1.00

Note: *–statistically significant

In investigated smonitzas with very clayey textural composition, total specific area is very big and it varies within the range between 137.0 and 209.9 m^2g^{-1}. The data on the specific area of smonitzas in Bulgaria are similar, 205-240 m^2g^{-1}, according to M i t c h u r i n (1975). High values of total specific area of the investigated soils are not connected only with high clay (particles < 0.001 mm) content, but also with its mineralogical composition, which contains mainly smectites. There are no significant differences in values of this physical parameter either between the investigated profiles or between samples from different depth zones.

Our investigations confirm the findings of many authors (V o r o n i n, 1958; K i t s e, 1977; V i t j a z e v and N i k i t i n, 1977; B o n d a r e v and K u m p a n, 1979) that total specific soil area increases with the increase of the ratio of the textural fraction < 0.001 mm. In the analysed samples from deeper layers, i.e. those that are less humous, as well as in carbonate ones, any increase of specific area was not found.

Soils with high specific areas have very unfavourable physicochemical properties, which has already been shown by G a j i ć and Ž i v k o v i ć (2001).

As it can be seen from the data presented in Table 1, the values of S/MH (ratio of specific area, m^2g^{-1} and maximal hygroscopic moisture) in the analysed soil samples vary within a very narrow range, from 8.3 to 12.9.

The mean value of S/MH amounts to about 11.50. Only in two profiles of 12 analysed, S/MH has a lower (prof. No 7, S/MH = 9.88) or a higher (prof. No 17, S/MH = 12.23) value than 11.50. This has not exerted any significant influence on the mean value of S/MH. The results of statistical analysis of our data show that in the analysed very clayey soils, numerical value of the coefficient, in

Mitcherlich's formula, for total specific area calculation, on the basis of maximal hygroscopic moisture, is somewhat higher, and amounts to 11.50.

Statistical evaluation of indicators of S/MH (Table 3) of smonitzas from Aleksinac valley show a fairly high validity of the experimental data.

T a b . 3. – Statistical evaluation of indicators of S/MH in smonitzas of Aleksinac valley

Soil	n	Min	Max	M	σ	m	V, %	P, %
Smonitza	90	8.3	12.9	11.5	0.71	0.07	6.17	0.61

Note: n –number of analyses; Min –lowest value; Max –highest value; M – mean arithmetical value; σ –square deviation; m –mean error; V –variation coefficient; P –precision indicator

The thickness of water film which is formed around soil particles at the maximal hygroscopic moisture can be calculated indirectly by Kutilek's formula (M i t c h u r i n , 1975), according to which, specific soil area equals:

$$S = 36.14*W_{0.2},\ m^2\ g^{-1} \qquad (1)$$

where $W_{0.2}$ is soil moisture at P/P_o = 0.2% of the mass. From the equation S = $36.14*W_{0.2}$ = 11*MH there follows that in very clayey soils, which were the subject of our investigations, at the moisture corresponding to the maximal hygroscopic moisture, a water film is formed with the thickness of 3-4 molecular layers. Similar result was obtained by P a k s c h i n a (1997) in her investigations of loamy and clayey soils.

C o n c l u s i o n

Total specific area of smonitzas in Aleksinac valley is fairly big, on average, about 174 m^2g^{-1}, and with the increase of soil mass dispersion degree (content of textural fraction < 0.001 mm) the area increases.

Specific area of these very clayey smonitzas equals the product of maximal hygroscopic moisture (MH), expressed as % per mass, and the coefficient 11.50, i.e. S = 11.50*MH (m^2g^{-1}).

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Received February 27, 2002
Accepted April 8, 2002

SPECIFIČNA POVRŠINA SMONICA ALEKSINAČKE KOTLINE

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R e z i m e

U ovom radu je dat prikaz ocene određivanja ukupne specifične površine (S) jako glinovitih zemljišta tipa smonice centralne Srbije na osnovu podataka o njihovom mehaničkom sastavu i maksimalnoj higroskopskoj vlažnosti. Ukupna specifična površina (m^2 g^{-1}) istraženih jako glinovitih smonica je jednaka u proseku proizvodu njihove maksimalne higroskopne vlažnosti (MH), izražene u procentima na masu, i koeficijenta 11.50, tj. S = 11.50*MH (m^2 g^{-1}).

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