

CHEMICAL COMPOSITION OF THE SOIL MATERIAL OF ALFISOLS FROM THE VISTULIAN FORMATION

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A b s t r a c t. Four pedons of Alfisols were selected from the Experimental Station Mochełek to study chemical composition of the soil material. The study area is located in the south-western border of the Krajeńska Upland, on the border of two geomorphological formations: erosion surface of floating waters (fluviglacial formation) and rolling ground moraine (glacial material). The investigated soils were classified as Typical Hapludalfs (pedon 11, 21 and 26) and Typical Glossudalfs (pedon 7).

Chemical composition was analysed using the following methods: fusion with Na_2CO_3 and dissolving in the HF and HClO_4 mixture. Results were presented in an oxide form and molar ratios ($\text{SiO}_2/\text{R}_2\text{O}_3$; $\text{SiO}_2/\text{Al}_2\text{O}_3$; $\text{SiO}_2/\text{Fe}_2\text{O}_3$; $\text{Al}_2\text{O}_3/\text{Fe}_2\text{O}_3$) were calculated.

In the studied soils, the content of SiO_2 was from 78.21 to 90.00 %. The lowest SiO_2 content was found in the illuvial horizons. Otherwise the illuvial process influenced Al_2O_3 and Fe_2O_3 distribution, the highest amounts of which were found in the illuvial horizons.

TiO_2 (0.15 to 0.63 %), had similar profile distribution to K_2O (1.74-3.88 %) and Na_2O (0.61-1.05 %). CaO and MgO contents were the highest in the parent material, including CaCO_3 (pedon 11 and 26). However, the highest amount of MnO was observed in the surface horizons (0.56-0.58 %).

Chemical composition of the studied soil material indicated a large influence of the illuvial process and particle-size on the total content and profile distribution of the analysed soil. However, the evident influence of parent material from which the analysed soils were formed, was not found.

K e y w o r d s: Alfisols, chemical composition, fluviglacial and glacial material.

INTRODUCTION

Alfisols, the most popular soils in Poland, are formed from various parent materials, i.e. fluviglacial and glacial material. Such a variety of parent materials results in various physicochemical properties of these soils and, in consequence, causes problems when diagnosing the argillic horizon. As it is known, the basic consideration in diagnosing

an argillic horizon is illuvial enrichment of the clay fraction in this horizon. However, in the case of such a varied texture of the parent material, it no longer is a sufficient parameter for the diagnosis. Hence it is necessary to perform other analyses, i.e. micromorphological, mineralogical and total chemical analysis.

The main purpose of these studies was to determine the influence of the illuvial process on the chemical composition of the soil substance of Alfisols formed from fluviglacial and glacial material. Another purpose was to compare these two parent materials on the basis of their chemical composition.

MATERIALS AND METHODS

For the study of the chemical composition of soil substance, four pedons of Alfisols were selected. The profiles selected in the Experimental Station in the Mochetek village were described in 1990. The station is located in the south-western border of the Krajeńska Upland at the border of the erosion surface of floating waters (fluviglacial formation) and rolling ground moraine (glacial material). Three investigated profiles (Nos 7, 11 and 21) were localised in a fluviglacial formation and the fourth profile was localised at the rolling ground moraine formed from a lodgement till (No. 26) [5]. The soils selected for the study were classified as Typical Hapludalfs (profile 11, 21 and 26) and Typical Glossudalfs (profile 7) [10]. Content of the fraction below 0.02 mm, clay fraction, organic carbon and pH of the investigated soils is shown in Table 1. A detailed characteristics of the analysed pedons was presented elsewhere [3].

The selected soil samples were brought to the laboratory and air-dried in room temperature and sieved with 1 mm sieve. Course fragments (>1 mm) were removed. Thus, only total chemical composition of the soil material in the fraction below 1 mm was determined. Total content of K, Na, Ca, Mg, Fe, Mn and Al was determined by atomic absorption spectrophotometry using Philips PU 9100 X and total Ti by tiron method after dissolution in H_2F_2 and HClO_4 (4:1) mixture. The content of total Si was determined by gravimetrical methods after fusing with Na_2CO_3 [4].

On the basis of selected results, ratios $\text{SiO}_2/\text{R}_2\text{O}_3$, $\text{SiO}_2/\text{Al}_2\text{O}_3$, $\text{SiO}_2/\text{Fe}_2\text{O}_3$ and $\text{Al}_2\text{O}_3/\text{Fe}_2\text{O}_3$ were calculated.

RESULTS AND DISCUSSION

Silica was the main component in the analysed samples of Alfisols. Its content ranged from 78.21% to 90.00% (Table 2). The lowest amount of SiO_2 was found

Table 1. Selected physical and chemical properties of investigated soils

Profile No.	Horizon	Thickness (cm)	Sampling depth	C-org. (%)	Content of fraction (%)		pH	
					<0.02	<0.002	H ₂ O	KCl
					(mm)			
7	Ap	0-27	10-25	0.73	20	11	6.0	5.1
	Eet	27-68	40-55	0.39	15	9	6.2	5.2
	E/B	68-93	80-90	0.21	23	12	6.5	5.5
	Bt	93-131	102-120	0.35	61	37	6.5	5.2
	C	>131	143-162		32	23	6.6	5.1
11	Ap	0-35	15-30	0.93	18	7	7.5	7.0
	Eet	35-58	45-50	0.11	20	12	7.0	6.3
	Bt	58-120	75-105	0.05	36	17	7.1	6.1
	C	>120	137-156		28	20	7.8	7.3
21	Ap	0-25	0-25	0.72	19	8	6.2	6.1
	Eet	25-50	30-45	0.15	21	7	6.6	5.7
	Bt	50-80	60-75	0.08	42	18	6.5	5.3
	C	80-140	90-110		41	16	6.4	4.9
26	IIC	>140	140-150		9	5	6.3	4.8
	Ap	0-33	5-30	0.61	22	10	6.2	5.0
	B1t	33-60	45-56	0.02	31	19	5.7	4.2
	B2t	60-98	72-85		36	23	5.5	4.1
	Cca	>98	120-146		32	15	7.9	7.4

in the Bt horizon of the profile No. 7, the highest amount, in the surface horizon of the profile 21. It is easy to observe a significant influence of the illuvial process on the profile location of silica. The above is proved by a low amount of SiO₂ in the illuvial horizon (mean - 82.37%), higher amount in the eluvial horizon (mean - 87.88%) and a relatively high level in the parent material (mean - 84.47%). A negative correlation coefficient between SiO₂ amount and the amount of clay fraction (-0.914) (Fig. 5) is also indicative of this influence. SiO₂ levels in the examined soils were similar to the levels obtained by other authors for analogous parent material [2,3,8]. The above authors paid attention to SiO₂ dearth in the illuvial horizons.

Al₂O₃ content ranged between 4.42 and 11.22 mg/kg. This last compound had a completely different localisation than SiO₂ with its maximum in the illuvial horizons. On the basis of molar ratios between SiO₂ and Al₂O₃ fluctuating between 11.8 (Bt horizon, profile No. 7) and 32.7 (glacial till, profile No. 26) (Fig. 2), a negative correlation was noticed. Profile No. 7 had the highest amount of Al and its lowest amount was found in glacial till of profile No. 26. The content of aluminium

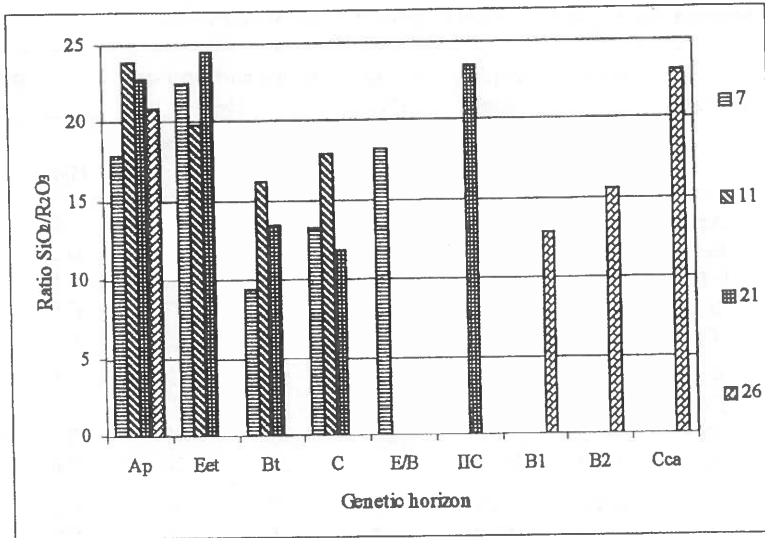


Fig. 1. The molar ratio SiO₂/R₂O₃ in investigated soils.

Table 2. Chemical composition of investigated soils (in %)

Profile	Horizon	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	TiO ₂	MgO	CaO	MnO	K ₂ O	Na ₂ O
7	Ap	86.91	6.90	1.33	0.38	0.17	1.08	0.058	2.38	0.77
	Eet	89.02	5.28	1.65	0.29	0.17	0.99	0.017	1.88	0.69
	E/B	86.25	5.80	2.68	0.42	0.45	0.96	0.024	2.71	0.70
	Bt	78.21	11.22	3.20	0.63	0.72	1.04	0.041	3.88	1.05
	C	82.90	8.32	2.62	0.44	0.52	0.98	0.029	3.31	0.87
11	Ap	89.09	5.03	1.43	0.29	0.16	0.93	0.056	2.27	0.74
	Eet	87.78	5.93	1.74	0.40	0.18	0.93	0.031	2.27	0.73
	Bt	84.20	6.25	2.98	0.52	0.67	1.08	0.037	3.38	0.88
	C	84.10	5.86	2.58	0.36	0.78	3.09	0.030	2.45	0.74
21	Ap	90.00	4.85	1.31	0.44	0.13	0.83	0.058	1.74	0.63
	Eet	88.84	4.81	1.75	0.15	0.25	1.02	0.028	2.65	0.85
	Bt	82.90	8.30	3.01	0.17	0.50	0.95	0.016	3.15	0.99
	C	81.90	9.48	2.99	0.38	0.56	0.92	0.022	2.94	0.79
	IIC	88.14	4.92	1.98	0.17	0.29	0.99	0.025	2.68	0.80
26	Ap	87.60	5.67	1.94	0.19	0.26	0.90	0.024	2.62	0.78
	B1t	83.80	8.85	2.78	0.29	0.40	0.88	0.017	2.35	0.61
	B2t	84.60	7.07	2.91	0.25	0.53	0.89	0.021	2.92	0.81
	Cca	85.30	4.42	2.54	0.19	1.00	3.05	0.028	2.62	0.84

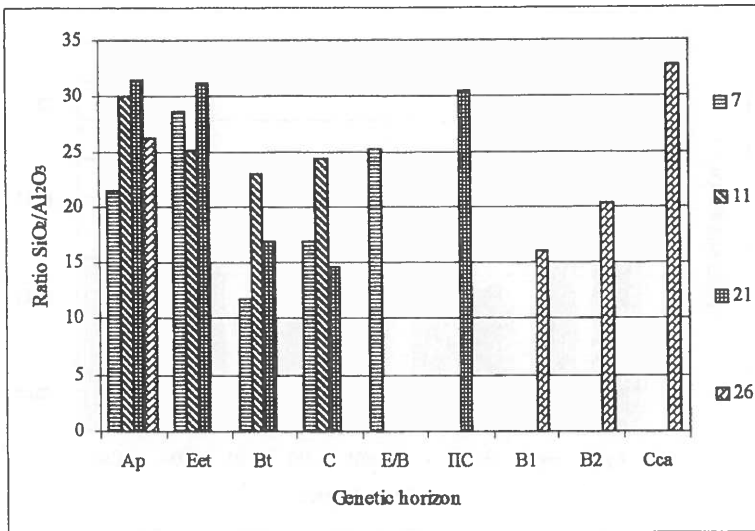


Fig. 2. The molar ratio $\text{SiO}_2/\text{Al}_2\text{O}_3$ in investigated soils.

had a very similar profile disposition as the clay fraction. Correlation coefficient between the levels of these two parameters equals 0.805, which means that with a decrease in the amount of clay fraction, the amount of Al decreases too. Results from the analysed Alfisols were very similar to those obtained by Kempieńska [6] for the Alfisols from Wierzchucinek (Krajeńska glacial till), and little lower than by Długosz [3] for the Alfisols from Gliszcz.

Another important soil parameter, indicative of illuvial process, is the content of iron. In the investigated soils it fluctuated from 1.33% (surface horizon of profile No. 7) to 3.20% (Bt horizon of profile No. 7) (Table 2). The profile disposition of Fe is similar to the disposition of Al. Iron amounts found in the examined soils were a little lower than those by Gliszcz [3] and the Wielkopolska glacial till [1].

In the analysed soils, a wide range of titanium was found, between 0.15% and 0.63% (Table 2). The lowest amount of titanium was found in the elluvial horizons where it ranged from 0.15 to 0.40% (Table 2); the highest amount, however, was found in the Bt horizon of the profile No. 7. Moreover, the profile disposition of titanium showed a considerable influence of the illuvial process. The content of TiO_2 in the examined parent material is varied as well. If compared to the glacial till, (0.19%), the fluviglacial material cumulates larger amounts of this element (0.38-0.44%) (Table 2). The IIC horizon of the profile No. 21 with 0.17% of TiO_2 is an exception. It is characteristic of the lithological discontinuity observed in the very profile. The amounts obtained in the glacial till are close to those found in the till from Gliszcz

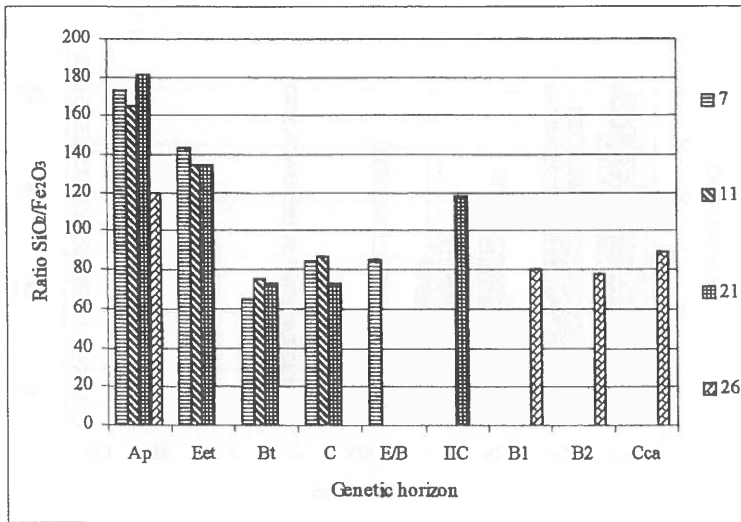


Fig. 3. The molar ratio $\text{SiO}_2/\text{Fe}_2\text{O}_3$ in investigated soils.

[3], but definitely lower than those by Kempńska [6] in the boulder till from Wierzchucinek, or Marcinek [7] in the till from Chomiąza with 0.51-0.6% TiO_2 .

Potassium in the profile disposition does not show any regularity related to the illuvial process, nevertheless, the largest amounts of K lay in the illuvial horizon. The reason for this is K presence in substantial amounts in the surface horizons. Such enrichment is the effect of the abundance of exchangeable K resulting from potassium fertilisation. The best example of this would be the profile No. 26. The quantity of this element in the investigated samples is between 1.74-3.88% (Table 2), which does not differ from the results obtained by other authors for the Alfisols analogous parent material [1,3,6].

The occurrence of magnesium is quite different. Its largest quantities were observed in the parent material, where the amount of Mg ranged from 0.13 to 1.00% MgO (Table 2). The highest MgO content was found in the glacial till horizon, whereas the lowest content in the surface horizon (0.13-0.26%). The amounts found in the soils of Mochetek are considerably lower in comparison to those specified by Długosz [3] and Cieśla [1]. Identical profile disposition was observed by Musierowicz [8].

Calcium distribution is quite similar to magnesium and its content equals 0.83-3.09%. The largest amount was observed in the Cca horizon of the profile No. 26, between 0.98-0.99% (Table 2) in the fluviglacial material, which is lower than the amount of Ca obtained in the examined glacial till. The exception is the parent material

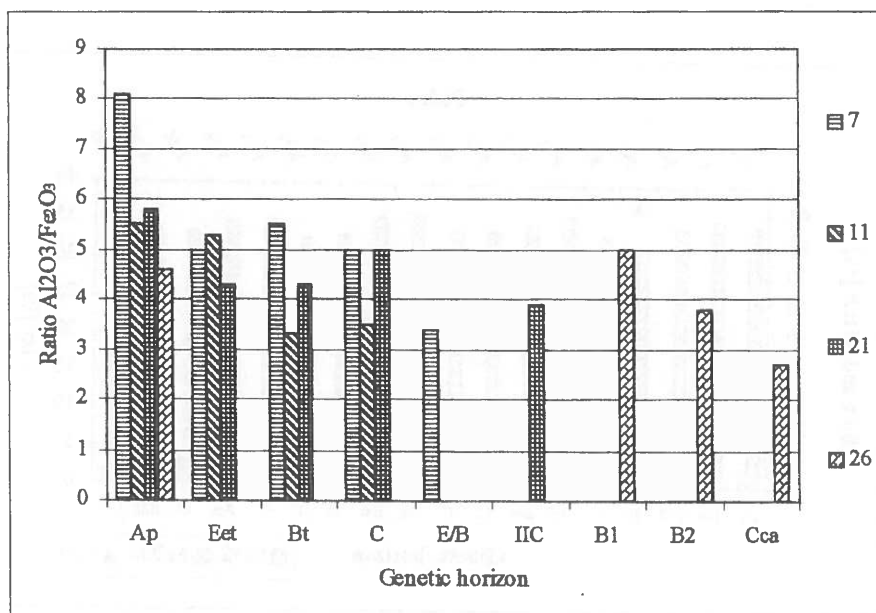


Fig. 4. The molar ratio Al_2O_3/Fe_2O_3 in investigated soils.

of the profile No. 11, which contains over 3% of CaO (Table 2). However, these amounts vary from those observed in other glacial till from this region [3,6].

Na_2O levels ranged from 0.63 to 1.05% (Table 2). The smallest amounts are found in the surface horizons (0.63-0.78%), the largest, in the illuvial horizons. The influence of the illuvial process can be seen in the profile distribution of this element. Apart from the components described above, small quantities of manganese were found, between 0.16-0.58% (Table 2). Mn exists in abundance in the A horizons. The results obtained do not confirm neither the results by Riemann [9], who showed the amount of MnO decreasing with depth, nor by Cieřla and Kociałkowski [2], who showed some accumulation of MnO in the deeper and surface horizons.

Analysis of the molar ratios: SiO_2/Fe_2O_3 (Fig 3), Al_2O_3/Fe_2O_3 (Fig. 4) and SiO_2/R_2O_3 (Fig. 1) indicates a significant influence of the illuvial process on the formation of the examined soils. There exists a visible narrowing of the SiO_2/Fe_2O_3 proportion (Fig. 3) in the Bt horizons, which is the effect of the SiO_2 dearth in these horizons on the one hand, and, on the other hand, their enrichment in iron. The narrowing of the Al_2O_3/Fe_2O_3 (Fig. 4) proportion is also the proof of iron mobility in the illuvial process. Hence, it can be stated that iron is more prone to this process.

C

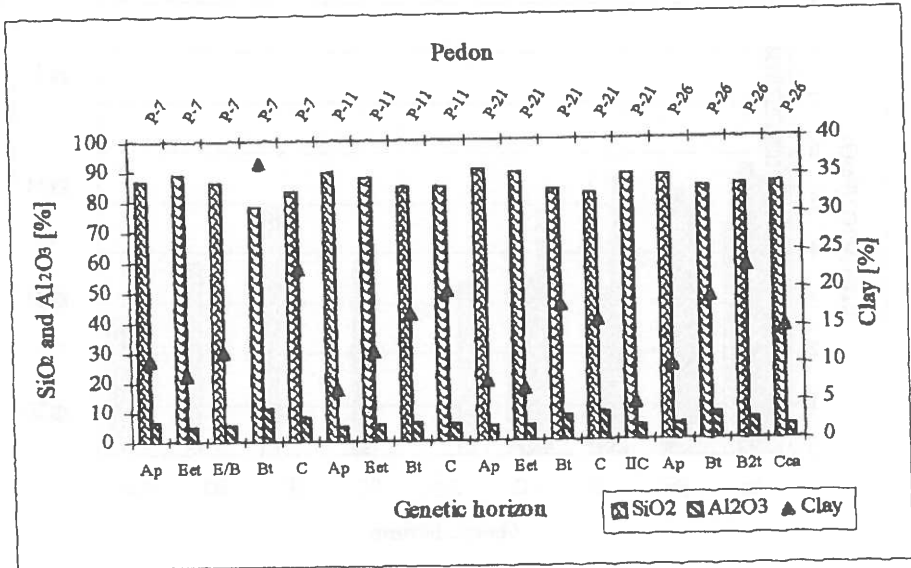


Fig. 5. The contents of SiO₂, Al₂O₃ and clay fraction in analysed soils.

ONCLUSIONS

The results obtained from complex analyses confirm the influence of the illuvial process on the formation of the studied soils. It is observed in lower SiO₂ amounts and higher amounts of Al₂O₃ and Fe₂O₃ in the argillic horizon. Lithological discontinuity in the profile No. 21 is proved by lower amounts of Al₂O₃, Fe₂O₃, TiO₂ and higher SiO₂ quantity in the C horizon of this profile. Differences in the analysed parent materials were visible mainly in the content of titanium, aluminium and calcium.

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