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ALTERATIONS OF SOME CHEMICAL AND PHYSICO-CHEMICAL PROPERTIES OF SELECTED SOILS IN FIELD ECOSYSTEMS

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A b s t r a c t. The research was conducted in 1991-1997 on the soils from arable fields situated near Łódź. To the detailed research there were stated four soil profiles which were different as regards their grain composition (two sand and two silt soils, all shallow) and typology (two profiles of brown leached soils, one pseudopodzolic-gley soil and one fallow glossic grey-brown podzolic soil).

Qualification of the directions of the alterations in the content of organic carbon and basic macroelements (P, K, Mg) in soil and hesitation of reaction, hydrolytic acidity and content of the exchangeable basic cations in the soil sorptive complex were the main target of our research.

The result of the 7-year-long research showed that different changes took place in the features of the examined soils. However, the exact assignment of the direction of these alteractions is extremely complex and does not warrant getting a satisfying answer. It is the result of taking various agriculture actions which are necessary to the appropriate maintenance of the ecosystems.

K e y w o r d s: arable soils, properties, soil chemistry.

INTRODUCTION

The uses that soils are put to, is an important factor in determining their physical and chemical properties [4,5,9,11,13]. In the case of field ecosystems, an important role is played by crop rotation, which to a greater extent determines the inflow of organic matter into the soil and to some extent - the inflow of nutrients, as the result of the fertilization used and mineralisation of post-harvest residues in the soil.

The aim of the research was to determine the direction of the changes in the content of organic carbon and basic macroelements (P, K, Mg) in the soil and to measure the fluctuation of the reaction, hydrolytic acidity, and the content of exchangeable basic cations in the sorption complex of the soil. Determination of the degree of soil salinity and its changes during the research period was also attempted.

MATERIALS AND METHODS

The research was conducted in the years 1991-1997 on soils from production fields situated near Łódź, Poland. Four soil profiles selected for detailed investigation had different granulometric composition (two sandy soils and two silty soils, all incomplete) and represented the following taxonomy units:

- brown leached soil derived from light loamy sand, with a bed of light loam - Łagiewniki site;
- brown leached soil derived from weak loamy and strong silty sand (in the Ap horizon), with a bed of light loam - Zegrzanki site;
- pseudogley soil (stagno-gleyic) derived from common silt interbedded with weak loamy sand and light silty loam - Nowe Łagiewniki site;
- glossic grey-brown podzolic soil derived from common silt interbedded with weak loamy sand and loose sand - Smardzew site.

The composition and important properties of the soils listed above are presented in Table 1.

In the first year of the research (1991) whole soil profiles were analysed and during the following years, (1992-1997) only the arable-humus horizons (0-20 cm) and sub-humus horizons (30-40 cm) were investigated on the assumption that at that depth, changes caused by anthropopressure are the clearest and furthermore, this is the layer of soil from which plants take most of their nutrients.

The following features were measured in the soil samples taken from the described depths:

- granulometric composition with the Casagrande method modified by Prószyński;
- C-organic with the Tiurin's method;
- available forms of P and K with the Egner-Riehm's method;
- available Mg with the Schachtschabel's method;
- pH potentiometrically;
- hydrolytic acidity with the Kappen's method;
- exchangeable basic cations with the Pullmann's method;
- salinity conductometrically in the water suspension in the 1:2 ratio.

RESULTS

The results of the research achieved, indicate that the measured properties of the soil from production fields undergo smaller or greater changes in time.

Table 1. Basic features of studied soils

Locality	Genetic horizon	Depth (cm)	Fraction contents with ϕ in mm (%)					Corg. (%)	pH		Available forms			Sorptive features			
											P	K	Mg	Hh	S	Th	V
			>1	1.0-0.1	0.1-0.02	<0.02	<0.002		H_2O	KCl	mg/100 g soil						(%)
Łagiewniki	Ap	0-20	13.9	70	20	10	1	0.92	4.8	4.1	2.4	2.1	0.9	3.97	1.37	5.34	25.6
	Bbr	30-40	9.5	73	14	13	1	-	4.8	4.3	1.6	1.0	0.5	2.77	0.93	3.70	25.1
	C	70-80	5.6	74	15	11	2	-	6.0	5.0	0.2	1.0	2.4	0.52	2.55	3.07	83.1
	IIC	115-125	6.1	59	15	26	18	-	6.3	4.8	0.5	3.5	10.2	0.97	7.23	8.20	88.2
Zegrzanki	Ap	0-20	3.8	52	40	8	2	1.05	4.7	4.2	1.7	3.8	4.0	2.92	1.72	4.64	37.1
	Bbr	30-40	3.5	71	20	9	2	-	4.6	4.4	0.4	1.0	1.4	1.87	1.20	3.07	39.1
	Bbr	50-60	3.9	76	17	7	1	-	5.1	4.7	0.3	1.0	1.4	1.12	1.31	2.43	53.9
	C	85-95	4.0	75	18	7	2	-	6.0	5.3	0.2	0.7	1.9	0.45	1.69	2.13	79.3
	IICg	115-125	5.0	58	21	21	12	-	6.4	5.4	0.7	3.5	5.6	0.37	5.68	6.05	93.9
Nowe Łagiewniki	Ap	0-20	2.7	33	52	15	1	2.28	5.8	5.4	0.8	1.4	9.1	2.55	7.25	9.80	74.0
	Gg	30-40	0.2	18	58	24	4	-	6.6	5.5	0.1	0.7	1.9	0.67	3.24	3.91	82.9
	Bfecn	55-65	11.8	79	15	6	1	-	6.7	5.6	0.1	0.7	1.4	0.52	2.52	3.04	82.9
	IICg	80-90	3.3	45	26	29	16	-	6.8	5.2	0.3	2.1	7.2	0.60	13.39	13.99	95.7
	IIICgg	110-120	0.6	35	41	24	16	-	8.2	6.9	0.6	2.7	3.7	0.22	9.46	9.68	97.7
Smardzew	Ap	0-20	1.2	46	41	13	1	1.23	5.1	4.4	3.4	8.3	3.6	3.75	2.18	5.93	36.8
	Eet,es	25-35	0.3	35	46	19	4	-	4.6	4.4	2.4	3.5	7.2	2.85	1.29	4.14	31.2
	IIE/B	50-60	0.4	74	20	6	2	-	5.4	4.7	0.4	1.7	1.9	0.75	1.65	2.40	68.8
	IIBt,fe	75-60	1.4	76	14	10	9	-	5.8	4.8	0.7	2.7	4.0	0.97	3.13	4.10	76.3
	IIC	95-105	0.4	90	7	3	2	-	5.9	4.9	0.4	0.7	0.9	0.45	1.65	2.10	78.6
	IIIC	135-145	0.4	34	46	20	8	-	5.4	4.5	0.5	2.4	6.0	1.12	3.91	5.03	77.7

Table 2. Range of some properties of studied soils in years 1991-1997

a) reaction, organic carbon and macroelements

Locality	Depth (cm)	pH_{H_2O}	pH_{KCl}	Corg. (%)	P	K	Mg
					mg/100 g soil		
			Sandy soils				
Łagiewniki	0-20	4.9-7.1	4.1-6.7	0.92-1.14	2.4-9.3	2.1-8.3	0.9-4.0
	30-40	4.8-6.5	4.3-5.7	-	0.4-2.9	1.0-5.0	0.5-5.5
Zegrzanki	0-20	4.5-6.2	4.1-5.9	1.00-1.17	1.3-5.4	2.1-7.5	1.2-9.0
	30-40	4.5-6.1	4.2-5.7	-	0.3-2.3	0.8-1.7	0.7-7.5
			Silty soils				
Nowe	0-20	4.6-6.6	3.9-6.4	1.40-2.28	0.8-8.3	1.4-37.4	1.7-16.0
Łagiewniki	30-40	4.8-6.6	4.2-5.5	-	0.0-0.4	0.7-7.5	1.9-5.7
	0-20	4.7-5.3	4.1-4.7	0.75-1.50	3.1-4.8	2.1-17.4	2.0-6.0
Smardzew	30-40	4.4-5.1	4.2-4.4	-	0.5-5.1	1.7-5.0	1.0-7.2

b) hydrolytic acidity (Hh) and exchangeable basic cations

Locality	Depth (cm)	Hh	Ca^{2+}	Mg^{2+}	K^+	Na^+
		mg/100 g soil				
			Sandy soils			
Łagiewniki	0-20	0.45-3.97	0.80-5.40	0.15-0.42	0.15-0.22	0.09-0.17
	30-40	0.75-2.77	0.50-4.20	0.10-0.51	0.09-0.13	0.07-0.19
Zegrzanki	0-20	1.65-4.87	0.40-2.40	0.11-0.61	0.09-0.19	0.09-0.19
	30-40	0.82-2.92	0.48-1.32	0.10-0.52	0.04-0.09	0.050.19
			Silty soils			
Nowe	0-20	1.20-5.47	0.66-6.10	0.12-1.15	0.12-0.96	0.10-0.17
Łagiewniki	30-40	0.67-2.25	1.40-2.70	0.16-0.53	0.05-0.20	0.09-0.18
	0-20	1.42-4.05	0.72-1.30	0.14-0.38	0.14-0.43	0.09-0.16
Smardzew	30-40	1.57-2.85	0.48-0.76	0.10-0.50	0.06-0.23	0.07-0.17

c) Sum of basic cations (S), sorptive capacity (Th), base saturation of soils (V) and electrolytic conducitivity

Locality	Depth (cm)	S	Th	V (%)	Conductivity (μS/cm)
		mg/100 g soil			
			Sandy soils		
Łagiewniki	0-20	1.30-6.07	5.04-6.52	25.6-93.1	100-426
	30-40	0.78-4.94	3.03-5.69	25.1-86.8	53-293
Zegrzanki	0-20	0.70-2.81	4.40-6.39	12.6-63.0	67-240
	30-40	0.70-1.59	2.15-3.62	19.3-66.0	40-326
			Silty soils		
Nowe	0-20	1.00-5.88	6.47-9.80	15.6-83.0	93-520
Łagiewniki	30-40	1.82-3.24	3.24-4.28	47.4-82.9	120-353
	0-20	1.25-2.18	2.81-5.93	27.1-49.5	60-206
Smardzew	30-40	0.78-1.50	2.50-4.14	25.7-45.4	33-300

It is described in some of the papers concerning soil science and agricultural chemistry [2,5,14]. The role of fertilization as an important element influencing the content and dynamics of nutrients in soil is often emphasized. One can suppose that the high content of phosphorus and potassium in the accumulation horizons of soils, stated by many authors [3,6,7,9,10], is the result of fertilization. Granulometric composition, especially the clayey fraction, according to others [1,6,7] is a factor which determines the content of available magnesium in the soil. Those authors did not state any dependency between the content of that element and the reaction of the soil. It should be mentioned that the research conducted by Siuta *et al.* [12] indicates that the increase in the content of colloidal clay increases the content of available potassium in the soil.

The investigated sandy soils (Łagiewniki and Zegrzanki) and the grey-brown podzolic soil derived from silt (Smardzew) contain about 1% of C-organic (Table 2a). Much richer in that element is the pseudogley soil derived from silt (Nowe Łagiewniki). In the sandy soils, the fluctuations of the content of C-organic are small, and therefore the values from the first and the seventh year of the research stay on the same level - in Łagiewniki respectively 0.93% and 0.95%, and in Zegrzanki - 1.05 and 1.0% of C-organic. In the silty soils the fluctuations are bigger, and in the pseudogley soils there was a decreasing tendency from 2.28% down to 1.50% of C-organic. In the last year of research in the grey-brown podzolic soil there was an increase in the content of that element from 1.23% in 1991 to 1.50% in 1997.

The content of available phosphorus and potassium in the sandy soils stayed within the range of very low and low during the entire period of investigation. Silty soils - as compared to sandy soils - showed somewhat greater content of those elements but even here, it was only medium (Table 2a, Fig. 1).

50% of the content of magnesium in the sandy soils was medium and 50% was very low and low. Definitely little magnesium was found in the grey-brown podzolic soil derived from silt (Smardzew). The content of that element was much better in soil from the Nowe Łagiewniki site (pseudogley soil - Table 2a, Fig.1). It is almost a rule that the content of available forms of P, K, and Mg in the Ap horizons is higher than that in the layers 30-40 cm deep, with only a few exceptions in soil from the Łagiewniki site.

The reaction of the described soils is usually very acid and acid regardless of their taxonomy (Table 1). There was a tendency of the pH to increase in the last years of the research period, but also in this case there were exceptions. For example, the

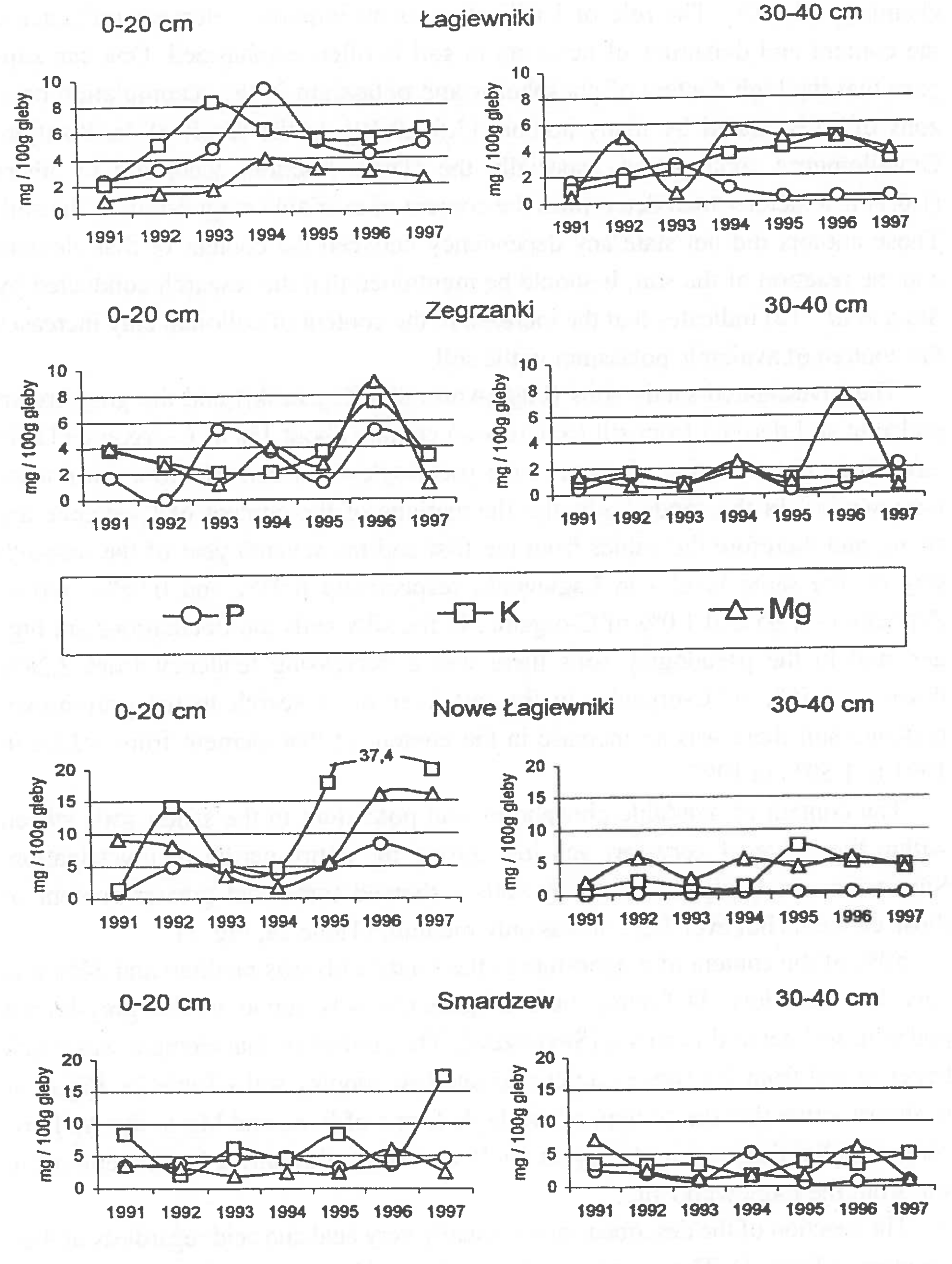

Fig. 1. Alterations of available forms of P, K, and Mg in soil in 1991-1997.

reaction of the grey-brown podzolic soil (Smardzew) had not change for 7 years and was very acid (pH of about 4.3 - Table 3).

More important changes in the pH of the soil were reflected by the values of hydrolytic acidity and the content of basic cations. In cases where an increase of the soil pH was stated, the content of basic cations was also higher, especially that of Ca^{2+}, Mg^{2+}, and K^{+} and the hydrolytic acidity was lower. The content of Na^{+} in the sorption complex did not change significantly and in several cases it was equal to the content of Mg^{2+} (Zegrzanki, Smardzew - Table 3). The degree of saturation of the sorption complex with basic cations was usually low (often under

Table 3. Alterations of reaction, hydrolytic acidity (Hh), exchangeable alkaline cations and features of sorptive soils in years 1991-1997

Locality	Years	Depth (cm)	pH KCl	Hh	Ca^{2+}	Mg^{2+}	K^{+}	Na^{+}	S	Th	V (%)
				me/100 g soil							
Łagiewniki	1991	0-20	4.1	3.97	0.80	0.27	0.16	0.14	1.37	5.34	25.6
	1992		4.1	3.70	0.82	0.21	0.19	0.12	1.34	5.04	26.6
	1993		4.2	3.75	0.84	0.15	0.22	0.09	1.30	5.05	25.7
	1994		6.2	0.45	5.40	0.42	0.16	0.09	6.07	6.52	93.1
	1995		6.2	1.05	3.52	0.30	0.15	0.13	4.10	5.15	79.6
	1996		6.5	0.67	4.00	0.24	0.15	0.17	4.56	5.23	87.2
	1997		6.7	0.60	4.88	0.20	0.19	0.12	5.39	5.99	90.0
	1991	30-40	4.3	2.77	0.50	0.21	0.10	0.12	0.93	3.70	25.1
	1992		4.3	2.10	0.72	0.32	0.09	0.07	1.20	3.30	36.4
	1993		4.3	2.25	0.52	0.10	0.09	0.07	0.78	3.03	25.7
	1994		5.3	0.97	1.92	0.51	0.10	0.09	2.62	3.59	73.0
	1995		5.0	1.12	2.92	0.42	0.13	0.16	3.63	4.75	76.4
	1996		5.7	0.75	4.20	0.42	0.13	0.19	4.94	5.69	86.8
	1997		5.3	0.90	3.76	0.33	0.13	0.13	4.35	5.25	82.9
Zegrzanki	1991	0-20	4.1	2.92	1.02	0.33	0.18	0.19	1.72	4.64	37.1
	1992		3.3	4.40	0.71	0.22	0.14	0.14	1.21	5.61	21.6
	1993		3.8	4.87	0.40	0.11	0.10	0.09	0.70	5.57	12.6
	1994		4.9	2.32	1.56	0.30	0.09	0.13	2.08	4.40	47.3
	1995		4.8	3.75	2.12	0.19	0.14	0.19	2.64	6.39	41.3
	1996		4.6	3.67	0.88	0.61	0.19	0.14	1.82	5.49	33.2
	1997		5.9	1.65	2.40	0.13	0.15	0.13	2.81	4.46	63.0
	1991	30-40	4.4	1.87	0.74	0.19	0.08	0.19	1.20	3.07	39.1
	1992		4.2	2.92	0.48	0.10	0.07	0.05	0.70	3.62	19.3
	1993		4.3	1.42	0.52	0.10	0.04	0.07	0.73	2.15	34.0
	1994		4.3	1.95	0.68	0.16	0.06	0.15	1.05	3.00	35.0
	1995		5.2	1.35	1.32	0.10	0.04	0.13	1.59	2.94	54.1
	1996		4.7	1.87	0.64	0.52	0.09	0.09	1.34	3.21	41.7
	1997		5.7	0.82	1.32	0.11	0.06	0.10	1.59	2.41	66.0

T a b l e 3. Continuation

Loca-lity	Years	Depth (cm)	pH KCl	Hh	Ca^{2+}	Mg^{2+}	K^+	Na^+	S	Th	V (%)
				me/100 g soil							
Nowe Łagiewniki	1991		5.3	2.55	6.10	0.81	0.18	0.17	7.25	9.80	74.0
	1992		4.9	3.75	2.72	0.60	0.35	0.17	3.84	7.59	50.6
	1993		4.7	4.12	2.60	0.21	0.17	0.11	3.09	7.21	42.9
	1994	0-20	3.9	5.47	0.66	0.12	0.12	0.10	1.00	6.47	15.6
	1995		4.7	4.50	1.84	0.31	0.30	0.13	2.58	7.08	36.4
	1996		6.4	1.20	3.60	1.15	0.96	0.17	5.88	7.08	83.0
	1997		6.2	1.20	3.80	1.14	0.55	0.13	5.62	6.82	82.4
	1991		5.5	0.67	2.70	0.30	0.10	0.14	3.24	3.91	82.9
	1992		4.2	1.95	1.48	0.53	0.11	0.18	2.30	4.25	54.1
	1993		4.4	1.42	1.52	0.16	0.05	0.09	1.82	3.24	56.2
	1994	30-40	5.3	0.90	2.12	0.42	0.10	0.11	2.75	3.65	75.3
	1995		4.7	2.25	1.40	0.25	0.20	0.18	2.03	4.28	47.4
	1996		4.6	1.72	1.78	0.43	0.15	0.15	2.51	4.23	59.3
	1997		5.2	1.65	1.56	0.29	0.13	0.13	2.11	3.76	56.1
Smardzew	1991		4.4	3.75	1.30	0.38	0.40	0.10	2.18	5.93	36.8
	1992		4.2	4.05	0.96	0.20	0.28	0.09	1.53	5.58	27.4
	1993		4.1	3.37	0.80	0.14	0.20	0.11	1.25	4.62	27.1
	1994	0-20	4.7	3.30	0.79	0.16	0.15	0.16	1.26	3.56	35.4
	1995		4.4	3.45	0.92	0.18	0.17	0.13	1.40	4.85	28.9
	1996		4.3	3.60	0.80	0.33	0.14	0.16	1.43	5.03	28.4
	1997		4.3	1.42	0.72	0.15	0.43	0.09	1.39	2.81	49.5
	1991		4.3	2.85	0.50	0.44	0.23	0.12	1.29	4.14	31.2
	1992		4.3	2.17	0.66	0.16	0.11	0.07	1.00	3.17	31.5
	1993		4.2	1.57	0.64	0.11	0.09	0.09	0.93	2.50	37.2
	1994	30-40	4.4	2.25	0.48	0.12	0.06	0.12	0.78	3.03	25.7
	1995		4.3	2.32	0.76	0.15	0.11	0.17	1.19	3.51	33.9
	1996		4.4	1.80	0.72	0.50	0.11	0.17	1.50	3.30	45.4
	1997		4.3	2.55	0.68	0.10	0.13	0.07	0.98	3.53	27.8

30%) and it was increased only in those years, in which the pH of the soil also grew (Table 3). The highest content in the cation composition of the sorption complex of the soils was that of the H^+ and Ca^{2+} ions and their mutual proportions were different in different years and sites (Fig. 2). It was especially clear in Łagiewniki and Nowe Łagiewniki, where the Ca^{2+} cation had a great advantage over the H^+ cation in the last four years of the research. In Zegrzanki and Smardzew, the content of hydrogen was the greatest in the sorption complex in almost every year of research (Fig. 2).

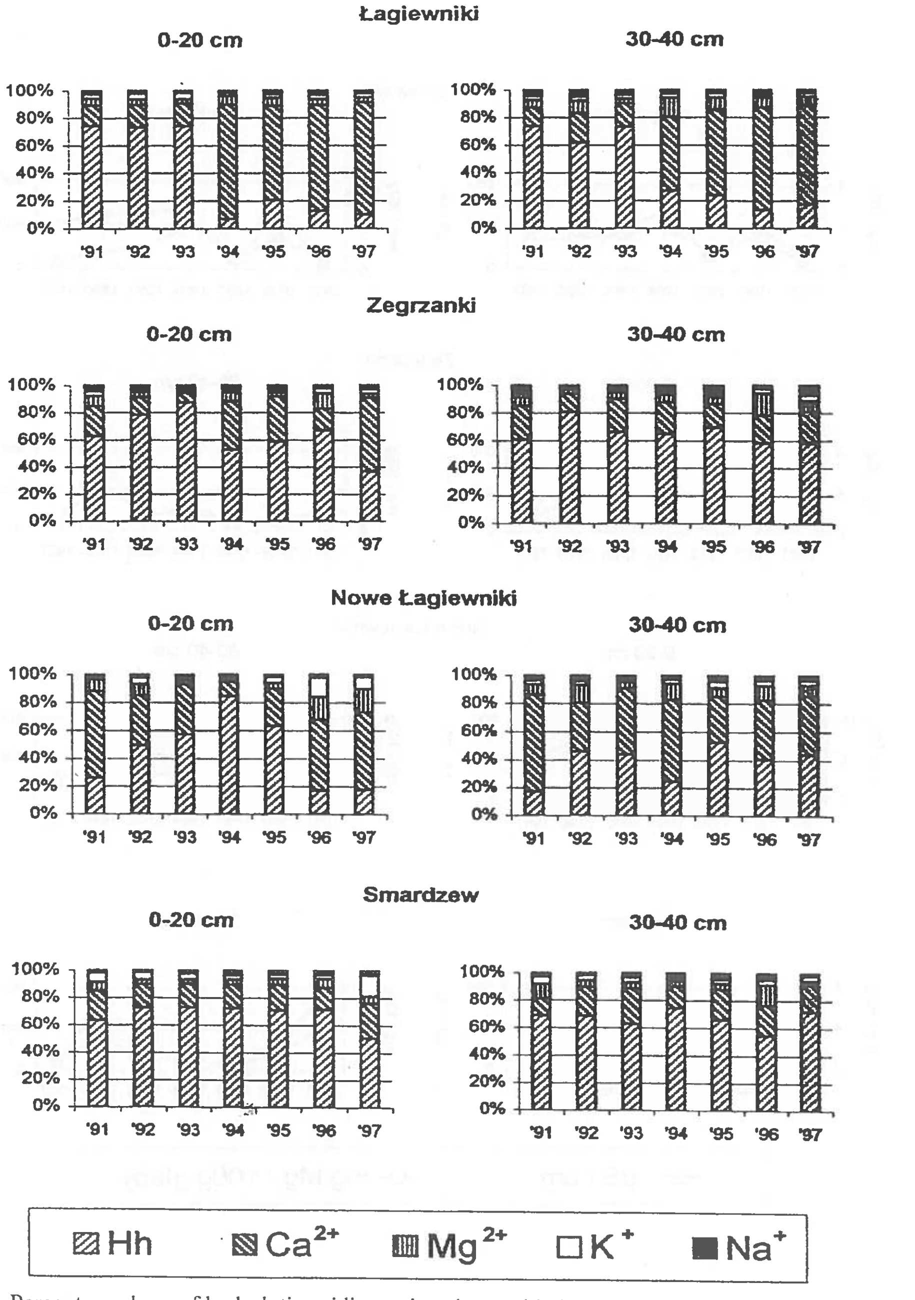

Fig. 2. Percentage share of hydrolytic acidity and exchangeable basic cations in sorptive complex of studied soils in years 1991-1997.

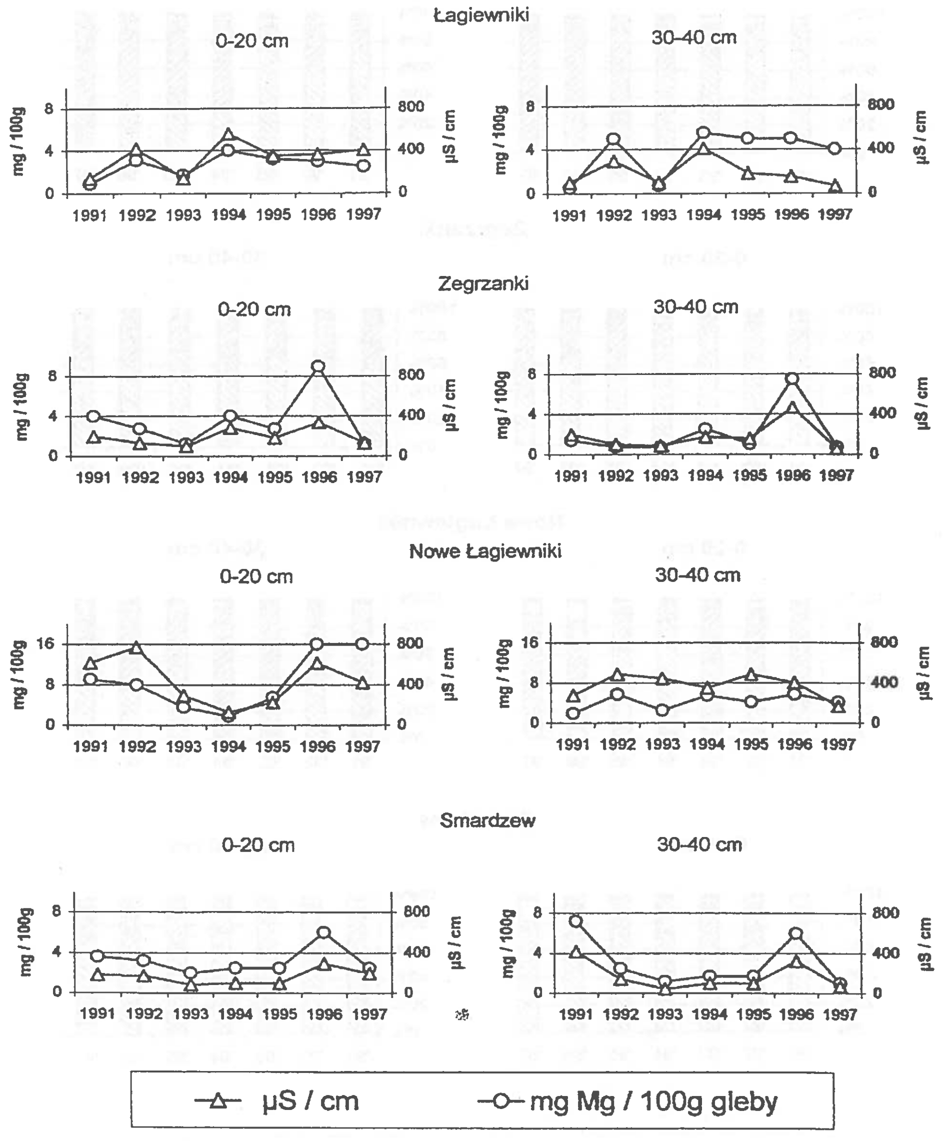

Fig. 3. Correlation between electrolytic conductivity (EC) and content of available Mg in soil.

The initial investigation of the electrolytic conductivity of the soils proved that it underwent great fluctuations (Table 2c), despite the fact that it did not exceed 4000 μS/cm, which is considered the bottom threshold of salinity. In the arable-humus horizons of the sandy soils, salinity is higher than in the deeper soil horizons (30-40 cm). In the silty soils, such a rule was not stated, however, a similar tendency was visible (Table 2).

One of the most interesting observations was the dependency between the electrolytic conductivity of the soils and the content of available magnesium (Table 3).

CONCLUSIONS

The results collected during seven years of research prove that there are changes of different intensity in the properties of the soils described. Most of those changes are due to the granulometric composition of the soils, but most are due to agrotechnical measures, especially fertilization. Stating the changes in the soil properties does not present a great difficulty but the detailed determination of the direction of those changes is a very complex task and it does not always guarantee satisfactory results. The reason for that is the diversity of the agrotechnical measures necessary for the proper functioning of field ecosystems. Undoubtedly, research conducted in conditions of strict, in-the-field experiment as opposed to conditions of production fields, would greatly clarify the issues described in this paper.

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