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ACIDITY AND RELATED PROPERTIES IN ARABLE SOILS IN THE MIDST OF 'KCW-KUJAWY' LIME AND CEMENT PLANT

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A b s t r a c t. The samples have been taken from 8 500 ha of the soils located arround the Lime and Cement Plant 'KUJAWY' at Bielawy. The surface and profile test points were located at the square grid intersections with a 500 m module. An environmental variation range in the soil has been determined with regard of forms of a soil acidity, secondary calcium carbonate content and exchangeable cations and soil solution composition.

A chemical analysis of the cement dusts emitted by Cement Plant demonstrates high level of calcium content (42-49 %), potassium (6 %) as well as the series of macro- and microelements that can influence on composition and properties of the soils and nutrition status of the plants.

The area surrounded of 'KCW-KUJAWY' has been divided between three zones of different pH-reactions and the other soil properties. The highest alkalinity was observed in the first zone, located close to the Cement Plant where reaction $pH_{(KCl)}$~ 8 is registered and a soil solution with sorptive complex are dominated by Ca^{2+} up to 95 % of saturation.

The lower alkalinity and Ca^{2+} concentration in a sorptive complex and a soil solution are registered in the second zone, located at a significant distance from the Cement Plant. In the third zone, the KCW has a little influence on the soils in consideration of pH-reaction and other properties. However, the relatively high amount of exchageable K^+ and in soil solution had been noted, also at the significant distance from KCW.

The classification 'by types' with regard of secondary accumulation of $CaCO_3$, pH-reaction and degree of the sorptive complex saturation with Ca^{2+} in a near top surface horizons indicates that it is neccessary to renew the valuation of the gray-brown podzolic soils and the brown soils located close to KCW towards the calcisols soil type (distinguished in the same classifications).

K e y w o r d s: soil acidity, cement dusts, soil sorption complex

INTRODUCTION

During the production process, as of the cement and other lime-originated products, in Lime & Cement Plant 'KCW KUJAWY' at Bielawy, the different dusty and gas contaminations are emitted into the surrounding environment. There is no doubt that such emission involves the determinable, environmental effects. Since 1991/92, in the Department of Soil Science at the Faculty of Agriculture in Bydgoszcz the studies had been performed to describe the KCW influence on soil properties over the surrounded area.

The purpose of present study was to describe changes in physical and chemical properties of the soils in relation to a large emission of the alkalic dusts.

MATERIALS AND METHODS

The analysis of the soil layers had been restricted to the area inside the circle of a radius = 5 km, i.e., to the area *ca.* 8 000 ha located around of 'KCW KUJAWY'.

The mean soil samples from the humus horizon was taken at the points determined by the square-grid at the module of 500 m. Total number of the samples is 335 and each one sample has been tested with regard of:
- the hydrolytic acidity by Kappen's method;

- the pH-reaction in H_2O and KCl by potentiometric method;
- content of $CaCO_3$ by Scheibler's method.

The analysis, that has been made on the base of the soil samples testing, leads to primary demarcating of the soil alkalinity zones. The results verification was made on the base of the samples analysis that had been taken from 60 open pits, with an additional testing of:

- mechanical composition by Prószyński's hydrometer method;
- C-organic with Tiurin's method;
- N-total after mineralization after Kjeldahl's method;
- exchangeable cations K, Na, Ca and Mg in a 1-N NH_4Cl solution after the previous rinsing of the hydro-soluble cations and anions.

Also, the chemical composition of a cement dusts from the precipitators or emitted into the atmosphere had been determined by melting with Na_2CO_3 and digestion in a hydrofluoric acid with an ASA and Flapho photometer.

RESULTS

The considerable amount of alkalizing materials contained in the cement dusts can be observed in the enclosed Table 1 as well as in the chemical composition and properties test results, i.e., 41.99 % CaO in the dusts discharged into atmosphere and 49.31 % CaO in the dust from precipitators. Also, the significant amount of K_2O should be pointed in the dusts, i.e., 6.67 % and 7.59 %.

The reaction and content of $CaCO_3$ in the surface soil samples is differentiated with regard of a zone (Table 2).

On the base of such obtained results concerned with reaction and other properties of a soil, the map was prepared with 3 zones marked for the different soil alkalization levels (Fig. 1).

The highest levels of pH(H_2O) and pH(KCl) have been observed in the soils of zone I, lower in the zone II and the smallest in the zone III.

The hydrolytic acidity is smallest in the zone I and the highest in the zone III. A secondary calcium carbonate accumulation is common in the zone I, occasionally observed in II and not registered in zone III.

Table 1. Chemical composition of cement dust emitted by Kujawy cement-lime plant

Component	Dust emitted to atmosphere	Dust from electrofilters
	% d.m.	
SiO_2	13.21	12.90
Fe_2O_3	4.26	3.71
Al_2O_3	7.26	6.42
CaO	41.99	49.31
MgO	1.23	1.37
K_2O	6.67	7.59
Na_2O	0.54	0.39
P_2O_5	0.12	0.11
pH KCl	10.03	10.25
	mg/kg d.m.	
Cd	43.9	31.8
Zn	530.6	280.8
Ni	30.8	31.4
Pb	772.1	936.5
Cr	34.3	36.8
Cu	59.6	38.9
Mn	325.3	288.3
Se	-	8.1

Table 2. Range of hydrolytic, active, and exchangeable acidity, and content of calcium carbonate in mean surface soil samples

Zone	Hh (mmol H^+/ 100 g)	pH H_2O	pH KCl	$CaCO_3$ (%)
I	0.02-0.32	7.66-8.45	7.33-8.03	0.17-5.77
II	0.06-0.73	7.01-8.16	6.76-7.63	0.00-0.82
III	0.51-2.74	5.60-7.45	5.14-7.16	0.00-0.30

The soil profiles which have been chosen for testing (Fig. 1), represent proper gray-brown podzolic soil, gray-brown pseudogley soil, brown soil and leached brown soil. The gray-brown podzolic soil contains sandy material in surface horizons which is underlayed with a sandy loam or medium-heavy loam (Table 3.)

The reaction of tested soils varies between pH (KCl) 4.97 and 7.92 in the humus horizon upon the test point and the $CaCO_3$ contamination in these horizons of the zones I and II has been determined though it does not exist in the soil parent rock.

The total carbon content in the closed to surface horizons varies from 0.63 to 0.96 %. More differencies can be noted with regard

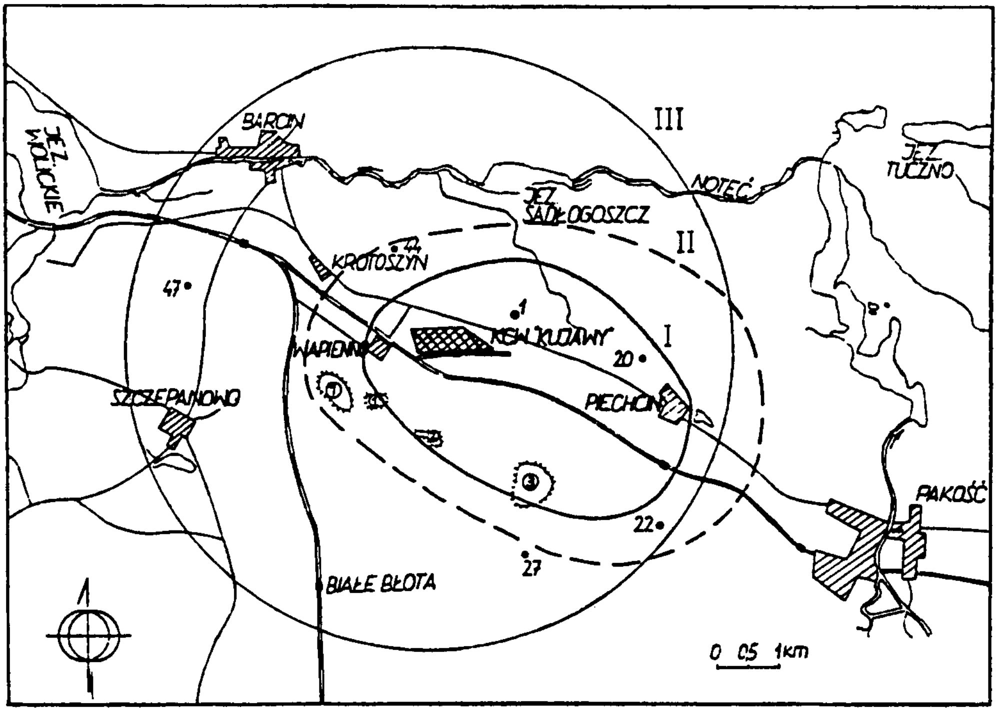

Fig. 1. Area of investigation, distinguished zones and profile locations. • number and profile location, extension zones (I and II) and extension of soil investigation (III).

on the total-N: from 0.48 to 0.144 %. It makes the changes in C/N which varies from 6.94 to 14.96.

Table 4 shows the amounts of exchangeable cations and their percentage share in a sorptive complex. The highest content of Ca^{2+} was reported in the humus horizon in the nearest locations to the 'KCW-KUJAWY' - 12.24 mmol(+)/100 g but the lowest contents are reported of the extreme distance from KCW - 1.59 mmol(+)/100g.

The Ca^{2+}contents in the zone I and II are higher in near-to-surface horizons than in the soil parent rock. The other exchangeable cations occur in smaller amounts and non-uniform distribution of such cations can be observed. The same pattern as for Ca^{2+} have been found for S, T and V.

The water-soluble cations content in a soil solution is differentiated with regard to the zone (Table 5).

The highest content of Ca^{2+}, from 10.6 up to 0.86 mg/100 g soil was found in the top horizons of the soil. An appreciable content is reported for Mg^{2+}- from 0.02 up to 1.90 mg/100 g of soil, and Na^{+}- from 0.17 up to 2.17 mg/100 g of soil. The content is more differentiated as 0.90 mg/100g of soil (B 10 profile) and 6.17 mg/100g of soil (B1 profile) has been reported in a near-to-top layer in the I zone.

DISCUSSION

With regard to soil reaction and other properties, e.g., sorptive complex conditions, the total area of the properties changes reach 8 500 ha (I zone - 1 500 ha, II zone - 1 400 ha). In the light of these results, the 'KCW-KUJAWY' influence onto surrounded soils cannot be restricted to two zones only, however, it is not confirmed by acidity factor. It seems, as the factor of influencing can be regarded K^{+} content in the soil, because - as reported in Table 4 - the exchangeable

Table 3. Some physicochemical properties of arable soils from selected profiles

Profile	Horizon	Depth (cm)	pH		$CaCO_3$ (%)	C total (%)	Organic matter (%)	N total (%)	C/N	Texture
			H_2O	KCl						
					Zone I					
B-1	Ap	0-30	7.97	7.92	1.53	0.70	1.20	0.048	14.58	pgmp
	Eet	30-65	7.98	7.42		0.18	0.31	0.014	12.86	pgm
	Bt	65-95	7.28	6.19						gl
	C	<95	6.95	5.76						pglp
B-20	Ap	0-38	7.50	7.39	2.21	0.96	1.65	0.119	8.03	glp
	BBr	38-70	7.52	7.41	0.98					gl
	BbrC	70-100	7.55	7.45						glp
	C	<100	7.42	7.35						glp
					Zone II					
B-22	Ap	0-32	7.40	7.28	0.28	0.75	1.29	0.144	6.94	pglp
	Eet	32-43	7.65	7.51		0.16	0.27	0.019	8.42	pgmp
	B1tg	43-65	7.40	7.01						glp
	B2tg	65-93	7.38	6.68						glp
	C	<93	6.65	5.72	0.34	0.63	1.08	0.071	9.84	gs
B-44	Ap	0-30	7.30	7.23						pgl
	Bbr	30-52	7.67	7.61						psg
	C	<52	7.72	7.25						psg
					Zone III					
B-27	Ap	0-30	5.64	4.97		0.69	1.18	0.076	9.08	pgl
	Eet	30-42	6.44	6.02		0.16	0.27	0.018	8.65	pglp
	Bt	42-90	4.78	3.91						glp
	C	<90	5.93	4.88						glp
B-47	Ap	0-41	6.65	6.40	0.17	0.93	1.60	0.063	14.76	glp
	Bbr	41-102	7.04	6.19						gl
	C_{CA}	<102	7.73	7.51	6.03					gl

K^+ amount is significant (3-9 %) and it can be in conjunction to the chemical composition of the dusts, especially very light dusts that are carried by a wind for long distances [2,4].

The saturation degree of a sorptive complex with an alkaline metallic cations in the zone I and II reaches the level above 90 % (Table 4), also in deeper parts of the soil profiles. It basically differs from an idea of the socalled ideal soil that should contain 65 % Ca, 10 % Mg, 5 % K and up to 20 % of H^+ in a sorptive complex [1]. However, the saturation degree of the complex in the zone III approaches the level regarded as specific for a natural soil in the surrounded region, outside of the influenced zones. It is distinctive that $CaCO_3$ content in a surface horizons is quite low (0.22-2.21 %) and this content is of secondary origin. A neutralization effect of such forms should be noted also.

A slight rising of the pH KCl reaction factor up to *ca.* 7 might be adviceable for the soil properties and a plant nutrition process [2,3,5], although the increase in reaction will change the sorptive complex and the soil solution components ratio, and thus the plant nutrition conditions.

Described changes of the soil properties that have been resulted from dusts emission, should be taken into consideration during the plants selection and nutrition method choosing.

A typological classification of the investigated soils is rather simple, if made without taking into consideration an anthropogenic alkalization and these can be divided between the brown soils and gray-brown podzolic soil. A new systematization of the soils in Poland reports the

Table 4. Sorption properties and cation molar ratios in soils

Profile	Horizon	Exchangeable cations and sorption capacity (mmol(+)/100 g)							Vs (%)	Degree of base saturation					Cation ratios		
		Hh	Ca	Mg	K	Na	S	T		Hh	Ca	Mg	K	Na	Ca/Mg	Ca/K	Ca+Mg/K+Na
							Zone I										
B-1	Ap	0.02	12.24	0.41	0.44	0.13	13.22	13.24	99.8	0.15	92.45	3.10	3.32	0.98	29.8	27.8	22.2
	Eet	0.16	2.54	0.26	0.16	0.14	3.10	3.26	95.1	4.91	77.92	7.98	4.91	4.29	9.8	15.9	9.3
	Bt	0.52	6.66	0.96	0.17	0.18	7.97	8.48	93.5	6.12	78.45	11.31	2.00	2.12	6.9	39.2	21.8
	C	0.67	2.20	0.41	0.08	0.17	2.86	3.53	81.0	18.98	62.32	11.61	2.27	4.82	5.4	27.5	10.4
B-20	Ap	0.26	11.72	0.44	0.35	0.13	12.64	12.90	98.0	2.01	90.85	3.41	2.71	1.01	26.6	33.5	25.3
	Bbr	0.23	10.32	0.47	0.23	0.09	11.11	11.34	98.0	2.02	91.00	4.14	2.03	0.79	21.9	44.9	33.7
	BbrC	0.19	9.83	0.45	0.20	0.09	10.57	10.76	98.2	1.76	91.36	4.18	1.86	0.84	21.8	49.2	35.4
	C	0.21	8.41	0.59	0.17	0.09	9.26	9.47	97.8	2.22	88.81	6.23	1.80	0.95	14.3	49.5	34.6
							Zone II										
B-22	Ap	0.36	7.15	0.03	0.27	0.09	7.54	7.90	95.4	4.56	90.51	0.38	3.42	1.14	238.3	26.5	19.9
	Eet	0.21	3.34	0.19	0.09	0.08	3.70	3.91	94.6	5.37	85.42	4.86	2.30	2.05	17.6	37.1	20.8
	B1tg	0.32	3.19	0.36	0.10	0.08	3.73	4.05	92.1	7.90	78.76	8.89	2.47	1.98	8.8	31.9	19.7
	B2tg	0.49	6.07	1.06	0.18	0.10	7.41	7.90	93.8	6.20	76.83	13.42	2.28	1.27	5.7	33.7	25.4
	C	1.12	9.02	1.46	0.27	0.13	10.88	12.00	90.7	9.33	75.17	12.17	2.25	1.08	6.2	33.4	26.2
B-44	Ap	0.31	5.58	0.30	0.41	0.24	6.53	6.84	95.5	4.53	81.58	4.39	5.99	3.51	18.6	13.6	9.1
	Bbr	0.09	4.01	0.21	0.25	0.23	4.70	4.79	98.1	1.88	83.72	4.38	5.22	4.80	19.1	16.0	8.8
	C	0.14	1.00	0.05	0.09	0.21	1.35	1.49	90.6	9.40	67.32	3.36	6.04	4.09	20.1	11.1	3.5
							Zone III										
B-27	Ap	0.14	1.59	0.05	0.20	0.21	2.05	4.19	48.9	51.07	37.95	1.19	5.01	4.77	31.8	7.9	4.0
	Eet	0.66	1.09	0.04	0.11	0.21	1.45	2.11	68.7	31.28	51.66	1.90	9.59	5.21	27.3	9.9	3.4
	Bt	2.44	2.96	0.45	0.22	0.22	3.85	6.29	61.2	38.79	47.06	7.15	3.50	3.50	6.6	13.5	6.7
	C	1.87	4.90	0.98	0.27	0.28	6.43	8.30	77.5	22.53	59.04	11.81	3.25	3.37	5.9	18.2	10.7
B-47	Ap	0.89	4.70	0.46	0.63	0.25	6.04	6.93	87.2	12.54	67.82	6.64	9.09	3.61	10.2	7.5	5.9
	Bbr	0.64	7.03	1.31	0.33	0.26	8.93	9.57	93.3	6.69	73.46	13.69	3.45	2.72	5.4	21.3	14.1
	CCa	0.12	17.46	0.98	0.22	0.27	18.93	19.05	99.4	0.63	91.65	5.14	1.15	1.42	17.8	79.4	37.6

Table 5. Contents of water soluble cations in soils

Profile	Horizon	Depth (cm)	Soluble cations (mg/100 g)			
			Ca	Mg	Na	K
			Zone I			
B-1	Ap	0- 30	10.60	0.58	0.76	6.17
	Eet	30- 65	8.37	0.45	0.57	1.57
	Bt	65- 95	7.25	0.81	1.13	0.20
	C	<95	4.87	0.61	0.86	0.20
B-20	Ap	0- 38	8.07	0.47	1.36	0.90
	BBr	38- 70	8.85	0.95	0.72	0.67
	BbrC	70-100	6.10	0.65	0.64	0.35
	C	<100	4.52	0.98	0.70	0.70
			Zone II			
B-22	Ap	0- 32	6.97	0.59	0.65	2.37
	Eet	32- 43	6.90	0.52	0.54	0.50
	B1tg	43- 65	4.37	0.95	0.66	0.95
	B2tg	65- 93	4.90	1.40	1.05	2.82
	C	<93	2.50	1.90	2.17	1.17
B-44	Ap	0- 30	3.56	0.23	0.26	6.72
	Bbr	30- 52	1.71	0.18	0.29	3.97
	C	<52	1.03	0.02	2.17	1.18
			Zone III			
B-27	Ap	0- 30	0.86	0.20	0.21	1.80
	Eet	30- 42	4.75	0.14	0.73	3.01
	Bt	42- 90	5.27	0.41	0.47	1.37
	C	<90	0.81	0.63	0.98	2.05
B-47	Ap	0- 41	5.48	0.72	1.59	10.11
	Bbr	41-102	4.68	1.03	0.98	0.78
	C_{CA}	<102	6.69	0.90	1.22	0.66

anthropogenic pararendzina type of a similar properties however, without of described industrial influence on biotope modifications [7]. In some classifications [6], the mentioned soils are categorized as calcisols. Since the investigated soil's status appear to be rather permanent, it is suggested to introduce such distinction to the new soil systematic.

CONCLUSIONS

1. On the basis of soil reaction, $CaCO_3$ content and the exchangeable cations in the sorptive complex of the soils, the zonal affect of 'KCW-KUJAWY' can be ascertained.

2. The changes of pH-reaction and high level of Ca^{2+} in a sorptive complex lead to recognize of the brown soils and gray-brown podzolic soil attributed to a zone I and partially to a zone II as an anthropogenic pararendzina type or calcisols.

3. Soil properties in the zone I and II recommend the necessity of the agrotechnology, fertilization and a plant rotation accordingly to the existing soil conditions.

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ZMIANY ODCZYNU I WŁAŚCIWOŚCI SORPCYJNYCH GLEB UPRAWNYCH W OTOCZENIU KOMBINATU CHEMICZNO-WAPIENNICZEGO KCW 'KUJAWY'

Z obszaru około 8.5 tyś. ha otoczenia Kombinatu Cementowo-Wapiennego KCW 'Kujawy' w Bielawach pobrano próby powierzchniowe i profilowe gleb uprawnych na podstawie siatki kwadratów o boku 500 m. Określono zasięg zmian środowiska glebowego w zakresie odczynu, zawartości węglanu wapnia oraz składu kationów wymiennych w kompleksie sorpcyjnym i roztworze glebowym.

Analiza chemiczna pyłów cementowych emitowanych przez Kombinat wykazała dużą zawartość wapnia (42-49 %) oraz potasu (6 %), jak również szereg innych makro- i mikroelementów, których ilości mogą rzutować na skład i właściwości gleb oraz odżywianie roślin.

W terenie otaczającym KCW 'Kujawy' wydzielono trzy strefy zmian odczynu i właściwości gleb uprawnych. Największą alkalizację zaobserwowano w strefie pierwszej, położonej najbliżej zakładu, w której odczyn wynosi pH_{KCl}~8 a w roztworze glebowym i kompleksie sorpcyjnym dominuje Ca^{2+} zajmując do 95 % wysycenia.

S ł o w a k l u c z o w e: kwasowość gleby, pyły cementowe.