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Lithology of soils in the Supraśl River valley (E Poland) and their ability to hold pollution

This work presents the results of studies on the interactions of soils of varied lithology, occurring in the Supraśl River valley, with selected kinds of pollutions. There were applied the farming and municipal wastes as well as petroleum products. Determinations of heavy metals such as: lead, zinc, copper and nickel were carried out. It was stated that the valley bottom, covered mainly by organic soils, is a good insulating horizon. The upland, covered by prevailed cohesive soils, could be also classified as an area with a high ability to retain pollution. The fluvioglacial terrace, overlain by cohesiveless soils, has the lowest insulating characteristics. The occurrence of surface soil cover increases the insulating ability of the studied area.

INTRODUCTION

The development of agricultural and industrial management results in an intensive influx of variable wastes and pollutions into the soils. These contaminations could be a serious menace for the purity of surface waters and groundwaters and create problems in design of water intakes and their protective zones. The other significant issue is the location of new dump depositories for various wastes. The correct management of any area requires detailed studies of its geological structure and the lithology of the soils, occurring there. In any case, the variability of pollutions should be considered.

The studies, discussed here, have been initiated by the Zakład Badań Geologicznych dla Budownictwa (Department of Geological Investigations Reseach for Building Operations, Warsaw). They define the insulating-sorptive properties of soils from the Supraśl River valley, between Sielachowice and Studzianki (Fig. 1). This is a preliminary study, presenting only a general opinion on soils interaction with selected

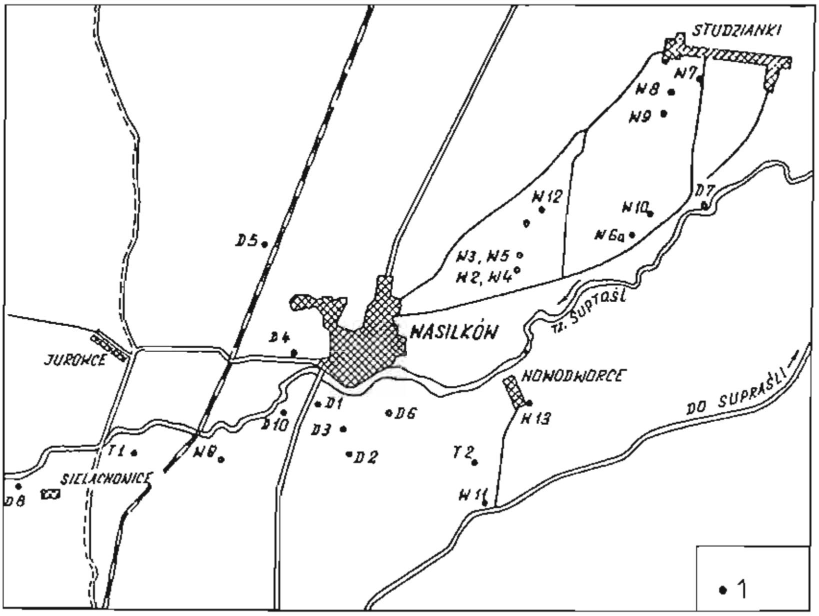

Fig. 1. Location sketch of studied boreholes (1)
Szkic sytuacyjny z lokalizacją otworów badawczych (1)

types of contaminations. The samples were delivered by the team of Prof. E. Falkowski, mapping this area.

Three main morphogenetic forms have been distinguished in the studied area: valley bottom, fluvioglacial terraces and upland.

The aims of complex laboratory analyses were as follows:

1. Definition of the lithology of the separated soil types, deposited in the studied area.

2. Description of properties of selected soils during the infiltration of water and standard suspensions determination of the coefficient of permeability and changes of suspension concentrations after filtration through samples of various soils.

3. Determination of the ability of the soil to retain pollution as well as definition of the abilities of selected soil types in the absorption and "restoring" of heavy metals (lead, zinc, copper and nickel).

LITHOLOGY OF SOILS

ORGANIC SOILS

Type I. Surface soil, up to 0.5 m thick, occurs over almost the whole of the area studied, covering deposits of various genesis (except in some valley areas, where organic sediments — peat-earth or peat, are outcropped). These are sandy deposits of varied size, variable humidity and the coefficient of permeability, containing $CaCO_3$ and organic matter (Tab. 1).

Type II. Peat-earth muck occurs in the valley bottom and on upland, on surface or under a thin surface soil but exceptionally under a peat layer. Generally the peat-earth muck overlies peat or warps. From a genetic point of view it is peat with variable physical and chemical features, resulting from weathering under varied conditions of humidity and temperature. This process transforms the fibrous peat structure to the granular one of peat-earth muck. The peat-earth muck is black in colour with brown tinge, granular with numerous roots, locally with boulders of magmatic rocks and quartz grains. It is highly plastic, wet and carbonateless (Tab. 1).

Type III. Peats occur mainly in the valley bottom but are also found on upland and fluvioglacial terraces. Mostly peats outcrop straight at the surface or are overlain by peat-earth muck or peaty soil. They overlie warps, organic sands or exceptionally — inorganic sands. Peats are black in colour, moderately or well decomposed with visible single fibres. They are plastic, wet and carbonatefree (Tab. 1).

Type IV. Mineral-organic warps occur in the valley bottom, underlying the peats. They are grey-black in colour, wet, plastic, carbonatefree or weakly carbonaceous and pelitic. These are silty sands or cohesive soils (Tab. 1a).

Type V. Muds are represented by two samples. First one has been collected from the channel bank ridge, the second from the valley bottom. They are grey or dark-grey in colour and contain organic matter with minimal carbonate content (Tab. 1).

Type VI. Organic sands. This group comprises all sands and silty sands, but does not include the surface soil and warp. The soils are characterized with an occurrence of more or less decomposed organic matter. They are commonly known from profiles of organic deposits from the valley bottom, underlying the warps or peats.

The analysed samples were collected from a depth of more than 1 m. They are silty sands, fine sands, sands with gravel and very gravelly sand, grey or grey-yellow in colour and with a low content of organic matter (Tab. 1).

MINERAL COHESIONLESS SOILS

The cohesionless soils occur mainly in the upland and on the fluvioglacial terrace. Two main features of these soils are:

— granulometric differentiation;

Table 1

Physical properties of organic soils

Litholo-gical type	Sample number	Sample depth [m]	Soil name	Humidity [%]	Roasting loss [%]	CEC [mval/100 g]	pH of water extract	Content of $CaCO_3$
Type I Surface soil	W2/11	0.1–0.3	fine sand*, grey-brown	6.5	2.57	20	6.72	<1
	W4/1	0.3	very gravelly sand*, brown	1.5	2.21	–	6.57	<1
	W3/1	0.0–0.4	medium sand*, dark-brown	3.4	2.14	23	6.30	<1
	W5/1	0.2	medium sand with gravel*, brown	–	2.15	–	6.29	<1
	T2/1	0.0–0.2	fine sand, black	27.2	9.07	–	6.53	<1
	W1/1	0.0–0.3	medium sand with gravel*, yellow-brown	3.5	1.63	–	7.09	<1
	D9/3	0.4–0.5	fine sand with iron admixture, rusty-brown	5.7	1.47	–	6.43	<1
Type II Peat-earth muck	D1/1	0.3	peat-earth muck**, black	184.8	53.83	–	6.88	<1
	D2/1	0.3	peat-earth muck**, black	144.7	71.06	97	6.80	<1
	D3/1	0.3	peat-earth muck**, brown-black	187.9	78.60	–	7.02	<1
	D5/1	0.2	peat-earth muck**, black-brown	57.5	18.34	97	5.72	<1
	W12/2	0.4	peat-earth muck**, black-brown	387.9	85.40	97	6.36	<1
Type III Peat	D1/2	0.6	peat**, black	306.8	70.32	–	6.88	<1
	D3/2	0.5	peat**, black	185.0	74.47	–	6.58	<1
	D4/1	0.2	peat**, black	199.2	66.44	97	5.88	<1
	W12/1	0.1–0.2	peat**, black	303.1	76.15	–	6.33	<1
	W12/3	1.0	peat**, black	407.7	77.59	–	6.55	<1
	D6/1	0.0–0.5	peat**, black	336.7	85.65	–	6.21	<1
	D6/2	0.5–1.0	peat**, black	512.6	88.91	–	5.91	<1
	D6/3	1.0–1.5	peat**, black	782.1	90.16	–	5.85	<1
	D6/4	1.4–2.0	peat**, black	314.5	34.86	–	5.74	<1
	T1/2	0.2–0.4	peat**, black	432.3	78.26	–	7.11	<1
Type IV Warp	D3/1	1.0	warp**	80.5	13.26	97	6.95	<1
	D2/2	0.6	warp**, grey-black	15.8	15.31	97	6.71	<1
	D3/3	0.8	warp**, grey-black	52.9	8.50	97	7.16	<1

Type IV Warp	D6/6	2.4–2.5	warp**, grey-black	45.2	8.25	–	7.39	3–5
	D6/7	2.5–2.6	warp**, grey	39.6	6.42	96	7.38	3–5
Type V Mud	D8/2	0.3–0.5	silty sand*, grey	21.3	3.41	86	6.01	<1
	D7/2	0.3–0.5	slightly clayey sand*, dark-grey	28.5	7.62	96	6.34	1–3
Type VI Organic sand	D2/3	1.2	fine sand*, grey-yellow	16.0	1.10	–	6.72	<1
	D3/4	1.0	silty sand*, grey-yellow	25.9	2.16	31	6.60	<1
	D6/5	2.0–2.4	silty sand*, grey	31.8	5.48	–	7.15	3–5
	D6/8	2.7–2.8	very gravelly sand*, grey	2.3	9.25	–	7.16	>5
	W12/4	1.2	fine sand with gravel*, grey	26.6	4.22	–	6.82	<1
	D10/2	0.4	medium sand*	0.3	19.74	–	6.15	<1

Letter at sample number indicates location area: W — upland, D — valley bottom, T — fluvioglacial terrace; first number — borehole number; second number — next sample number in borehole; the soil name according to: * — granulometric analysis after K. H. Head (1992), ** — content of organic mater, *** — genesis; CEC — cation exchange capacity

— the occurrence of admixtures, including: iron compounds, calcium carbonate and organic matter (the presence of the latter permits inclusion in the organic soils class).

Macroscopic studies and the results of sieve analysis confirm the opinion that the discussed soils are very variable: from silty sand to very gravelly sand. In Table 2 two groups are distinguished on the basis of an occurrence of iron compounds, forming the orstein horizons. This group is classified as type VII — orsteined sand — different from type VIII — sands — (without iron compounds or with a minimum content). In both groups horizons with calcium carbonate are noted, they increase the pH value of water extracts from the studied samples (pH < 7) have been detected. The mean value of the coefficient of permeability of sands in relation to water is variable and mainly depended on their fractions. The granulometric composition of the studied sandy soils is distinctly differentiated even within the individual morphogenetic subdivisions. It was difficult to define larger fields for such divisions with common insulating-sorptive characteristics (Tab. 2).

MINERAL COHESIVE SOILS

Type IX. Cohesive soils. The samples of cohesive soils were mainly collected from the over-flood terrace on the upland. These soils contain various fractions, from sandy clayey sand to clay. The clayey fraction of the studied cohesive soils is illite or illite-montmorillonite in type (Tab. 3, Fig. 2), that defines their high sorption capacity (about 100 mval/100 g of soil) and high activity in relation to some pollutions. Moreover, these soils are impermeable or weakly permeable due to their cohesion. They are of various colours, from green-brown to rusty, they are wet, plastic, with a varied content of $CaCO_3$.

Table 1a

Hydrometer analysis of warps

Sample number	Fraction			Soil name
	f_p	f_π	f_i	
D1/3	42	39	19	clayey and sandy silt
D3/3	50	27	23	sandy clay with silt
D6/5	89	10	1	silty sand
D6/6	86	13	1	silty sand
D6/7	83	17	0	silty sand

Explanations in Table 1

MODEL STUDIES OF SOIL PERMEABILITY AND ITS SORPTION ABILITY IN RELATION TO VARIOUS SUSPENSIONS

COEFFICIENT OF PERMEABILITY

Filtration studies were carried out on samples of the following lithological groups: surface soil, variably grained sands, orsteined sands and very gravelly sand, organic soils.

Model studies of the coefficient of pemeability of selected soils in specific profiles and of their ability to retain pollution, included in various suspensions, were executed as follows: soil samples, 141 and 150 g, were concentrated to a volume of 98 cm^3 (volume density 1.44 and 1.53 g/cm^3) and placed in a Kamieński tube and filtrated. The final value of the coefficient of permeability (k_{10} in m/h) was calculated for a temperature of 10°C. After process of filtration the filtrates samples were collected and analysed.

The procedure of soil profiles studies was as follows:

1. Distilled water was filtrated through the soil sample, located uppermost in the profile, the coefficient of permeability k_{10} was measured and the filtrate was collected.
2. Selected suspension was filtrated through the same sample, to determine the coefficient of permeability and collect the filtrate sample.
3. The next soil sample was placed in a Kamieński tube and described the procedure was applied, except of the fact that the filtrate, migrated through the upperlaid sample, was used for filtration in the same soil profile.

Such a procedure reflected the natural structure of the profile and enabled studies of the retention of some components of the initial suspensions when filtrated through the soil profile as a whole.

Farm and municipal wastes were used as basal suspensions in investigations on filtration phenomena. They contained typical pollutions, characteristic for country farms (initial suspensions *A, D*) and city houses (initial suspensions *B, C*). These suspensions were filtrated through filters and diluted to various concentrations (from 0.549 to 3.787 g/dm^3 of solid residue). Their characteristics are presented in Table 4. Moreover, the determination of the general filtration of oil and gasoline in the ratio

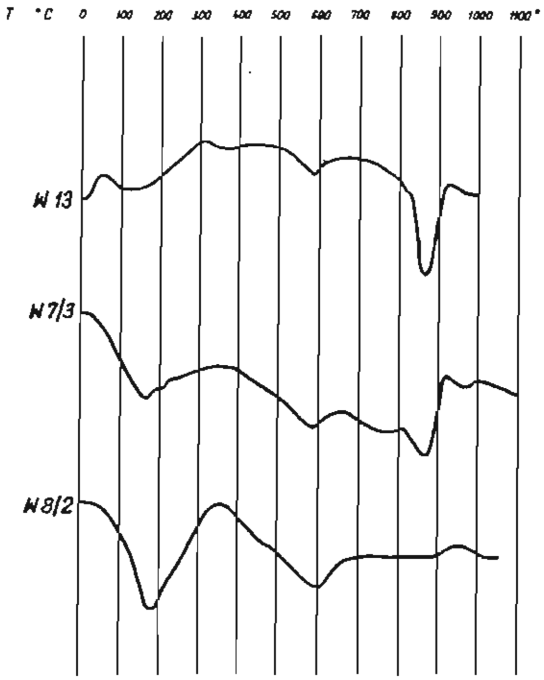

Fig. 2. Thermograms of selected samples (W13, W7/3, W8/2) of cohesive soils, grain size <0.25 mm
Termogramy wybranych gruntów spoistych (W13, W7/3, W8/2) o frakcji <0,25 mm

1:6 (density 0.89 g/cm^3) were performed for selected profiles (without the calculation of the coefficient of permeability).

Values of the coefficient of permeability of studied samples both in relation to water and standard suspensions are presented in Table 5. This data indicates that the coefficient of permeability, determined in relation to distilled water, depends on granulometric composition of the soil (the very gravelly sand has the highest value, the lowest one is for fine sands). Decrease of filtration velocity is visible for some orsteined soils and for some organic ones. A low coefficient of permeability was defined in surface soils, composed typically as very gravelly sand or sand with gravel. However, it should be noted that the samples of orsteined sand had damaged primary structure during analyses and this may increase their permeability. Probably they form the beds less permeable in comparison with the results of laboratory studies.

The coefficient of permeability, determined in relation to standard suspensions, commonly has a lower value than the one calculated in relation to distilled water but the differences are significantly higher for organic soils (soils and peat-earth muck and orsteined beds) than for other sands (of various size). This could indicate that these soils (organic and orsteined ones), reacting with the suspensions, became less permeable to them.

Table 2

Physical properties of mineral cohesionless soils

Lithological type	Sample number	Sample depth [m]	Soil name	Humidity [%]	CEC [mval/100 g]	pH of water extract	Content of $CaCO_3$ [%]
Type VII Orsteined sand	W2/2	0.35	very gravelly sand, light-brown	4.3	39	6.92	<1
	W2/3	0.7	very gravelly sand, brown	4.3	27	7.46	<1
	W4/2	0.4	very gravelly sand, rusty	1.1	–	6.92	1–3
	W4/4	0.7	very gravelly sand, dark-brown	1.6	–	6.79	<1
	W3/3	0.7	fine sand, rusty-yellow	5.1	16	6.64	<1
	W5/4	0.7	medium sand, dark-rusty	1.8	–	6.49	<1
	W1/2	0.3–0.5	medium sand , rusty	2.6	–	6.90	1–3
	T2/2	0.4	silty sand, rusty-yellow	2.2	–	6.48	<1
Type VIII Sand	W4/3	0.6	very gravelly sand, yellow-brown	1.3	27	7.31	3–5
	W3/2	0.4	fine sand, yellow	4.4	12	6.45	<1
	W5/2	0.4	fine sand, light-yellow	2.1	–	6.01	<1
	W5/3	0.5	silty sand, light-yellow	2.7	–	6.09	<1
	T2/3	0.5	fine sand, light-yellow	4.8	–	6.82	<1
	W1/3	0.5–0.7	medium sand, yellow	3.5	–	7.40	3–5
	D10/3	0.8	medium sand with gravel, grey-yellow	8.7	–	5.82	<1
	W11/1	1.5–1.8	very gravelly sand, yellow	–	–	6.12	<1

Explanations in Table 1

Table 3

Physical properties of mineral cohesive soils

Sample number	Sample depth [m]	Humidity [%]	Roasting loss [%]	CEC [mval/100g]	Fraction			Soil name	General mineral composition of clay fraction	Content of $CaCO_3$ [%]
					f_p	f_π	f_i			
W7/3	0.7	27.8	3.76	97	3	43	54	clay	illite-montmorillonite	>5
W9/2	0.5	17.7	2.50	–	29	49	22	sandy and silty clay	illite-montmorillonite	<1
W10/3	1.0–1.2	12.2	1.38	–	29	58	13	clayey and sandy silt	illite-montmorillonite	>5
W8/2	0.3–0.6	21.3	3.33	98	42	31	27	sandy and silty clay	illite-montmorillonite	<1
W6/1	0.9–1.3	16.1	1.68	–	53	20	27	sandy clay with silt	illite	<1
W13/1	2.0–2.1	12.7	1.68	96	63	24	13	clayey sand	illite	>5

Explanations in Table 1

CHANGES OF PROPERTIES OF STANDARD SUSPENSIONS AND DISTILLED WATER, FILTERED THROUGH SAMPLES

The aim of the studies of the solid residue of the filtrate, obtained after water and suspension filtration through selected samples, was to define the soils ability for "cleaning" these suspensions. Later this residue was burnt in an oven at a temperature of 500°C, in order to give so-called "roasting losses". The difference of masses of the solid residue and that of roasting losses (conventionally regarded as the content of organic matter) is mostly effected by the mineral part of residue. Data, presented in Table 6, indicates that the majority of suspensions are partly cleaned during migration through the soil beds. The observed differences result from the lithology of the beds, being filtrated, and the type of suspension but mainly they depend on its concentration and pH value. Only the farm waste with an initial pH value lower than 7 (suspension 1) was not cleaned but on the contrary — it was enriched both with mineral and organic components. Other suspensions were cleaned in various rate: from several percent to several tens of percent of mineral and organic components. It was stated that in many profiles the main part of the pollution was absorbed by the surface soil layer. In general the profiles held 4–61% of pollutions, including 17–80% of organic elements. The studies of the solid residue and the roasting losses of suspensions, obtained after the filtration through the beds with distilled water, indicate that the filtrates captured part of the fine (colloidal) fractions, occurred in the soils. In most cases these are mineral components but the mass of suspensions is different for different beds. The obtained data, referred to pollutions remaining in filtrated suspensions, was calculated with some error, re-

Table 4

Characteristics of standard "solutions" (suspensions)

Standard suspension number	Solution type	Colour*	pH	Initial suspension	Solid residue [g/dm^3]	Roasting losses, organic components [g/dm^3]	Mineral components [g/dm^3]
1	farm	10	6.56	A	1.250	0.745	0.505
2	municipal	4	7.90	B	0.981	0.306	0.675
3	municipal	3	8.32	C	0.549	0.159	0.390
4	farm	10	8.00	D	0.867	0.524	0.343
5	farm	10	7.98	D	0.957	0.582	0.375
5a	farm	10	7.97	D	0.596	0.264	0.332
6	farm	10	8.42	D	0.738	0.352	0.386
7	farm	10	7.70	A	0.622	0.405	0.217
8	gasoline+oil	10	3.60	–	–	–	–

* — standard colour scale from 1 to 10

sulting from the enrichment of suspensions with colloidal components, derived from the soil. The analyses documented that a single washing of samples before suspensions filtration had not prevented this phenomenon. It enhances the sensitivity of studied soils for intensive water flow — higher than for natural filtration. The samples of orsteined sand should be included in such soils.

SORPTION ABILITY OF SOILS

ION EXCHANGE CAPACITY

The studies of ion exchange capacity were accomplished by means of method the methylene blue (*Metody badań gruntów spoistych*, 1990) for selected soils, representing various lithological types. The obtained results are presented in Tables 1–3. The highest capacity of ion exchange is characteristic for the cohesive soils of illite-montmorillonite type (about 100 mval/100 g — Tab. 3). Some organic soils, particularly peats and peat-earth muck with a high content of organic matter, are characterized also with high ion exchange capacity value. The surface soils studies indicated their ability for interactions (about 20 mval/100 g of soil). The obtained ion exchange capacity value of about 16–39 mval/100 g for orsteined sand results mainly from a high content of clay. The soils with a high ion exchange capacity value could react with the components of pollution, absorbing them into their own exchange complex to place of ions, mainly calcium and magnesium, occurred in their sorption complex and delivered to solution.

Table 5

Coefficient of permeability values of selected samples from studied profiles for filtration of water and standard suspensions

Sample number	Soil name	Roasting loss [%]	Probable Fe_2O_3 content [%]	Coefficient of permeability [m/h]							
				destilled water	solution						
					1	2	3	4	5	6	7
W2/1	surface soil (fine sand)	2.63	1.38	0,49; 0.50; 0.43	0.34	–	0.30*	–	–	–	–
W2/2	orsteined very gravelly sand	–	2.76	0.67; 0.43; 0.62	0.38	–	0.54*	–	–	–	–
W2/3	orsteined very gravelly sand	–	0.61	0.73; 0.85; 0.88	0.83	–	0.68*	–	–	–	–
W4/1	surface soil (very gravelly sand)	2.21	–	0.27	–	–	–	–	0.10	–	–
W4/2	orsteined very gravelly sand	–	1.11	0.98	–	–	–	–	0.67	–	–
W4/3	very gravelly sand with iron compounds	–	–	3.51	–	–	–	–	1.91	–	–
W4/4	orsteined very gravelly sand	–	1.00	0.93	–	–	–	–	0.88	–	–
W3/1	surface soil (medium sand)	–	2.14	0.48; 0.43	–	0.41	–	–	–	–	–
W32	fine sand with iron compounds	–	1.42	0.26; 0.27	–	0.28	–	–	–	–	–
W3/3	orsteined fine sand	–	1.92	0.13; 0.22	–	0.24	–	–	–	–	–
W1/1	surface soil (medium sand with gravel)	1.63	–	0.31; 0.39	–	–	–	0.24	–	–	–
W1/2	orsteined medium sand	–	0.85	0.68; 0.74	–	–	–	0.56	–	–	–
W1/3	medium sand	–	–	1.02; 0.63	–	–	–	0.55	–	–	–
T2/1	surface soil (fine sand)	9.07	–	0.38	–	–	–	–	0.16	–	–
T2/2	orsteined silty sand	–	0.50	0.31	–	–	–	–	0.28	–	–
T2/3	fine sand	–	–	0.37	–	–	–	–	0.39	–	–
W5/1	medium sand with gravel	–	–	0.19	–	–	–	–	–	0.12	–
W5/2	fine sand	–	–	0.07	–	–	–	–	–	0.05	–
W5/3	silty sand	–	0.50	0.29	–	–	–	–	–	0.26	–
W5/4	medium sand	–	0.68	1.31	–	–	–	–		0.61	–
D2/1	peat-earth muck	70.32	–	0.73	–	–	–	–	0.28**	–	–
D3/2	peat	–	–	2.54	–	–	–	–	–	–	1.14
T1/2	peat	78.26	–	1.19	–	–	–	–	–	–	0.42
D6/3	peat	–		0.04	–	–	–	–	–	–	0.02

1–7 — solutions numbers as in Table 4; * — solution changed for each sample; ** — solution 5a

Table 6

Properties of standard suspensions, filtrated through selected samples

Standard suspension number	Sample number	Soil type	pH/solid residue [g/dm^3]	Content of organic components in suspension [g/dm^3]	Content of mineral components in suspension [g/dm^3]
1			6.56/1.250	0.754	0.505
	W2/1	suface soil	6.18/1.998	1.123	0.975
	W2/2	orstein	6.01/2.034	1.016	1.018
	W2/3	orstein	6.11/1.583	0.841	0.742
2			7.90/0.981	0.306	0.675
	W3/1	surface soil	7.45/0.319	0.097	0.222
	W3/2	sand	6.97/0.280	0.120	0.160
	W3/3	orstein	7.00/0.942	0.059	0.883
3			8.32/0.549	0.159	0.390
	W2/1	surface soil	6.61/0.341	0.103	0.238
	W2/2	orstein	7.13/0.471	0.126	0.303
	W2/3	orstein	7.34/0.573	0.100	0.281
4			8.00/0.867	0.524	0.343
	W1/1	surface soil	7.78/0.871	0.588	0.283
	W1/2	orstein	8.05/0.657	0.354	0.303
	W1/3	medium sand	8.15/0.646	0.365	0.281
5			7.98/0.957	0.582	0.375
	T2/1	surface soil	7.63/0.639	0.314	0.325
	T2/2	orstein	7.55/0.492	0.284	0.208
	T2/3	fine sand	6.80/0.513	0.253	0.260
5a			7.97/0.596	0.264	0.332
	D2/1	peat-earth muck	7.70/0.862	0.472	0.390
	D2/2	organic mud	7.20/1.002	0.503	0.499
6			8.42/0.738	0.352	0.386
	W5/1	surface soil	6.95/0.534	0.257	0.277
	W5/2	fine sand	8.12/0.482	0.157	0.325
	W5/3	silty sand	7.98/0.538	0.241	0.297
	W5/4	orstein	7.36/0.643	0.236	0.407
7			7.70/0.622	0.405	0.217
	D3/2	peat	6.67/0.599	0.401	0.198
	D6/3	peat	6.53/0.439	0.336	0.103
	T1/2	peat	6.70/0.588	0.405	0.183

SORPTION OF HEAVY METALS

Among the many chemical compounds, being the menace for quality of groundwater, the significant role belongs to heavy metals. They can occur in a dissolved form in water but may also be bound by the solid particles of soil sediments. The deposit

Table 7

Amount of Pb, absorbed by the soil (mg/1000 g of soil)

Sample	H_2O (destillitized)	20 [mg/dm^3]*	50 [mg/dm^3]	80 [mg/dm^3]	Pb desorption [mg/dm^3]
Peat-earth muck**	0	400.0	999.0	1591.0	0.175
Orstein (W5/4)	–	395.0	984.0	1250.0	2.075
Clay (W7/3)	0	400.0	1000.0	–	–
Surface soil (D9/3)	0	391.1	988.0	–	0.410
Carbonate sand (W6a/3)	–	396.0	987.0	1586.0	0.212
Carbonate orstein (W1/2)	–	400.0	994.0	1590.0	–
Sandy and silty clay (W8/2)	–	400.0	999.0	1597.0	0.137
Quartz sand (W5/2)	–	384.0	983.0	1370.0	0.312
Peat (D4/1)	–	386.0	988.0	1585.0	0.175
Maximum amount of Pb, absorbed by sample	0	400.0	1000.0	1600.0	–

* — accepted content of Pb in drinking and farming water is 0.1 mg/dm^3; ** — mixture of peat-earth muck from samples: D1/1, D2/1, D3/1, W12/2

studies (especially of deposits of river valleys) indicate that heavy metals are mainly absorbed by iron and manganese hydrooxides, carbonates, clay minerals (most active are minerals of the smectite group, most weakly react the ones of the kaolinite group) and organic matter. The sorption of heavy metals depends on several factors of mineralogical, chemical and physical character, typical for individual soil beds. In addition to the character of the solid phase, mentioned above, there are other factors which have a significant influence on process activity. These include the pH of the environment, the heavy metal content within the migrating solution and the time of solution (suspension) — soil interaction.

In the studied deposits of the Supraśl River valley and surrounding areas, the active beds, absorbing heavy metals, could be highly active clay minerals, of surface soil as well as orstein sandy-gravelly layers. But the studies also indicated that sandy and sandy-gravelly soils, with predominating coarse quartz as component but also with calcite in small amount, could bind relatively large ion amount of heavy metals. According to E. Helios-Rybicka (E. Helios-Rybicka,1986; E. Helios-Rybicka, J. Kyzioł, 1991) it is not valid if in an aquatic environment, polluted with metals, the ion binding by components of soil layer results from sorption processes or it results from precipitation or coprecipitation. But it is known that metals, held in the soil layer due to precipitation or coprecipitation, are more intensively bound with the solid phase and activated more intensively during changes of condition (pH variability, biological activity, etc.). In sandy-gravelly soils the carbonates (calcite) increase the pH value of solutions. Zinc and lead are almost completely precipitated as hydrooxides at pH between 7 and 8. Metals are also easily coprecipitated with iron and manganese oxides. In case of aluminosilicates adsorption acts mainly on the surfaces of particles of heavy

Table 8

Amount of Cu and Zn, absorbed by soil (mg/1000 g of soil)

Sample	Cu*		Zn*	
	8 mg/dm^3	16 mg/dm^3	8 mg/dm^3	16 mg/dm^3
Peat-earth muck**	158.8	316.2	156.8	316.8
Orstein (W5/4)	158.8	305.2	127.6	140.8
Clay (W7/3)	159.8	317.6	159.4	319.4
Surface soil (D9/3)	153.0	304.4	120.0	231.2
Carbonate sand (W6a/3)	115.2	317.8	157.8	316.6
Carbonate orstein (W1/2)	160.0	319.0	159.0	315.8
Sandy and silty clay (W8/2)	158.6	316.8	158.6	317.4
Quartz sand (W5/2)	156.0	273.4	104.0	64.0
Peat (D4/1)	147.8	314.4	156.0	314.0
Maximum metal amount, absorbed by sample	160.0	320.0	160.0	320.0

* — accepted content in drinking and farming waters is: for Cu — 0.5 mg/dm^3, for Zn — 5 mg/dm^3; ** — mixture of peat-earth muck from samples: D1/1, D2/1, D3/1, W12/2

minerals or ion exchange takes place due to an exchange of calcium and magnesium ions. Heavy metals, in the presence of organic matter, could be accumulated, creating metalic-organic connections. It could be assumed that the "possible" traps for heavy metals in the studied area are the surface soil layers, organic (I–VI types) ones, orstein beds (type VII) and mainly the clay layers with illite-montmorillonite character of clay fraction (type X). It could be supposed that the sandy-gravelly beds (type VIII) with a lower coefficient of permeability and containing calcium carbonate, will hold the heavy metals at last partly. The relatively high pH value of suspensions will favour the sorption which is important particularly in organic beds. Basing on data from literature (I. Bojakowska et al., 1992; E. Helios-Rybicka, 1986; E. Helios-Rybicka, J. Kyzioł, 1991; E. Osmęda-Ernst, S. Witczak, 1991) regarding to relatively highest soil ability for lead sorption, during the first phase of investigation the ability of selected soils for lead holding was stated. The samples of: peat-earth, orstein, clay, soil and carbonate sand, orstein with carbonates, peat and clear carbonate sand were examined. The static batch method was applied. From each sample, after drying to constant mass, 4 portions, each of 5 g were weighed. 100 cm^3 of destilled water was added to one portion of each sample. To the remaining three, solutions of $Pb(NO_3)_2$ containing 20, 50 and 80 mg/dm^3 of Pb were added. Samples were shaken for 4 hours and left for about 20 hours but later they were centrifugated and the lead content in solution was determined[1]. The applied method of Pb determination is based on the reaction of lead complexing by ditizone (diphenylocarbazon). The formed helate is extracted from the water layer to a organic-chloroformic one. Later the absorption of the chloroformic

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[1] Studies of lead content in these samples were done by J. Mikołajkow and E. Wojasińska.

layer, containing coloured lead complex with ditizone, was measured. The measurement has been peformed for the wave length of polarized light of 515 nm (in VIS spectrophotometer of *Hach*). The absorption value is proportional to the lead concentration in the studied sample, according to the Lambert-Beer law. Metals, interferring in such determinations, are eliminated by citrates and cyanides at a suitable pH value of sample. The mentioned method is accepted by the Environment Protection Agency (EPA USA). The obtained results, calculated for lead amount, sorped by the soil, were presented in Table 7.

Similar studies for copper and zinc sorption were performed for the same samples, using solutions sulfate of these metals, with concentration of 8 and 16 mg/dm^3 (Tab. 8). The determination of both metals was accompnished with the spectophotometric method, by measurement of the absorption of polarized light of proper wave length by the coloured complexes of these metals. For copper such wave lenght equals 560 nm and the coloured complex consists of copper compounded with diphenylorubean acid, but for zinc this lenght equals 520 nm.

The data from Tables 7–8 indicated that all studied soils were characterized by high sorption abilities in relation to lead, copper and zinc. Peat-earth muck and cohesive soils had maximum sorption values in relation to lead, included in solutions of varied concentrations, but minimum values were characteristic for quartz sand and orstein at the highest solution concentration (80 mg/dm^3). Similar relations were characteristic for copper and zinc sorption values.

Index studies of the filtration of a mixture of motor oil and gasoline were carried out using a ratio of 6:1 with a density of 0.89 mg/cm^3, the filtration time was 18 to 20 hours. They indicated that for a sequence of surface soil, orstein, very gravelly sand, orstein (each bed 2.5 cm thick) 90 cm^3 of the 510 cm^3 of mixture filtrated was absorbed by the soil (15%). A profile consisting of beds of peat-earth muck and organic sand (each 5 em thick) was observed to filtrate 60% and absorb 40% of such a mixture. In a sequence of surface soil, fine sand, silty sand, orstein (total thickness 10 cm) the mixture was absorbed only in the surface soil layer. Individual beds of this sequence have held from 25 to 38% of mixture but the rest of it persisted above the surface soil layer, only 38% of mixture has filtrated through the orstein bed.

CONCLUSIONS

The detailed analysis of laboratory results and field data has documented the basic criterium for distinguishing soils with varying sorptive-insulating properties (properties which determine the ability to hold different pollutions) as being the soil origin defining the lithology:

— soil granulometry, particularly for inorganic soils (but also for organic ones), influencing permeability;

— content of organic matter, influencing — among others — the sorptive abilities of individual beds;

— mineralogical character of the clay fraction of cohesive soils, defining the ion exchange capacity;

— content of iron compounds, concentrated within orstein horizons;
— occurrence of calcium carbonate;
— sorptive abilities in relation to heavy metals.

These factors influence soil properties such as: ion exchange capacity, coefficient of permeability for water and various suspension types, rate of holding the components of these suspensions and sorptive properties for heavy metals.

Analysis of variability of mentioned factors, of co-occurrence or lack of some components in individual beds and profiles, referred to the geomorphology of the studied area, has indicated that three basic morphogenetic units (Tab. 1) are characterized with various insulating-sorptive abilities (it reflects their ability for holding the individual components of pollutions, mainly of farm and municipal wastes). The character of a discussed area could result from the properties of the whole studied profile, but in many cases the most significant could be only one layer of it.

The soils with a high ability to hold such components, i.e. the cohesive soils, occur on the upland, which could be included to regions with good insulating ability, except of areas of coarse, non-orsteined sands. The organic soils with positive sorptive abilities such as: peats, warp and muds, covering the valley bottom, locate on the second place. The valley bottom area could be considered as an area with good insulating abilities. The organic soils occur also as small sheets on the upland and on the fluvioglacial terrace. The latter characterizes with variable and negative insulating abilities due to occurrence of variably grained sandy deposits. Good insulating conditions have been found in those profiles where a secondary orsteining process took place and fine sands occurred. The relatively good sorptive conditions are typical for soil, especially fine grained, with higher content of organic matter. An occurrence of such soil increases the insulating-sorptive abilities of discussed areas.

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WPŁYW LITOLOGII GRUNTÓW NA ICH ZDOLNOŚCI DO ZATRZYMYWANIA ZANIECZYSZCZEŃ W DOLINIE SUPRAŚLI

Streszczenie

W pracy przedstawiono badania dotyczące współdziałania różnych gruntów z wybranymi rodzajami zanieczyszczeń. Zastosowano zawiesiny typu gospodarczego i komunalnego oraz substancje ropopochodne. Wykonano również badania sorpcji metali ciężkich: ołowiu, cynku, miedzi i niklu.

Obszar badań obejmował dolinę Supraśli na odcinku od Sielachowic do Studzianek, na którym wydzielono trzy główne formy morfogenetyczne: dno doliny, tarasy fluwioglacjalne i wysoczyznę.

Po szczegółowej analizie uzyskanych danych laboratoryjnych oraz materiałów terenowych uznano, że jednym z podstawowych kryteriów dla wyróżnienia gruntów o różnych właściwościach sorpcyjno-izolacyjnych, a więc takich, które będą wykazywały różne predyspozycje do zatrzymywania różnego typu zanieczyszczeń, będzie w pierwszym rzędzie geneza gruntów, określająca ich litologię, a w tym:

— granulometria, zwłaszcza w odniesieniu do gruntów nieorganicznych (ale także w przypadku gruntów organicznych), wpływająca między innymi na przepuszczalność;

— zawartość substancji organicznej, wpływająca między innymi na zdolności sorpcyjne warstw;

— charakter mineralogiczny frakcji iłowej gruntów spoistych określających pojemność wymiany jonowej;

— zawartość związków żelaza, skupiających się w poziomach orsztynowych;

— obecność węglanu wapnia;

— zdolności sorpcyjne w stosunku do metali ciężkich.

Czynniki te wpływają na kształtowanie się takich właściwości gruntów jak: pojemność wymiany jonowej, współczynnik filtracji w stosunku do wody i różnego typu zawiesin, stopień zatrzymywania składników z tych zawiesin oraz właściwości sorpcyjne w stosunku do metali ciężkich.

Zdolności sorpcyjno-izolacyjne rozpatrywanych obszarów mogą wynikać nie tylko z właściwości całego badanego profilu, lecz także w wielu przypadkach decydującą rolę będzie odgrywała tylko jedna warstwa, pod warunkiem, że jest to warstwa ciągła. Tak więc, przy prognozowaniu zachowania się gruntów w stosunku do różnego typu zanieczyszczeń, zrzucanych w dolinę rzeczną i obszary przyległe, można wstępnie założyć, że dobre warunki do ich zatrzymywania stwarzają rejony, których profil zawiera grunty spoiste lub silnie organiczne. Są to niektóre obszary dna doliny wypełnione torfami, madami, namułami oraz część wysoczyzny, na której występuje ciągła warstwa gruntów spoistych. Gorsze warunki występują na tarasach fluwioglacjalnych i w tych częściach wysoczyzny, w profilach których obserwujemy wyłącznie grunty sypkie, zwłaszcza średnio- i gruboziarniste (bez przewarstwień orsztynowych) z cienką warstwą gleby piaszczystej słabopróchnicznej.