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Influence of solid waste dumped under wet conditions in Siedliska Landfill on water contamination in surrounding pools

Introduction.

In 1981 a municipal landfill was located on the premises of a brickyard in Siedliska near Elk. Geological examinations of the waste dump area (11) showed that the whole area was covered by a thick layer of boulder clay with local cavities filled with water sands. Influents of underground water and accumulation of rain water caused the appearance of four water reservoirs in clay excavations whose area was estimated at between about 1000 m^2 and 32 000 m^2 each.

From the beginning the exploitation of the landfill in Siedliska was carried out in the wrong way (16, 18). Water relationships were not stabilized and the wastes were stored in one of the clay excavations filled with water. The Center of Research and Monitoring of the Environment in Suwalki found that a large amount of surface water in the clay-pit where wastes were stored was contaminated as well as water in the nearby reservoirs. It was necessary to treat these waters. In order to choose the right technology of treatment and design the size of the treatment plant it is necessary to obtain information about the amount and properties of treated sewage.

The problem of wastes storage in flooded (wet) conditions can be found in many old landfills in the country and in the recently built sites. Such a technique of wastes storage is risky as far as water pollution is concerned (1, 2). Recognition and estimation of the situation on the landfill in Siedliska may help in avoiding similar mistakes at other sites.

The aim of the research

The aim of the research was:

- estimation of the amount and degree of pollution of the water collected in clay-pits (clay excavations) being on the municipal landfill in Siedliska near Elk as the data necessary for designing the way of their neutralization.

– presentation of how improperly constructed and exploited landfills endanger the water environment situated close to this place.

Description of the site and methodology of the research

The description of the site. The area of the tested landfill constitutes the waste land – worked out clay excavations filled with water and partly with municipal wastes. We can differentiate 3 reservoirs within the border of the fencing which were determined as „C", „A" and „D" (fig.). Outside the fencing in the close neighbourhood of the landfill on the east side there is the fourth reservoir marked „B". The names of the reservoirs used in the documents of the landfill site were also adopted for the purposes of this research.

The storage of the wastes was in the northern part of the landfill in reservoir

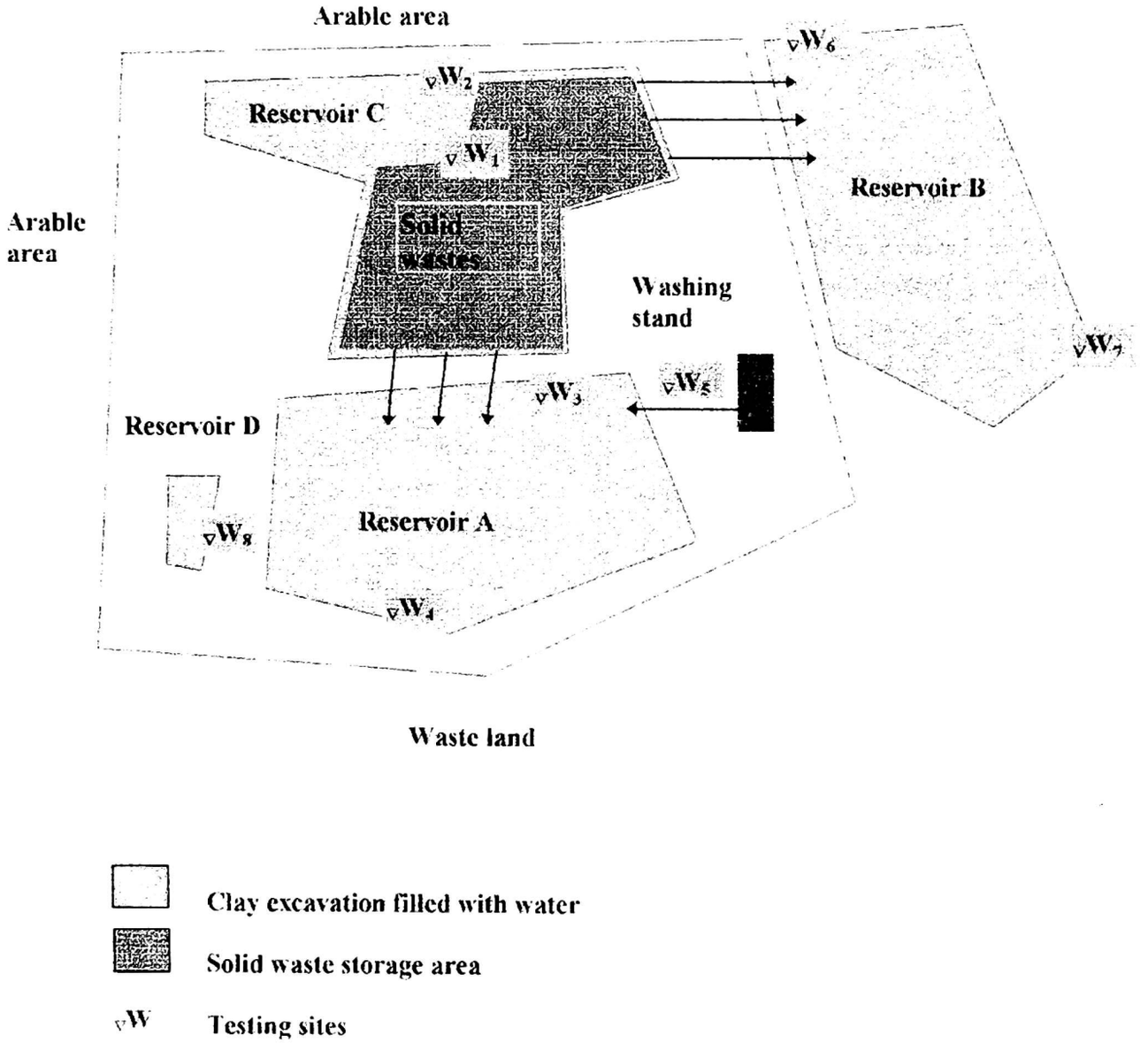

FIG. Distribution of testing sites for the estimation of the amount and degree of pollution of the water collected in clay excavations being on the MSW Landfill in Siedliska near Elk

„C" (fig.). The rest of the area comprises water reservoirs and land covered with grass. The landfill is equipped with a washing stand for waste trucks' wheels and for washing waste containers. The area of the landfill is fenced with barbed wire, and the entrance is closed by a gate. There is no green isolation zone around the site.

Arable grounds in majority and meadows and pastures in minority surround the area of the landfill. There are no buildings where people live in the direct neighbourhood of the site (within 500 m). There are only the buildings of the brick yard there.

According to data of the Enterprise of Municipal Services in Elk about 800 000 m^3 of municipal wastes from Elk and its administrative area were stored in the landfill over a period of 10 years. They occupy about 70% of reservoir „C". The rest of the area is composed of water partly covered by floating wastes.

Wastes deposited in the reservoir force out water which is in it. It was observed that some water flows towards the east to reservoir „B", and some towards the south, through a dyke, to reservoir „A" (fig.).

The only source of inflow of pollutants to reservoir „B" seems to be leachage from reservoir „C".

Apart from the leachage from reservoir „C" to reservoir „A" the sewage from the washing stand of waste trucks' wheels and containers gets there too.

No flow of contaminants to reservoir „D" was observed. Some pollutants can get there from the landfill by air.

Determination of morphometric parameters of water reservoirs. The estimation of the amount (volume) of water in the reservoirs situated on the Siedliska landfill was carried out by the comparision of archival topographic maps of the area and subsequently exploitation documentation of clay layers along with the present maps of the terrain.

Bathymetric examinations of the reservoirs were carried out too. The measurements were made in September 1992.

The mean depth of reservoirs „A", „B" and „D" was calculated on the basis of bathymetric examinations. Cross-sections of the reservoirs and their mean depths were calculated on the basis of the obtained data.

The mean depth of reservoir „C" was calculated from the difference between map levels representing the bottom of the excavation before its exploitation as a landfill, and the map showing the present state of the landfill. Reservoir „C" was divided into two sections for calculation purposes:

- the part of the reservoir situated under the waste heap, where hydration was assumed to be about 30%.
- the remainder of the reservoir where waste hydration was assumed to be about 80%.

The area of the water reservoirs was calculated on the basis of measurements taken from the topographic map in the scale 1 : 500.

The volume of water collected in the reservoirs was calculated according to the formula:

$V = A \times H_{av}$ [m^3]

for reservoirs „A", „B" and „D"

and

$V = A \times H_{av} \times u$ [m^3]

for reservoir „C"

where:

V – volume of water in a reservoir [m^3]

A – area of a reservoir [m^2]

H_{av} – mean depth of a reservoir [m]

u – wastes hydration in reservoir „C" [%]

Distribution of research sites for measurement of the degree of pollution. The distribution of the water sampling sites is presented in the figure. The sites were marked as W_1–W_8.

Reservoirs „C", „B" and „A" have got 2 testing sites each. In reservoir „C" the site W_1 was situated in close proximity to the heap of newly stored wastes. The site W_2 was situated in the northern part of reservoir „C" at a distance of about 50 m from the wastes heap. In reservoir „B" the site W_6 was in the region of the water inflow from reservoir „C", the second site W_7 was on the opposite side of the reservoir. In reservoir „A" the site W_3 was in the northern part of the reservoir, in the region of the inflow of pollutants from reservoir „C". The second site W_4 was on the opposite side of the reservoir.

In further calculations it was assumed that average concentrations of pollutants in the reservoirs would be the arithemic mean of concentrations from two sites in a given reservoir.

In reservoir „D" there was only one site W_8, because reservoir „D" was much smaller than the other reservoirs. It was assumed that physico-chemical properties in a site were representative for water of the whole volume of the reservoir.

The site W_5 was below the outlet of the pipe carrying away sewage from the washing stand to reservoir „A".

Determination of properties of water and sewage and loads of pollutants gathered in the reservoirs. The samples were taken twice: in September and October 1992. They were taken from the reservoirs at a depth of about 0,5 m under the surface of the water-level using a scoop. The sampling of sewage from the washing-stand was carried out at the outlet of a collector from the washing-stand to reservoir „A".

Reaction, electrolytic conductivity, dissolved organic and mineral substances, chlorides, sulphates, COD, total nitrogen, nitrate nitrogen, ammonia nitrogen, total phosphorus, and phosphate phosphorus were determined in the water samples.

The loads of pollutants gathered in the water reservoirs were determined in two ways. Their values were calculated in kilograms of a kind of pollutant and also for better presentation they were recalculated for the loads of pollutants produced by person equivalent (pe) during 24 h (pe/d) and during the year (pe/a). Unit loads given by Cywiński and others were used for these calculations (6).

They are:

- dissolved substances – 100–120 g/pe d,
- organic dissolved substances – 50–60 g/pe d,
- total nitrogen – 12–13 g/pe d,
- COD (calculated as 1,43 BOD_5) – 60–70 g/pe d.

The amount of sewage produced by person equivalent within 24 h was calculated on the basis of the standards of water usage (200 m^3/pe d) (17).

Results and conclusions.

Hydrometric measurements show (fig., tab. 1) that the water reservoirs take up a large area of the present landfill (reservoirs „C", „A" and „D") and the terrain designed for a future landfill (reservoir „B"). The total area of the water reservoirs is about 7,15 ha and it comprises about 111,6 thousand m^3 of water.

Reservoir „C", where the wastes are stored, is the largest one as far as the area is concerned-about 3,18 ha. Its depth is on average 2,34 m (in the range 0,92–3,24 m) and about 33,6 thousand m^3 of water is collected in it. Reservoirs „B" and „A" have got the same area (about 1,77 and 2,10 ha) but their depth is different (reservoir „B" – 2,90 m, reservoir „A" – 1,19 m). And therefore the amount of collected water is different too (reservoir B – 51,5 thousand m^3, reservoir „A" – 25,0 thousand m^3). Reservoir „D" is much smaller. Its area is 0,10 ha, depth 0,70–2,0 m (on average 1,50 m) and there is about 1,5 thousand m^3 of water in it.

The data presented in tables 7 and 8 show that the amounts of collected water in the four investigated reservoirs correspond to the amount of sewage let out within 24 h from about 558 thousand pe or produced within the period of one year by 1528 pe.

In reservoir „C" (fig.), where the wastes were stored, a very high degree of water pollution was observed (tab. 2). This was proved by very high levels of electrolytic conductivity (on average 10,69 mS/cm at W_1 site – close to the wastes heap and 4,41 mS/cm at W_2 site – situated about 50 m from the wastes heap) and the amount of dissolved substances (on average 10 106 mg/dm^3 for W_1 site and 4270 mg/dm^3 for W_2 site). These values exceed the values found in the municipal sewages (6) and they do not correspond to the previous standards for sewages carried away to the municipal sewage system (12). Mineral substances predominate among the dissolved substances (on average 87,3 % of TDS). It proves that the intensive biochemical changes take place in the wastes heap and in the leachate and it indicates the high degree of mineralization of organic substances. In the water of reservoir „C" there are relatively few chlorides (87–200 mg/dm^3, on average 144 mg/dm^3) and sulphates (34–107 mg/dm^3, on average 71 mg/dm^3). These concentrations correspond to the standards expected for clean surface waters (13). The COD of the analysed samples was rather high. In the W_1 sample at the wastes heap it was 1222 mg O_2/dm^3, at W_2 site (50 m from the wastes heap) it was 532 mg O_2/dm^3, and in reservoir „C" it was 877 mg O_2/dm^3 on average. The values were lower than the ones given in literature for the majority of leachate of municipal landfill outflow (5, 10, 14). In the case of W_1 however they exceeded the accepted concentration of COD (valid in the past) in the sewages discharged to municipal sewage systems (1000 mg O_2/dm^3) (12). In the water of reservoir „C" a high con-

TABLE 1. The results of hydrometric measurements of reservoirs „A", „B", „C" and „D" located on the MSW Landfill in Siedliska near Elk

No	Reservoir	Area [× 1000 m^2]	Depth [m]			Volume [× 1000 m^3]
			min.	max.	av.	
1.	„C"	31.8	0.92	3.24	2.34	33.6
2.	„B"	17.7	1.50	4.40	2.90	51.5
3.	„A"	21.0	0.30	2.90	1.19	25.0
4.	„D"	1.0	0.70	2.00	1.50	1.5
5.	Total	71.5				111.6

TABLE 2. The physici-chemical properties of the water collected in reservoir „C" located on the MSW Landfill in Siedliska near Elk

No	Physico-chemical properties	Unit	The research sites		
			W_1	W_2	av.
1.	Reaction	pH	7.46	7.65	7.55
2.	Electrolytic conductivity	mS/cm	10.69	4.41	7.55
3.	Total dissolved substances TDS	mg/dm^3	10 106	4 270	7 188
4.	Mineral dissolved substances	mg/dm^3	8 838	3 715	6 276
		% TDS	87.5	87.0	87.3
5.	Organic dissolved substances	mg/dm^3	1 268	556	912
		% TDS	12.5	13.0	12.8
6.	Chlorides	mg Cl^-/dm^3	200	87	144
7.	Sulphates	mg SO_4^{2-}/dm^3	107	34	71
8.	COD	mg O_2/dm^3	1 222	532	877
9.	Total nitrogen	mg N/dm^3	370	78	224
10	Ammonia nitrogen	mg NH_4^+/dm^3	343	93	218
11.	Nitrate nitrogen	mg NO_3^-/dm^3	0.76	0.63	0.70
12.	Total phosphorus	mg P/dm^3	72	29	51
13.	Phosphate	mg PO_4^{3-}/dm^3	23	17	20

centration of biogenic compounds was observed. The concentration of general nitrogen ranged from 78 to 343 mg/dm^3 (on average 224 mg/dm^3) and general phosphorus 29–72 mg/dm^3 (on average 51 mg/dm^3). These values were many tens of times greater than the standards accepted for surface waters.

The sewage carried from the washing-stand (W_5 site; fig.) was the additional source of contamination of reservoir „A" (tab. 5). This was acid sewage (pH 5,07), probably containing fatty acids being semi-products of the decomposition of organic substances found in the municipal wastes. This supposition is proved by a very high COD (3018 mg O_2/dm^3) and the relatively high proportion of dissolved organic substances in the total amount of dissolved substances (47% of TDS). This sewage was characterised by high conductivity (4,37 mS/cm) and total amount of dissolved substances (5917 mg/dm^3). These values exceeded significantly the ones accepted for sewage carried off to sanitary sewage

systems (12). In the sewage from the washing-stand very high concentrations of biogenic compounds – total nitrogen (197 mg/dm^3) and total phosphorus (52 mg/dm^3) were found. There were relatively few chlorides (76 mg/dm^3) and sulphates (90 mg/dm^3) in this sewage. These concentrations correspond to the standards accepted for clean surface waters (13).

In reservoir „A" situated in the southern part of the landfill (fig.), higher values of pollution indexes than in reservoir „C" were observed (tab. 2, 4). Conductivity values were 11,83 mS/cm at W_3 site and 12,29 mS/cm at W_4 site (on average in reservoir „A" – 12,06 mS/cm). Dissolved substances were 12 713 mg/dm^3 and 12 773 mg/dm^3 respectively (on average 12 743 mg/dm^3). These are mainly mineral substances (93% TDS) which means that organic pollutants from the wastes and the sewage carried away from the washing-stand (W_5) underwent significiant mineralization. There were few chlorides (on average 271 mg/dm^3) and sulphates (87 mg/dm^3) in the waters of reservoirs „A" and „B" and in the sewage carried from the washing-stand. These concentrations correspond to the standards accepted for clean surface waters (9). The COD values were rather high although they were significantly lower than in the sewage carried off from the washing-stand. In the water taken from site W_3 the COD values were 1102 mg O_2/dm^3 and at site W_4 734 mg O_2/dm^3 (918 mg O_2/dm^3 on average in reservoir „A"). The concentrations of total nitrogen (on average 46 mg/dm^3), ammonium nitrogen (on average 31 mg/dm^3), total phosphorus (2,40 mg/dm^3) and phosphates (on average 0,60 mg/dm^3) were several times lower in reservoir „A" than in reservoir „C" and the sewage from the washing-stand (W_5). The higher degree of water pollution in reservoir „A" was probably caused by the inflow of very polluted sewage from the washing-stand. The reduction of biogenic compounds was probably caused by plants-reeds growing on a large area of the reservoir.

The water in reservoir „B" situated in the eastern part of the landfill was slightly polluted (fig.). The COD of the water taken at site W_6 was 301 mg O_2/dm^3 on average and at site W_7 – 222 mg O_2/dm^3 (tab. 3). They are indexes corresponding to the municipal wastes having low concentrations of pollution (6). The values of electrolytic conductivity and the amount of dissolved substances in the water of reservoir „B" were rather high (tab. 3) but they were several times lower than in the waters of reservoirs „C" and „A" (tab. 2 and 4). The samples taken at sites W_7 and W_8 had a conductivity of 2,78 and 3,00 mS/cm, respectively (2,89 mS/cm on average in reservoir „B"), and total dissolved substances of 2677 and 2665 mg/dm^3 respectively. Mineral substances were the main pollutants in reservoir „B" (about 87,5% TDS). The concentration of nitrogen compounds was relatively low (total nitrogen – 19,2 mg/dm^3, ammonium nitrogen – 10,4 mg/dm^3 on average). It exceeded the standards accepted for clean surface waters a little (13). The amount of total phosphorus (2,4 mg/dm^3 on the average) several times exceeded the above mentioned standards for clean water.

TABLE 3. The physico-chemical properties of the water collected in reservoir „B" located on the MSW Landfill in Siedliska near Elk

No	Physico-chemical properties	Unit	The research sites		
			W_6	W_7	av.
1.	Reaction	pH	7.88	7.94	7.91
2.	Electrolytic conductivity	mS/cm	2.78	3.00	2.89
3.	Total dissolved substances TDS	mg/dm^3	2677	2665	2671
4.	Mineral dissolved substances	mg/dm^3	2345	2322	2334
		% TDS	88.0	87.0	87.5
5.	Organic dissolved substances	mg/dm^3	332	344	338
		% TDS	12.0	13.0	12.5
6.	Chlorides	mg Cl^-/dm^3	55	55	55
7.	Sulphates	mg SO_4^{2-}/dm^3	9.3	8.9	9.1
8.	COD	mg O_2/dm^3	301	222	262
9.	Total nitrogen	mg N/dm^3	18.9	19.5	19.2
10	Ammonia nitrogen	mg NH_4^+/dm^3	9.8	10.9	10.4
11.	Nitrate nitrogen	mg NO_3^-/dm^3	0.11	0.15	0.13
12.	Total phosphorus	mg P/dm^3	2.3	2.6	2.4
13.	Phosphate	mg PO_4^{3-}/dm^3	0.42	0.47	0.45

TABLE 4. The physico-chemical properties of the water collected in reservoir „A" located on the MSW Landfill in Siedliska near Elk

No	Physico-chemical properties	Unit	The research sites		
			W_3	W_4	av.
1.	Reaction	pH	8.69	8.69	8.69
2.	Electrolytic conductivity	mS/cm	11.83	12.29	12.06
3.	Total dissolved substances TDS	mg/dm^3	12 713	12 773	12 743
4.	Mineral dissolved substances	mg/dm^3	11 843	11 936	11 890
		% TDS	93.0	93.0	93.0
5.	Organic dissolved substances	mg/dm^3	870	839	854
		% TDS	7.0	7.0	7.0
6.	Chlorides	mg Cl^-/dm^3	269	272	271
7.	Sulphates	mg SO_4^{2-}/dm^3	85	89	87
8.	COD	mg O_2/dm^3	1 102	734	918
9.	Total nitrogen	mg N/dm^3	49	43	46
10	Ammonia nitrogen	mg NH_4^+/dm^3	28	34	31
11.	Nitrate nitrogen	mg NO_3^-/dm^3	0.30	0.23	0.27
12.	Total phosphorus	mg P/dm^3	2.60	2.20	2.40
13.	Phosphate	mg PO_4^{3-}/dm^3	0.63	0.58	0.60

The water of a small reservoir – „D" – situated in the south-west part of the landfill (fig. – W_8 site) was polluted least of all. Most of the physico-chemical parameters determined in the water of this reservoir (tab. 5) corresponded to the standards of inland surface waters of III class (13). Only the COD values (280 mg O_2/dm^3) and total phosphorus (5,64 mg/dm^3) did not correspond to the standards of water

TABLE 5. The physico-chemical properties of the water collected in reservoir „D" located on the MSW Landfill in Siedliska near Elk (site W_8) and sewage from the washing stand of waste trucks wheels and containers (site W_5)

No	Physico-chemical properties	Unit	The research sites	
			W_8	W_5
1.	Reaction	pH	8.54	5.07
2.	Electrolytic conductivity	mS/cm	0.60	4.37
3.	Total dissolved substances TDS	mg/dm^3	543	5 917
4.	Mineral dissolved substances	mg/dm^3	402	3 136
		% TDS	74.0	53.0
5.	Organic dissolved substances	mg/dm^3	142	2 781
		% TDS	26.0	47.0
6.	Chlorides	mg Cl^-/dm^3	7	76
7.	Sulphates	mg SO_4^{2-}/dm^3	19	90
8.	COD	mg O_2/dm^3	280	3 018
9.	Total nitrogen	mg N/dm^3	4.0	197.4
10	Ammonia nitrogen	mg NH_4^+/dm^3	0.0	–
11.	Nitrate nitrogen	mg NO_3^-/dm^3	0.03	0.41
12.	Total phosphorus	mg P/dm^3	5.64	52.2
13.	Phosphate	mg PO_4^{3-}/dm^3	0.25	36

purity. It cannot be stated what the source of this water pollution was.

The data presented in table 6 show that water in the landfill in Siedliska contains large amounts of pollutants. Totally there are about 700 Mg of dissolved substances mainly in the form of mineral salts (629 Mg). There are small amounts of chlorides (about 14,5 Mg) and sulphates (5 Mg) but large amounts of fertilizer substances (total nitrogen 9,7 Mg, total phosphorus 1,9 Mg). The pollutants contained in the water require 66 Mg of oxygen for their chemical oxidation. The majority of pollution can be found in the waters of reservoir „C", „B" and „A". Most of the kinds of pollutants are distributed relatively similarly in the three reservoirs: „C", „B" and „A". Attention should be paid to the fact that about 90% of the fertilizer compounds (total nitrogen and total phosphorus) are included in the water of reservoir „C".

The water of reservoir „D" contains only a fraction of the total percentage of the pollution load and this constitutes only a marginal problem in the future reclamation works.

The presentation of the pollution loads in particular reservoirs of the landfills expressed in kilograms or megagrams (tab. 6) can be useful for designing water treatment systems. Tables 7 and 8 show the above loads recalculated for person equivalent. The data show that pollutants collected in surface waters within the area of the landfill in Siedliska are equivalent to the amount of pollutants produced during 24 h (tab. 7) by about 800 thousand pe in case of COD and total nitrogen, 6,3 mln pe in the case of the amount of dissolved substances and about 11,4

TABLE 6. Loads of pollutants gathered in reservoirs „A", „B", „C" and „D" on the MSW Landfill in Siedliska near Elk

No	Pollutant	Unit	Reservoir				Total
			„C"	„B"	„A"	„D"	
1.	Total dissolved substances	[kg]	241 517	137 289	318 575	869	698 250
2.	Mineral dissolved substances	[kg]	210 874	119 968	297 250	643	628 735
3.	Organic dissolved substances	[kg]	30 643	17 373	21 350	227	69 593
4.	Chlorides	[kg Cl^-]	4 838	2 827	6 775	11	14 451
5.	Sulphates	[kg SO_4^{2-}]	2 386	468	2 175	30	5 059
6.	COD	[kg O_2]	29 467	13 469	22 950	448	66 334
7.	Total nitrogen	[kg]	7 526	987	1 150	6	9 669
8.	Ammonia nitrogen	[kg NH_4^+]	7 325	535	775	0	8 635
9.	Nitrate nitrogen	[kg NO_3^-]	24	7	7	0	38
10.	Total phosphorus	[kg]	1 714	123	60	9	1 906
11.	Phosphate	[kg PO_4^{3-}]	672	23	15	0	710

TABLE 7. Volume of water and loads of pollutants gathered in the water reservoirs on the MSW Landfill in Siedliska near Elk determined as loads of pollutants produced by person equivalent during 24 hours (pe/d)

No	Pollutant	Volume of water and load of pollutant [pe/d]				
		„C"	„B"	„A"	„D"	Total
1.	Volume of water	168 000	257 000	125 000	8 000	558 000
2.	Total dissolved subst.	2 195 609	1 248 081	2 896 136	7 900	6 347 726
3.	Mineral dissolved subst.	3 834 072	2 181 236	5 404 545	11 691	11 431 544
4.	Organic dissolved subst.	557 145	315 872	388 182	4 127	1 265 326
5.	COD	342 640	156 616	266 860	5 209	771 325
6.	Total nitrogen	627 167	82 250	95 833	500	805 750

mln pe in the case of dissolved mineral substances. Correspondingly, they are equivalent to the amount of pollution produced within a year (tab. 8) from about 2,2 thousand pe in the case of COD and total nitrogen, 17,4 thousand pe in the case of the amount of dissolved substances and about 31,3 thousand pe in the case of dissolved mineral substances.

The above data show that the pollution loads are very high and they require a lot of financial and material investment to be removed. These costs will not be lower than the expenditure which would be necessary to construct a sewage-treatment plant for a town of several or even tens of thousands of inhibitants.

The physico-chemical properties of the water collected in the region of the landfill in Siedliska show that they are mineralized to a large extent. There is a lack of organic compounds which could otherwise be decomposed. Large amounts of fertilizer compounds (nitrogen and phosphorus) and small concentrations of chlorides and sulphates let us assume that the utilization of plants for water purification could be advantageous (10).

TABLE 8. Volume of water and loads of pollutants gathered in the water reservoirs on the MSW Landfill in Siedliska near Elk determined as loads of pollutants produced by person equivalent during a year (pe/a)

No	Pollutant	Volume of water and load of pollutant [pe/a]				
		„C"	„B"	„A"	„D"	Total
1.	Volume of water	460	704	342	22	1 528
2.	Total dissolved subst.	6 015	3 419	7 935	22	17 391
3.	Mineral dissolved subst.	10 504	5 976	14 807	32	31 319
4.	Organic dissolved subst.	1 526	865	1 064	11	3 466
5.	COD	939	429	731	14	2 113
6.	Total nitrogen	1 718	225	263	1	2 207

Summing up, it can be stated that conventional methods of sewage treatment will not be useful in treating the water from the landfill in Siedliska (4, 9). The methods of agricultural usage of the sewage can be useful (3, 7, 8, 15).

Conclusions.

1. The storage of wastes in flooding (wet) conditions causes the pollution of water which is in the contact with wastes. There are many dissolved substances in leachate, generally mineral ones (about 80%), many nitrogen compounds (mainly ammonium) and phosphorus. There were small amounts of chlorides and sulphates in the leachates from the landfill in Siedliska, which is not typical for municipal landfills.

2. The sewage from washing trucks' wheels and containers is highly polluted, they exceed significantly (the admittedly out of date) standards of sewage discharged into the municipal sewage system. Their reaction is acid. Organic substances comprise about 50% of the content of the dissolved substances. COD is very high as well as the amounts of biogenic compounds – nitrogen and phosphorus compounds. There were small amounts of chlorides and sulphates as in the leachate from the wastes. The sewage, after being introduced into surface waters, causes their significant pollution.

3. The storage of municipal wastes in flooding conditions, without regulating the water relationship of the dump, may cause serious consequences in the surrounding water environments. In the neighbourhood of the landfill in Siedliska, after 10 years of improper storage of wastes, the waters in the reservoirs were more polluted than average municipal sewage. The pollution load collected in them was equal to the pollution load produced during 24 h by a few million inhabitants or produced during a year by several thousand or even tens of thousands of inhibitants.

4. The physico-chemical properties of the waters polluted by waste show that conventional methods will not be suitable for their treatment. These properties suggest that agricultural methods of sewage utilization could be useful. The application of such methods should be preceeded by technological research.

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Streszczenie

Wpływ odpadów komunalnych składowanych w warunkach podtopienia na wysypisku w Siedlcach k. Ełku na poziom zanieczyszczenia wody. W pracy badano wpływ wysypiska zlokalizowanego w Siedliskach k. Ełku na środowisko wodne terenów przyległych. Określono ilości i stopień zanieczyszczenia wód zgromadzonych w wyrobiskach jako dane niezbędne do zaprojektowania sposobu ich unieszkodliwienia.

Wykazano, że składowanie odpadów przez ponad 10 lat spowodowało zanieczyszczenie ponad 110 tys. m^3 wód. Stwierdzono, że we wszystkich wodach na terenie wysypiska znajduje się 700 mg substancji rozpuszczonych, w tym 629 mg w postaci mineralnej (ok. 80%). Średnie stężenie zanieczyszczeń wód zbiornika, w którym składowano odpady, wyrażone wskaźnikiem ChZT wyniosło średnio 877 mg O_2/dm^3. Stwierdzono także dużą zawartość związków biogennych w badanych wodach.

Zgromadzone odcieki nie są podatne na oczyszczanie biologiczne. Zasugerowano przydatność unieszkodliwiania tych wód przez rośliny – trzciny i wierzby.

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