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M. M. Bohoslavets[1], L. I. Chelyadyn[2], M. I. Medvid[3]
[1]head of Environmental Protection Department of the Petrochemical of the Precarpathian region (Nadvirna, Ivano-Frankivsk region, Ukraine)
[2]Ph. D., Associate Professor, Professor of Chemistry of the Ivano-Frankivsk National Technical University of Oil and Gas (Ivano-Frankivsk, Ukraine)
[3]assistant, Department of General Geology, Engineering Geology and Hydrogeology of the Ivano-Frankivsk National Technical University of Oil and Gas (Ivano-Frankivsk, Ukraine)
e-mail: chelyadyn@ukr.net[2]

PHYSICAL, ELECTRICAL AND CHEMICAL ASPECTS OF TECHNOLOGY OF INFILTRATES TREATMENT OF DOMESTIC WASTE LANDFILLS

Environmental protection of territories of landfills includes filtrates treatment, that occur in the body of a landfill and are extremely toxic, as they have harmful effect on flora, fauna and people and that's why this problem is so important. Almost all ingredients of filtrates of solid domestic waste (SDW) dumps exceed limiting quality criterions (LQC), though the most dangerous for water resources is concentration of ammonium nitrogen, nitrates and organic compounds, which have the greatest influence on DOCO index. For filtrates treatment of SDW dump the technology of reverse osmosis is mostly used and the article highlights electrical, chemical and sorption technology. Results of investigation of filtrates treatment by such technology indicate its perspectives as it has been got decrease of DOCO index up to 334,3 mg/dm^3 and ammonium nitrogen – 36,0 mg/dm^3, and also by other indices, for example nitrates – 6,8 mg/dm^3. As a result it became possible to achieve decrease of DOCO almost twice and decrease of concentration of ammonium ions more than three times.

Introduction

Water resources are mainly polluted by sewage, filtrates from different sites [1] which contain harmful components. So this problem is of extremely great importance for society, as far as environmental safety is decreased as a result of polluted environments that get into hydrosphere.

An ecological problem appears on the territories of domestic waste damps due to their accumulation, as far as they influence three main factors of the landfill environmental safety, namely pollute the atmosphere, water resources by filtrates, and also soil.

Since such sites are mainly located outside big cities, districts or villages, where there are no effective purifying structures, sewage treatment of refuse landfills is a great problem.

Table 1 contains indices of sewage (filtrates) of two enterprises of the Precarpathian region and limiting quality criterions (LQC) in Ukraine [2] for waste into water resources.

The filtrates of these sites include different types of contaminations (mechanical, chemical, biological), which require specific technology of water treatment, as far as composition of filtrates according to indices of ingredients is different (table 1), namely: concentration of one contaminating component can exceed several times allowed values for waste into water resources, for example for an infiltrate of a landfill IF according to DOCO index in comparison with LQC it's 7 times as big and for a landfill L it's 15 times as big.

The analysis of data in table 1 indicates the fact that filtrate L of a SDW landfill is characterized by high concentration of organic substances – more than 12,8 g/dm^3, and inorganic component is prevailed by sodium chloride, that is equal to almost 75 % from the sum of dissolved mineral salts. High values of a filtrate's COI indicate that by chemical composition filtrate has great concentration of high-density metals, caused by metal-containing substances, present in SDW, that can corrode and form complex compounds with organic ligands – products of biological and chemical decomposition of organic substances. Such

average chemical composition of filtrates with slight differences, depending on local conditions of accumulation territories, is characteristic for all SDW damps in Ukraine.

Table 1. – Indices of landfills filtrates and limiting demands

p/ch	Quality index, concentration, mg/dm^3	Filtrate IF	Filtrate L	LQC
1	Smell, points	3	5	2–3
2	Transparency, cm	3	4	10–20
3	Water index pH	8,4	8	6,5–9
4	BSK_5, mgO_2/dm^3	2 280,0	952,0	325
5	Chlorides	1 747,4	4 751,0	350
6	Nitrogen ammonium and ammonia	36,0	324,0	30
7	Nitrates	92,3	9,56	45
8	Nitrites	5,25	0,58	3,3
9	Iron (general)	94,4	77,0	2,5
10	Copper	25,9	77,0	0,5
11	Lead	0,5	1,0	0,1
12	Petroleum products	7,6	77,0	10
13	SPAR	8,82	0,32	25
14	Stuck substances	472,0	362,6	380
15	Dry remains (90 ºC)	15 010	28 300,0	1 000
16	COI	5 750	12 630	810

In filtrates of SDW damps almost all ingredients exceed LQC, though the most dangerous for water resources is concentration of ammonium nitrogen, nitrates and organic compounds that influence the most COI index.

Environmental protection of landfills territories and also water resources that are situated outside landfills from filtrates contaminations is an extremely important problem as it influences people, flora, and fauna.

Industrial enterprises and public utilities mostly use oxidation treatment (OT) of sewage [3] which occupy great territories and the process of treatment requires abidance by certain parameters (temperature not lower than 10 ºC, bacteria nutriment, great amount of dispersive air, and so forth), and treatment efficiency is by index, for example COI, not more than 70–85 %.

Foreign publications contain different technologies for SDW filtrates treatment, collected by SDW drain systems, but the most widely used one is the technology of reverse osmosis [4], applied for filtrates treatment of landfills in many foreign countries. The technology makes it possible to achieve great treatment efficiency, that allows forcing the purified filtrate to surface basins, and the concentrated product that occupies near 10–20 % goes back to the body of a damp. The main disadvantages of the technology include a great cost of capital expenses for unit production and putting into operation and operation costs for ensuring the operation.

Filtrate treatment with the help of electrical and plasma treatment [5] is a perspective technology which is characterized both by cost of implementation and quality of treatment as a winning one. As a result of technological difficulties it hasn't got wide industrial application. Thermal technologies of filtrate treatment (evaporation and drying) are connected with evaporation of great amount of water, that requires considerable expenditures of energy, and also partially cause atmosphere pollution.

The usage of sorption technologies for filtrates treatment from heavy metals with application of natural adsorbents or sorbents made of raw materials of vegetable waste is described in [6].

The authors [7] introduce the technology of anaerobic treatment of filtrates by the method of successive treatment in anaerobic reactor UASB and anaerobic stage which is accompanied by receipt of biogas. A great disadvantage of anaerobic process is sensitivity to temperature and pH changes, and also to different toxic substances that are contained in filtrates. Evaluation of implementation of different ways of anaerobic and aerobic technologies is given in [8].

However, application of this technology did not succeed in Ukraine, that is due to cost and different composition of filtrates, which occur on our SDW landfills, so further on study of technologies of filtrates treatment with the help of physical and chemical method is given.

Sewage treatment by physical and chemical method in comparison with sewage oxidation treatment (OT) is conducted by technology that includes local treatment units, which operate by physical, electrical and chemical technology [9]. Such technologies are more effective and give an opportunity of sewage treatment to desired efficiency by some indices. Perspectives of this method of SDW landfills treatment is shown by a number of advantages in comparison with anaerobic systems. These advantages include: low cost of purifying structures construction, flexibility of operation, ability to change quickly mode of treatment, easy starting of unit operation, simplicity of maintenance and convenience of automation.

The approval of SDW damp filtrates treatment by electric, chemical and sorption method is given in [10] and it shows that decrease in COI is considerable but not sufficient for their dropping in all types of water resources, for example fishing and household resources.

The aim of this paper is working out a new complex electric, chemical and sorption technology of IF landfill filtrate treatment on the basis of new devices, natural sorbents and optimal parameters of water treatment technology.

Methodology of study and content

The main stages of a complex electric, chemical and sorption technology are as follows.

The first stage includes electric treatment of sewage in the first electric device, where oxidation and resumption of harmful components of sewage take place. Reactions have several stages: transfer of molecules of organic substance to anions, formation of atomic hydrogen, chemical resumption of organic substances and formation of fine-dispersed H_2 and O_2:

$$R + \hat{e} \rightarrow R^-; \quad 2H^+ + 2\hat{e} \rightarrow H_2; \quad R^- + H^+ \rightarrow RH,$$
$$2R + H_2 \rightarrow 2RH, \quad R + H^+ + \hat{e} \rightarrow RH.$$

The second stage of sewage treatment takes place in th/ls, where depending of quantity of mechanic stuck fallouts and formed as a result of electrical treatment contaminations, at the entrance of the settler by changing the slope of inclined planes higher sewage treatment efficiency takes place due to flotation by fine-dispersed H_2 light and heavy contaminations on inclined planes in a thin-layer settler (th/ls).

The third stage of treatment is sewage retreatment after th/ls in electrical device II, as far as by electrical treatment takes place the process of synthesis of «available chlorine». Chlorine, that gives off, dissolves along with formation of hydrochloric and perchloric acid and further on of hypochlorite:

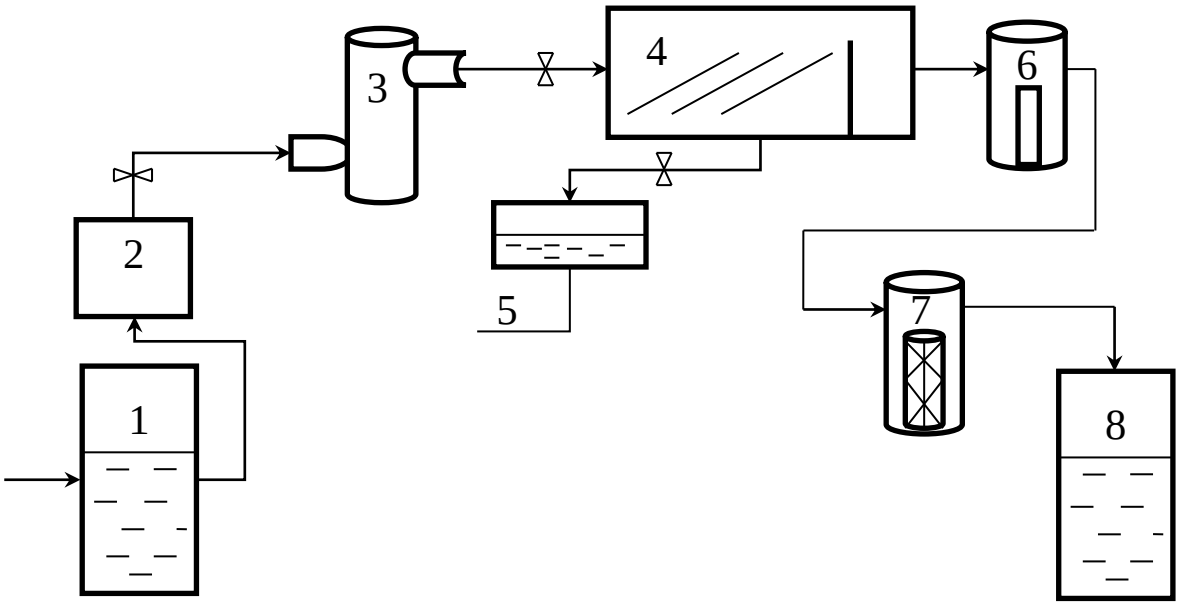
$$Cl_2 + H_2O \leftrightarrow HClO + HCl, \qquad HClO + HCl + 2OH^- \leftrightarrow H_2O + Cl^- + ClO,$$

which influence electrical and chemical destruction of organic compounds and decrease of their toxicity at the third stage. The fourth stage includes the method of filtration and sorption of sewage treatment in designed automatic filters-adsorbers, which are filled with natural sorbent – zeolite and clynoptiolite of different fractional composition.

Physical and chemical indices of a real filtrate of SDW landfill IF at the average within the fourth quarter of 2017 are as follows: pH 7; COI 934,3 mgO_2/dm^3; nitrogen ammonium 36,0 mg/dm^3, nitrites 6,8 mg/dm^3; chlorides 372,6 mg/dm^3; sulfates 808,6 mg/dm^3.

Different samples of zeolite and clynoptiolite from Sokyrnyky field [11] were used for filtrating loads of a filter, which is characterized by the following average indices: for a fraction 0,5–3 mm, bulk density – 1,1–1,18 kg/dm^3, specific surface – 20,1–40, 8 m^2/g, size of pores 3,5–4,2 A.

For sewage treatment we studied the technology of physical and chemical treatment with the help of electric treatment method and filtration through sorption material on a unit, which consists of a container for sewage, centrifugal pump, electric devices, thin-layer settler (th/ls) [12] with a capability of inclined planes installation, rectifier, camera for accumulation of water treatment mud, filters-adsorbers, container for purified water collection. Electrical and chemical processes that cause floatation of stuck fallouts including on petroleum products in a thin-layer settler and influence the destruction of soluble contaminations take place in sewers. Sewage treatment was conducted according to the following technology under dynamic conditions in such a way is shown in the picture.



Picture. – Scheme of a laboratory unit for sewers treatment

Sewage from the container was forced by a pump during half an hour in a quantity of 40 dm^3 through the electrical device.

Under the influence of direct current (U = 12–24–36 B, I = 1,0–10 A) concentration of ingredients in sewage was determined on different stages before and after treatment in a certain technological apparatus with application of techniques [13–15] and treatment efficiency α, % for certain ingredients after a settler or filter was determined.

One of the indices of water contamination often used is COI, which is a generalized index for contaminations (organic and inorganic), and therefore this index was determined before and after treatment.

Results and discussion

The results of the study with the usage of real sewage are given in the table 2.

Table 2. – Results of filtrate treatment with the help of electrical and chemical technology

Number of a sample	Before treatment			Parameters of technology			After treatment			
	Stuck fallouts, mg/dm^3	ammonium, mg/dm^3	COI, mgO^2/dm^3	Tension I electrical device, V	Tension II electrical device, V	Expense, dm^3/h	Stuck fallouts, mg/dm^3	ammonium, mg/dm^3	COI, mgO^2/dm^3	Treatment efficiency α, (COI)%
1	12,6	8,7	685,09	36	12	6	3,0	2,0	74,61	89,1
2	11,4	23,7	772,56	36	12	6	6,1	1,5	93,86	87,9
5	15,5	15,3	655,54	36	12	8	3,2	1,4	58,14	91,1
7	19,8	22,4	781,52	36	24	8	2,3	1,2	50,16	93,6
9	15,4	18,3	617,85	24	24	8	3,2	0,8	37,42	93,9
1	12,6	48,7	685,09	24	24	8	3,3	3,7	29,34	95,7
2	11,4	23,7	772,56	24	36	10	3,7	2,0	62,38	91,9
5	45,5	15,3	655,54	12	36	10	3,5	1,8	43,82	93,3
7	49,8	22,4	781,52	12	36	10	3,6	1,3	55,65	92,8
9	75,4	18,3	617,85	12	36	12	4,5	0,9	50,34	91,8

At the last stage sewage got for further treatment with the help of filtration by loading into two parallel filters.

Samples of sewage were taken from container 1 and after a settler and were determined change of p/p concentration, stuck fallouts and other indices, comparing them with the initial ones, determining the degree of their decrease.

The study has shown that filtrate treatment of SDW landfills in cylindrical electrical devices increases treatment efficiency from contaminations in a thin-layer settler for 16–25 %.

Optimal parameters of electrical and chemical treatment technology implementation are the following: expense 8 dm^3/h and 24 v on electrical device I and device II.

The suggested parameters of physical, electrical and chemical technology give an opportunity to treat effectively sewage, as far as electrical treatment before the settler causes floatation of stuck fallouts and p/p to the upper part of a thin-layer settler by gases of electrolysis.

For increasing filtrates treatment efficiency from soluble contaminations investigation of their adsorption by different fractions of zeoliolite and clynoptyolite with the help of filtration method was conducted and the results are given in the table 3.

Table 3. – Indices of filtrate treatment with the help of electrical, chemical and sorption technology

Number of a sample/filter	Before treatment			After treatment			Treatment efficiency α, %		
	Stuck fallouts, mg/dm^3	Ammonium, mg/dm^3	COI, mgO^2/dm^3	Stuck fallouts, mg/dm^3	Ammonium, mg/dm^3	COI, mgO^2/dm	Stuck fallouts	ammonium	COI
1/**I**	32,6	48,7	685,09	3,0	2,0	52,15	90,8	95,9	92,4
3	91,4	23,7	772,56	6,1	1,5	43,86	93,3	93,6	94,3
6	45,5	15,3	655,54	3,2	1,4	38,14	93,7	90,8	94,1
8	49,8	22,4	781,52	2,3	1,2	50,16	95,4	94,6	93,6
10	75,4	18,3	617,85	3,2	0,8	47,42	95,7	95,6	92,3
1/**II**	32,6	48,7	685,09	3,3	3,7	46,50	89,9	92,4	93,2
3	91,4	23,7	772,56	1,6	2,0	62,38	98,2	91,6	91,9
6	45,5	15,3	655,54	3,5	1,8	32,12	92,3	88,2	95,1
8	49,8	22,4	781,52	3,6	1,3	51,34	92,7	94,2	93,4
10	75,4	18,3	617,85	4,5	0,9	49,65	94,0	95,1	91,9

Note – I – filter with a fraction 1–3 mm of a zeolite, II – filter with a fraction 0,5–1 mm

Suggested physical, electrical, chemical and sorption technology gives an opportunity to treat sewage effectively, as far as electrical treatment before settler cause destruction of soluble contaminations and further flotation of stuck fallouts and p/p to the upper part of a thin-layer settler by gases of electrolysis and zeolite absorbs residual soluble and nonsoluble contaminations, that were not separated in a settler.

Conclusions

The study of filtrate treatment indicates that conduction of filtrate treatment by electrical, chemical and sorption technology increases its treatment efficiency from up to 89,9–98,2 %, ammonium nitrogen to 89,9–98,2 % and filtration by zeolite clynoptilolite increases it more 2÷4 %, that is proved by index COI, that is equal to 91,9–95,1 %, since concentration of organic and inorganic contaminations decreases.

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Богославец Н. М., Челядын Л. И., Медвидь М. И. **Физико-электрохимические аспекты технологии очистки инфильтрата полигона бытовых отходов**

Защита окружающей среды территорий полигонов твердых бытовых отходов (ТБО) от загрязнения включает и очистку инфильтратов. В инфильтратах свалок ТБО почти все ингредиенты превышают гигиенический норматив, однако наиболее опасным для водных ресурсов является содержание аммонийного азота, нитратов и органических соединений. Проведены исследования электросорбционной технологии очистки фильтрата свалок твердых бытовых отходов. Статический и динамический режим реализации обеих стадий технологии исследованы на модельных установках. Результаты исследований по очистке фильтрата по такой технологии указывают на ее перспективность, поскольку получено уменьшение показателя химического потребления кислорода в 334,3 мг/дм^3 и азота аммонийного – 36,0 мг/дм^3, а также по другим показателям, например, по нитритам – 6,8 мг/дм^3. В результате удалось добиться уменьшения химического потребления кислорода почти в два раза и снижения концентрации ионов аммония более чем в три раза.