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REDUCTION OF ENVIRONMENTAL HAZARD OF HUDROGEN SULFIDE EMISSION FROM SEWERAGE PIPELINES AND VISUAL POLLUTION, FORMED BY DEGASSING UNITS

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Abstract. At some sites of the sewage collector in Kharkov concentration of hydrogen sulfide in the underroof space exceeds in thousands of times daily average MPC. As a result the gaseous emissions from the sewage network in the city atmosphere the content of hydrogen sulfide in the atmosphere of residential development area may exceed the MPCd.a. The degasifier, installed above the sewage shaft efficiently rectifies gas releases. Design solutions are developed, which allow to harmonize degasifiers on sewerage nets with urban environment of different application.

Key words: sewerage pipelines, hydrogen sulfide, atmosphere, videoecology, degasifier

Introduction

The sewage disposal by the sewerage pipelines brings a range of risks for environmental safety of air, water and soil environments in settlements. Thus formation and emission of gas compounds from the sewer nets through the shafts and wells pollute the atmosphere in neighboring urban districts, as in these emissions concentration of series of the compounds mainly sulfur-containing – hydrogen sulfide, sulfur dioxide, mercaptan (alkyl sulphydrate), dimethyl sulphide (DMS), exceeds not only daily average MPC for residential areas, but also MPC for working ones. The highest rate of maximum permissible concentration (MPC) excess in gas release from the sewer nets is marked for hydrogen sulfide – highly toxic and chemically active compound of the second hazard category (MPC working area – 10, MPC daily average – 0,008 mg/m³). Besides, the concentration of hydrogen sulfide, its derivatives and oxidation products in operational environments of the concrete sewerage pipelines (fine water, underroof space, condensate water on the roof) activate biogenic sulfuric corrosion of the roof, that reduces operating life of these pipelines (from planned 50 to 10–15 years). [1–6]. Gravity sewerage pipeline is a particular biological contact "reactor", in which spontaneous chemical and microbiological processes take place. They in particular cause forming of gas compounds in sewage disposal, which are released in the atmosphere of the underroof space of gravity sewerage pipelines. These compounds partially dissolve in condensate water on the building vault or interact with concrete directly, or after microbiological transforms. But main volume of gas compounds accumulates in the underroof space (Table 1) and is released through open shafts and wells into urban atmosphere.

Table 1

Chemical compounds in the underroof space atmosphere of sewerage pipelines [6].

Sr. No.	Compound	Arrangement of concentration by volume
1	Carbon dioxide	0,2–1,2 %
2	Hydrocarbons and their chlorinated derivatives	
	a. Hydrocarbons, mainly aliphatic C6-C14, C8-C12 (benzines)	to 500 ppm
	b. Chlorinated derivatives of hydrocarbons, mainly trichloroethene, dichloride of etherin and carbon tetrachloride	10–100 ppm
3	Hydrogen sulfide	0,2–10 ppm
4	Odorous gases and vapors	
	a. Sulfides (mainly mercaptan, DMS, some ethyl mercaptan)	10–50 ppb
	b. Amines (mainly trimethylamine and dimethylamine, some diethylamine)	10–50 ppb
	c. Aldehyds (mainly butyl aldehyd)	10–100 ppb

Formation of hydrogen sulfide in the sewage disposal results from microbiological processes of disassimilation sulfate reduction (renovation of sulfates with the hydrogen sulfide emission), which obligate aerobic sulfate-reducing bacteria perform. The activity level of hydrogen sulfide formation and its emissions in the air of the pipeline depends on many factors: COD of sewage water, concentration ratio of sulfates and COD, temperature, pH and Eh of sewage water, flow turbulence and others.Thus the hydrogen sulfide concentration in the underroof space of different sections fluctuates very significantly even within 24 hours [7]. The processes of hydrogen sulfide emission through the sewer shafts into the urban environment and its dispersion are studied rather partially, but the particular calculations and measurements testify high ecological hazard of the process for the urban environment/

Providing ecological safety of sewerage pipelines running and protection of urban atmosphere from pollution of toxic gas compounds, released from sewerage pipelines, various engineering solutions are developed: suppression of hydrogen sulfide formation in sewage disposal, suppression of hydrogen sulfide elutriation from sewage disposal in the underroof space, clearing of gas releases. In Ukraine there is some experience of usage of gas-cleaning plants– PU "Kharkovvodokanal". On its basis such protective measure of urban atmosphere is recommended by regulatory documents of Ukraine – Ukrainian national construction regulation [8]. However, under installation among residential buildings, park areas, recreation areas, especially in city districts, which have historical value, such degasifiers form strong visual discomfort – videopollution. At present special attention is paid to the issues of ecological safety of visual environment all over the world. That is why without harmonization of degasifiers at sewerage pipelines with current built-up area, their usage in cities is appeared as environmentally hazardous.

The research objective is experimental estimation of environmental hazard of gas releases from sewerage pipelines of Kharkov for residential areas of the city, and also improvement of videoecological characteristics of degassing plants at sewerage nets.

Objects and research methods

Experimental researches were carried out at the sewerage pipelines nets of Kharkov. Measurements of hydrogen sulfide concentration in the atmosphere of underroof space were performed with three gas analyzers: UG-2, "Dozor", a mine interferometer ShI-11. The obtained data was applied for the calculation of the hydrogen sulfide concentration in the gaseous emission according to the method, developed in [9] and for calculation of its dispersion in the environment of the particular districts in Kharkov. The calculation of hydrogen sulfide dispersion was performed with the program "EOL +". OND-86 (National statutory document) "Calculation procedure of repugnant substances concentration in open air, contained in emissions of enterprises" is basically applied to the calculation.

Results and discussion

The chemical composition of the underroof space atmosphere of the sewerage pipelines, identified in different shafts in Kharkov, is presented in Table 2.

Table 2

The ecologically hazardous concentration of gas compounds in the underroof atmosphere of the sewerage pipelines at collector section in Kharkov

Measure-ment date	Mine No.	Concentration of gas compounds							
		SO_2, mg/m^3	Rate of MPC excess working area/ daily average, quantity of MPC	H_2S, mg/m^3	Rate of MPC excess working area/ daily average, quantity of MPC	CO, mg/m^3	Rate of MPC excess working area/ daily average, quantity of MPC	CO_2, volu-me %	CH_4, volu-me %
1	2	3	4	5	6	7	8	9	10
01.02.13	4	35	3,5/70	24,6	2,46/3075	0	–	0,75	0
28.03.13		35	3,5/70	42,7	4,27/5337	0	–	0,57	
15.05.13		35	3,5/70	137	13,7/17125	0	–	0,63	
04.07.13		35	3,5/70	126,6	12,6/15825	0	–	0,63	
08.08.13		35	3,5/70	188,1	18,8/23512	4,2	–	0,84	
01.02.13	6	35	3,5/70	9,5	-/1187	0	–	0,57	0,57
28.03.13		0	–	7,6	-/950	0	–	0,38	0,19
15.05.13		0	–	12,6	1,26/1575	0	–	0,42	0,21
04.07.13		0	–	11,6	1,16/1450	0	–	0,42	0,21
08.08.13		35	3,5/70	17,8	1,78/2225	0	–	0,63	0,42
01.02.13	8	0	–	4	-/500	0	–	0,2	0,2
28.03.13		0	–	6	-/750	0	–	0,2	0,4
15.05.13		0	–	6	-/750	0	–	0,2	0,4
04.07.13		0	–	12	1,2/1500	0	–	0,2	0,6
08.08.13		0	–	12	1,2/1500	0	–	0,4	0,4

1	2	3	4	5	6	7	8	9	10
01.02.13	10	35	3,5/70	10,4	0,4/1300	0	–	0,19	0
28.03.13		0	–	9,5	-/1188	0	–	0,57	0,38
15.05.13		0	–	8,4	-/1050	0	–	0,21	0,21
04.07.13		0	–	12,5	1,25/1563	0	–	0,62	0,42
08.08.13		35	3,5/70	20,9	2,9/2613	0	–	0,63	0,84
01.02.13	11	0	–	12	1,2/1500	0	–	0,2	0,2
28.03.13		0	–	18	1,8/2250	0	–	0,4	0,4
15.05.13		0	–	23	2,3/2875	0	–	0,4	0,4
04.07.13		0	–	24	2,4/3000	0	–	0,4	0,6
08.08.13		0	–	28	2,8/3500	0	–	0,4	0,6
01.02.13	12	35	3,5/70	52,1	5,21/6513	0	–	0,76	0,76
28.03.13		35	3,5/70	113,7	11,37/14213	3,9	–	0,76	0,57
15.05.13		35	3,5/70	36,9	3,69/4612,5	0	–	0,42	0,42
04.07.13		35	3,5/70	38	3,8/4750	0	–	0,63	0,21
08.08.13		35	3,5/70	250,8	25,08/31350	0	–	1,25	1,25

As it is seen from the table data, hydrogen sulfide has the highest excess of MPCworking area/daily average, in gas environment of the underroof space of sewerage pipelines (in tens/hundreds times). Shafts No.11 and 12, in gas environment of the underroof space, whose hydrogen sulfide concentration accesses 31350 MPC daily average, are extremely close to residential development (from 35 to 50 m). At the whole explored section of the collector, these mines are represented as the most ecologically hazardous for urban atmosphere and safety life-sustaining ability of population, living in the area of their location.

The calculation of gas emissions dispersion in the district, where the shaft No.11 is located, was performed. Daily average MPC was taken as a standard indicator. The map of hydrogen sulfide dispersion, released from the shaft No.11 in the atmosphere of the particular city district, is represented in Fig. 1.

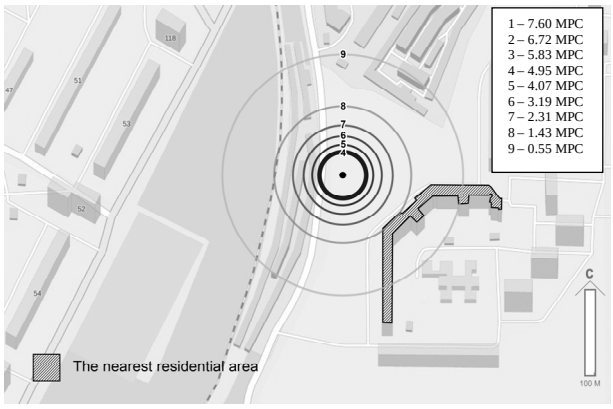


Fig. 1. The map of hydrogen sulfide dispersion, released from shaft No.11 (the Collector of KhTZ) in the city atmosphere

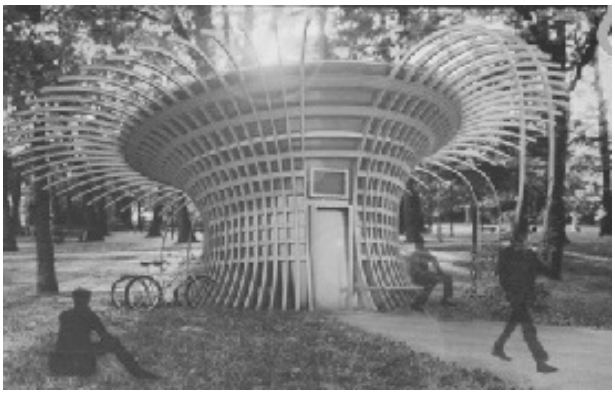
Calculation of hydrogen sulfide dispersion in the explored area has shown, that in the nearest point, located in residential construction (42 m), hydrogen sulfide concentration is equal to 0,0091 mg/m^3, that in 1,14 times excesses daily average MPC. The distance to ecologically safe area is 105 m [8, 9].

At the shaft No.12 in 2014 of PU "Kharkovvodokanal" a filter-degasifier was installed for protection of urban environment from ecologically hazardous emissions from sewerage pipelines (plant of dry chemical filtration), that provided the effect of hydrogen sulfide removal 98–100 %. This environmentally friendly mechanism can be referred to hardscaping, which pollute visual environment very much (Fig. 2). This plant, located among park area, creates strong visual discomfort and cause fair blames of the population.

Fig. 2. Current plants of dry chemical filtration among park areas

Without solution of videoecological problems, that are caused by such environmental constructions, their usage is represented as little long-term and ecologically hazardous. With interview method of the staff and students of the architectural faculty of KNUCA (250 people) grade estimation of degassing plants,

which are run at present (Fig. 2) and of designer solutions, recommended for these plants (Fig. 3) for harmonization with environment (Table 3), was performed. Estimation was performed in 10-grade scale as per 6 factors: outline, altitude restriction of a building, coloristic solutions, intension of environment, connection of artificial and natural environment, creation of enclosed space [10–13].



a)

b)

Fig. 3. Designer solutions, that are recommended for the degassing plants: a) park area, b) residential area

Table 3

The grade estimation of visual harmonization of a degassing plant with environment

Sr. No.	Outline	Altitude restriction of a building	Coloristic solutions	Intension of environment	Connection of artificial and natural environment	Creation of enclosed space
Current condition	3	8*	0	3**	0	9***
Project proposal	10	8	10	8	9	9

* Urrent solution unreasonably occupies a lot of space;

** Current solution supercharges environment, and project proposal vice-versa harmonizes a plant with environment, that decreases;

*** At places, where the given plant is, there are no wide gaps.

Physical form of the current plant got 23 grades, and project proposal concerning improvement of visual characteristics of the degassing plant got 54 grades. Proposed design solutions harmonize degassing plants with environment.

Conclusions

1. The performed measurements of hydrogen sulfide content in the atmosphere of the underroof space of the sewerage collector have shown, that at some sections it accesses 31350 of daily average MPC.
2. The performed calculations of hydrogen sulfide dispersion, released from the shafts, have shown, that the residential development is located in the section of above-level hydrogen sulfide content (daily average MPC). Ecologically safe section is located in the distance of 105–150 m from the shafts.
3. Installed above the shaft degasifier cleans effectively gas emissions from the shaft, however its visual characteristics form videopollution of the urban environment and affect adversely on psycho-physical condition of population.
4. Design solutions have been developed, which allow to harmonize degasifiers at sewerage nets with urban environment of different application.

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