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Research paper

Industrial Sewage Water Cleaning in Oil and Gas Mining Complexes

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Abstract

The state of existing water drainage cleaning systems of separated oil and gas mining complexes and observed it relying on the example of cleaning household sewage water with correspondence to ecological and sanitary requirements of water drainage systems has been analyzed. The methodology to clean household sewage water on separated units of oil and gas mining complexes has been produced. While reconstructing water drainage systems of these complexes, there has been offered to use the pre-cleaning of sewage water applying special filters and self-cleaning ability of soil that lets introduce the system of water drainage without direct throwing to water sources. There has been shown the example of calculation of filtration wells-absorbers with underground filtration fields and drawings of the general plan of sewerage cleaning systems, pre-cleaning filters and mixed underground filtration fields.

Key words: *the oil and gas mining complex, sewage water, filtration fields, filtration wells-absorbers, the pre-cleaning.*

1. Introduction

The development of technology to clean household sewage water and prepare oil industrial sewage water for its further utilization or usage in the process of fluids mining, in some extent, is actual for all oil and gas mining complexes (OGC).

The essential factor is huge volumes of sewage water that require cleaning on all OGC; that's why, it is important to choose technologies of cleaning and preparing sewage water with minimum material and energetic expenditure. It must effectively reduce the capacity of pollutants to needed level. The cleaning system must be simple and reliable in the machine form [1].

Engineering communications of OGC are a complicated complex, which includes water drainage cleaning systems, used for cleaning and utilizing sewage water.

The specification of OGC implies that oil and gas wells are situated beyond villages and for their serving and exploitation there is being used the whole complex of buildings where people live and work.

The production wastes of OGC are sewage water that consists of formation water and household drainage water.

Cleaning of sewage formation water is operated in the way of settling in open sediment bowls. Settled water is pumped to receiving barns of bush pump station. From receiving barns settled water is given to injection wells and pumped in oil and gas formation for its intensification.

Household sewage water goes from sanitary knots and shower industrial and non-industrial corps and constructions. Before throwing to water sources sewage water requires compound previous processing and decontamination to the level that provides the interests of sanitary and fishing economy usage of the last. According to the source [2], these claims are followed by pre-cleaning filters with extra setting of filtration fields.

There has been investigated the issue of prognostic rating the degree of ecological risk of physical factors influence on environment [3].

The source [4] states that soil and ecological monitoring is the observing system of soil conditions.

The cost of water drainage pipes made of different materials and huge expenditure to install water drainage nets have been scrutinized in the work. There has been explained projecting or revamping of water drainage nets taking into account modern materials [5, 15].

There has been shown the correlation between pipes materials and the choice of calculation tables of hydraulic counting in water drainage nets. There has been demonstrated the analysis of peculiarities of hydraulic calculation of sewerage pipelines made of polymeric materials [6].

There have been analyzed the aspects of hydraulic calculations of water drainage nets in modern conditions. There have been produced scientifically explained proposals as regards the choice of calculation tables of hydraulic counting in water drainage nets [7].

In the source [8] there is observed the increase of ecological safety of water drainage constructions. The investigation of general principles, methods and approaches of formalization of ecological and legal insight of ecological safety as a component of national safety in Ukraine are reflected in the scientists' works. Mentioned works [9, 10, 11] confirm the fact of permanent attention to the problem of cleaning sewage water, but the issue of choice of efficient and sanitary and ecologically profitable method leaves not to be fully solved.

The complex of sewerage system must guarantee sanitary comfort in canalized structures and non-barrier remove of sewage water in

conditions that exclude the danger of polluting and infecting the area.

While mounting or restoring water drainage constructions of sewage water cleaning it is required to use the ability of soil to recreate dangerous, in a hygienic sense, organic substances into inorganic ones, which are digested by plants, and introduce in a maximum way non-sewage systems of water drainage.

On oil and gas mining enterprises there are being used, in general, mechanical or physical and chemical methods of sewage water cleaning, in particular, using adsorbents [1, 15, 16].

The constructions of mechanical cleaning include: sand pickers, oil traps, settlers, flotation units, etc., on which there are being removed heavily dispersed impurities from sewage water. Mechanical cleaning is used as an individual method when water after this way is possible to be applied in technological processes of production.

It is feasible to intensify mechanical cleaning of sewage water immediately, using physical and chemical cleaning that implies adding chemical reagents in sewage water.

The work aim is to choose an optimal method of sewage water cleaning without adding any reagents in it, which will satisfy all hygienic norms, account the actuality of local cleaning of sewage water in detached producers and can be offered while projecting or reconstructing water drainage systems in OGC.

For it there have been formulated such tasks:

– to carry on the work analysis of available water drainage cleaning constructions of OGC;

– to observe advantages and technologies correspondence of sewage water cleaning to modern norms and standards;

– to produce and explain rational schemes of water drainage cleaning constructions reconstruction, considering local sanitary conditions and hygienic requirements.

2. Main body

A big part of issues is linked with the population's health and caused by available in water pathogenic microorganisms and chemical pollution. Sewage water is an appropriate environment for development of different microorganisms, including pathogenic, which are pathogens and distributors of infectious diseases. Non-cleaned sewage water filths natural habitat and, synchronously, creates conditions for emergence of the people's illnesses and epidemics.

To warn inappropriate influence of water on the population's health and sanitary level of life it is needed to protect surface and underground water supplying sources from pollution and also exploit rightly the systems of water supply and water drainage.

There is offered to use the methodology of household sewage water cleaning in separated structural units of oil and gas mining complexes that includes:

1.The explanation of general statements:
1.1. Climatological, geographical and geological characteristics of the object;
1.2. Output data on projection;
1.3. Fire-preventive acts, safety technics, labour protection and industrial sanitary.
2. The production of architectural and technological part. Water drainage and sewerage:
2.1. Architectural and building solutions;
2.2. The protection of constructions from corrosion;
2.3. The determination of sewage quantity in specialized buildings;
2.4. The determination of pollution concentration in sewage water;
2.5. The general plan.
3. Technological scheme description and calculation of sewerage cleaning constructions
3.1. The scheme of station work;
3.2. The calculation of receiving reservoir;
3.3. The classification of methods to clean sewage water biologically;
3.4. Cleaning methods on sill areas (soil sewage water);
3.5. The methods to clean sewage water with active mud;
3.6. Technological parameters of sewage water cleaning in aerotanks;
3.7. Interstitial aerators;
3.8. Compact sets of factory production;
3.10. A special construction;
3.11. The system of pre-cleaning of sewage water on sill areas;
3.12. The calculation of filters with changeable loading;
3.13. Constructions and work principles of pre-cleaning filters;
3.14. Filtration fields;
3.15. Sewage water cleaning in the soil from small objects;
3.16. The underground filtration fields calculation with drainage;
3.17. The calculation of wells-absorbers;
3.18. The choice of a grease picker.
4. Technical re-equipping the systems to pump household sewage water:
4.1. The calculation and project of pump set;
4.2. Hydraulic calculation of the system of sewage water supply;
4.3. General approaches to select the amount of water drainage;
4.3.The choice of water pipelines according to the material;
4.4. The determination of sewerage pump work parameters;
4.5. The tension loss calculation on the supply line.
5. Electrical equipment and automatics:
5.1. Electricity supply;
5.2. Electrical equipment and net distributors 0,4 kV;
5.3. Electricity accounting;
5.4. Protective acts.
6. The rate of influence on natural habitat.

For practical calculations there has been chosen an oil and gas mining object in eastern Ukraine, using which, it is necessary to make a reconstruction of sewerage cleaning constructions. The oil and gas mining complex is situated not far from the village of Vyasovo, Krasnokutskiy district, Kharkiv region.

Available constructions were introduced into exploitation in 1984 and need restoring because of their wear and tear and also inability to clean sewage water fully before its throwing to the surface water source. Sewerage cleaning constructions include:

- the receiving reservoir of filthy water;
- the compact set with an aerotank-settler;
- the productive construction with a setting to pre-clean;
- the water reservoir after pre-cleaning;
- mud areas – 2 pcs.;
- the contact reservoir;
- the reservoir of washing water.

The number of sewerage drains in OGC of Krasnokutskiy district, Kharkiv region is determined according to the maximum second expenditure of household water on record to "The norms of water supply and water drainage of Krasnokutskiy unit in mining of oil, gas and condensation" № 05-44-709/31 from 20.08.2015, which are defined according to the norms of water expenditure on workers and administrative and technical staff, shower needs, in the canteen and medical point (table 1).

The concentration of sewage water pollution on record to suspended substances for specialized constructions (workers) is defined with the help of the formula:

$$C_{en}^{p} = \frac{a \cdot 1000}{q}, \quad mg / l, \tag{1}$$

where $a = 65$ *g/day* – the number of polluting substances per one worker. As on the enterprise a person spends only 8 hours per day, then the number of polluting substances per one person is

$$a = 65\frac{7}{24} = 18{,}96 \text{ , g/day,} \quad (2)$$

$q = 25\,l$ / day – the individual norm for the water consumption of a person.

The concentration of sewage water pollution according to suspended substances for showers is:

$$C_{en}^{\partial} = \frac{a \cdot 1000}{q} \quad ,mg / l, \quad (3)$$

where *a = 65 g/day* – the amount of polluting substances per a worker. As on the object a person spends only 1 hour per day, then the number of polluting substances per one worker is $a = 65 \cdot 1/24 = 2{,}7$ g/day.

$q = 500\,l$ / day – the water consumption of one shower net.

Table 1: The quantity composition of sewage water

The name	The amount	The measurement units	The norm of water consumption, m^3	The sewage water loss,m^3/day
Workers	300	persons	0,025	7,5
ETW	58	persons	0,012	0,696
Showers	9	nets	0,5	4,5
The canteen	45	dishes	0,016	0,72
The medical point	4	visits	0,013	0,052
				13,468

There has been suggested the full biological cleaning in the recovery water drainage cleaning constructions. Sewage water contains pollution of mineral and organic origins. The effect of sewage water cleaning of OGC after each stage of cleaning in percentage is shown in table 1.

While throwing sewage water to water sources it is vital to provide the requirements of sanitary and eco-protective legal acts. Usually, sewage water having gone through net cleaning is given to the underground filtration fields in sand pickers and primary settlers (settling period is less than 30 min).

In this case, sewage water passes the full biological cleaning and pre-cleaning. There has been constructively produced and put forward a pre-cleaning filter with polystyrene loading (fig.1).

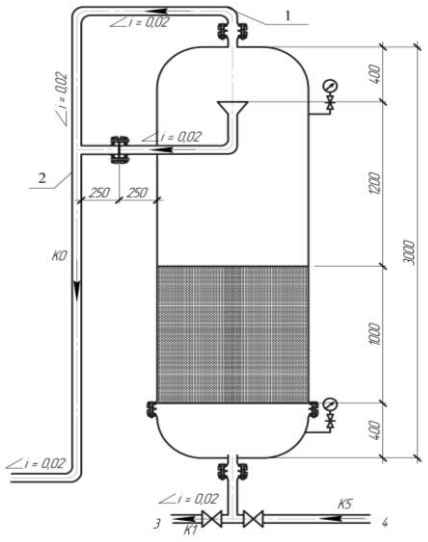

Fig. 1: The filter of pre-cleaning of sewage water:

1. – Emergency re-pouring. 2. – Cleaned water removing. 3. – Removal after polystyrene loading. 4. – Giving of sewage water to the pre-cleaning block.

Then sewage water after the pre-cleaning block is directed to the underground filtration field. While filtering pre-cleaning sewage water the loading on soil will be less and the longevity of filtration cycle will be bigger; so, such underground filtration fields will be able to receive cleaning water longer. 90()

The general plan of sewerage cleaning constructions of water drainage in OGC Stepove is shown on fig. 2.

The pre-cleaning of sewage water in natural conditions on the underground filtration fields constitutes an eco-friendly technology because of the absence of reagents for technological processes and reliability provision of constructions in sanitary and hygienic point of view.

Table 2: The effect of sewage water cleaning after each stage of cleaning in percentage

Pollution	The effect of cleaning %			
	The aerotank	The settler	The pre-cleaning block	The filtration fields
Suspended substances	70	40	35	95
BOCfull of unlit fluid	80	25	0,05	95
BOCfull of lit fluid	80	25	0,05	95
Ammonium salts nitrogen	80	60	20	95
Phosphates	80	60	20	95
Detergents	80	60	20	95
Chlorides	80	60	20	95
Surfactants	80	60	20	95

Other privileges of this technology are such: exploitation primitiveness, small energy expenditure, little amount of serving staff and work dependability.

To solve this issue there were carried on searching works, found free piece of land with weakly expressed relief and done geological excavations.

The list of geological data is such: soil is light loam; the depth of groundwater settling is less than 2 m; groundwater is not aggressive.

As seen, local soils (loam) have reduced filtration ability, that's why, there is proposed a system with artificial fields of underground filtration where filtration environment constitutes artificially poured sand monolith. Exactly in the upper soil layer with adherence to prosperous oxygen regime there are existing intensive processes of pre-cleaning of sewage water from organic pollution.

Simultaneously with physical and mechanical processes in soils, there are operating biochemical ones. We allocate:

a) individual chemical processes linked with acidification of organic substances in sewage water with air oxygen that is available in soils, and also processes connected with chemical collaboration of substances of organic and mineral origins with soil particles;

b) biochemical ones – as a cooperation result of microorganisms, which live in sewage water and soil.

The cross section of combined construction with the underground filtration fields is shown on fig. 3.

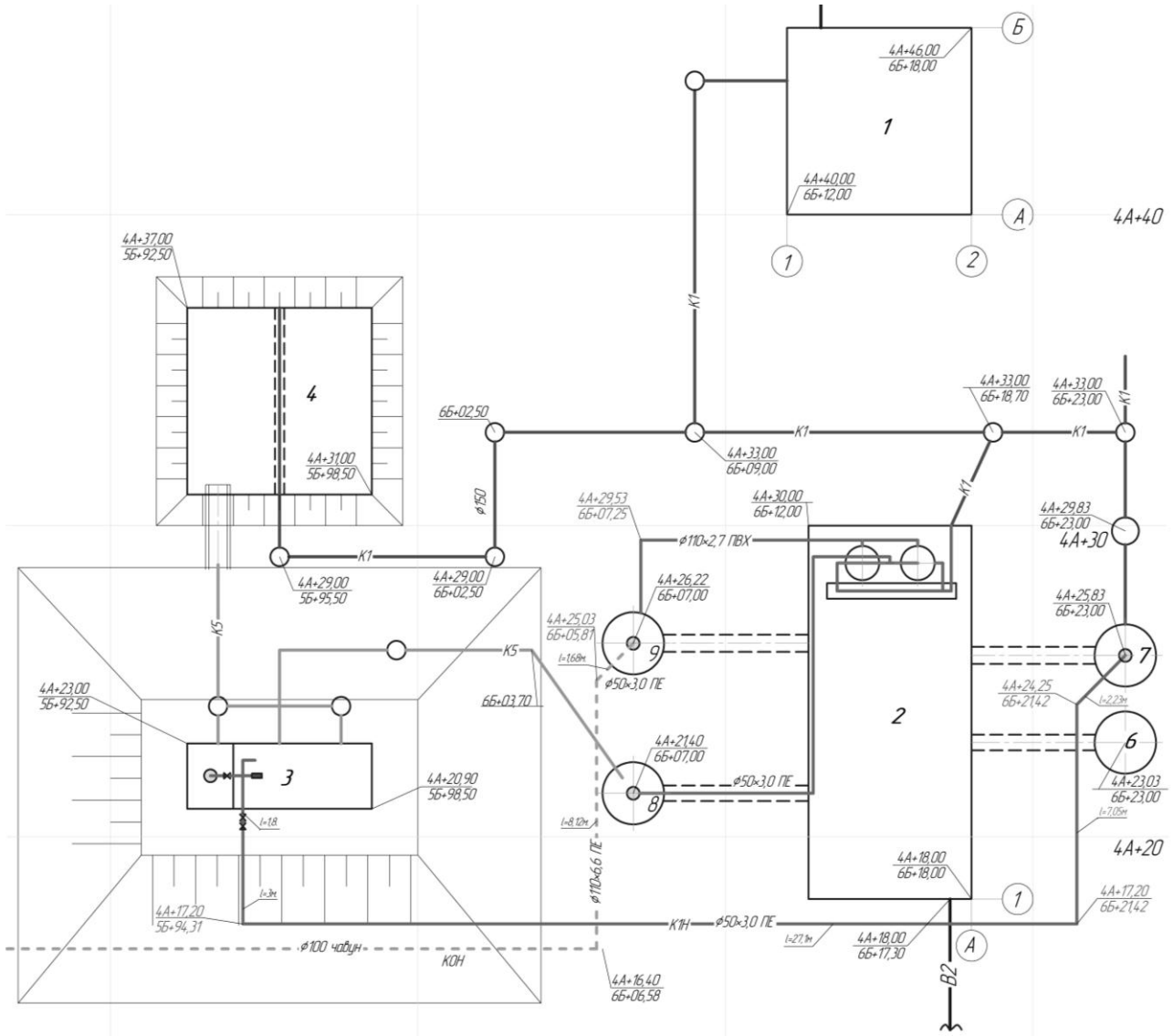

Fig. 2: The general plan of sewerage cleaning constructions of water drainage in OGC Stepove

1. – The productive construction; 2. – Setting of sewage water pre-cleaning; 3. – The compact set; 4. – Mud area; 5. – The contact reservoir; 6. – The reservoir of washing water; 7. – The receiving reservoir of filthy water.

K-1 – household sewage water; K-5 – cleaned sewage water; B-1 – household water pipeline;

Altogether, there have been offered eight stages so as to build filtration fields: digging the pit; drilling filtration wells with the diameter of 800 mm; pouring the rubble layer with fraction of 10-50 mm with the thickness of 250 mm from the well top; pouring the rubble layer with fraction of 2-10 mm with the thickness of 250 mm; pouring the gravel layer with the thickness of 500 mm; mounting the irrigation systems; handle sand pouring of pipes with sand with the thickness of 350 mm from the pipe top; filling with local soil layer and setting the heaps. The calculation of filtration fields is made according to permitted loading of sewage water on irrigation pipes (qday=0,025 $m^3/(m^2 \cdot day)$) accounting the filtration ability of soils. The average daily expenditure of sewage water per one filtration field with the drainage system is Q=10m^3/day [14].

As the average annual amount of precipitation is 550 mm, therefore, the loading on irrigation pipes is decreased. Let us take the coefficient of loading decrease as K_1 =0,9. Because there is offered heavily grained dripping, the loading on irrigation pipes of filtration fields we accept accounting the coefficient K_2=1,2. K_3 – is the coefficient that is up to the exploitation regime of fields, we accept as K_3=1,2. Let us define the length of irrigation pipes per each underground filtration field, m:

$$L = \frac{Q}{q_{\text{day}} k_1 k_2 k_3} = \frac{10}{0,025 \cdot 0,9 \cdot 1,2 \cdot 1,2} = 308,0 \qquad (4)$$

We accept 3 filtration fields and the line scheme of irrigation system. The drainage length is l_1=*10 m.*, the distance between parallel drainage is 1 m., as, additionally, there have been done pits with the depth of 1,2 m.

The irrigation net is projected with drainage plastic corrugated pipes with the diameter of 110-160 mm [5, 6, 7].

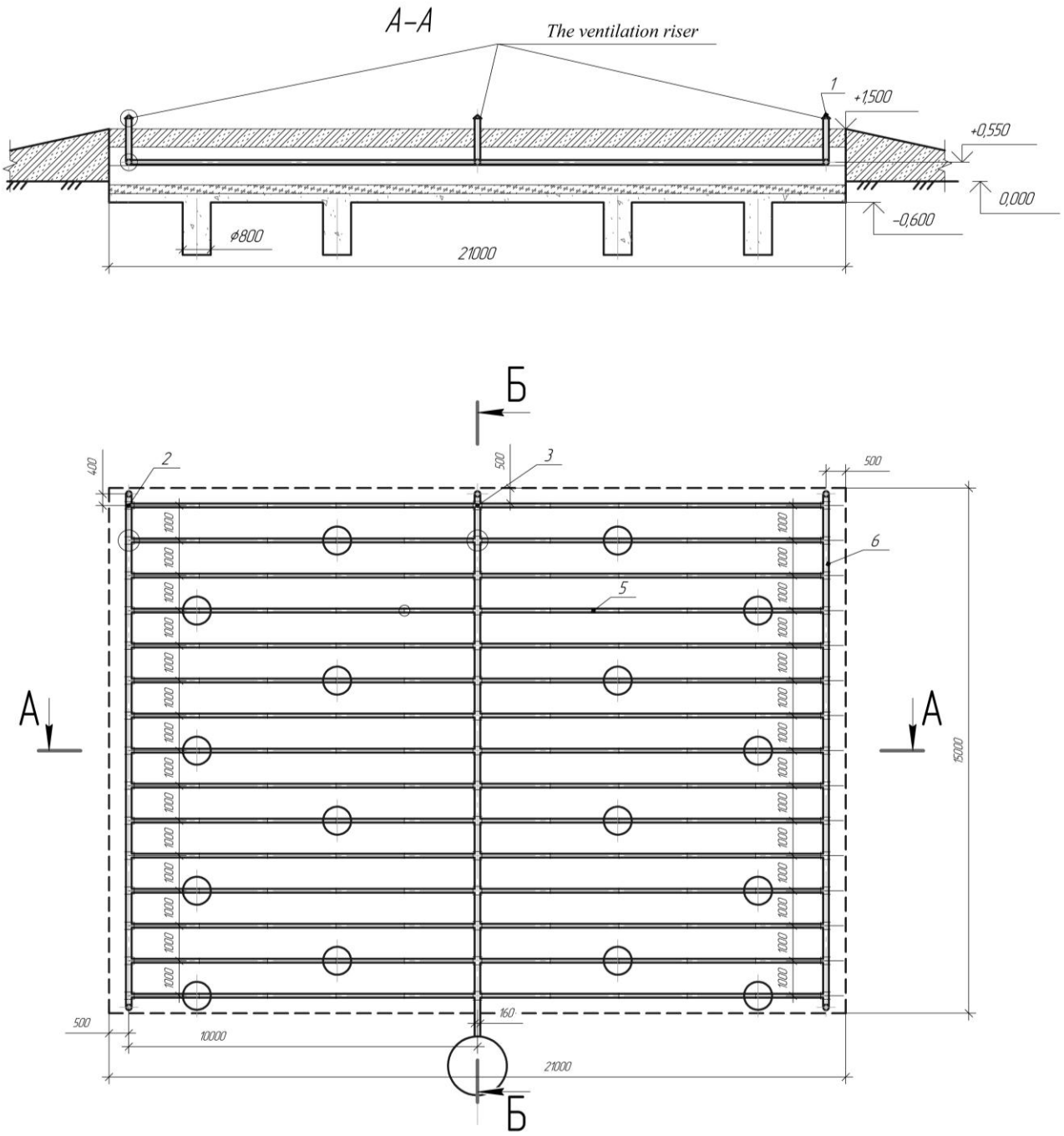

Fig. 3: The section of combined construction of filtration wells and one underground filtration field.
1. – The ventilation riser. 2. – The unpressurised PVC pipe, d 160 mm. 3. – The unpressurised PVC pipe, d 110 mm.

The distance between ground surface and the pipe shell is taken as 0,5 m, the inclination is 0,02.

Plastic pipes are put with propyls (the width of which is 15 mm) on the half of the pipe diameter, which are made after 200 mm.

To provide optimal work of filtration fields at the pipes ends of the irrigation system there are being projected ventilation risers with the diameter of 110 mm with a fluxer at the end (its height is 0,7 m under ground surface). The drains amount is defined according to the formula, pcs:

$$n_{\text{dr}} = \frac{L}{l_1} = \frac{308}{10} = 11 \quad (5)$$

The square of one underground filtration field is:

F=10·30·1=300 m^2 = 0,03 ha

The general square of all underground filtration fields is:

F_1=0,03·3·1,2 = 0,108 ha

To clean sewage water efficiently and fully we set the row of filtration wells-absorbers under filtration fields. Calculations are made, accounting the possibility to use technical equipment of reconstruction object, natural conditions and sanitary and hygienic requirements.

Let us define the filtration square of the well shell:

$$F_{well} = \pi d_{well}\,(0{,}25 d_{well} + L_n) = 3{,}14 \cdot 0{,}8(0{,}25 \cdot 0{,}8 + 2{,}5) = 6{,}78 \text{m}^3 \quad (6)$$

The bandwidth of one filtration well is:

$$Q_k = F_{well} \cdot q_l = 6{,}78 \cdot 0{,}1 = 0{,}678 \text{ m}^3 \quad (7)$$

where q_l is permitted loading of sewage water.

On one underground filtration field there is 10 m^3/day of sewage water, one filtration well-absorber can let 0,678 m^3/day of sewage water. The necessary number of wells-absorbers for underground filtration fields is, pcs:

$$n_{\text{k}} = \frac{Q}{Q_{\text{k}}} = \frac{10}{0,678} = 15 \quad (8)$$

So, take 15 pieces of filtration wells.

That's why, for projecting we take a combined construction that advances the sewage water cleaning on filtration fields by filtration wells (fig. 3). There have been suggested two constructing queues of filtration fields with wells-absorbers.

Therefore, projected plan of combined constructions of underground filtration fields lets carry out the pre-cleaning of sewage water on them to limited permitted concentrations.

But for guarantee to stick to cleaning requirement, not exceeding limited permitted concentrations of OGC, all the system of water drainage has to function reliably. To provide ecological and sanitary and hygienic requirements to drinking water and sewage one of OGC is a basic of rational usage and water resources protection.

3. Conclusions

As a result of performed studies, there has been solved an important scientific task, which implies technical re-equipping of water drainage cleaning constructions of OGC that prevents dangerous impact on natural habitat and dependable sanitary and technical effect; it means:

1. To increase the efficiency of full biological cleaning and intensify work of water drainage cleaning constructions there has been offered a combined method of full biological cleaning in sewage water, which includes filtration wells and filtration fields.

2. There have been produced practical recommendations directly for water drainage cleaning constructions of OGC Stepove of Krasnokutskiy district, Kharkiv region with the productivity of 30 m^3/day. There has been determined the number of filtration wells (15 pcs) and a combined underground filtration field with the size of rectangular card 15 m Ч 21 m.

3. To diminish the negative effect on environment there have been put forward poured combined constructions of underground filtration fields of sewage water with wells-absorbers as pre-cleaning constructions.

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