*Science and Innovation. 2014. V. 10. No. 1. P. 30—40*

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# METHOD OF SEWAGE SLUDGE DEWATERING WITH THE USE OF GEOTUBE TECHNIQUE ELEMENTS AT THE BORTNICHY AERATION STATION

*The research deals with major environmental and social problem, dehydration of sewage sludge with the help of GeoTube technique elements. Dehydration process of sludge of different origin has been developed. A pilot installation has been designed and produced. This installation is realized as a filter module placed in the tank of Bortnichy's sewage treatment plant where the aerobically-stabilized sludge treated with flocculant Praestol 859 BS and water from filtration fields are delivered to. It can be used for reduction of workload on sludge fields, as well as for purification of supernatant water and dewatering of accumulated sludge.*

*Key words: waste water, rainfall, technology, dewatering, geotextile, sludge fields.*

Collection and disposal of sludge obtained during the purification of waste water of different nature and origin, including the municipal wastewater, usually require a lot of money, human resources, high-tech equipment and so on. At the same time, this sludge is a huge and virtually unused source which with the help of theoretically substantiated approach can provide a basis for generating the electricity and heat energy, as well as for producing the organic and mineral fertilizers. Sludge treatment consists of the following stages: stabilization, conditioning, dewatering, decontamination, and processing. The sludge problem has been studied in many researches [1—17].

The sludge generated at wastewater treatment plants of urban settlements is characterized by low filtration loss which complicates its intense dehydration. To improve the filtration loss the sludge structure should be changed to stimulate the consolidation of solid particles so that the surface of dispersed phase and the dispersed medium decreases and, consequently, so does the surface energy of water with solid particles. The changes in sludge structure are associated with quantitative redistribution of forms of water bounds towards increasing content of the free water at the expense of the bounded one. This change in the sludge structure gives a possibility to dehydrate it more deeply and rapidly.

The first step in process flow design of sludge treatment is compaction (densification) aimed at removing the free water. On average, 60 % of free water is removed at this stage, with the sludge mass decreasing 2.5 times. To implement this stage on practice there are used the gravity, the flotation, the centrifugal, the vibratory, and the filtration techniques, as well as their combinations [1]. The gravitational compression which is the simplest and the most economical way, applies to the excess sludge and the fermented sludge. The process is carried out in vertical or radial ponds during 4—24 hours, with the compacted sludge having humidity of 85—97 %. In some cases, the process of consolidation is intensified by coagulation, agitation, and simultaneous densification of various kinds of sludge by heating them up to 80—90 °C. The sludge compaction by flotation (mainly, pressure flotation) is a result of attachment of particles of activated sludge to air bubbles; having sticked to each other they are floating to the surface. The flotation process is faster than the gravitational one and is controllable.

To intensify the consolidation the process flow design often includes the stage of sludge conditioning. Its essence is reduced to changing the structure and form of water bounds. As a result, the sludge better releases water, which entails more intense dehydration. Conditioning is carried out by both the reagent and the reagent-free methods. In the first case, the suspension is treated with reagents possessing the coagulating or flocculating properties which provide the consolidation of fine and colloidal particles, the formation of large flakes and their rapid precipitation. The less common methods are heating, freezing/thawing, electrocoagulation, and exposure to radiation. They also efficiently contribute to further sludge dewatering.

Today, the most common method is sludge dewatering with the use of special equipment, such as: vacuum filters, centrifuges, filter presses, and vibration presses. The mostly often used are centrifuges and vacuum filters which can handle almost all the types of sludge after its initial conditioning by inorganic coagulants. Another important advantage of this equipment is sludge treatment without extraction of sand and spread of stench. At the same time, it is necessary to keep in mind that for the normal operation of vacuum filters the ancillary equipment, such as vacuum pumps, blowers, receivers, and centrifugal pumps, is required. A quite long operational use of such devices has revealed the following shortcomings: the complexity and high cost of maintenance, significant reagent consumption (up to 20 % of weight of sludge dry matter), and low specific power [8]. A more advanced technology is dewatering with the use of scroll centrifuges, as well as belt, frame, and chamber filter presses. The apparent progress is application of synthetic organic flocculants for sludge conditioning [9]. The generally recognized advantage of the mechanical dewatering is a quick filter cycle with a significant decrease in the sludge volume due to low initial moisture content of the resulting cake. On the other hand, the typical mobile systems for mechanical dehydration are characterized by low capacity with respect to large-scale utilization of significant amount of accumulated sludge which requires large quantity of relevant equipment. Usually, it is an impractical step from the economical and technological standpoint. In addition, frequent downtime can happen because of abrasive wear of moving parts. Therefore, continuous monitoring of process and ongoing changes of operational modes are required when changing the composition and characteristics of the source material. In its turn, the dewatered sludge should be immediately removed for safe storage or further processing, especially, in the view of the fact that its storage in open areas leads to rehydration as a result of precipitation impact.

The comparison of existing approaches to mechanical sludge dewatering indicates that each of the above methods has both the advantages and the disadvantages. When choosing any of these approaches it is necessary to take into account the whole process flow design of sludge treatment and utilization, as well as the operating modes of wastewater treatment plants. If sludge fermented in thermophilic conditions is dehydrated for its further utilization as fertilizer, it is advisable to use the centrifuges or the belt filter presses with flocculants. This equipment is also effective in treatment plants having a capacity of up to 100 000 $m^3$/day with further composting. When the mud is to be burnt, before dehydration it is recommended to use the frame or chamber filter presses.

Depending on the degree of involvement of natural processes the sludge draining beds can be divided into two main categories: the in vivo dehydration and the heavy dehydration. The first option means the placement of sludge under conditions of natural processes of evaporation and decantation, i.e. the sludge is located at sites with surface water drainage areas or on compacting sites. The second option means the use of specially constructed sites with artificial drainage, heating, option of creating vacuum in the drainage system, and with artificial water-resistant coating. No permanent criteria regulating the option choice exist. It is defined by local factors: climatic conditions, capacity of treatment facilities, their financial situation, and so on. Dimensions of site and number of sludge releases are determined depending on moisture content in sludge, spill range, and method of disposal after drying.

The beds for intense sludge drying are divided into the traditional sites (with vertical and horizontal drainage) and the improved ones (with vacuum option in the drainage system and artificial waterproof coating with air blowing). Thirdly, there are the cascade beds with natural foundation and surface water drainage through monk wells at the ends of the structure. They belong to the transition sludge beds used to obtain a pure filtrate and to speed up dehydration. Obviously, sludge dewatering on the sludge beds is associated with secondary pollution and requires significant capital expenditures and large areas for placement. For the large cities with good infrastructure the use of natural processes of dehydration is deemed unsustainable from both economical and environmental standpoints. To effectively address the problem of sludge treatment it is necessary to implement the innovative advanced methods.

The gravitational dehydration is the easiest and cheapest way. The dehydrated sludge is delivered to the sludge beds (because there are no methods for full utilization of sludge) equipped with drainage system. The releasing free water returns to the treatment plant, with the sludge getting more transportable and processable. However, this method does not provide a significant decrease in water content and the sewer waters contain significant amount of suspended solids, which is an additional burden on the purification system and leads to secondary sludging of waste ponds.

The situation with implementation of Geotube gravitational technology is completely different: this technique allows us to quickly dehydrate large volumes of wastes, even much larger for the same period of time as compared with any of the known mechanical methods (Fig. 1). The capacity of dehydrating complex always corresponds to the power of pumping equipment, with the water released in this process containing a small amount of mechanical suspended particles. The working containers are made of geo-textile filter material with high durability. The unique filtration performance and retaining capacity of the containers provide an unprecedented output without significant capital expenditures. The above mentioned technique was developed by the Dutch company TenCate Geosynthetics, in the 1980's. Initially, it was focused mainly on the construction of hydraulic structures, dams, and protective fence. Later, it was extended to dehydration of various objects [18—25].

For dewatering the large volumes of sludge (during purification of the pond sediment, sludge beds, ponds, lakes, etc.) the special containers are used. They have a capacity from 28 to 1500 $m^3$ and are made of geotextile filter material. Dehydration process occurs by feeding the sludge treated with a solution of flocculant to the container and then, by filtering it through the filter material. The containers are installed on open areas and equipped with filtrate drainage system. After their complete filling the sludge is subject to additional dewatering in natural conditions, either by drying (in the summer) or by freezing (in the winter). The dehydrated sludge from container is delivered for utilization by one of the known methods (e.g., gasification). The containers are for single use only. The Geotube dewatering technique has some undeniable advantages:

- A dramatic decrease in the area of facilities, as compared with the use of sludge beds, and possible multilayer placement of Geotube containers, which minimizes the cost of drainage site and allows us to place a high-efficient processing facility on limited space;

- Rapid construction and elimination of facilities;
- Permanent compliance of efficiency of dewatering complex with efficiency of hydraulic earth-moving facilities;
- Insuspectability to abrasion and particle size of mechanical impurities in the pulp fed for dehydration;
- Possible dehydration on the next location of dehydrated material;
- No sophisticated equipment; easy control of filling, removal, and disposal of sludge;
- Low financial costs;
- Fabric property to quickly pass water and to retain solids;
- No expenses on spare parts and filter fabric during operation;
- Self-cost of dewatering in the Geotube containers is lower by 20—30 % as compared with that in the hardware system;
- Neither overdose / underdose of conditioning reagent (flocculant) nor disruptions in the pulp supply do affect significantly the ultimate dehydration efficiency because of sufficient time of sludge residence in the container;
- In-process installation and dismantling of industrial infrastructure of any capacity;
- Planned site with optional infrastructure, inasmuch as the sludge draining bed itself can be used as a production site;
- Simplicity and aesthetics of the process; no complex elements;
- Continuous mode of dehydration process until the free water is completely released with biostabilization and geoconsolidation of solid phase;
- Protection of dehydrated sludge from wind and water erosion;
- Low power consumption of the process.

Geotube technique is a proven economic method for addressing the problems related to the consolidation of shores and construction of offshore structures, building of sandy dune body, creation of wetlands and other natural landscapes, as well as for the construction of malls, dams, breakwaters, and submerged structures. Geotube technique has been successfully used to prevent damage from storms, to ensure environmental protection, to construct various hydrostructures, and even to build the man-made islands. Geotube has been successfully implemented in the CIS countries. *Admir Eurasia* Inc. has designed and provided technical assistance of large-scale project dealing with the use of Geotube geotextile containers for cleaning of the Komsomolske Lake having an area of 30 hectares, in Nizhnevartovsk, Russian Federation. The project was aimed at improving the environmental conditions of the lake bottom by cleaning and deepening it with the help of Geotube dewatering technique. The works were carried out in several stages. At the first stage, the production site was prepared where the containers for filtering were placed. At the second stage, the first layer containers were placed and the main and distributing pipelines were installed to provide supply of pulp from the dredger to the container. When the first layer containers had been filled, the second layer was arranged. This approach allowed the contractor to reduce the area under process equipment by about 80%. The use of technique made it possible to dewater the bottom sludge almost at the place of its occurrence without special transportation means and infrastructure facilities for mechanical dehydration and to transform the muddy swamp into a recreation zone [25].

***Fig. 1.*** Cascade-like placement of Geotube containers

The operation of municipal wastewater treatment plants is not limited to wastewater treatment. An important prerequisite for their effective operation is processing and disposal of sludge generated during the cleaning process. For the metropolises it is impractical to use mechanical sludge dewatering due to the problems outlined above. One can see it from the example of two landfills in St. Petersburg with a total area of 118.7 ha (*Severnyi* and *Volkhonka 2*) which accumulated 4.9 million m$^3$ sludge i.e. were filled up to the critical limit [12]. Having compared the feasibility studies for numerous proposals on sludge treatment the city gave preference to the static dewatering of sludge in geotubes. At present, 7.9 % of sludge stockpiled at the Severnyi landfill has been treated by this technique. Till 2016, the entire accumulated sludge will be processed in the same way, which means that the environmental hazard caused by this sludge will be neutralized.

The Bortnychi aeration station (BAS) is the only wastewater treatment plant in Kyiv and the surrounding towns and villages of Kyiv Oblast (Vyshgorod, Irpin, Vyshneve, Bortnychi, Gnidyn, Schaslyve, Chabany, Kotsiubynske, Pukhivka, Novosilky, Sophiivska Borschahivka, and Petropavlivska Borschahivka). It was designed and built in the 1960s and currently it is operated in the face of accident risk. One of the reasons for the disastrous situation at the station is huge amount of sludge in the silt detention pond loaded over the critical limits (according to various estimates, the load is 10—14 million tons as compared with a little bit more than 3 million tons of designed capacity). This enormous mass is restrained by the barrage dams whose height is permanently growing because of approximately 10 000 m$^3$ of sludge supplied daily from the WWTP. The periodical local breaks of these dams are a warning of danger of irreparable situation. Given the elevation difference of 46 m between the silt detention ponds and the Dnieper River, it is hard to imagine the negative consequences of such a man-made accident. The only reasonable way of prevention is immediate sludge treatment. The first step in this direction is to develop new technological solutions of sludge dewatering directly at the BAS station in order to decrease the sludge volume and thereby to reduce daily load or to relieve the silt detention ponds and to further utilize the dehydrated sludge (e.g. by gasification technique).

In view of the above it seems to be appropriate to use under these conditions and at this point to test efficiency of GeoTube elements. According to the estimates, it has undeniable advantages as compared with the other dewatering methods mentioned above. To understand the situation with the silt detention ponds we have selected the samples of sludge from the pond no.1 at a distance of 20—25 m from the dam. The samples have been taken by a bathometer from a depth of 1, 2, 3, and 4 m and analyzed (measurement of the dry matter and the water content) both in the BAS laboratory and in the laboratory of Institute of Bioorganic Chemistry and Petrochemistry of NASU.

The results obtained are identical and showed in Table 1. Thus, the average moisture content in the selected sludge samples is 95.6 %. It corresponds to about 11.5—13.4 million m$^3$ of water and 0.5—0.6 million m$^3$ of dry matter. In our opinion, in general, the values reflect the real situation, insofar as there is no reason to expect any sharp fluctuations in the content of solids and water in other silt detention ponds. This means that if the mirror level of silt detention ponds drops by the 1—2 m due to removing the excess water, it will definitely mitigate the current overload.

For getting the necessary data for further work we have carried out the following activities:

- The degree of dewatering of sludge taken from the BAS detention ponds has been determined;
- The laboratory facilities for studying sludge dewatering under static conditions with the use of geotextile material made by Rivne nonwovens plant have been established according to the scheme: sludge inside the container – filtrate from the container;
- The dynamics of dewatering of BAS raw sludge treated with flocculant Praestol 859 BS with

the use of geocontainer have been studied;
- The dynamics of dewatering of BAS raw sludge treated with flocculant Praestol 859 BS have been studied with specifying the maximum efficiency (capacity) of geocontainer;
- The dependence of the dynamics of dewatering of BAS raw sludge in geocontainer on concentration of flocculant Praestol 859 BS has been established;
- The process of dewatering of digested sludge of BAS in geocontainer has been studied with the use of iron-titan containing coagulant;
- Feasibility of the use of geotextile containers for conditioning and sludge compaction has been studied according to the scheme: sludge outside the container → filtrate to the container;
- A laboratory installation working under the scheme: sludge outside the container → filtrate to the container with a filter cloth regeneration system has been developed and tested.

To confirm the experimental results obtained in the laboratory of the Institute and at the BAS with the use of geocontainers both for the direct and the inverse filtering it is necessary to confirm the feasibility of dynamic sludge dewatering with respect to the real object in real time. To this end, we have developed a pilot installation, the filter module of which is showed on Fig. 2.

The study has been conducted in accordance with flow design showed on Fig. 3. The filter module is placed in the tank to which an aerobically stabilized sludge treated by flocculant Praestol 859 BS with the supernatant water from the draining beds in a ratio of about 1:1 is fed (hereinafter referred to as "the tank") (Fig. 4). The working condition of the filter module is total immersion (Fig. 5).

The pilot facility includes:
- A filter module consisting of 12 sections (or elements) where there is placed geotextile having the total area of 6 m$^2$ (the total internal volume of the module is 180 dm$^3$);
- A regeneration unit of the filter module, which provides air dosage inside the module under certain pressure from the compressor;
- A filtrate drainage unit consisting of a centrifugal pump and a filtrate meter;
- An air supply and filtrate drainage line and a unit for distribution of air and filtrate among the sections of filter module.

***Fig. 2.*** Picture of the pilot facility filter module

The pilot facility for sludge dewatering under dynamic conditions has been tested in the autumn-winter period. During the experiment, filtrate was taken periodically, its amount was measured by the meter and the samples were taken for analysis as showed in Table 2.

At the end of the experiment, at a pressure of 2 atm., air was supplied by short pulses to all the sections of the module. This was enough for full regeneration of geotextile and recovery of its filter properties. The facility had been working in the shop almost three months without losing its

*Table 1*

**Sludge of the BAS draining bed taken at different depth**

| Depth of sampling, m | Dry matter, % | Water content, % |
|---|---|---|
| 1.0 | 4.0 | 96.0 |
| 2.0 | 3.3 | 96.7 |
| 3.0 | 4.0 | 96.0 |
| 4.0 | 6.0 | 94.0 |

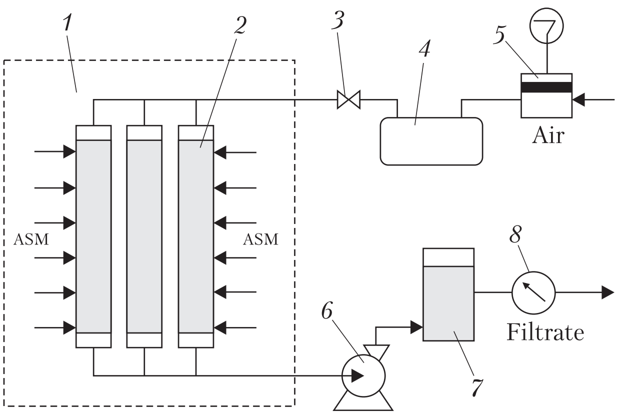



***Fig. 3.*** Flow design of facility for dewatering of aerobically stabilized sludge mixtures treated with flocculants Praestol 859 BS, and return water from sludge draining bed (hereinafter referred to as «ASM»): *1* — ASM mixture; *2* — filter module; *3* — valve; *4* — receiver; *5* — compressor; *6* — pump; *7* — buffer capacity; and *8* — meter

***Fig. 4.*** Location of the pilot facility filter module in the tank to which aerobically stabilized treated sludge and supernatant water from draining beds are supplied

efficiency with respect to purified water (~50 $dm^3/m^2 \cdot h$).

Fig. 6 and 7 show the filter module before and after regeneration, respectively; Fig. 8 illustrates the process of filtrate drainage.

The results obtained with the help of pilot facility indicate a real opportunity to improve the situation for the BAS, which is critical primarily because of excessive overflow of sludge draining beds. To solve the problem it is necessary either to terminate the station operation, or to allocate land for construction of new sludge beds, or to totally release the existing ones from the accumulated sludge. It is clear that the first option has no prospects. Almost the same situation exists with the allocation of additional space: it is unavailable. The third option is as real as its practical implementation is possible, in our view, only through the use of GeoTube technique, especially in view of experience of the sewage treatment plant in St. Petersburg (Russia) and in Chisinau (Moldova), as reported above.

The comprehensive study of situation has led to the conclusion that it is possible to place the GeoTube containers directly on the sites, under certain conditions. For example, let us consider a container with the following dimensions, in meters: height is 2.6, width is 12, and length is 60. Thus, the container can hold 1500 $m^3$ of sludge, in average. If the volume of filtered water is 75—80 % the container of this size can bear 7500—9500 $m^3$ of sludge (let us take 8500 $m^3$ for the calculation). The area of absorption field is 200 000 $m^2$, and the

*Table 2*

**Characteristics of the filtrate obtained under dynamical conditions with the use of pilot facility**

| Sample | Chemical oxygen demand, mg $O_2/dm^3$ | Dry matter, $mg/dm^3$ | Suspended particles, $mg/dm^3$ |
|---|---|---|---|
| Untreated sludge | 9400 | 10500 | 9250 |
| No. 1 (1 hour) | 980 | 1020 | 455 |
| No. 2 (2 hours) | 480 | 650 | 280 |
| No. 3 (3 hours) | 300 | 430 | 100 |
| No. 4 (4 hours) | 240 | 745 | 42 |
| No. 5 (5 hours) | 240 | 675 | 30 |

volume with an average depth of 5 m is 1 000 000 m$^3$. This means that one filed contains 1 000 000 m$^3$ of sludge. To pump this amount to the geocontainers it is necessary to have 125 containers. If the containers are located each on other, in such a way as 6 containers are located in line along the field's width, and, for example, there are 11 lines, then 125 containers can be arranged in two layers only. The total height of them will be a little bit more than 5 meters. In this case, about 50 000—55 000 m$^2$ of the total field's area of 200 000 m$^2$, i.e. a little bit more than a quarter, will be involved. This is an acceptable value given the prospect of release of 700 000—750 000 m$^3$ of field's volume for future works. This is an example of possible application of the classical GeoTube technique, i.e. the implementation of option when the sludge is loaded into geocontainer, with the water being filtered through geotextile out the container. Naturally, such a scheme requires a drainage system that would ensure the drainage of filtered water with further return of this water to the beginning of the process of biological wastewater treatment.

Degrading the existing mirror level of the sludge draining beds based on the experience of operating the pilot facility described above can be an alternative solution which, in our opinion, also can significantly mitigate the critical situation. This proposal is reduced to placing the special filter modules connected to the air supply system for the regeneration of filter cloth and suction of filtrate from the filter elements inside the accumulated sludge. Like in the first case the filtrate formed has to return through the existing channels to the beginning of the process of biological wastewater treatment. This system works very effectively and does not require any sophisticated equipment. It is easy to maintain, can be easily mounted in the workplace and dismantled. For preliminary estimates let us assume that the area of filter cloth (the working part of the filter module) totals 1500 m$^2$. Then, proceeding from the capacity of the pilot facility (1.2 m$^3$ daily/m$^2$) the industrial facility is capable of producing up to 1800 m$^3$ of filtrate daily or 540 000 m$^3$ annually (300 working days). This means lowering of mirror level by more than two meters. Under the real conditions we should expect about 300 000 m$^3$ of filtrate, which is equivalent to lowering of the mirror of sludge detention pond by 1.5 meter annually. This means not only release of significant space of sludge detention ponds, but also a decrease in the load on guard dams.

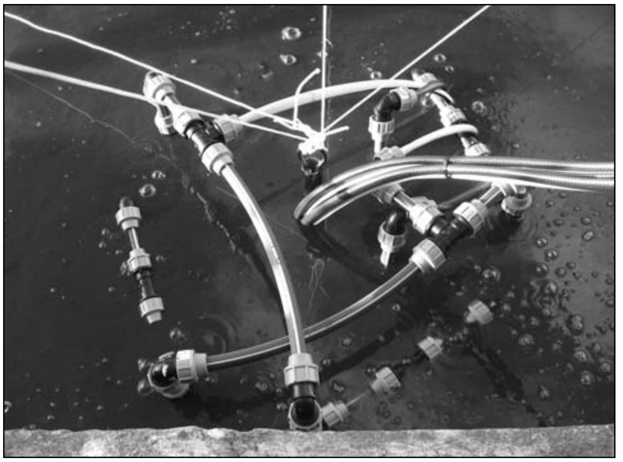
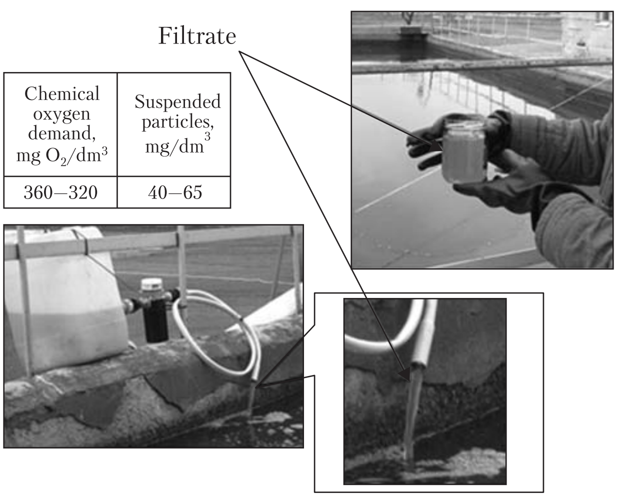


***Fig. 5.*** Operating condition of pilot facility filter module (full immersion in the tank)

***Fig. 6.*** Filter module brought up to the tank surface after operation without regeneration

***Fig. 7.*** The filter module after regeneration




| Chemical oxygen demand, mg $O_2/dm^3$ | Suspended particles, mg/$dm^3$ |
|---|---|
| 360—320 | 40—65 |

***Fig. 8.*** Process of filtrate drainage

After the implementation of developed approach the next measure which helps to solve another serious problem of BAS is to clean the so-called supernatant water returning from the sludge draining beds to the station to the beginning of the process. Due to excessive overflow of sludge draining beds the drain system works hardly and, as a result, the extremely polluted supernatant water returns to the beginning of the process. This water has a chemical oxygen demand (COD) factor at the level of 10—20 thousand mg $O_2/dm^3$. To address this issue we have proposed several options for the arrangement of similar pilot facility. One of them is a pumping station for supplying the supernatant water to BAS. Currently, there is every reason to believe that it is possible to realize the post-treatment of reverse supernatant water up to COD of 300-350 mg $O_2/dm^3$ by suspended solids (50—100 $dm^3$). Another option to be considered is locating at the BAS a facility for purification of supernatant water at the point of its reception from sludge draining beds.

Finally, there is a quite feasible proposal to reduce the load on sludge draining beds by dewatering the sludge produced daily at the station (8—10 thousand $m^3$). In practice, the optimal volume of taken off filtrate is regulated by pumping the sludge to filtration fields. In other words, if, for example, 70 % of water is filtered the volume of sludge to be fed to the sludge fields will be 2.4-3.0 thousand $m^3$/daily. Thus, the use of Geotube technique in its classic version, as well as in the form of the pilot facility described above addresses the problems related to accumulated sludge.

REFERENCES


1. Yakovlev, S.V., Karelin, I.A., Zhukov, A.I., and Kolobanov, S.K. (1975). Sewer System. Fifth edition, revised and amended. Moscow: Stroyizdat (in Russian).
2. Fedoseev, I.V., Fadeev, G.N., and Barkan, M.Sh. Technology of Recycling of Urban Wastewater Sludge. International Exhibition and Congress WasteTech-2005 (2005) (in Russian).
3. Treatment and disposal of sewage sludge. Moscow: Stroyizdat (1985) (in Russian).
4. Medvedev, A.S., Strizhko, V.S., and Rudan, O.V. Neutralization of Municipal WWTP Sludge. *Ecology and Industry of Russia* (2002) (in Russian).
5. Vaysfeld, B.A., Shelomkov, A.S., and Mongait, L.I. Removal, Drainage and Deposition of Sewage Sludge. *Water Supply and Sanitary Engineering*, 8, 21—22 (1999) (in Russian).
6. Pokhil, Yu.N., Bagaev, Yu.G., Venekurtsev, V.M. et al. Accelerated Dewatering of Sewage Sludge on Sludge Fields. *Water Supply and Sanitary Engineering*, 3, 14 (2004) (in Russian).

7. Epoyan, S.M. and Pantelyat, G.S. Methods for Intensification of Municipal Wastewater Dewatering. *Water Supply and Sanitary Engineering,* 9, 22—23 (1997) (in Russian).
8. Zhukov, N.N. Status and Prospects of Development of Facilities for Treatment of Sludge from Municipal Water and Sewage Pipelines in Russia. *Water Supply and Sanitary Engineering,* 12, 1, 3-6 (2002).
9. Yakovlev, S.V. and Voronov Yu. V. (2004). Sewerage and Sewage Treatment. Moscow: Publishing House of the Association of Civil Engineering Universities.
10. *Rose, P.* Decanter Centrifuges Solve Sludge Backlog Problem. *Water & Wastewater International* (2005).
11. Hultman, B. and Levlin, E. (1997). Sustainable Sludge Handling. In: Plaza, E., Levlin, E. and Hultman, B. (Eds). Advanced Wastewater Treatment: Report № 2, Joint Polish-Swedish reports, Div. of Water Resources Engineering, KTH, 5.
12. Karmazinov, F.V., Probirsky, M.D., and Vasiliev, B.V. Experience of Saint Petersburg Municipal Enterprise for Water Supply and Wastewater Treatment in Sludge Treatment and Disposal. *Water Supply and Sanitary Engineering*, 12, 1, 13—15 (2002) (in Russian).
13. Khramenkov, S.V. Integrated Solution for the Development and Implementation of New Technologies of Recultivation of Sludge Draining Beds of Aeration Stations with the Return of Land Taken Out of Circulation. *Water Supply and Sanitary Engineering*, 12, 1, 17—20 (2002) (in Russian).
14. Afanasyeva, A.A. and Lovtsov, A.E. Processing of Precipitation Formed in the Preparation and Purification of Waste Rainwater. *Water Supply and Sanitary Engineering,* 6, 13-16 (2004) (in Russian).
15. Grigorieva, Zh.L. Experience in Sewage Sludge Dewatering with the Use of Centrifuges in St. Petersburg. *ECWATECH* 2006, 793, (2006) (in Russian).
16. Glick, Scott. Patent of US no. 20040140041. Geotextile Tube Repair, Construction and Reinforcement Method and Apparatus. *Publ.* 22.07.2004.
17. Glick, Francis Scott. Patent of US no. 20060280563. Geotextile Tube Repair, Construction and Reinforcement Method and Apparatus. *Publ.* 14.12.2012.
18. Bradley, Anthony S. Patent of US no. AU 2000065143. Apparatus and Method for Deploying Geotextile Tubes. *Publ.* 10.05.2001.
19. Jensen, Kyle R., Allen, Ronald P., and Keys, Daniel. Patent of US no. 8075783. Water Remediation and Biosolids Collection System and Associated Methods. *Publ.* 31.07.2008.
20. Theodore, Marcus G. Patent of US no. 7416668. Wastewater Chemical/Biological Treatment Plant Recovery Apparatus and Method. *Publ.* 27.03.2007.
21. Daekyoo, Hwang. Patent of US no. 2010020051. Concurrent Disposal and Consolidation of Dredged Sediment of Using Horizontal Drains and Vacuum Loading. *Publ.* 08.12.2010.
22. Patent of US no. 20060102565. Alford, Paul W.: System and method for dewatering sludge, slurry or sediment. Publ. 18.05.2006.
23. Patent of US no. 7455773. Harmon, John, Gong, Terry, Theodore, and Marcus G.: Package wastewater chemical/biological treatment method. Publ. 25.11.2008.
24. Patent of US no. 20060102565. Alford Paul, W.: System and Method for Dewatering Sludge, Slurry or Sediment. *Publ.* 18.05.2006.
25. http://www.admir-ea.ru.
26. Rublevskaya, O.N. and Krasnopeev, A.L. Experience in Introduction of Cutting-Edge Techniques and Methods of Wastewater Sludge Treatment. *Water Supply and Sanitary Engineering,* 4, 65-69 (2011) (in Russian).

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## СПОСІБ ЗНЕВОДНЕННЯ ОСАДІВ СТІЧНИХ ВОД З ВИКОРИСТАННЯМ ЕЛЕМЕНТІВ ТЕХНОЛОГІЇ GEOTUBE НА БОРТНИЦЬКІЙ СТАНЦІЇ АЕРАЦІЇ

Робота присвячена вирішенню важливої екологічної та соціальної проблеми — зневодненню осадів стічних вод за допомогою елементів технології GeoTube. В лабораторії ІБОНХ НАНУ відпрацьовано динаміку зневоднення різних за природою осадів. Розроблено та створено пілотну установку — фільтрувальний модуль, який розміщено у резервуарі Бортницької станції аерації, куди подається аеробно-стабілізований мул, оброблений флокулянтом Praestol 859 BS, і надмулова вода із мулових майданчиків. Установка може використовуватися для зменшення навантаження на мулові майданчики, очищення зворотної надмулової води та зневоднення накопичених мулів.

*Ключові слова:* стічні води, осади, технологія, зневоднення, геотканина, мулові майданчики.

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## СПОСОБ ОБЕЗВОЖИВАНИЯ ОСАДКОВ СТОЧНЫХ ВОД С ИСПОЛЬЗОВАНИЕМ ЭЛЕМЕНТОВ ТЕХНОЛОГИИ GEOTUBE НА БОРТНИЦКОЙ СТАНЦИИ АЭРАЦИИ

Работа посвящена решению важной экологической и социальной проблемы — обезвоживанию осадков сточных вод с помощью элементов технологии GeoTube. В лаборатории ИБОНХ НАНУ отработано динамику обезвоживания разных по природе осадков. Разработана и создана пилотная установка — фильтровальный модуль, размещенный в резервуаре Бортницкой станции аэрации, куда подается аэробно-стабилизированный ил, обработанный флокулянтом Praestol 859 BS, и надиловая вода из иловых площадок. Установка может использоваться для уменьшения нагрузки на иловые площадки, очищения обратной надиловой воды и обезвоживания накопленных илов.

*Ключевые слова*: сточные воды, осадки, технология, обезвоживание, геоткань, иловые поля.

The paper was received on 12.06.13