UDC 628.356.665 (579.04)
DOI: 10.18372/2306-1472.67.10436

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STABILIZATION OF ACTIVE SLUDGE AFTER WASTEWATER TREATMENT CONTAMINATED BY PETROLEUM PRODUCTS

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Abstract

Purpose: *Biochemical purification of wastewater containing refined petroleum products takes place due to the oxidation of pollutants by active sludge organisms. As a result of this process the intense consumption of pollutants by active sludge and its growth occurs. Therefore, the possibility to use active sludge containing refined petroleum products after wastewater treatment requires its stabilization.* ***Methods:*** *In this work the oxidation by a 30% hydrogen peroxide solution was studied for its use as a stabilizer. Chemical oxidizers, including hydrogen peroxide destroy organic polymers retaining free water thus promoting water release from the structure of sludge particles. On the other hand remains of fine structured oxidized biopolymers can lead to filter clogging, that is, reduce moisture exchange of sludge.* ***Results:*** *The experiment was carried out to find out the correlation between the doses of hydrogen peroxide and the resistivity value of sludge filtration.* ***Discussion:*** *Stabilized active sludge can be used as a fuel for boiler rooms, which in its turn will reduce natural gas consumption for the enterprise needs.*

Keywords: active sludge; chemical stabilization; hydrogen peroxide; resistivity of sludge filtration

1. Formulation of the problem

Classical biological treatment at the wastewater treatment plants cannot work without active sludge. During biological treatment of the wastewaters the biochemical oxidation of organic matter by sludge organisms takes place. Organic matter from wastewater feeds the active sludge, causing its growth and producing the excessive active sludge that should be removed from treatment facilities and recycled [1, 3].

The active sludge is a biomass of microorganisms and macroorganisms, mainly of heterotrophic species that biochemically oxidizes soluble organic matter by oxygen. In the end result carbon dioxide and water are formed. Exactly in the course of this process the fertility of the land is lost, degradation of the biosphere occurs and carbon dioxide emissions increase, so, the active sludge should be recycled.

2. Analysis of the research and publications

The sludge has humidity of 98%, so it is necessary to concentrate this sludge before further treatment. Several methods such as flotation concentration, pressure flotation, electric flotation, ultrasound treatment, filtration, cavitation and others are used for this purpose [2, 4].

Along with the heat and reagent treatments the methods, such as the addition of mineral ashes after burning, including those obtained from the combustion of sludge itself, can be used for active sludge and sediments air conditioning of primary clarifiers and intensifying the process of concentration.

Chemical stabilization of sludge sediment is carried out to enhance its water loss during dehydration. The lime is widely used to intensify the treatment process of active sludge. 10% of dry matter by weight (for fermented – 12%) is recommended to add to raw sludge.

The anaerobic digestion can be used to stabilize the active sludge. Increased temperature (to 55 °C) intensifies this process accelerating fermentation twofold and more and slightly reducing water loss of sludge. The period of drying of fermented sediments increases by 1.5 times. The active sludge sediment yield increases by 20% during mixing. By rising the temperatures of the process and mixing active sludge sediment the basis for technologies with use of methane fermentation was formed. Capacity of facilities with such treatment was increased by 2 times.

Sterilization of sediment before fermentation for 15 – 20 minutes at 100 – 120°C reduces its processing time by 30%. Pasteurization of sediment for several hours at the temperature of 85 – 95 °C increases a processing speed by 14.8%.

Ultrasound treatment of active sludge provides dispersion of active sludge sediment surface and its uniform distribution in the reactor.

For active sludge treatment the aerobic stabilization can be used. By this way the sludge is compacted to the concentration of 10 – 15 g/l by dry matter then heated to the temperature of 50 – 55 °C for 2 – 2.5 hours while maintaining aerobic conditions. Then aerobic active sludge is subjected to stabilization to achieve a specific resistance of the filter at $10 – 40\times10^{10}$ cm/h. The processing time was reduced from 4 days to 6 – 7 hours under the aerobic conditions comparing with the conventional stabilization [5, 6, and 9].

Aeration or oxygenation of the sludge sediment before its sealing improves sludge sedimentation properties and water loss. Fermented active sludge before sealing is saturated with oxygen by aeration, mixing with oxidizing agents or chemical treatment. As chemical oxidants peroxide or permanganate solutions are used.

The effect of stabilization of active sludge can be obtained in different ways – biological, chemical, physical, and their combination [9]. The feasibility of the use of any method of stabilization is determined by several conditions, the majority of which is the type of an active sludge, its quantity, the possibility and conditions of further use, availability of site for its disposal.

During the treatment of wastewater containing refined petroleum products the active sludge adsorbs petroleum and other organic matter that is why a strong oxidizer is required for its stabilization.

The sludge treatment by a chemical oxidant such as hydrogen peroxide, without a doubt, will have an effect on the properties of sludge that must be considered during the next mechanical dehydration. Thus, making arrangements for sludge air conditioning before mechanical dewatering the change in moisture exchange of sludge after its treatment by oxidants must be taken into account.

Chemical sludge air conditioning before mechanical dehydration is usually performed by coagulation using ferric chloride and lime. The doses of these agents are normalized only for concentrated sludge. For non-concentrated sludge contaminated by petroleum products containing wastewater that was removed from the block of biochemical oxidation with the intensified process the empirically chosen coagulant doses were: ferric chloride – 10% and lime – 25% of the dry sludge residue.

When processing a non – stabilized sludge by coagulants a sludge resistivity decreased from 438×10^{10} cm/h to 38.66×10^{10} cm/h, i. e. by more than 10 times.

Sludge resistivity that is measured by pressure loss at its initial constant value per a filter surface unit with the help of filtering a unit of mass sludge physically and numerically expresses the ability of sludge to moisture exchange, in particular the degree of suitability for dehydration on filters. The value of resistivity to filtering, often called "an index of filtration capacity" describes the structure of the sludge and is dependent on removal of free water by the most efficient way [7, 8].

Chemical oxidizers, including hydrogen peroxide, destroy organic polymers that keep free water, that is promote its release out of the structure of sludge particles. On the other hand remains of damaged (oxidized) biopolymers with fine structure can lead to clogging of filter media, that is, to reducing the moisture exchange of sludge [10].

3. Purpose of the study

The purpose of the experiment was the selection of the optimal dose of hydrogen peroxide which is necessary in order to stabilize the active sludge after treatment of wastewater contaminated by petroleum products.

4. Study results

In order to find the optimal dose of hydrogen peroxide with which the oxidation of water-keeping biopolymers is sufficiently ensured but relatively few adverse oxidation products are formed the measurements of the resistivity of sludge filtration upon different doses of hydrogen peroxide were made The sludge, which was previously air conditioned by coagulants with the mentioned above doses was subjected to processing by hydrogen peroxide.

During the experiment 30% aqueous solution of hydrogen peroxide was used. The measurement results are shown in Table 1.

Table 1. Dependence of sludge filtration resistivity (r) from hydrogen peroxide doses (D_n)

D_n	r	D_n	r	D_n	r
0	38.66	15	11.81	60	15.05
1	17.70	20	11.54	70	15.39
3	13.36	25	11.57	80	14.30
5	12.01	30	10.13	90	18.64
7	12.15	40	10.53	100	24.78
10	11.21	50	14.01		

Due to shortcomings of the standard method for determining the resistivity of sludge filtration a slight deviation of the data was observed (Fig.1). However, the correlation coefficient of these data appeared to be rather high, indicating the presence of correlation between the above parameters:

$$k_{D_n r} = \frac{\sum D_r - nM_{D_n} M_r}{(n-1)\sigma_{D_n}\sigma_r} = \frac{10366.5 - 17 \cdot 35.65 \cdot 17.3}{16 \cdot 33.38 \cdot 19.32} = 0.9449 \quad (1)$$

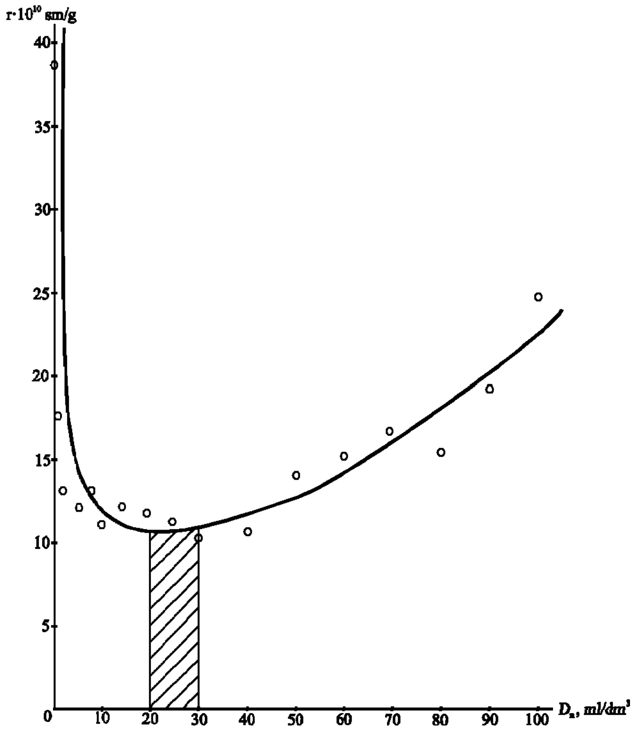

Fig. 1. The dependence of the resistivity of sludge filtration (r) from the doses of 30% hydrogen peroxide (D_n)

Some data, deviations of which seemed most significant, were tested by the criterion of cases according to standard methods and their reliability was confirmed. In particular, for the value with coordinates D_n = 15 mg/dm^3, r = 27.81 × 10^{10} cm/h the criterion of cases with M_r = 17.3 and σ_r = 19.32 equal:

$$T = \frac{27.81 - 17.3}{19.32} = 0.54 \quad (2)$$

which is smaller than the tabular value TS_t = 2.4 (for n = 17). All calculations were performed by the conventional method.

Doses presented in Fig. 1 shows a sharp decrease of the curve even at low doses of hydrogen peroxide, but then an increase of the resistivity of sludge at doses of hydrogen peroxide with 50 – 100 ml/dm^3. The extreme area of the curve indicates the optimal dose of hydrogen peroxide with 20 – 30 ml/dm^3 (30% solution).

The sludge treatment by hydrogen peroxide dose of 22 ml/dm^3 will allow oxidize chemically volatile organic compounds, stabilize the sludge, and reduce resistivity of its filtration by 8 times.

5. Conclusions

Study results allowed us to find out the optimal dose 30% hydrogen peroxide solution equal 22 ml/dm3 required to stabilize the active sludge. Upon such treatment the resistivity of sludge filtration was reduced by 8 times. The stabilized active sludge, obtained from oxidation of containing refined petroleum products wastewater, can be used as a fuel for boiler rooms which in its turn will reduce natural gas consumption for the enterprise needs.

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Received 26 February 2016

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Мета: Біохімічне очищення стічних вод, що містять продукти переробки нафти, відбувається за рахунок окиснення забруднювальних речовин організмами активного мулу киснем повітря. У результаті цього процесу відбувається інтенсивне споживання забруднювальних речовин активним мулом, а також його ріст. Тому у подальшому, щоб було можливе використання активного мулу після очищення стічних вод, що містять продукти переробки нафти, його необхідно стабілізувати. **Методи:** У нашій роботі ми дослідили, в якості стабілізатора – окиснення 30% розчином перекису водню. Хімічні окиснювачі, зокрема, перекис водню, руйнує органічні полімери, які утримують вільну воду, тобто сприяють її вивільненню із структури часток мулу. З іншого боку, залишки окиснених біополімерів мають дрібну структуру і можуть призвести до закупорки фільтруючих матеріалів, тобто до зменшення вологовіддачі мулу. **Результати:** У ході роботи був поставлений експеримент зі зміною дози перекису водню і визначенням величини питомого опору мулу фільтрації. **Обговорення:** Стабілізований активний мул може бути використаний в якості палива на котельні, що, в свою чергу, зменшить витрати природного газу на потреби підприємства.

Ключові слова: активний мул; перекис водню; питомий опір мулу фільтрації; хімічна стабілізація.

Е.И. Семёнова[1], Л.Р. Решетняк[2], Н.А. Бублиенко[3], Е.С. Смирнова[4], Т.А. Шилофост[5]. Стабилизация активного ила после очистки сточных вод загрязненных нефтепродуктами
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Цель: Биохимическая очистка сточных вод, содержащих продукты переработки нефти, происходит за счет окисления загрязняющих веществ организмами активного ила кислородом воздуха. В результате этого процесса происходит интенсивное потребление загрязняющих веществ активным илом, а также его рост. Поэтому в дальнейшем, чтобы было возможно использование активного ила после очистки сточных вод, содержащих продукты переработки нефти, его необходимо стабилизировать. **Методы:** В нашей работе мы исследовали, в качестве стабилизатора – окисление 30% раствором перекиси водорода. Химические окислители, в частности, перекись водорода, разрушает органические полимеры, содержащие свободную воду, то есть способствуют ее высвобождению из структуры частиц ила. С другой стороны, остатки окисленных биополимеров имеют мелкую структуру и могут привести к закупорке фильтрующих материалов, то есть к уменьшению влагоотдачи ила. **Результаты:** В ходе работы был поставлен эксперимент с изменением дозы перекиси водорода и определением величины удельного сопротивления ила фильтрации. **Обсуждение:** Стабилизированный активный ил может быть использован в качестве топлива на котельной, что в свою очередь уменьшит расходы природного газа на нужды предприятия.

Ключевые слова: активный ил; перекись водовода; удельное сопротивление ила фильтрации; химическая стабилизация.

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