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ПОЛИМЕРНАЯ КОМПОЗИЦИЯ ДЛЯ ОЧИСТКИ СТОЧНЫХ ВОД ОТ РАЗЛИЧНЫХ ПРИМЕСЕЙ ТЕКСТИЛЬНОГО ПРОИЗВОДСТВА

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В настоящей статье рассмотрены вопросы разработки новых и усовершенствования традиционных методов очистки сточных вод красильно-отделочных производств. Разработан состав композиции на основе местных природных минеральных солей (бентонит Навбахорского происхождения, бисульфит натрия, полиакриламид и сульфат алюминия) для очистки сточных вод текстильной промышленности. Изучено влияние размера частиц бентонита на степень обесцвечивания сточных вод при различных скоростях потока. При диапазоне скорости подачи сточных вод от 0,5 до 2,0 м/с при размере частиц бентонита-адсорбента в пределах 0,25-1,0 нм достигается максимальная степень обесвечивания сточных вод, и она составляет 84-87 %. Для мелкопористых адсорбентов (БКА-100 и БКА-200) эффективность по обесцвечиванию практически не зависит от размера частиц и колеблется от 85 до 87 %. Установлено, что при применении бентонитового композиционного адсорбента марки БКА-400 достигается наибольшая степень очистки: по интенсивности окраски 83-87 %, по взвешенным веществам 80-84 %. Наиболее высокая степень очистки сточных вод предложенным составом, по-видимому, объясняется тем, что в процессе адсорбции, кроме сорбции примесей сточных вод на поверхности адсорбентов, происходит сорбция ионов и молекул растворенных веществ на поверхностях пузырьков воздуха и вынос их в пенный слой. Показатели очистки сточных вод красильно-отделочного цеха с использованием бентонитового композиционного адсорбента приведены в табл. 2, по данным которой видно, что степень удаления загрязнений разработанным нами методом значительно выше, по сравнению с отстаиванием осадков оксигидратов алюминия или железа с адсорбированными загрязнениями. Причем эффекты снижения величины показателя химического потребления кислорода (ХПК) и концентрации ПАВ в сточных водах в среднем составили 65 % и 82 % и по сравнению с эффектами снижения этих же показателей при отстаивании осадков оксигидратов на 48-54 % и на 54-61 % соответственно.

Ключевые слова: полимерная композиция, полиакриламид (ПАА), загрязнения, очистка сточных вод, интенсивность окраски, взвешенные вещества, селективности адсорбента, краситель, бентонит

POLYMERIC COMPOSITION FOR PURIFICATION OF WASTEWATER FROM VARIOUS IMPURITIES IN TEXTILE INDUSTRY

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This article deals with the development of new and improvement of traditional methods of wastewater treatment of dyening and finishing industries. The composition was developed on the basis of local natural minerals (bentonite Navahermosa origin, sodium bisulfite, polyacrylamide and aluminium sulphate) for the treatment of wastewater of the textile industry. The influence of bentonite particle size on the degree of wastewater discoloration at different flow rates was studied. With a range of wastewater supply flow rates from 0.5 to 2.0 m/s with a particle size of bentonite adsorbent in the range of 0.25-1.0 nm, the maximum degree of wastewater bleaching is achieved and it is in the range of 84-87%. For microporous adsorbents (CAD-100 and CAD-200) the effectiveness of the discoloration also does not depend on the particle size and ranges from 85 to 87 %. It was found that, for fine-pored adsorbents (BKA-100 and BKA-200), the efficiency of discoloration also practically does not depend on the particle size and ranges from 85 to 87 %. The highest degree of wastewater treatment according to the proposed composition, apparently due to the fact that in the adsorption process, in addition to the sorption of sewage impurities on the surface of adsorbents, there is a sorption of ions and molecules of dissolved substances on the surfaces of air bubbles and their removal in the foam layer. The wastewater treatment parameters of the dyeing and finishing shop using the bentonite composite adsorbent show that the degree of removal of contaminants by the method developed by us is much higher compared to the sedimentation of aluminum or iron oxyhydrates with adsorbed contaminants. Moreover, the effects of reducing the value of COD and concentration of the surfactant in the wastewater was, on average, 65 % and 82 %, and compared to the effects of reducing the same parameters at defending precipitation of oxyhydrates at 48-54 % and 54-61 %, respectively.

Key words: polymer composition, polyacrylamide (PAA), pollution, wastewater treatment, color intensity, suspended solids, adsorbent selectivity, dye, bentonite

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INTRODUCTION

The aim of this work is to develop methods for maximum purification of wastewater from suspended particles of finishing plants in various processes using chemicals.

In modern conditions, the issue of environmental protection from industrial emissions is given great attention. For textile finishing enterprises, the most acute problem is the treatment of wastewater from impurities of various origins, including toxic metal ions.

Currently, coagulants and flocculants widely used in wastewater treatment of textile industry enterprises can be used both independently and jointly. If the results of the use of mineral coagulants to some extent systematized, it is impossible to say for a large group of new flocculants and, especially, their combined use with coagulants. The correct theoretical selection of specific reagents for wastewater treatment of the textile industry, moreover, for their individual flows, as well as careful studies to determine the optimal doses of coagulants and flocculants, pH, speed and time of intensive mixing and flocculation, the temperature of the treated wastewater can provide a fairly high degree of purification for dyes, suspended solids and other indicators.

Thus, according to the authors of [1-3], the two-stage coagulation treatment of wastewater of worsted plants provides a high purification effect both in the content of dyes and surfactants, and in the Cr^{3+} ions. According to the data of the same authors for wastewater of the textile industry, containing along with dyes of different classes of textile auxiliary substances (TAS), dispersants, inorganic molecular solutes, more effectively carrying out mandatory coagulation treatment in two stages. In the first stage pH = 5-7, in the second-the pH value is adjusted within a wider range and eventually provides a fairly high degree of purification of surfactants and dyes. Industrial waste water containing surfactants anionoactivs separately subjected to electro-chemical coagulation at pH = 4.5 to 5.0.

For wastewater treatment from dyes and surfactants, the authors of [4] proposed a method of introducing organic coagulant and sodium silicate with an interval of 3-10 min with a duration of purification of 10-40 min, the purification stage reaches 98%.

In the interaction of hydrolyzing mixed coagulants $Al_2(SO_4)_3$ and $FeSO_4$ with Ca $(OH)_2$, the degree of purification of the effluents can be approximated to the values of the maximum permissible concentrations (MPC) for these surfactants [5].

The results of experiments conducted by the authors [6] showed that the most effective reagents for the treatment of industrial wastewater from surfactants is aluminum sulfate, lime and polyacrylamide (PAA), as well as flocculant WSPC-402. Many examples show the effectiveness of flocculants for the treatment of waste water from dyes and surfactants. The separate use of mineral coagulants in most cases provides the necessary effect of purification by the intensity of color, however, the joint use of coagulants and flocculants improves the structural and mechanical properties of precipitation, while reducing their volume and humidity, allows several times to reduce the dose of mineral coagulants. The use of flocculants accelerates the separation of liquid and solid phases during coagulation.

Thus, in studies [7], the consumption of sodium polyphosphate with a degree of polymerization from 20 to 40 was from 0.5 to 200 g per 1 m^3 of the processed solution containing dyes and suspended solids. At different flocculant doses, the removal efficiency of the suspension and dissolved cationic dyes varies from 10 to 90% regardless of the pH value.

The authors of the work [8] found that the effect of wastewater treatment of dyeing and finishing shops of the worsted cloth factory in terms of intensity of color can reach 92% with the use of flocculant VA-2 dose of 5 mg/l in combination with aluminum sulfate dose of 150 mg/l, which is 2 times more than the cleaning effect when using only aluminum sulphate the same dose.

According to the authors of [9] the optimal dose of PAA (and WSPC -402) 2-3 mg/l for 20-30 min settling removes 90-95% of the suspended particles. The hydraulic particle size at the height of the settling zone of 2 m is less than 1.8% of the volume of wastewater at a humidity of 90-95%. According to the authors [10], the use of PAA doses of 0.5-2 mg/l can reduce the settling process from two hours to 20-30 min, and PAA dose of 3 mg/l-up to 10-20 min.

In General, to the issue of wastewater treatment of textile enterprises industry flotation treated a lot of swelling and foreign specialists. A great contribution to the development and implementa vision of new design solutions of flotators, as well as new ones nological schemes, including for the purpose of re-recycling of treated water, and made the staff of the Department of Wastewater MSU at the head of the Y. M. Gentle [11-18].

The problem of wastewater treatment of textile enterprises has a number of features, which is primarily due to the large volume of discharged water. Thus, the specific amount of wastewater generated in the processes of finishing production is 200-350 m^3 per 1 ton of produced fabrics. The detailed analysis of technological and waste water at one of the large finishing enterprises showed that the main source of pollution with dyes, surfactants and other suspended substances are dyeing and finishing factories.

EXPERIMENTAL PART

Reagents and materials. The paper used bentonite of Navbahor origin (Uzbekistan) with a particle size of 0.1 to 1.0 mk, sodium bisulfite – $NaHSO_3$, PAA and aluminum sulfate – $Al_2(SO_4)_3{\cdot}18H_2O$ (Russia) physical and chemical properties of which are described in [19, 20].

*Instrumentatio*n. The selectivity or efficiency of cleaning for this component is calculated by the formula

$$R = \frac{C_{sou} - C_{filt}}{C_{sou}} \cdot 100\%$$

where, $C_{sou}{\cdot}C_{filt}$ – concentration of this component in the separated solution in source wastewater) and filtrate (mg/l).

Conditions of the experiment. To develop a rational technology of the maximum of sewage treatment enterprises of the cotton industry, which we adhered to the principle of the separation of waste according to the pollutant at two of the main thread:

1st flow – wastewater dyeing, printing and sizing workshops;

2nd flow – wastewater desizing, bleaching otwarci and range of shops.

The process of deep wastewater treatment of these two streams is a combination of the following treatment methods: settling in thin-layer sedimentation tanks with and without reagents, filtration on bubbled adsorption plants. In this case, the proposed technological scheme allows the above methods of cleaning in a combination of parallel and sequential methods.

In laboratory settings conducted studies to determine the selectivity of (R, %) mentioned methods according to the basic indicators of sewage of the enterprises of the cotton industry at various values of operating parameters. The initial values of the main indicators of the waste water of the 1st stream entering the deep treatment at the bubbled adsorption plant correspond to the values of the indicators of these flows that passed through solid polymer compositions consisting of a system of bentonite-bisulfite sodium-polyacrylamide (PAA)-aluminum sulfate i.e. bentonite composite adsorbent (BCA).

The composition of the composition for wastewater treatment are presented in Table 1.

Table 1
The ratio of the components in bentonite composite adsorbent
***Таблица 1.* Соотношение компонентов, входящих в состав бентонитового композиционного адсорбента**

Type of composition	The ratio of components in the composition			
	Bentonite	$NaHSO_3$	ПАА	$Al_2(SO_4)_3$
BCA – 100	1,0	0,05	0,05	0,1
BCA – 200	1,0	0,05	0,1	0,1
BCA – 300	1,0	0,10	0,2	0,1
BCA – 400	1,0	0,15	0,1	0,2
BCA – 500	1,0	0,3	0,2	0,3

Metrological processing. Calculation of metrological characteristics of the presented methods was carried out in accordance with [22].

RESULTS AND DISCUSSION

In [21, 25] proposed sewage purification from impurities by the creation of technological schemes, allowing to re-recycling of deeply treated wastewater in various technological process of manufacturing tissues. As a flocculant has been proposed PAA ionogenic the possible co-monomer acrylamide, the drug VPK-101, and as a coagulant used was aluminium sulphate $Al_2(SO_4)_3 \cdot 18H_2O$ and ferrous sulfate – $FeSO_4$.

The author M. M. Amonova has developed and experimentally tested a new scientifically based complex technology of deep wastewater treatment of the cotton industry;

experimentally, the choice of flocculants and rational combination of doses of mineral coagulant and flocculants at their joint use;

- rational technological modes of purification and the ratio of the design parameters of thin-layer sedimentation tanks are determined;

In the development of the method [23], we investigated the possibility of maximum (up to 90%) purification of industrial waters from surfactants and dyes by chemical method consisting in their isolation from the solution by adsorbed reagents.

Since the intensity of color and surfactant are the main indicators of pollution for the wastewater of the textile industry, the studies on the effect of the size of the adsorbent particles and the rate on the adsorption process were primarily carried out for these indicators.

It is known that an increase in the flow rate of more than 2.0 m/s leads to a significant increase in energy costs with a slight increase in the permeability of the adsorbent. Therefore, for the adsorbent type BCA-500 studies have been conducted to study the effect of the size of the adsorbent particles on the efficiency of discoloration at the rate of wastewater supply in the range of 0.5 to 2.0 m/s.

Depending on the degree of discoloration of the particle size at a specific value of the wastewater flow rate, according to the developed object-oriented programming environment DELPHI 5.0, take the form of a parabola. These relationships with the equations of the approximation is illustrated in Fig. 1 [24].

Since the velocity value in the range from 0.5 to 2.0 m/s almost equally affects the efficiency of the adsorbent BCA-500 by discoloration (Fig. 1), then in further studies the flow rate over the adsorbents was assumed to be 1.0 m/s.

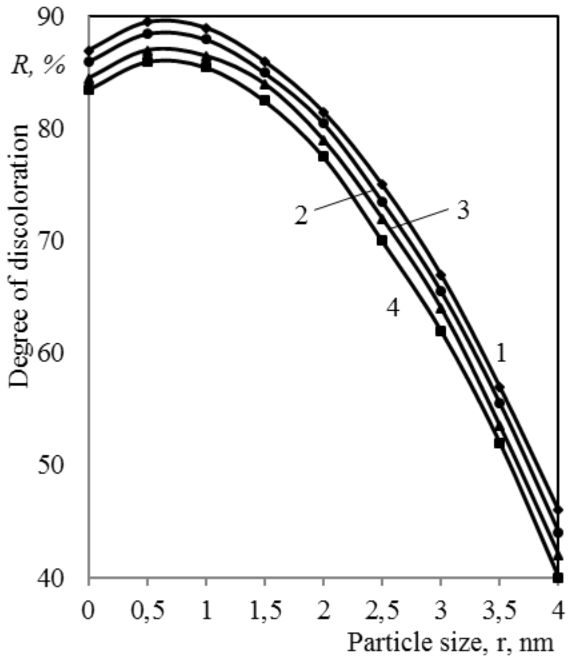

Fig. 1. The effect of particle size on the degree of discoloration of wastewater at the following flow rates over the adsorbent of BKA-500 type: 1 - V= 0.5 m/s, $y = -363.1 x^2 + 123.6 x + 84.8$; 2 - V= 1.0 m/s, $y = -374.2 x^2 + 115.9 x + 85.6$; 3 - V= 1.5 m/s, $y = -415.98 x^2 + 131.4 x + 83.1$; 4 - V= 2.0 m/s, $y = -392.9 x^2 + 116.7 x + 83.01$

Рис. 1. Влияние размера частиц на степень обесцвечивания сточных вод при следующих значениях скорости потока над адсорбентом типа БКА-500: 1 - V= 0,5 м/с, $y = -363,1 x^2 + 123,6 x + 84,8$; 2 - V= 1,0 м/с, $y = -374,2 x^2 + 115,9 x + 85,6$; 3 - V= 1,5 м/с, $y = -415,98 x^2 + 131,4 x + 83,1$; 4 - V= 2,0 м/с, $y = -392,9 x^2 + 116,7 x + 83,01$

According to the research results, the curves of discoloration at the maximum initial value of the color intensity –K0 = 1:40 (Fig. 2).

From Fig. 2 it can be seen that 87% discoloration is achieved by using the adsorbent BCA-400 regardless of the particle size.

In accordance with the experimental studies developed by us, they were aimed at studying the efficiency of wastewater treatment in the dyeing and finishing shop by the bentonite composite adsorbent method and determining the optimal process parameters.

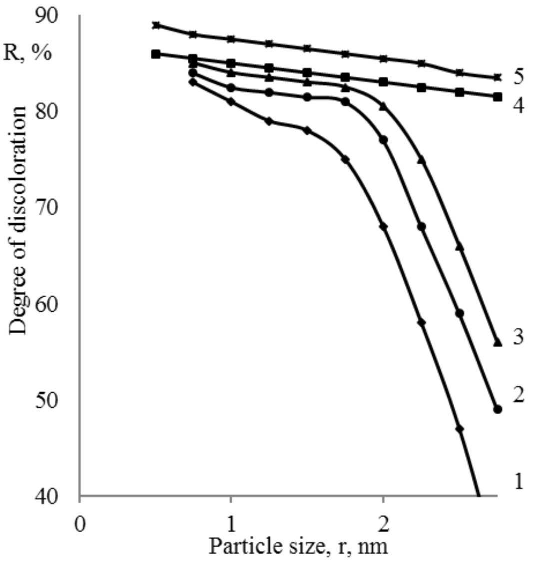

Fig. 2. Influence of particle size on the degree of discoloration of waste water for 1-d flow on the adsorbents: 1 - BCA-100; 2 - BCA-200; 3 - BCA-300; 4 - BCA-400; 5 - BCA-500
Рис. 2. Влияние размера частиц на степень обесцвечивания сточных вод для 1-го потока на адсорбентах: 1 - BCA-100; 2 - BCA-200; 3 - BCA-300; 4 - BCA-400; 5 - BCA-500

The efficiency of the process of bentonite composite adsorbent was estimated by the degree of removal of surfactants, dyes and other textile auxiliary substances (TIA) from wastewater by the indicators of COD, color intensity and concentration of surfactants, in addition, the degree of removal of suspended solids was determined.

A series of experiments on the bentonite composite adsorbent of waste water of the dyeing and finishing shop was carried out at the contact action plant. The studies were carried out in accordance with standard methods. Pressure flotation of waste water of the dyeing and finishing shop was carried out at saturation with air of 30, 50 and 100% purified water.

The study of the kinetics of the removal of contaminants from the waste water of the dyeing and finishing plant showed that the highest degree of purification for all indicators of pollution is achieved under the regime of 50% recirculation of purified water. The process of flotation ends in 20-25 min, with the cleaning effect on the intensity of color is 83-87, by suspended solids-80-82%, in terms of COD-69-71%, by surfactant-71-73%.

Table 2

Indicators of wastewater treatment of paint and finishing shop by bentonite composite adsorbent

Таблица 2. **Показатели очистки сточных вод красильно-отделочного цеха с помощью бентонитового композиционного адсорбента**

Indicators	Before cleaning			After cleaning			Cleaning efficiency, %		
	min. value	max. value	environments. the value	min. value	max. value	environments. the value	min. value	max. value	environments. the value
Intensity of colouring by breeding	1:100	1:400	1:250	1:16	1:40	1:28	83	87	85
Suspended solids, mg/l	240	430	335	40	55	47	80	84	82
Dry residue, mg/l	1400	2500	1950	300	680	490	-	-	-
Ash content of dry residue, %	41	44	42	42	46	44	-	-	-
CHOD, mg O_2/l	500	920	710	150	300	225	61	68	65
BOC full, mg O_2/l	250	350	300	110	30	70	54	58	56
pH	7,70	10,20	8,90	5,33	7,64	6,47	-	-	-

The high degree of removal of surfactants and other organic contaminants from the waste water of the dyeing and finishing plant is explained by the fact that in the process of bentonite composite adsorbent, in addition to sorption of these substances on the surfaces of adsorbents, there is a sorption of ions and molecules of dissolved substances on the surfaces of air bubbles and their removal into the foam layer [18].

SUMMARY

The proposed technology contributed to the wastewater treatment of the textile industry from the main pollutants-dyes, surfactants, dressing preparations, etc. the Study of the effect of the size of bentonite particles on the degree of discoloration of wastewater at different flow rates and kinetics of removal of impurities from wastewater shows the principal possibility of using bentonite-containing compositions. It was found that the use of bentonite composite adsorbent BKA-400 brand reaches the highest degree of purification: the intensity of color-83-87%, by suspended solids 80-84%. On the basis of the obtained data and developed new chemical methods to achieve almost 83-87% completeness of the impurity from the solutions.

ЛИТЕРАТУРА

1. **Швецов В.Н.** Очистка природных и сточных вод. Сб. научн. тр. ОАО "НИИ ВОДГЕО". Водоснабжение и санитарная техника. 2009. С. 76.
2. **Гришин Б.М., Салмин С.М.** Исследование реагентной очистки природных вод с применением алюмосодержащих коагулянтов. Сб. тр. Международ, науч.-практ. конф.: Актуальные проблемы инженерных наук в области промышленности, экологии и охраны водных ресурсов. Пенза: ПГУАС. 2012. С. 116-119.
3. **Домрачева В.А., Шийрав Г.** Адсорбционное извлечение ионов тяжелых металлов углеродными сорбентами в статических условиях. *Цветные металлы*. 2013. № 1. С. 43-48.
4. **Вихрев В.И., Симонов А.Д., Шевченко В.С.** Термическая утилизация осадков сточных вод. *Чистый город*. 2013. № 1. С. 27-32.
5. **Веляев Ю.О., Майоров Д.В., Матвеев В.А.** Исследования эффективности применения алюмосиликатного коагулянта на основе нефелина. *Водоснабжение и сан. техника*. 2013. № 3. ч.1. С. 32-37.
6. **Вихрев В.И.** Термическая утилизация осадков сточных вод. *Водоочистка*. 2013. № 3. С. 11.
7. **Анисимов Д.В.** Удаление фосфора из сточных вод. *Экология производства*. 2012. № 5. С. 84-87.
8. **Андрианов А.П.** Очистка сточных вод с применением технологии мембранного биореактора. *Экология производства*. 2012. № 11. С. 66-74.
9. **Анциферов А.В., Филенков В.М.** Повышение эффективности очистки сточных вод промышленных предприятий на биологических очистных сооружениях. *Водоочистка*. 2013. № 3. С. 29-35.
10. **Мамитова А. Д., Атаханова Р.А.** Очистка сточных вод красильно-отделочных производств. *Водоочистка*. 2013. № 6. С. 32-34.
11. **Ласков Ю.М., Ефимова Н.А.** Очистка сточных вод красильно-отделочных предприятий хлопчатобумажной промышленности физико-химическими методами. В кн.: Вопросы очистки сточных вод. М.: 1980. С. 102-108.
12. **Бляшина М.В., Саблий Л.А.** Использование анаэробно-аэробного биореактора для очистки сточных вод. *Водоочистка*. 2013. № 4. С. 19-23.
13. **Большаков Н.Ю.** Биологические методы очистки сточных вод от органических веществ и биогенных элементов. *Экология производства*. 2013. № 4. С. 64-69.
14. **Савдур С.Н., Понкратова С.А.** Системный подход в моделировании технологического процесса очистки нефтесодержащих сточных вод. *Вестн. Казан. технол. ун-та*. 2010. № 7. С. 218-226.
15. **Данилович Д.А.** Обеспечение энергоэффективности процессов очистки сточных вод и обработки осадка в новациях СП 32.13330.2012 «Канализация. Наружные сети и сооружения». *Чистый город*. 2013. № 1. С. 18-21.
16. **Крылов И.О., Луговская И.Г.** Использование природных шунгитовых сорбентов в системах очистки сточных вод. *Ресурсосберег. технол. Экспресс-информация. ВИНИТИ*. 2011. № 6. С. 10-32.
17. **Малахатка Ю.Н., Тарасова Г.И.** Сорбент на основе аспирационной пыли. *Сорбц. и хроматограф. проц*. 2013. Т. 13. Вып. 4. С. 476-481.
18. **Селицкий Г.А., Ермаков Д.В.** Пути повышения глубины очистки кислых сточных вод. *Экология производства*. 2011. № 4. С. 70-78.

REFERENCES

1. **Shvetsov V.N.** Natural and waste water treatment. Sat. scientific. Tr. JSC "NII VODGEO". *Vodosnabjeniye i sanitarnaya texnika.* 2009. P. 76 (in Russian).
2. **Grishin M., Salmin S.M.** Investigation of reagent purification of natural waters with the use of aluminum-containing coagulants. Sat. Tr. International, scientific - prakt. Conf.: Actual problems of engineering Sciences in the field of industry, ecology and water resources protection. Penza: PGWS. 2012. P. 116-119 (in Russian).
3. **Domracheva V.A., Shiyrav G.** Adsorption extraction of heavy metal ions by carbon sorbents in static conditions. *Tsvetniye Metally*. 2013. N 1. P. 43-48 (in Russian).
4. **Vikhrev V.I., Simonov A.D., Shevchenko V.I.** Thermal utilization of sewage sludge. *Chistiy Gorod*. 2013. N 1. P. 27-32 (in Russian).
5. **Velayev Y.O., Mayorov D.V., Matveev V.A.** Research of efficiency of application of aluminium coagulant on the basis of nepheline. *Vodosnab. Sanita. Tekhnika*. 2013. N 3. Pt. 1. P. 32-37 (in Russian).
6. **Vikhrev V.I.** Thermal utilization of sewage sludge. *Vodoochistka*. 2013. N 3. P. 11 (in Russian).
7. **Anisimov D.V.** Phosphorus removal from wastewater. *Ekol. Proizvodstva*. 2012. N 5. P. 84-87 (in Russian).
8. **Andrianov A.P.** Wastewater treatment applying membrane bioreactor technology. *Ekol. Proizvodstva*. 2012. N 11. P. 66-74 (in Russian).
9. **Antsiferov A.V., Filinkov V.M.** Increase of efficiency of wastewater treatment of industrial enterprises in biological wastewater treatment plants. *Vodoochistka*. 2013. N 3. P. 29-35 (in Russian).
10. **Mamitova D.A. Atakhanova R.A.** Waste water Treatment of the dyeing and finishing industries. *Vodoochistka*. 2013. N 6. P. 32-34 (in Russian).
11. **Laskov M.Yu., Efimova N.Ah.** Wastewater treatment of dyeing and finishing enterprises of the cotton industry by PHY-Zico-chemical methods. In: Problems of wastewater treatment. M.: 1980. P. 102-108 (in Russian).
12. **Blyashina M.V., Sable L.A.** The use of anaerobic-aerobic bioreactor for wastewater treatment. *Vodoochistka*. 2013. N 4. P. 19-23 (in Russian).
13. **Bolshakov N.Y.** Biological treatment of wastewater from organic substances and biogenic elements on biotechnology. *Ekol. proizvodstva*. 2013. N 4. P. 64-69 (in Russian).
14. **Sawdor S.N., Pankratova S.A.** A systematic approach to the modeling of technological process of cleaning of oily waste water. *Vestn. Kazan. Technol. Un-ta*. 2010. N 7. P. 218-226 (in Russian).
15. **Danilovich D.A.** Energy efficiency of wastewater treatment processes and treatment of sludge in innovations SP 32.13330.2012 “Sewerage. External networks and constructions”. *Chistiy Gorod*. 2013. N 1. P. 18-21 (in Russian).
16. **Krylov I.O., Lugovskaya I.G.** Use of natural shungite sorbents in wastewater treatment systems. *Resursosbereg. Tekhnol. Ekspress-informatsiya. VINITI*. 2011. N 6. P. 10-32 (in Russian).
17. **Malahatka Yu.N., Tarasova G.I.** Sorbent on the basis of aspiration of dust. *Sorbts.Khromatograf. Prots*. 2013. V. 13. N 4. P. 476-481 (in Russian).
18. **Selitsky G.A., Ermakov D.V.** The ways of increasing the depth of purification of acidic waste water. *Ekol. Proizvodstva*. 2011. N 4. P. 70-78 (in Russian).

19. **Павлов Д.В., Колесников В.А.** Универсальная система очистки промышленных сточных вод. *Водоочистка*. 2013. № 1. С. 12-16.
20. **Сизых М.Р., Батоева А.А., Тимофеева С.С.** Локальная очистка сточных вод красильно-отделочных производств. *Водоснабжение и сан. техника*. 2013. № 3. ч. 1. С. 28-31.
21. **Шамян В.Л.** Глубокая очистка сточных вод предприятий текстильной промышленности. *Водоснабжение и сан. техника.* 1997. № 4. С. 21-23.
22. ISO 5725.1-6 Точность (правильность и прецизионность) методов и результатов измерений. Ч. 2. Основной метод определения повторяемости и воспроизводимости стандартного метода измерений.
23. РМГ 61-2010. Государственная система обеспечения единства измерений. Показатели точности, точности методов количественного химического анализа. Методы оценки.
24. **Забнева О.В.** Биофильтрование водного раствора хлорфенола через слои активного угля. *Химия и технология воды*. 2013. Т. 35. № 1. С. 64-75.
25. **Шамян В.Л.** Коэффициент агломерации взвешенных веществ в процессе осаждения сточных вод предприятий хлопчатобумажной промышленности. «Экологическая безопасность в строительстве» (Москва, 28-30 октября 1998г.). Матер. заоч. науч.-техн. симпоз. М.: 1998. С. 103-105.

19. **Pavlov D.V., Kolesnikov V.** Universal system of industrial waste water treatment. *Vodoochistka*. 2013. N 1. P. 12-16 (in Russian).
20. **Sizykh M.R., Batoeva A.A., Timofeeva S.S.** Local waste water treatment of paint-and-finish industries. *Vodosnabzheniye San. Tekhnika*. 2013. N 3. Pt. 1. P. 28-31 (in Russian).
21. **Shamyan V.L.** Deep cleaning of wastewater of the textile industry. *Vodosnabzheniye San. Tekhnika*. 1997. N 4. P. 21-23 (in Russian).
22. ISO 5725.1-6 Accuracy (trueness and precision) of measurement methods and results. Pt 2. Basic method for the determination of repeatability and reproducibility of a standard measurement method. (in Russian).
23. RMG 61-2010. State system for ensuring the uniformity of measurements. Indicators of accuracy, accuracy, precision of quantitative chemical analysis techniques. Methods of evaluation. (in Russian).
24. **Zabneva O.V.** Biofiltration aqueous solution of the chlorophenol through the layers of active carbon. *Khim. Tekhnol. Vody*. 2013. N 1. P. 64-75 (in Russian).
25. **Shamyan V.L.** The coefficient of the agglomeration of suspended solids in the sedimentation process of wastewater of the cotton industry. “Environmental safety in construction” (Moscow, 28-30 October 1998). Materials of the correspondence scientific and technical Symposium. M.: 1998. P. 103-105 (in Russian).

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