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Study of the Biochemical Method for Wastewater Purification from Textile Productions from Dyes and Suspended Substances

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ABSTRACT

Wastewater treatment in textile production is a multi-stage process that requires correct step-by-step processing, since textile auxiliary substances can be toxic. In this regard, this article discusses the combined, i.e. sorption-coagulation-flocculation treatment of waste water from textile production. The use of a combined cleaning method contributes to a more complete removal of surfactants, inorganic and organic substances, dyes, suspended solids and various salts.

The effective conditions for the sorption of the dye from an aqueous solution selected by the sorbent have been determined. It was found that the effective mass of the sorbent is within 0.2; 0.3; 0.4; 0.5; 0.6 g per 100 ml of solution. It was found that an increase in mass significantly increases the purification of the solution from the dye, and leads to a decrease in the optical density at the points corresponding to 0.4 and 0.6 g.

It has been determined that the initial values of the main indicators of wastewater entering the deep purification at a bubbling adsorption unit correspond to the values of the indicators of these flows passing through a system consisting of kaolin-bentonite-aluminum sulfate-ferric chloride.

Since the main indicators of pollution are the intensity of coloring and surfactants for wastewater from textile and silk-winding factories, studies on the effect of the size of adsorbent particles and speed on the adsorption process were primarily carried out for these indicators. At the same time, it was determined that the maximum (up to 97%) wastewater treatment from surfactants and dyes by a chemical method when using the composition K-5 and K-6 is achieved with a particle size of sorbents of 0.5-0.6 nm.

KEYWORDS: BOD-biochemical oxygen consumption, COD-chemical oxygen consumption, PAA-polyacrylamide, optical density, adsorbent, caolin, bentonite, concentration, unfixed dye, surfactant.

In order to develop a new rational technological method for maximum purification of wastewater from enterprises of the cotton industry, the study of data on the main indicators of wastewater pollution in the industry under study was carried out. From the above, it follows that the wastewater of this industry is a complex physical and chemical system. At various stages of the finishing industries of the textile industry, wastewater contains various types of dyes, synthetic surfactants, fibrous impurities, mineral salts and suspended substances that require cleaning from them.

As you know, the stages of decoction, bleaching, dyeing and finishing of fabrics consume about 25-30% of the used process water, while washing and finishing fabrics after decoction, dyeing and printing requires a huge amount of 70%, and sometimes 80% of process water. On the one hand, the specificity of the main wastewater pollution from enterprises of the textile industry, and on the other hand, their high degree of dispersion does not make it possible to create a unified technological scheme for wastewater treatment in this industry [1, p.14].

Surfactants, like dyes, are biochemical stable compounds, the oxidation of which in the process of biochemical purification is extremely slow and incomplete. If the presence of dyes in water bodies creates only unfavorable conditions for the development of aquatic organisms due to disruption of the processes of photosynthesis, then the presence of surfactants has a toxic effect on many aquatic organisms and slows down the process of self-purification of water bodies. Wastewater from dyeing and finishing industries must be cleaned not only before being discharged into a reservoir, but sometimes even before being sent to biochemical treatment [2, p.77; 3, p. 44; 4, p.174]. Proceeding from this, in the present work, preference was given to physicochemical methods of deep purification of wastewater.

The aim of our work is to develop and improve an environmentally efficient combined method for treating wastewater generated during various production processes.

The work is devoted to the study and improvement of the composition of preparations used in the process of wastewater treatment, formed during dyeing, finishing and bleaching of fabrics, followed by sedimentation and filtration. Therefore, the task was to determine the optimal ratio of inorganic substances for the purpose of theoretical and practical comparison of the physico-chemical properties of the proposed “adsorbent-coagulant-flocculant”.

Table 1 presents data on wastewater pollution of textile enterprises, JV TSK LLC.

The textile factories still have a high level of water consumption. Water consumption for production purposes mainly depends on the technological scheme of the enterprise, the type of processing of cotton yarn, as well as on the volume of production. Water consumption in recycling water supply systems for industrial processes is hundreds of millions of cubic meters of water per year, while the amount of fresh water reaches 3.5 m^3 or more per 1 ton of processed cotton yarn and fabric.

To solve the problem of preventing pollution of water bodies and their rational use, it is necessary to create resource-saving chemical-technological water systems at enterprises.

It should be noted that the chemical - technological system of the textile industry is a set of apparatuses, machines and other auxiliary devices (elements), as well as material, energy and other flows (connections) between them, functioning as a whole and intended for the processing of initial substances (raw materials) into products [5, p.108; 6, p.80; 7, p.56; 8, p.92].

Table 1. Indicators for wastewater pollution of textile enterprises of the second stream

Sewage pollutant	Consentration, mg/dm^3	
	Enterprise JV LLC “TSK”	Standard for reservoirs
pH	8,5	7,0
Unfixed dye, mg/l	11,3	<0,5
Surfactant, mg/l	40	1,0-1,5
Chlorides, mg/l	43	3,5
Sulfates, mg/l	280	16-18
Suspended substances, mg/l	250-300	17-21
COD, mg/l	350	
BOD full. mg/l	276	

In addition to the above stages, the textile industry must pay great attention to contaminated wastewater, which must be cleaned of impurities. The latter are the main sources of wastewater pollutants and environmental protection [9, p.48; 10, p.68; 11, p.32].

In this work, finely dispersed bentonite and kaolin were used as a sorbent with a weight ratio of 1:1, and as coagulants, crystalline hydrate of aluminum sulfate and ferric chloride, and as a flocculant PAA with a molecular weight of 30,000.

Model solutions of waste water were prepared on the basis of residual baths and rinsing after printing and after dyeing cotton fabric with active dyes (for example, direct bright orange). The choice of various classes of dyes is due to their peculiarity of being selected by the substrate to be painted from the dye bath: acidic ones are chosen up to 95 ... 98%, and direct ones, on the contrary, have a rather low indicator - about 30%.

In order to determine the effective conditions of sorption of the dye selected by the sorbent from an aqueous solution, the efficiency of the mass of the sorbents, the sorption time, and the pH of the medium were determined. The effective mass of the sorbent is within the range of 0.2; 0.3; 0.4; 0.5; 0.6 g per 100 ml of solution. In fig. 1 (the choice of the effective mass of the sorbent in the process of removing direct bright orange (1) and acidic bright red anthraquinone (2) from the solution, the dependence of the optical density A of the residual bath of the dye solution on the mass of the sorbent is shown.

From the data obtained, it can be seen that an increase in mass significantly increases the purification of the solution from acidic bright red anthraquinone, and it can be noted from the above dependence that the optical density decreases at the points corresponding to 0.4 and 0.6 g. Therefore, based on economic considerations and the kinetic regularity of the effective the mass of sorbents is taken as a mass of 0.4 g.

In order to establish the optimal value of the sorption time, the experiments were carried out as follows: a dye with a selected sorbent mass of 0.5 g is filtered on a shaking apparatus for 5, 10, 15, 20, and 25 min (Fig. 2, curve 1 - selection of an effective sorption time by the studied sorbents in the process of removing direct bright orange from the solution and Fig. 2, curve 2 - the choice of the effective sorption time by the studied sorbents in the process of removing the acidic bright red anthraquinone from the solution).

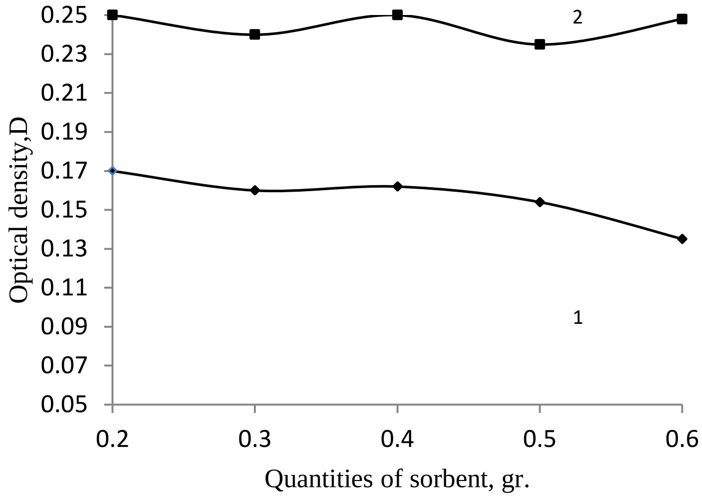


Fig.1. Dependence of the optical density of the second stream on the mass of the adsorbent.

1-Bright orange dye; 2-Bright red anthraquinone dye;

Based on the data of two diagrams, it was decided to take 15 min for the effective sorption time of direct and acid dyes, since with further filtration the optical density of the model solutions begins to increase.

The effective pH value of the medium was selected in the range of 3, 5, 7, 9, 11, and 13 at the selected sorbent mass and sorption time (Fig. 3, curves 1 - the choice of an effective sorption pH medium by the studied sorbents during the removal of direct bright and Fig. 3, curves 2 - the choice of an effective medium for pH sorption by the studied sorbents in the process of removing the acidic bright red anthraquinone from the solution).

The obtained dependences indicate that the maximum possible absorption of the dye by the selected sorbents takes place in an acidic medium; therefore, the interval 3 ... 5 was chosen as the optimal pH medium.

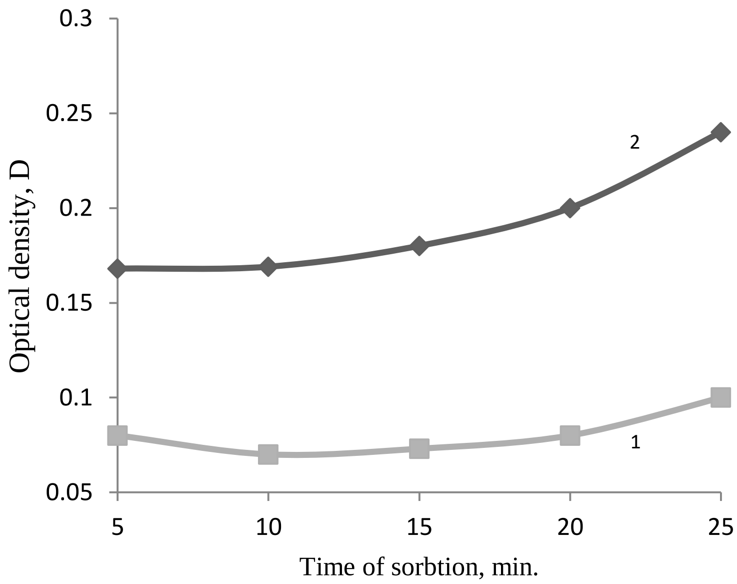


Fig.2. Dependence of the change in the optical density of the second flow wastewater on the sorption time.

1 - selection of the effective sorption time by the studied sorbents in the process of removing direct bright orange from the solution;

2 - selection of the effective sorption time by the studied sorbents during the removal of acidic bright red anthraquinone from the solution.

In a laboratory setup, studies were carried out to identify the selectivity (R, %) of the above methods according to the main indicators of wastewater from textile enterprises at various values of operating parameters.

The initial values of the main indicators of the wastewater of the 2nd stream entering the deep purification at the bubbling adsorption unit correspond to the values of the indicators of these streams passing through solid compositions consisting of the kaolin-bentonite-aluminum sulfate-ferric chloride system, i.e. composite sorbent.

The composition of the composition for wastewater treatment is presented in table. 2.

In work [12, p.24; 13, p.106; 14, p.60], it is proposed to purify wastewater from impurities by creating technological schemes that allow the reuse of deeply purified wastewater in various technological processes of fabrics production.

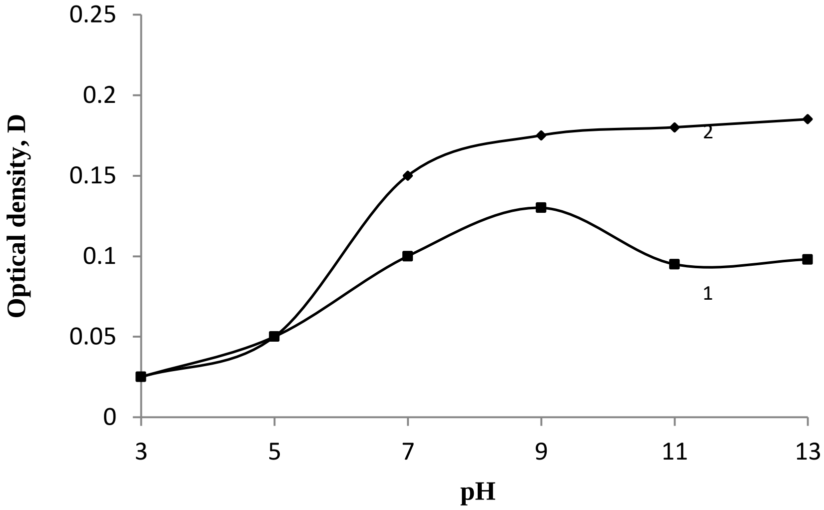


Fig.3. Change in the optical density of the wastewater solution of the second stream from the pH of the medium.

1 - selection of an effective medium for pH sorption by the studied sorbents in the process of removing direct bright orange from the solution;

2- selection of an effective medium for pH sorption by the studied sorbents in the process of removing acidic bright red anthraquinone from the solution.

Table 2. The ratio of the components that make up the composition for wastewater treatment

Composition type	Composition ratio in composition			
	Sorbent, g/l		$FeCl_3 \cdot 6H_2O$	$Al_2(SO_4)_3 \cdot 18H_2O$
	Kaolin	Bentonite		
C – 1	2,0	-	0,5	0,25
C– 2	3,0	-	0,75	0,50
C – 3	-	1,0	0,5	0,25
C – 4	-	2,0	0,75	0,50
C – 5	2,0	1,0	0,75	0,50
C – 6	3,0	2,0	0,75	0,50

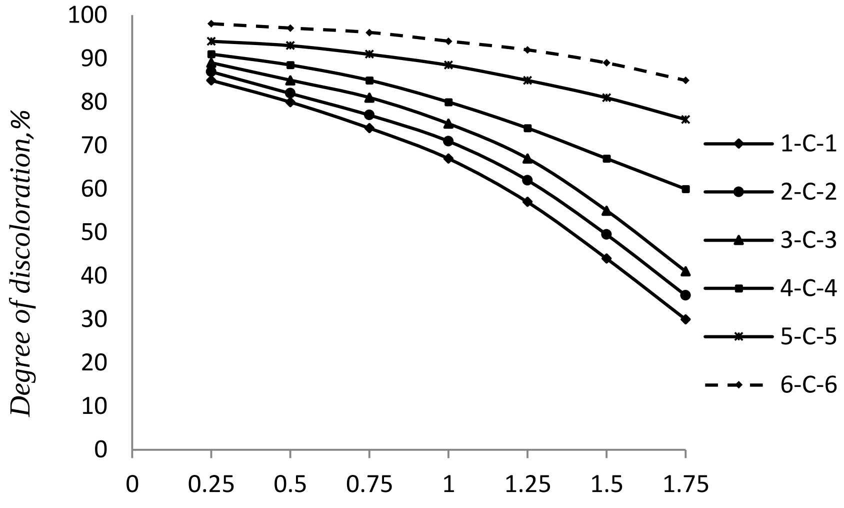
In order to develop the method, we investigated the possibility of maximum (up to 97%) purification of industrial waters from surfactants and dyes by a chemical method, which consists in their separation from the solution by adsorbed reagents.

Since the main indicators of contamination for wastewater from silk-winding enterprises are the intensity of color and surfactant, the studies on the effect of the size of the adsorbent particles and the rate on the adsorption process, first of all, were carried out for these indicators.

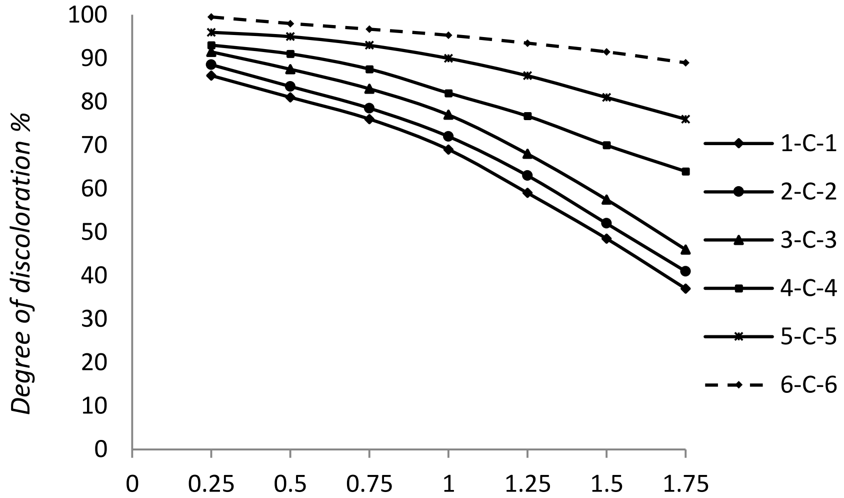
Fig. 4. (a, b) it can be seen that 97% discoloration is achieved when using the composition C-5 and C-6, the particle size of which is 0.5-0.6 nm.

For fine-porous compositions C-1 and C-2, the bleaching efficiency also practically depends on the particle size and fluctuates in the range from 84 to 86% [15, p.48; 16, p.151; 17, p.88; 18, p.535; 19, p.537].

In this case, the maximum efficiency of bleaching is achieved with a particle size of 0.5 to 0.6 nm. For the adsorption of C-3 grades, the optimal particle size limit is limited to 0.8 nm, and for the C-4 grade composition - to 0.1 nm.



Kaolin particle size r,nm. (a)



Bentonite particle size, r, nм. (b)

Fig.4. Influence of the particle size of kaolin (a) and bentonite (b) on the degree of discoloration of wastewater for the 2nd stream

Taking into account the low concentration of fibrous solubility in textiles, it was decided to use combined and integrated methods to increase the efficiency of wastewater treatment.

Thus, we can conclude that a new scientifically substantiated integrated technology for deep wastewater treatment has been developed and experimentally tested [20, p. 41]. Experimentally made a choice and rational a combination of doses of mineral coagulant and sorbent when they are combined use and particle size of the sorbent.

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