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IMPROVEMENT OF WASTEWATER TREATMENT SORPTION-COAGULATION-FLOCCULATION METHOD

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***Abstract:* We studied the treatment of wastewater from silk-winding production using traditional (activated carbon grades AU-e) and alternative sorbents (kaolin and bentonite in a combined method with the simultaneous involvement of coagulants $FeCl_3 \times 6H_2O$, $Al_2(SO_4)_3 \times 18H_2O$).**
It was found that the best option among the reagents considered is to use $FeCl_3 \times 6H_2O$ and $Al_2(SO_4)_3 \times 18H_2O$ as a coagulant, and kaolin and bentonite as a sorbent in concentrations of 0.75 mg/l, 0.5 mg/l, 2.0 g/l and 2.0 g/l, respectively.
***Keywords:* cleaning, sorbent, kaolin, bentonite, method, concentration, efficiency, suspended substances, surfactant, coagulant, the intensity of staining, composition.**

ABBREVIATION:
COD - chemical oxygen demand;
BOD - Biochemical oxygen demand;
PAA – Polyacrylamide;
PVA - Polyvinyl alcohol;
CMC - Carboxymethyl-cellulose;

INTRODUCTION

Currently, wastewater treatment from various industries is an urgent problem due to the continuing growth of anthropogenic load on the environment. Among the pollutants, a special place is occupied by wastewater from silk-winding production, which leads to a change in organoleptic, physical and chemical properties, a decrease in oxygen content, an increase in COD, BOD and other indicators of wastewater. As noted in [1, 2], the wastewater of silk-winding production contains various types of dyes, synthetic surfactants, fibrous impurities, mineral salts and suspended substances that require cleaning from them. Steaming, decoction, bleaching, dyeing and finishing processes consume approximately 50-60% of the process water used, while washing fabrics after dyeing and printing requires 40% and sometimes 50% of the process water. On the one hand, the specificity of the main wastewater pollution of enterprises, 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 the selected industry.

MATERIALS AND METHODS

As expected, surfactants, like dyes, are biochemical stable compounds, the oxidation of which in the process of biochemical purification is very difficult and extremely slow and incomplete. Moreover, if we take into account that the presence of dyes in water bodies creates only unfavourable 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 silk-winding industries must be treated not only before being discharged into a reservoir but sometimes even before being sent for biochemical treatment. Based on the above and the specificity of silk fabric production, in this work, preference was given to physicochemical methods of deep purification of wastewater.

Considering the above, in order to develop a rational technology for deep purification of wastewater from silk-winding enterprises, we adhered to the principle of separating wastewater by the nature of pollution into two main streams:

1st stream - wastewater generated in the process of steaming cocoons, boiling silk fabric in a soapy solution in order to release silk glue (sericin) and natural dyes, as well as dressing components, which should be easily removed from the fabric before finishing.

2nd stream - wastewater from dyeing, printing shops and rinsing of printed fabrics after printing.

In silk weaving, all shallow twist yarns are sizing: viscose, acetate, chlorine, lavsan and others, as well as the staple yarn of all mixtures and silk yarn. The following chemical materials are used for the preparation of the dressing:

adhesives – the main component of the dressing, which ensures the bonding of individual fibres and the formation of a film. Used starches (potato, rice, corn, etc.) and animal glue (gelatin, casein, etc.).

Widely used chemical adhesives – polyvinyl alcohol (PVA), carboxyl methyl-cellulose (CMC), polyacrylamide (PAA) and others, which are used to prepare to dress, in pure form or as a partial replacement food;

splitters are chemical materials that break up large molecules of starch products, resulting in the necessary viscosity of the dressing.

Recently, chloramine has been widely used as a cleavage agent, which provides uniform splitting of starch grains without decomposition. wetting agents and softeners that prevent the formation of a hard and brittle film on the threads.

As softeners, oleic soap is used, which creates a cotton increase in the hygroscopicity of the straightened yarn, and retains the flexibility of the starch film. The degree of contamination of wastewater of the 1st stream is approximately 1.5-2.0 times less than that of the 2nd stream, so the consumption of chemical reagents for cleaning the 1st stream should decrease compared to the 2nd stream. Based on this idea, it is proposed to divide the wastewater of silk-winding production into two streams [4-5].

The process of deep wastewater treatment of these two streams is a combination of the following treatment sequences: settling in thin-layer settling tanks using reagents, filtration on solid compositions of sorbent-coagulant: kaolin-bentonite-iron chloride-aluminium sulphate. At the same time, the proposed technological scheme allows performing the listed cleaning methods in a combination of parallel and sequential methods. The required amounts of coagulants are expressed in the values of the lowest doses of anhydrous aluminium sulphate combined with the minimum dose of iron chloride, which reduces the colour intensity of wastewater by about 70-90%, depending on the initial water composition [5].

Table 1 shows the composition and concentration of wastewater pollution at the enterprise JV LLC "BBS". According to the data presented in Table 1, the values for suspended particles in wastewater are quite high. Since the process of bubbling mixing of chemical reagents and wastewater with subsequent sedimentation is a fairly effective and low-energy retention process, it significantly speeds up the sedimentation process. The sedimentation rate of suspended solids according to the proposed method is increased by enlarging the settling particles and introducing chemical reagents - sorbents and coagulants into the wastewater. It is known from the literature [6-8] that during adsorption, the concentration of molecules of the absorbed substance on the surface of the sorbent occurs under the action of the force field of the surface.

Table 1.

Composition and concentration of wastewater pollution from silk-winding production of the first and second flows

Indicators	Concentration, mg / l	
	Stream-1	Stream-2
pH	8,0	9,6
Suspended substances, mg/l	150-200	350-400

Dyes, mg/l: natural synthetic	1,7 -	- 11,6
Surfactant, mg/l	20	40
Total alkalinity, mg-eq/l	9,1	8,0
Dry residue	200	400
Chlorides, mg/l	31	48
Sulfates, mg/l	50	170
BOD full, mg O_2/l	126	247
COD, mg O_2/l	160	210
Phosphorus (in terms of P_2O_5)	2,5	6,7
Ammonium ion	4,6	5,7
Transparency by font, cm	2	3

RESULTS AND DISCUSSION

The force field of the surface is formed as a result of the presence of the boundary molecules of the solid phase, in contrast to intraphase molecules, of greater free energy. As a result, the boundary molecules attract molecules from the contracting phase. In this case, intermolecular interactions can be conditionally divided into three types:

1) interaction between sorbent and water molecules;
2) between the molecules of the sorbent and the extracted substance;
3) between the molecules of the extractable substance and water.

The difference in the energies of these three processes is the energy with which the substance extracted from the solution is retained on the sorbent surface. Adsorption is a reversible process, i.e. the sorbed substance can pass from the adsorbent back into solution.

Table 2.

Changes in the efficiency of wastewater treatment of the second stream depending on the sorbent dose

Incoming water		Sorbent, g/l		Cleaning efficiency,%
COD, mg O_2/д	Colour intensity by breeding,%	Kaolin	Bentonite	
212	1:320	0,5	-	64,18
212	1:320	1,0	-	67,43
212	1:320	1,5	-	69,71
212	1:320	2,0	-	72,18
212	1:320	2,5	-	75,07
212	1:320	3,0	-	77,23
176	1:240	-	0,5	65,72
176	1:240	-	1,0	69,15
176	1:240	-	1,5	71,86
176	1:240	-	2,0	74,35
164	1:410	2,0	0,5	79,23
164	1:410	2,0	1,0	82,45
164	1:410	2,0	1,5	86,53
164	1:410	2,0	2,0	89,19
191	1:280	2,5	0,5	90,15
191	1:280	2,5	1,0	93,95
191	1:280	2,5	1,5	98,14
191	1:280		2,0	98,76
130	1:346	3,0	0,5	91,28
130	1:346	3,0	1,0	94,36

130	1:346	3,0	1,5	98,65
130	1:346	3,0	2,0	99,12

To determine the optimal concentration of the sorbent during the purification process, we carried out studies at various ratios of the sorbent kaolin and bentonite (Tables 2 and 3). Since the developed composition has a complex composition, it is difficult to determine in the presence of a joint presence whether the sorbent or coagulant has a greater effect on the degree of wastewater treatment.
Therefore, referring to the literature, when determining the concentration of the sorbent and the concentration of coagulants $Al_2(SO_4)_3 \cdot 18H_2O$ and $FeCl_3 \cdot 6H_2O$, they were kept constant and equal to 0.5 and 0.75 mg/l, respectively [7].

Table 3.

The efficiency of wastewater treatment of the second stream with optimal doses of mineral coagulants

COD, mg O_2/l	The intensity of colour breeding, %	Coagulants, g/l		Cleaning efficiency			
		$Al_2(SO_4)_3$	$FeCl_3$	by COD		by weighted values	
				O_2 mg/l	%	mg/l	%
212	1:320	0,25	0,3	40,23	80,84	246,72	70,49
212	1:320	0,50	0,4	42,23	79,89	249,43	71,26
212	1:320	0,75	0,5	48,28	77,01	251,81	71,94
176	1:210	0,25	0,3	37,31	82,23	287,53	82,15
176	1:210	0,50	0,4	32,14	84,69	289,46	82,70
176	1:210	0,75	0,5	31,18	85,15	297,15	84,90
164	1:410	0,25	0,3	41,24	80,36	251,43	71,84
164	1:410	0,50	0,4	43,56	79,25	252,61	73,60
164	1:410	0,75	0,5	45,40	78,38	260,77	74,50
191	1:280	0,25	0,3	28,45	86,49	336,75	96,10
191	1:280	0,50	0,4	26,76	87,25	339,42	96,97
191	1:280	0,75	0,5	25,14	88,03	340,81	97,37
130	1:346	0,25	0,3	55,40	73,61	307,45	87,84
130	1:346	0,50	0,4	52,61	74,94	309,14	88,32
130	1:346	0,75	0,5	58,15	72,30	314,65	89,90

The speed of sorption and desorption processes depends on the concentration of the substance on the adsorbent surface and in the solution. According to the indicators of wastewater treatment of the second flow in Table 3, the degree of removal of contaminants by this method is much higher than the sedimentation of aluminium or iron oxyhydrates with adsorbed contaminants. The efficiency of reduction of COD and surfactant concentration in wastewater was on average 65% and 82%, while the efficiency of reduction of the same indicators in oxyhydrate sediments sedimentation was 48-54% and 54-61% respectively. The high degree of removal of surfactants and other organic contaminants from silkworm sewage is explained by the fact that in the process, in addition to the sorption of these substances on the surfaces of adsorbents there is sorption of ions and molecules of dissolved substances on the surfaces of air bubbles and their removal into the foam layer.

Table 4.

Wastewater treatment indexes of the second stream

Indicators	Before cleaning	After cleaning	Cleaning efficiency, %

	min. value	Max. value	average value	min. value	Max. value	average value	min. value	Max. value	average value
Color intensity by dilution	1:130	1:212	1:170	1:21	1:45	1:34	94	98	96
Suspended substances, mg/l	350	400	375	35	65	50	98	96	97
Dry residue, mg/l	2900	3100	3000	120	260	190	-	-	-
Ash content of dry residue, %	32	56	44	30	52	41	-	-	-
COD, mg O_2/l	160	210	185	25	58	42	72	88	80
BOD full, mg O_2/l	126	247	187	42	64	53	67	74	71
pH	8,6	9,6	9,1	7,37	8,43	7,90	-	-	-

The proposed technology helped to clean the wastewater of silk-winding enterprises from the main pollutants-dyes, surfactants, dressing preparations, etc.

The study of the influence of the bentonite particle size on the degree of wastewater discolouration at different flow rates and the kinetics of removal of impurities from wastewater showed the principal possibility of joint use of kaolin and bentonite-containing compositions [8].

It was found that when using a composite adsorbent of the K-5 brand, the highest degree of purification is achieved: in terms of colour intensity – 91-97%, in terms of suspended substances-91-95%.

Based on the obtained data, new chemical methods have been developed that allow almost 93-97% complete separation of impurities from solutions.

CONCLUSION

The sorption treatment of wastewater from silk-winding production was studied using traditional (activated carbons of AU-E grades) and alternative sorbents (kaolin and bentonite in a combined method with the simultaneous involvement of coagulants $FeCl_3 \cdot 6H_2O$, $Al_2(SO_4)_3 \cdot 18H_2O$).

In order to reduce the cost of the sorption treatment process, as well as to develop a rational technology, according to the nature and degree of wastewater pollution, it is proposed to divide them into two streams.

Also, the prospects of using available alternative physicochemical methods of wastewater treatment are shown.

The sorption-coagulation treatment of wastewaters of silk-winding production has been investigated.

It is shown that of the considered reagents, the best option is to use $FeCl_3 \cdot 6H_2O$, $Al_2(SO_4)_3 \cdot 18H_2O$ as a coagulant, and kaolin and bentonite as a sorbent in concentrations of 0.75 mg/l, 0.5 mg/l, 2, 0 g/l and 2.0 g/l, respectively [8-9].

Thus, the research revealed the types of specific reagents (sorbent and coagulant) and their optimal doses during bubbling mixing and settling. The optimal doses of reagents were determined according to the results of studies on reducing the colour intensity, suspended solids and COD.

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