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WASTEWATER TREATMENT OF CELLULOSE PRODUCTION BASED ON LOCAL RAW MATERIALS

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Currently, the cotton industry is associated with a significant consumption of water from natural sources, including low-grade lint, cotton wool, and other cellulose used in textiles. In production, 1 ton of pulp and paper products consumes 100 or more liters of water, of which at least 30% is fresh water, which leads to an increase in the amount of wastewater [1].

The advantages of producing cotton pulp from annual plants instead of perennial plants are particularly important due to the fact that they use much less water, do not use toxic chlorine, sulfur and other reagents in the production [2].

It was previously announced by the authors that wastewater can be purified and reused in cellulose production plants [3]. The fact that drinking water can be reduced by 5-10 times due to repeated reuse of wastewater shows how urgent the work is in times of water scarcity.

In order not to harm the environment, it is necessary to clean the waste water up to the values of limit substance amount (PDK), at present, it is necessary to further increase the requirements for the quality of waste water of the enterprises.

In wastewater treatment practice, it is necessary to widely use membrane separation methods, which have such advantages as high purification levels in closed-loop water supply, compactness of equipment, wide automation, and low cost of treatment compared to traditional treatment facilities [4].

The following requirements for wastewater entering the membrane treatment are: initial purification from large dispersed suspended solids; pH value from 3 to 12; temperature should not exceed the level at which membrane separation occurs.

This article presents the results of research on the reuse of wastewater from the pulp industry in the process of obtaining cotton pulp after treatment using mechanical and physicochemical methods.

The object of the study was wastewater from the technology of cellulose extraction from low-grade lint in oxygen-alkaline high-temperature (130^0C) conditions. The composition of this wastewater includes: salts of fatty acids, hemicellulose, resins, the presence of.

The chemical oxygen demand (COD_5) determined by the arbitration method was 9700 mg-Og/l, free alkalinity 5.0 mg-eq/l, pH>12.

Filtration followed by neutralization and coagulation was used for the initial treatment of the investigated wastewater.

The wastewater was filtered under vacuum in a quartz-sand filter. According to the amount of sediment retained in the filter, it was determined that the concentration of suspended substances in wastewater is 1 g/l.

The wastewater was neutralized due to its high pH value. Therefore, concentrated sulfate 60% nitric acid was added to it until it reached pH=6.7 and pH=9.0. It uses water coagulants that are widely used in wastewater treatment practice: aluminum sulfate ($AI_2(SO_4)_3$*18H2O) and iron sulfate (II) ($FeSO_4*7H_2O$). Therefore, in order to reduce the consumption of reagents, it is necessary to carry out the coagulation process when the pH value is in the optimal range: when using $AI_2(SO_4)_3*18H_2O$ - pH=4.5-7; when using $FeSO_4$-$7H_2O$ - pH=8-10 [5].

The results of wastewater neutralization are presented in table 1.

Table 1
Changes in wastewater (COD5) and pH values after neutralization

Neutralizing agents	Wastewater pH	Amount of waste water (COD_5), mg O_2/l
Nitric acid (HNO_3)	6.7	1370
	9.0	1230
Sulfuric acid (H_2SO_4)	6.7	1460
	9.0	1290
Alkali and alkali (NaOH)	6.7	2180

The analysis of the COD_5 values in Table 1 shows that the neutralization of wastewater can be accompanied by oxidative processes that lead to a decrease in the COD_5 value. For example, the COD_5 of the wastewater in the initial state decreased to 1230 and 1280 after neutralization when HNO_3 and H_2SO_4 were used as neutralizing agents, respectively.

Then, the wastewater under study was treated using coagulants in the form of 10% aqueous solutions - $AI_2(SO_4)_3*18H_2O$ and iron sulfate (II) $FeSO_4*7H_2O$ - to remove finely dispersed mineral and organic components.

The wastewater sample that had undergone the neutralization stage was added with solutions of $AI_2(SO_4)_3*18H_2O$ and $FeSO_4*7H_2O$, recalculated according to $A1^{3+}$ and Fe^{3+}, until the concentrations reached 50, 100, 200, 300, 400, 500 mg/l. The samples were mixed on a magnetic stirrer for 2 minutes and left to stand for 2 hours. During this time, the appearance of particles and their sedimentation were observed in samples №1 and №3, whose concentrations were recalculated according to $A1^{3+}$ and Fe^{3+} were 500 mg/l (table 2).

The data in table 2 show that the type of neutralizing agent affects the purification process in which coagulants are used. The coagulation process was found to be effective when $AI_2(SO_4)_3*18H_2O$ was added to the wastewater at a pH of 6.7. Under these conditions, the process proceeds with the clarification of the wastewater. The degree of purification was 38.8% compared to the previous stage (COD5), which corresponds to a total degree of purification of 71.4%. The initial purified water obtained by this method meets the requirements for wastewater undergoing membrane purification.

Table 2
Changes in the pH and COD values of wastewater after the addition of coagulants until a concentration of 500 mg/l is reached, recalculated in accordance with $A1^{3+}$ and Fe^{3+}

Example	Neutralizing agents	Initial pH of wastewater	Coagulant	(COD), mg-O_2/l
1	HNO_3	6,7	$Al_2(SO_4)_3*18H_2O$	427

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2	H_2SO_4	6,7		534
3	HNO_3	9,0	$FeSO_4*7H_2O$	261
4	H_2SO_4	9,0		319

The cleaning efficiency (COD_5) was determined by the change in value and the light transmission coefficient determined in a cuvette with a layer thickness of 1 cm in a photoelectrocalorimeter at a wavelength of 360 nm.

As a result, after the filtration process, the following parameters were achieved: (COD_5) 1360 mg O_2/l, the light transmission coefficient was 98.5%, which means that the purification level is 93.5%.

Sodium ions dissolved in wastewater were sorbed using N-form cations. The results are presented in table 3.

Table 3

Sorption of Na^+ ions from wastewater by ion exchange

Cationite	**Static exchange capacity of catio exchangers for Na^+ ions, mg-eq/g**	**Partition coefficient, ml/g**
KU-2×8	5.4	184
KU-1	3.1	110

Along with the ion-exchange capacities of ion exchangers, the rate of ion-exchange - the kinetics of the process - is also of practical importance. The rate of ion-exchange in cation exchangers was characterized by the amount of sodium ions (mg-eq/g) absorbed from 0.1 N NaCl solutions under static conditions per unit of time (minute). In this study, KU-2×8 and KU-1 cation exchangers used in industry were studied. The static exchange capacities of cation exchangers in the H-form in 0.1 N NaCl solution were determined: KU-2×8 - 5.4 mg-eq/g, KU-1 - 3.1 mg-eq/g.

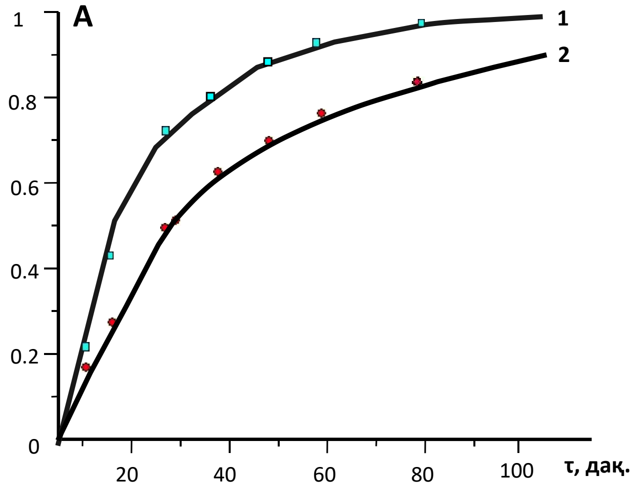

Fig. 1. Sorption rate of sodium ion in cationites. Cationites: 1 – КU-2×8, 2 – КU-1.

From the kinetic curves (Fig. 1), it can be seen that the saturation level of the KU-2×8 cationite during the sorption process for 30 minutes was 2.8 mg-eq/g, while that of the KU-1 cationite was 1.6 mg-eq/g. In order to study in detail the mechanism of exchange of hydrogen ions for sodium ions, the well-known time-dependent ion-exchange rate relationships were used: $\lg(1–A)=k_1\tau$ – for thin-layer kinetics; and $A=k(\tau)^{1/2}$ – for gel kinetics; where A is the corresponding amount of ions sorbed on the cationite – the degree of equilibrium for solution systems (dynamic method), but under static conditions their solutions in a limited volume are used in large ratios of the liquid phase to the cationite (in our conditions Sphase: Qphase = 1000 ml: 1 g.). τ – time, minutes. Based on experimental and computational data, kinetic curves were constructed. When constructing the graph of the dependence of $\lg(1–A) – \tau$, the experimental points do not lie on a single straight line for the studied cation exchangers. Undoubtedly, the internal diffusion mechanism of kinetics has a dominant effect on the sorption rate. The limiting effect of gel kinetics can be assessed both by the coordinates of the dependence of A on $\sqrt{\tau}$ for the initial stages of the process, and by the curves of the dependence of Bt on τ for the entire process, where $A<0.4$, where the experimental points lie on a straight line to a first approximation, Bt is a non-dimensional quantity and is a function of A.

Conclusion

According to the results of the conducted studies, the purification of wastewater generated during the production of cellulose by the oxygen-alkali cooking method using the ion-exchange method after the initial filtration, neutralization and coagulation stages is recommended for widespread use in the future in a closed water circulation system for the production of cellulose from cotton raw materials.

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