Development of wastewater treatment technology with purpose of their reuse in process of obtaining cotton pulp

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Abstract. Today, an urgent problem is developing a technology for producing cotton cellulose from low-grade linters with the rational use of water resources. This issue is especially relevant for the Republics of Central Asia.
Also, the development of a technology for the production of cotton pulp would provide an acute shortage of pulp and paper, protect the environment, reduce energy costs, reduce water and chemical costs, and rationally use available raw materials.
The paper presents the results of studies on the possibility of cleaning waste liquor and wash water for reuse in obtaining cotton cellulose.
The object of the study is the cooking solution, spent liquor, used water after pulping and washing, their sanitary characteristics, and the quality indicators of the products obtained.
The discoloration of wastewater, the residual amount of sodium hydroxide, the change in the optical density of the cooking solution, and the chemical composition of the waste liquor and washing water after discoloration were experimentally studied.

1 Introduction

The problem of environmental protection in our country is given exceptionally great attention. This issue has been deeply reflected in the Constitution of the Republic of Uzbekistan in recent years and in the fundamental laws on land, its subsoil, waters, forests, atmospheric air, and wildlife, as well as in special resolutions on nature protection by the Oliy Mazhilis and the Cabinet of Ministers of the Republic of Uzbekistan [1].

President of Uzbekistan, Sh.M. Mirziyoyev, by his Decree of February 7, 2017, approved the Action Strategy for five priority areas of the country's development in 2017-2021.

The strategy was developed based on a comprehensive study of relevant and significant issues for the population and entrepreneurs, analysis of legislation, law enforcement

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practice, and foreign experience. The document was published in the global Internet networks and was widely discussed with the participation of experts and the public. [2].

Currently, the pulp and paper industry of the Republic of Uzbekistan requires the creation of new technological processes that reduce water consumption, reduce the amount and toxicity of wastewater, and gas emissions, which allows the organizing closed cycles of water use and chemical regeneration, which is one of the most important areas of scientific and technical progress.

Based on the previous, this work aims to study the possibility of decolorizing waste liquor and wash waters generated in the process of obtaining cotton cellulose from lint, which is the main environmental pollutant.

The object of the study was the cooking solution, spent liquor, washing waters, their purification after washing, and quality indicators of the resulting cotton cellulose.

In laboratory conditions, we obtained cotton cellulose by alkaline cooking (AC) under the following conditions: mass concentration - 7%, NaOH consumption - 2%, cooking temperature - 140 ° C, and duration - 180 minutes.

After alkaline pulping, the cellulose mass was squeezed out, while the spent liquor weighing 2-3 times the mass of the feedstock remained in the cellulose.

The first series of experiments aimed to study the sanitary characteristics of the spent liquor, the flow rate of washing water in a neutral environment, and the physicochemical properties of the resulting cellulose.

Spent liquor is a dark brown liquid that contains a large amount of organic impurities and inorganic substances. The dark brown color of the spent liquor is due to the lignin contained in the solution. Although it is absent in cotton fiber, it enters the raw material through natural satellites such as leaves, seeds, and other parts of the cotton plant.

The inorganic weeds of the lint include dust, sand, and others that get into the fiber during the collection and transportation of raw cotton.

Washing of cotton cellulose after cooking was carried out with separate portions of distilled water.

It has been experimentally established that after alkaline cooking for washing one volume of pulp to a neutral environment, 3-5 equal volumes of pure water are consumed, depending on the degree of weediness of the lint. Therefore, along with the maturity of the fiber, its contamination also belongs to the main indicators of the quality of the lint.[3]

The waste liquor and each individual portion of the washing water were sent to study its sanitary characteristics.

The optimal consumption of $CaCl_2$ for decolorizing waste liquor and washing waters was experimentally determined, the decrease in the pH of the medium was studied, the residual amount of sodium hydroxide was determined, and the consumption of washing waters.

The results of the study of physical and chemical indicators and sanitary characteristics of waste liquor and wash water are presented in Table 1, from which it follows that the optical density waste liquor before and after bleaching has a fairly large difference, by 1.4. This shows that adding CaCl2 to decolorize the spent liquor instantly precipitates a large amount of organic matter in the original solution. [4]

Table 1. Physical and chemical indicators and sanitary characteristics of spent liquor, cooking solutions, and washing water

№	Test solution	Consumption $CaCl_2$ at lye bleaching and wash water, in % of the mass of the feedstock	Optical density before discoloration	Optical density after bleaching	pH environments
1	Spent liquor after AC	1	1.505	0.105	12
2	Water after first rinse	0.5	0.6	0.045	9.6
3	Water after second wash	0.25	0.185	0.035	7.2

The difference after the first and second washings is significantly small, indicating that during the first CaCl2 decolorization of the spent liquor, the bulk of the organic impurities were removed from the solution and almost gone.

This indicates the removal of a large amount of dissolved organic impurities in the spent liquor, which can be seen when comparing these wastes. By bleaching the spent liquor, we have improved the sanitary characteristics of the spent liquor (photos 1-4).

For comparison, photos 1-4 show samples of the resulting solution before bleaching and after bleaching. Therefore, in these samples, one can notice a big difference in the state to which the spent liquor can be decolorized.

Fig. 1 shows the results after bleaching with $CaCl_2$.

a *b* *c* *d*

Fig. 1. a) Spent liquor after silk pulping b) After adding $CaCl_2$ c) First flush with the addition of $CaCl_2$ d) Second wash with addition of $CaCl_2$

Fig. 1 confirms the results presented in Table 1. Washing cotton cellulose after alkaline cooking allows a sharp decrease in the optical density and pH of the medium, thereby improving the sanitary characteristics of the solution.

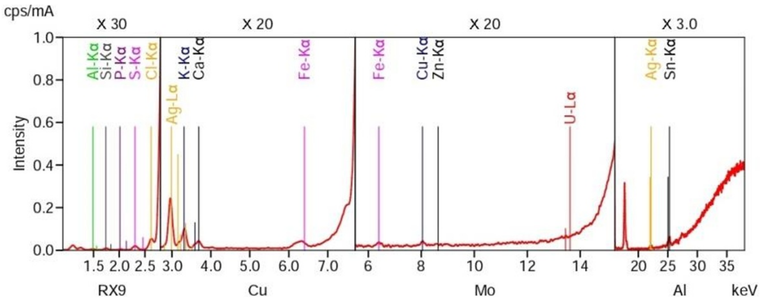

Fig. 2. Spent liquor after alkaline pulping

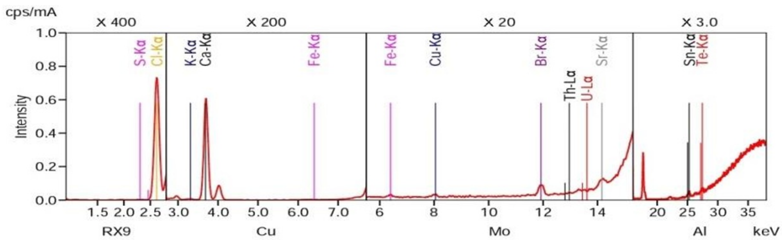

Fig. 3. Waste liquor after cleaning with addition of $CaCl_2$

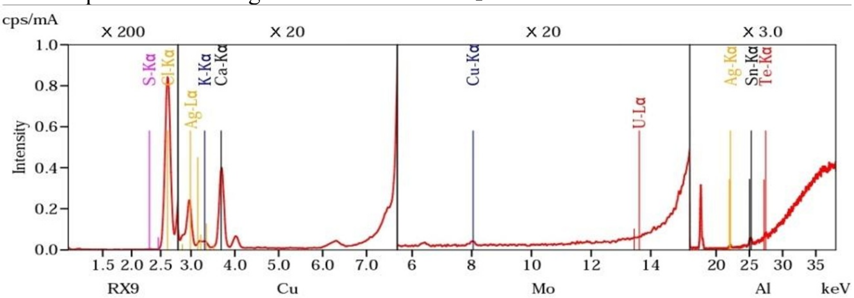

Fig. 4. Waste water after first flush, purified with $CaCl_2$

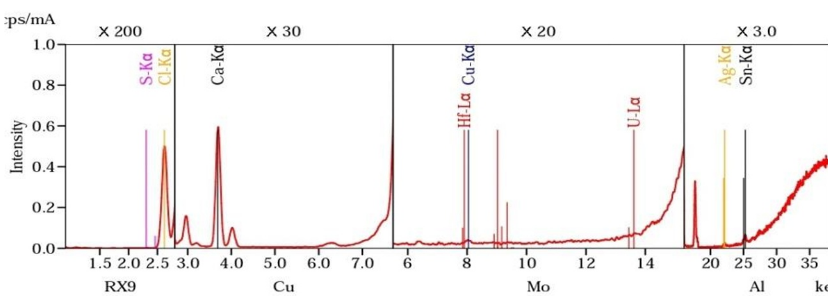

Fig. 5. Wastewater from second flush, purified with $CaCl_2$

As the missing part of the alkali, it is possible to use the ash after the waste liquor has been boiled out and calcined, which consists of 96% alkali, which saves alkali.

The intensity spectrum of X-ray fluorescent analyses of the studied substances (2-5) shows which elements remained before and after bleaching.

In addition to the above, the washing water used after cleaning can be used to dilute the pulp before alkaline pulping, bleaching, and acidification of the pulp, as well as in the first and second washes of the resulting cotton pulp.

Further studies aimed to determine the residual chemicals contained in the spent liquor.

The chemical composition of the spent liquor was studied after decolorization with $CaCl_2$, using the device Rigaku (Applied Rigaku Technologies, lnc.).

After bleaching for its chemical composition, a study of the spent liquor showed that mainly 78% of it consists of S, K, and the remaining 22% of the following inorganic compounds (Table 2).

Table 2. Chemical composition of spent liquor after bleaching

№	Test solution	S	K	Cu	Ag	Sn
1	Spent liquor after alkaline pulping	3.32	11.0	0.530	0.593	1.28
2	Spent liquor after alkaline pulping with addition of $CaCl_2$	2.10	10.8	0.476	0.578	1.22
3	Solution after first wash	2.47	7.94	0.468	0.573	1.22
4	Solution after second wash	1.74	-	0.432	-	1.19

Based on the data in Table 2, it can be concluded that it is possible to additionally use the spent liquor after bleaching as an alkali in further brews.

Due to the high contamination of the original lint, in some cases, the spent liquor can be sent for disposal, where, after evaporation and calcination, it can be used as an alkali in the following brewings [5].

Further studies were aimed at identifying the possibility of the reuse of spent liquor in the technology of alkaline pulping of cotton linters.

Table 3 shows the quality indicators of cotton cellulose obtained by reusing treated wash water in the alkaline cooking of cotton lint 2 grade B type of medium weediness.

In the beginning, with an increase in the frequency of use of purified washing water, the quality indicators of pulp changed insignificantly. Starting from the fifth and sixth cycles of using purified washing water, there is a slight decrease in whiteness and an increase in the content of extractives and ash elements in the resulting cellulose.

It should be noted that with an increase in the frequency of use of purified washing water, the average degree of polymerization and the yield of cellulose are preserved.

The data in Table 3 show that cotton cellulose with good quality indicators can be obtained with four times the use of purified washing water in the process of alkaline cooking from lint 2 grade B type of medium weed.

The developed technology for the production of cotton cellulose with the reuse of purified rinsing water in the cooking stage makes it possible to reduce the consumption of fresh water by 4-5 times; in addition, it helps to save sodium hydroxide consumption by 60% -70% of the total need.

In producing cotton pulp for chemical processing with repeated use of recycled water, it is recommended to pay attention to the quality control of cotton pulp. Especially on the content of α - cellulose, whiteness, ash, and fat-wax substances in the composition of cellulose. [6, p.448]

In addition to the above, the washing water used after cleaning can be used in pulp dilution before alkaline pulping, in the stages of pulp bleaching and acidification, and in washing the resulting cotton pulp.

According to the result of the calculated balance, the use of purified washing water in the dilution of the mass before alkaline cooking, bleaching, and acidification, as well as in the washing of the mass obtained by cellulose, saves the used fresh water by 15–20 times.

4 Conclusions

1. The possibility of using purified washing water instead of fresh water in alkaline pulping of cotton linters and obtaining cellulose without reducing its quality has been investigated and shown.
2. It is proposed to use purified washing water in pulp dilution before alkaline pulping, before the stages of bleaching, and acidification, as well as in washing the resulting cotton pulp;
3. The use of purified washing water in alkaline pulping of cotton linters, in diluting the mass before alkaline pulping, bleaching, and acidification, as well as in washing the mass obtained by pulp, saves 15-20 times the used fresh water.
4. Saving water and chemicals, as well as multiple return of water in alkaline cooking technology, helps to eliminate the impact of harmful emissions on the environment.

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