ENVIRONMENTAL PROTECTION OF THE HYDROSPHERE: COAGULATION PURIFICATION OF TRANSPORTER AND WASHING WATER OF SUGAR FACTORIES

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DOI: https://doi.org/10.20535/2218-930032024315338

The sugar industry is one of the water-intensive industries, producing a large amount of wastewater. These flows are divided into three categories. A feature of category 2 wastewater is a significant amount of suspended solids, organic and inorganic impurities. Such wastewater is cleaned and used in recirculating systems. Often, the degree of wastewater treatment does not meet technological requirements. This leads to the gradual accumulation of pollutants, the activation of the development of microorganisms. The consequence is the deterioration of the quality of beets. Therefore, the research of effective physico-chemical methods of wastewater treatment is relevant. They must ensure the necessary efficiency of cleaning and clarifying water, freeing from microorganisms, reducing foaming. This will reduce the specific consumption of fresh water of the plant and the amount of effluents, which will have a positive effect on the state of the hydrosphere. The purpose of the work is to study the physical and chemical treatment of transporter and washing water of a sugar enterprise. The task of the work is to study the parameters of sewage treatment with aluminum salts, to determine the efficiency of the treatment, the degree of removal of microorganisms, and the effect on foaming. Initial parameters of effluents: suspended solids 4900 mg/L, chemical oxygen demand 3600 mg O_2/L, optical density 0.766 units, pH 7.18. Aluminum salts were used: aluminum dihydroxosulfate, aluminum hydroxochloride, aluminum sulfate in amounts of 0.01 and 0.1% by weight of water. The use of basic aluminum salts (aluminum dihydroxosulfate, aluminum hydroxochloride) ensures high cleaning efficiency: according to chemical oxygen demand up to 52.78 and 49.72 %, respectively; by suspended substances up to 92.61 and 91.12 %, respectively. A significant discoloration of wastewater is also observed (by 78.46 and 78.07 %, respectively). Conditions are created to reduce the foaming of effluents. The significant effectiveness of removing microorganisms from wastewater when using basic aluminum salts has also been proven: from 66.3 to 85.1 %, depending on the type of microorganisms.

Keywords: *ecology, hydrosphere, coagulation, aluminum salts, wastewater, sugar industry.*

Received: 17 November 2024 Revised: 26 December 2024 Accepted: 29 December 2024

1. Introduction

The sugar industry is one of the water-intensive branches of the food industry. About 200 m^3 of water is used to produce 1 ton of sugar. A plant with a capacity of 6000 tons of beets per day consumes no less than 125000 m^3 of water. Therefore, a large amount of wastewater is generated at sugar factories. They have different sources of origin and indicators of pollution. Such wastewater is divided into 3 categories (Bublienko, 2021, Sorokin, 2018).

1st category: barometric water of condensers of evaporation units, vacuum devices, ammonia water, condensates of spent steam, water from heating massecuite, cooling equipment. Such water is usually used in circulating water supply.

Category 3: diluted conveyor washing sludge, sour water from pulp, water from

washing equipment, effluents from the laboratory, etc. Such water is the most polluted and contains many dissolved components, suspended solids of mineral and organic origin.

During the transportation and washing of sugar beets, sewage of the second category is formed. Such wastewater is called transporter and washing. Their number is more than 60 % of total waste water consumption (Sorokin, 2018, Laxmeshwar et al, 2018).

The peculiarity of these wastewaters is a very significant amount of suspended solids, chemical impurities of organic and inorganic origin. Waste water contains sucrose, saponin and other beet components.

Saponin causes intense foaming in effluents (Zhou et al, 2023, Sharma et al, 2023). This reduces the efficiency of cleaning, negatively affects the technological process. Also, saponin has high toxicity for hydrobionts when it enters hydrosphere objects. Saponin worsens the organoleptic parameters of water, disrupts oxygen processes in water bodies (Ondevilla et al, 2023).

Indicators of second-category wastewater pollution depend on the characteristics of beets, technologies of collection, transportation, and washing: COD (chemical oxygen demand) 2500 – 6000 mg O_2/L, suspended components 2200 – 20000 mg/L, saponin content 5 – 20 mg/L (Sorokin, 2018, Rohovyk et al., 2021).

Such wastewater at factories is mechanically and chemically treated and used in reversible hydrotransportation systems (Wei et al, 2022, Yadav et al, 2021, Shrivastava et al, 2022).

The consequences of low-quality cleaning and repeated use of this water are the gradual accumulation of insoluble and soluble impurities. This activates the development of pathogenic microorganisms (bacteria, mycelial fungi, yeast). This has a negative effect on the quality of the raw material – beets.

The research of effective methods of processing such wastes is relevant. These methods should provide the necessary efficiency of cleaning, clarification of water, release from microorganisms, and also minimize foaming. This will make it possible to reduce the specific consumption of fresh water of the sugar factory, the amount of effluents. All this will have a positive effect on the state of the hydrosphere.

The purpose of the work is to study the physical and chemical treatment of transporter and washing water of a sugar enterprise.

The task of the work is to study the parameters of sewage treatment with aluminum salts, to determine the efficiency of the treatment, the degree of removal of pathogenic microorganisms, and the effect on foaming.

2. Materials and Methods

Experimental studies were carried out in laboratory conditions. Transporter and washing water (2 categories) of the sugar factory was used.

To determine indicators of wastewater treatment (physico-chemical, technological, microbiological) standard methods were used (Vorontsov et al, 2021, Semenova et al, 2019).

The changes in the following indicators were studied: the concentration of suspended solids, the COD index, optical density, the effect of removing the main groups of microorganisms from wastewater. The efficiency of sewage treatment was

determined by the ratio of the number of pollutants removed to the initial concentration of the pollutant (expressed in %).

The pH of the test liquid was monitored with a pH-340 meter.

Aluminum salts were used for physical and chemical cleaning: aluminum dihydroxosulfate, aluminum hydroxochloride, aluminum sulfate. Their amount was 0.01 and 0.1 % to the amount of water. The temperature of the process is 20 °C, the processing time is 20 minutes.

3. Results and Discussion

Scientists of the Department of Ecology and Eco-Management of the NUFT are researching methods of wastewater treatment in various branches of the food industry, including the sugar industry. The research object was the transporter and washing wastewater of a sugar factory with the following parameters: suspended solids 4900 mg/L, COD 3600 mg O_2/L, optical density 0.766 units, pH 7.18.

Aluminum salts were added to transporter and washing wastewater in the amount of 0.01 and 0.1 % by mass of effluent (contact time 20 minutes).

The results of research and calculations are shown in Table 1.

The analysis of the obtained results showed that the best indicators were obtained from wastewater after treatment with aluminum dihydroxosulfate (cleaning efficiency according to COD 44.17 – 52.78 %, suspended substances 91.32 – 92.61 %, decolorization effect 77.42 – 78.46 %).

The pH indicator of wastewater after treatment is 5.46 – 6.23, which is slightly acidic. This reduces the foaming activity of the water. This indicator remains stable for a long time.

Wastewater after treatment with aluminum hydroxochloride also had fairly high-quality indicators (cleaning efficiency according to COD 43.61 – 49.72 %, suspended substances 89.53 – 91.12 %, decolorization effect 76.63 – 78.07 %).

Treatment of wastewater with aluminum sulfate had worse results (cleaning efficiency according to COD 33.89 – 46.94 %, suspended solids 86.59 – 87.04 %, decolorization effect 75.85 – 76.11 %). This is explained by the lower ability of this salt to form flakes, which reduces the effectiveness of coagulation.

An important indicator of the quality of transporter and washing water is its microbiological purity. After all, microbiological contamination of water causes infection of sugar beets.

The influence of aluminum salts on the content of various groups of microorganisms in transporter and washing water was also investigated. Aluminum salts (aluminum dihydroxosulfate, aluminum hydroxochloride, aluminum sulfate) were added to conveyor washing wastewater in the amount of 0.01 % by weight of the effluent.

As a control, transporter and washing wastewater was used without the addition of reagents, after mechanical settling.

The results regarding the efficiency of removal of different groups of microorganisms are shown in Table 2.

Table 1. *Indicators of physical and chemical treatment of transporter and washing wastewater*

Type and amount of reagent, %		COD, mg O_2/L	Suspended substances, mg/L	Cleaning efficiency, %		pH	Optical density, units	Decolouration, %
				for COD	for suspended solids			
Aluminum sulfate	0.01	2380	657	33.89	86.59	6.52	0.185	75.85
	0.1	1910	635	46.94	87.04	5.93	0.183	76.11
Aluminum hydroxochloride	0.01	2030	513	43.61	89.53	6.32	0.179	76.63
	0.1	1810	435	49.72	91.12	5.67	0.168	78.07
Aluminum dihydroxosulfate	0.01	2010	425	44.17	91.32	6.23	0.173	77.42
	0.1	1700	362	52.78	92.61	5.46	0.165	78.46

The significant efficiency of removing microorganisms from wastewater when using basic aluminum salts (aluminum dihydroxosulfate, aluminum hydroxochloride) was determined.

Table 2. *Microbiological indicators of physical and chemical treatment of conveyor-washing wastewater*

Type and amount of reagent, %	Efficiency of removal of microorganisms, %			
	thermophilic	mesophilic	mucus-forming	mycelial fungi
Aluminum sulfate, 0.01	72.3	76.5	81.5	56.5
Aluminum hydroxochloride, 0.01	74.4	80.2	84.3	65.3
Aluminum dihydroxosulfate, 0.01	77.3	83.5	85.1	66.3

When using aluminum dihydroxysulfate, the effect of removing thermophilic microorganisms reached 77.3 %, mesophilic – 83.5 %, mucus-forming – 85.1 %, mycelial fungi – 66.3 %.

Moreover, basic aluminum salts had a much higher efficiency than aluminum sulfate (even with lower consumption of reagents). The antimicrobial action of aluminum dihydroxosulfate was somewhat greater compared to aluminum hydroxochloride.

4. Conclusions

Physico-chemical treatment of waste water of category 2 of sugar factories makes it possible to comprehensively solve their purification, will reduce the specific consumption of fresh water of the sugar factory, the amount of generated effluents. This will have a positive effect on the state of the hydrosphere.

The use of basic aluminum salts (aluminum dihydroxosulfate, aluminum hydroxochloride) ensures high cleaning efficiency: according to COD up to 52.78 and 49.72 %, respectively; by suspended substances up to 92.61 and 91.12 %, respectively. A significant discoloration of wastewater is also observed (by 78.46 and 78.07 %, respectively). Conditions are created to reduce foaming of effluents.

The significant efficiency of removing microorganisms from waste water when using basic aluminum salts has also been proven: from 66.3 to 85.1 %, depending on the type of microorganisms.

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ЕКОЛОГІЧНИЙ ЗАХИСТ ГІДРОСФЕРИ: КОАГУЛЯЦІЙНЕ ОЧИЩЕННЯ ТРАНСПОРТЕРНО-МИЙНОЇ ВОДИ ЦУКРОВИХ ЗАВОДІВ

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Цукрова галузь є однією із водоємних, утворює велику кількість стічних вод. Ці стоки поділяють на три категорії. Особливістю стічних вод 2 категорії є значна кількість завислих часточок, органічних та неорганічних домішок. Такі стічні води очищують і використовують в оборотних системах. Часто ступінь очищення стоків не задовольняє технологічним вимогам. Це зумовлює поступове накопичення забруднень, активізацію розвитку мікроорганізмів. Наслідком є погіршення якості буряків. Тому актуальним є дослідження ефективних фізико-хімічних способів обробки стоків. Вони повинні забезпечувати необхідну ефективність очищення і освітлення води, звільнення від мікроорганізмів, зменшення піноутворення. Це зменшить питомі витрати свіжої води заводу і кількість стоків, що позитивно впливатиме на стан гідросфери. Мета роботи – дослідження фізико-хімічного очищення транспортерно-мийної води цукрового підприємства. Завданням роботи є дослідження параметрів очищення стоків солями алюмінію, визначення ефективності очищення, ступеню видалення мікроорганізмів, вплив на піноутворення. Початкові показники стоків: завислі часточки 4900 мг/дм^3, хімічне споживання кисню 3600 мг O_2/дм^3, оптична густина 0,766 одиниць, pH 7,18. Використовували солі алюмінію: алюміній дигідроксосульфат, алюміній гідроксохлорид, алюміній сульфат у кількості 0,01 та 0,1 % до маси води. Використання основних солей алюмінію (алюміній дигідроксосульфат, алюміній гідроксохлорид) забезпечує високу ефективність очищення: за хімічним споживанням кисню до 52,78 та 49,72 % відповідно; за завислими речовинами до 92,61 та 91,12 % відповідно. Також спостерігається суттєве знебарвлення стічної води (на 78,46 та 78,07 % відповідно). Створюються умови для зменшення піноутворення стоків. Також доведена значна ефективність видалення мікроорганізмів зі стічної води при використанні основних солей алюмінію: від 66,3 до 85,1 % залежно від виду мікроорганізмів.

Ключові слова: *екологія, гідросфера, коагуляція, солі алюмінію, стічні води, цукрова промисловість.*