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WASTE WATER TREATMENT PLANTS EFFICIENCY IN TEXTILE INDUSTRY

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Abstract Water pollution under the influence of the textile industry is becoming a global problem. According to statistical data, 20-25% of wastewater originates from the textile industry. Waste water treatment is carried out to a level that corresponds to emission limit values or to a level that does not violate environmental quality standards. The prevention of deterioration of the water recipients quality is carried out in accordance with the regulations regulating the limit values of pollutants in surface and underground waters, limit values of priority, hazardous and other polluting substances and the regulation regulating the limit values of the emission of pollutants into water, taking stricter criteria than these two. From textile factories, water containing various chemicals for finishing and dyeing fabric is released into waterways. The paper describes the generation of technological waste water in textile industry plants, where dyeing, drying and ironing of final products are carried out, as well as waste water generated after the starching process and after laboratory tests. Also, an assessment of the efficiency of the waste water treatment plant based on the samples quality parameters of technological waste water samples from the textile plant before and after purification is presented.

Keywords: Textile industry wastewater; wastewater treatment; efficiency of wastewater treatment plants.

1. INTRODUCTION

From textile factories, water containing various chemicals for finishing and dyeing fabric is released into waterways. In addition to technological waste water, sanitary - fecal waste water and atmospheric waste water from roofs and manipulative surfaces are also generated. After treatment, technological waste water is discharged into a natural water receiver [1].

2. WASTE WATER TREATMENT

In order to prevent the deterioration of the quality of natural water resources and the environment in general, in accordance with the Law [2] the quality parameters of waste water, as well as the methods and conditions of its discharge, are defined. Waste water treatment is carried out to a level that corresponds to emission limit values or to a level that does not violate environmental quality standards.

The efficiency of the purification process is expressed as a percentage reduction of a certain parameter of pollution or as the amount of released pollutant per unit of product obtained or per unit of raw material used. A legal entity or an entrepreneur that has waste water treatment facilities and/or that discharges its waste water into a recipient or public sewer is obliged to harmonize its emissions with the prescribed limit values for the emission of polluting substances into water in accordance with the

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Regulation [3]. Waste water quality control is carried out, in accordance with this Regulation, at least three or four times a year, by an authorized laboratory.

Rulebook [4], prescribes waste water monitoring, which includes measuring the quantity and testing the quality of waste water, which aims to provide information and necessary data on the amount of waste water, concentration and mass flow of pollutants in waste water and treated waste water.

2.1. Treatment of Technological Waste Water After the Dyeing Stage of Textile Products

The dyeing stage takes place in special hermetically sealed machines, in which temperatures sometimes reach up to 950. After that, they are dried in special plants and ironed, which forms the final shape and achieves complete uniformity in weaving. As waste, from this stage of the production process, packaging from paints and auxiliaries, waste technological water and scrap dyed textile products are created, Figure 1.

Figure 1. Working unit of dyers [5].

Figure 2. Starching line [5].

One of the ways to treat this type of technological waste water in textile plants is to drain the water through a pipeline into an equalization pool, in which a turbine mixer ensures equalization of the flow and concentration of waste water, i.e. homogenization of waste water. In addition to equalizing the composition of waste water, in special cases, chemicals can be dosed in order to neutralize or otherwise improve the composition. The method of its implementation depends on the composition of waste water. The process of chemical precipitation is based on the conversion of dissolved waste water substances with suitable reagents into insoluble compounds, which are then removed by precipitation or flotation (in the case of higher concentrations) or filtration (in the case of lower concentrations) [5].

Chemical treatment, i.e. neutralization of chemically aggressive substances, which have reached the raw wastewater, is carried out because only separation processes and physical treatment take place in the continuation of the treatment. Such substances would interfere with the development of the mentioned processes, and they would not be eliminated in any of them, so they would end up in the recipient, Figure 3. and 4.

Considering that the waste water contains large amounts of floating materials from the equalization pool, it is drained by gravity to the floater, to the next stage of processing. In the flotation device, waste water treatment is carried out by the process of flotation, aeration and sedimentation. Today, the application of flotation in waste water treatment is preferred, because it flows 6-8 times faster than sedimentation and is completed in 15-30 minutes. At the same time, a very high degree of

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removal of suspended material is ensured, with a significant reduction in the concentration of surfactants in the waste water and an increase in the oxygen content, which greatly facilitates the later stages of processing. Flotation is used as an alternative method to other separation procedures, sedimentation, centrifugal separation and filtration. In the waste water treatment of the observed textile industry company, flotation was chosen from the potential separation procedures due to greater efficiency and economic justification.

Aeration i.e. the removal of part of the biological load (dissolved) is achieved by using air in the flotation process. Sedimentation is performed in a special chamber, with a reduced fluid flow rate and conditions for gravitational separation of contents of higher specific gravity. Due to special requirements regarding the quality of the effluent, a tertiary treatment is provided - filtering on a sand filter [5].

Figure 3. Example of a waste water purification system in a textile plant [5].

Figure 4. System for technological waste wwater purification of the textile plant to the receiver [5].

The collection and laboratory analysis of waste water samples generated in the textile plant, which deals with the production of dyed textile products, treated waste water and the natural water recipient upstream and downstream of the inflow of previously treated waste water, was carried out.
The results of laboratory analyzes of these samples, are:

- at the entrance to the purification system
  - sample 1., Table 1 and sample 3., Table 2
- technological waste water at the exit from the purification system
  - sample 2., Table 1 and sample 4., Table 2
- upstream of the inflow of previously treated waste water
  - sample 5., Table 3
- downstream from the inflow of previously treated waste water узорак 6., Table 3

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- sample 6., Table 3.

Table 1. Presentation of the efficiency assessment of the waste water treatment plant based on the quality parameters of sample 1 (before treatment) and 2 (after treatment) [5].

PARAMETER	Before the waste water treatment plant	After the waste water treatment plant	Emission limit values for certain groups or categories of pollutants for technological waste water	Efficiency %
Ammonium ion (NH_4 - N) mg/l	7,52	<0,04	20	99,5
Sulfates mg/l	289,6	23,4	1000	91,9
Chemical oxygen consumption (mg O_2/l)	2940	620	200	78,9
Biological oxygen consumption BOC5 (mgO_2/l)	853,9	139,5	30	83,6
Suspended substance at 103 - 105°C	43	3	80	93
Phosphorus P (mg/l)	0,955	0,203	1	78,7
Phenolic index (mg/l)	0,054	<0,01	0,1	81,5
Index of hydrocarbons C_{10} - C_{40} (mg/l)	12,59	< 0,05	10	99,6
Total chromium Cr (mg/l)	0,205	0,045	0,5	78,0
Total inorganic nitrogen N (mg/l)	8,14	<0,15	500	98,2

Table 2. Presentation of the efficiency assessment of the waste water treatment plant based on the quality parameters of sample 3 (before treament) and 4 (after treatment) [5].

PARAMETER	Before the waste water treatment plant	After the waste water treatment plant	Emission limit values for certain groups or categories of pollutants for technological waste water	Efficiency %
Ammonium ion (NH_4 - N) mg/l	10,26	<0,04	20	99,6
Sulfates mg/l	526,6	37,7	1000	92,8
Chemical oxygen consumption (mg O_2/l)	6750	178	200	97,4
Biological oxygen consumption BOC5 (mgO_2/l)	813,9	63,1	30	92,3
Suspended substances at 103 - 105°C	451	42	80	90,7
Phosphorus P (mg/l)	1,78	0,138	1	92,3
Phenolic index (mg/l)	0,48	0,012	0,1	97,5
Index of hydrocarbons C_{10} - C_{40} (mg/l)	0,78	< 0,05	10	93,6
Total chromium Cr (mg/l)	8,0	0,213	0,5	97,3

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Table 3. Presentation of the influence of pretreated technological waste water injection on the quality of the natural water receiver based on receiver quality parameters before (sample 5) and after injection (sample 6) [5].

Parameter	Unit	Emission limit values (1)					Upstream recipient 17-04-1787	Downstream recipient 17-04-1788
		Cl. I(2)	Cl. II(3)	Cl. III(4)	Cl. IV(5)	Cl. V(6)		
pH - value		6,5-8,5	6,5-8,5	6,5-8,5	6,5-8,5	6,5-8,5	7.8	7.4
Suspended substances	mg/l	25	25	-	-	-	4	<2
Biological oxygen consumption 5	[mg/l]	-(8) (or PN)	-(8)	7	25	>25	2.4	2.5
Chemical oxygen consumption (bichromatic method)	[mg/l]	10 (or PN)	15	30	125	>125	<10	<10
Total nitrogen	[mg N/l]	1 (or PN)	2	8	15	>15	1.5	1.5
Sulfates	[mg/l]	50 (or PN)	100	200	300	>300	11.7	11.8
Iron (total)	[µg/l]	200	500	1000	2000	>2000	50	186
Faecal coliforms	cfu/100ml	100	1000	10000	100000	>100000	1445450	193650
Total coliforms	cfu/100ml	500(11)	10000	100000	1000000	>1000000	230550	289700
Intestinal enterococci	cfu/100ml	200	400	4000	40000	>40000	>2420	>2420

According to the results shown in Tables 1. and 2., the efficiency of the waste water treatment plant is high and ranges from 78% to 99.6%. However, despite the high efficiency of the waste water treatment plant, the values of the chemical and biological oxygen consumption 5 parameters of the treated waste water are higher than the permitted values, which indicates a significant organic load of the waste water of the textile plant, which has not been reduced to the range of permitted values. A possible lowering of the value of these parameters can be achieved by changes and optimization of the use of chemical agents in certain phases of the technological process of work in the textile plant. In addition to testing samples of waste technological waters, samples of the recipient upstream and downstream from the point of inflow of waste technological waters were also tested, with the aim of evaluating the impact of effluents from textile plants, which produces dyed textile products, on the quality of the river - the recipient. Samples of surface water and waste water were taken simultaneously in order to obtain the most realistic picture of the effect of effluents from the factory on the recipient. Based on the results of the samples taken, upstream and downstream of the inflow of waste technological waters, laboratory sample 5 and sample 6, Table 3., and the Regulation [7], it can be concluded that there was no significant deviation of the parameter values between the two samples 5 and 6 (upstream and downstream) and that they were in the same value ranges. There was no change in the class of individually observed parameters, i.e. the waste water of such a textile plant do not have a negative impact on the recipient and wastewater at this level of purification and quality did not affect the quality class and status of the natural recipient. After the discharge of waste water from such a textile plant, the recipient maintained the same surface water quality class, class V, in all parameters.

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A significant deviation occurs only in the Fe content, which can be connected to the assumption that coagulants based on Fe salts were used in the waste water treatment, which can only be confirmed after the description of the waste water treatment. High values of microbiological parameters in the samples upstream and downstream of the waste water inflow indicate that the river is burdened by the discharge of sanitary wastewater [5].

2.2. Treatment of Technological Waste Water After the Starching Process

For the starching process, the chemical Politex 460 TT is used as a means. According to the Rulebook [6], this chemical is not classified as dangerous. The basis of this chemical is starch, i.e. carbohydrate, polysaccharide, made up of glucose units linked together by glycosidic bonds. Starch molecules have many hydroxyl groups, so they can connect with each other through hydrogen bonds, resulting in starch grains, solid and compact structures, insoluble in cold water.

The starching solution is prepared by dissolving the chemical in powder form in water in a 400l vessel - cauldron and heating it to 95°C for 5 minutes, then transferring it to another vessel - cauldron and then to the starching tub through which passes the textile base. Excess starch mass is removed during winding on the base roller by mechanically shaking off the excess starch mass, which remains in the tub through which the textile base continues to pass. After starching, the fibers are dried at a temperature of 120 - 130°C and wound on rollers that are sent to the loom for further weaving, Figure 2.

After the starching process, the rollers are washed with warm water. The used water is collected in a tub and, together with the rest of the starchy mass, is discharged into the floor drains and further into the city's sewer system. Waste water sampling for analysis is also carried out at this outlet position. The water used to prepare the starching solution is taken from the surrounding river, transferred by pumps to the basin for coarse filtration and ion softening and then, by boiler room pumps, delivered to the technological line for starching. After that, the aforementioned washing of boilers, rollers and tubs is carried out with hot water.

Samples of technological waste water were taken at the point of discharge into the city sewer network. The results of measurement of pollution parameters in waste water from a textile plant, whose production process includes the starching process, before its discharge into the city sewage network, for the period from May 2019 to March 2020, are given in Table 4 [5].

Based on the measurement results, it was determined that elevated values in the technological waste water of the textile plant, whose production process includes the starching process, occur for the following parameters: chemical oxygen consumption, biological oxygen consumption 5, pH - value, total nitrogen (biological treatment can be applied), noticeable color, noticeable odor at 25°C (can be removed by adsorption), visible waste materials (can be removed by grids and sieves). To correct this parameter, it is necessary to introduce an oxidizing agent.

One of the solutions, in the case of a textile plant engaged in the production of colored textile products, is to build a receiving tank with a volume of at least 20 m^3, with a pump that will deliver water evenly to the plant, before the equalization pool and the flotation tank. Such an additional basin would solve the efficiency of the rest of the wastewater treatment plant. Also, one of the solutions for setting the limit values of waste water to normal is anaerobic and aerobic digestion, better known as bacterial

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culture. Anaerobic digestion is a bacterial process that takes place in the absence of oxygen, while in aerobic digestion the bacterial process takes place in the presence of oxygen. Under aerobic conditions, bacteria quickly consume organic matter and convert it into carbon dioxide. The costs of aerobic digestion are much higher, because oxygen needs to be constantly added to the system.

Table 4. Measured values of technological wastewater pollution parameters on the discharge into the city sewage network for the period March 2019 – March 2020 [5].

Parameter	Unit	Measured values					Emission limit values
		March 2019.	June 2019.	October 2019.	December 2019.	March 2020.	
Ph - value	-	6,0	6,8	7,0	8,2	8,8	6,5 - 9,5
Biological oxygen consumption 5	mg/l	50087	2016	618.5	2351	236,5	1000
Chemical oxygen consumption	mg/l	2659	1475	20,9	107,9	155,4	500
Total nitrogen	mg/l	>1000	5,8	97,8	7,2	7,2	150
Sulfates	mg/l	/	11,8	/	10,7	24,2	400
Turbidity of the water	NTU	/	79,1	68,5	69,4	20,6	/
Noticeable color	-	white	opalescent white	without	without	without	/
Perceptible odor on 25°C	-	on starch	without	without	without	without	/
Visible waste materials	-	without	without	present	without	without	/

Also, one of the solutions is tertiary purification, which includes the removal of remaining biological oxygen consumption 5, chemical oxygen consumption and suspended substances, total organic carbon, mineral matter, heavy metals, nitrogen and phosphorus compounds, pathogenic germs. It is rarely used in the treatment of municipal waste water and more often in the treatment of industrial waste water. The most common techniques are: adsorption on activated carbon, electro dialysis, reverse osmosis, ion exchange, use of chemical additives - coagulants and oxidants [5].

3. CONCLUSION

The efficiency of the purification process is expressed as a percentage reduction of a certain parameter of pollution or as the amount of released pollutant per unit of product obtained or per unit of raw material used. A legal entity or an entrepreneur who has waste water treatment facilities and/or discharges its waste water into a recipient or public sewer is obliged to harmonize its emissions with the prescribed limit values for the emission of polluting substances into water.

The efficiency of the wastewater treatment plant, which is created after the painting stage, is high and ranges from 78% to 99.6%. However, the values of the chemical oxygen consumption, biological oxygen consumption 5 parameters of the treated wastewater are higher than the permitted values, which indicates a significant organic load in the wastewater of the textile plant, which has not been reduced to the range of permitted values. A possible lowering of the value of these parameters can be achieved by changes and optimization of the use of chemical agents in certain phases of the technological process of work in the textile plant.

In order to evaluate the impact of effluents from textile plants, which deals with the production of dyed textile products on the quality of the river - the recipient, it can be concluded that there was no significant deviation in the values of the upstream and downstream parameters. They were in the

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same value ranges, i.e. the wastewater of such a textile plant do not have a negative impact on the recidivist and the waste water at this level of purification and quality did not affect the quality class, which retained, in all parameters, the same quality class of surface water, class V.

A significant deviation occurs only in the Fe content, which can be connected to the assumption that coagulants based on Fe salts were used in the waste water treatment, which can only be confirmed after the description of the waste water treatment. High values of microbiological parameters in the samples upstream and downstream of the waste water inflow indicate that the river is burdened by the discharge of sanitary waste water.

One of the solutions, in the case of a textile plant engaged in the production of colored textile products, is to build a receiving tank with a volume of at least 20 m^3, with a pump that will deliver water evenly to the plant, before the equalization pool and the flotation tank. Also, one of the solutions for setting the limit values of waste water to normal is anaerobic and aerobic digestion, better known as bacterial culture.

Tertiary treatment, which includes the removal of remaining chemical oxygen consumption and biological oxygen consumption, suspended matter, total organic carbon, mineral matter, heavy metals, nitrogen and phosphorus compounds, pathogenic germs, can also be one of the solutions for normalizing the composition of wastewater. It is rarely used in the treatment of municipal waste water, and more often in the treatment of industrial waste water. The most common techniques are: adsorption on activated carbon, electrodialysis, reverse osmosis, ion exchange, use of chemical additives - coagulants and oxidants.

In the technological waste water of the textile plant, whose production process includes the starching process, deviations from the permitted values occur for the following parameters: chemical oxygen consumption, biological oxygen consumption 5, pH-value, total nitrogen (biological treatment can be applied), noticeable color, noticeable odor at 25°C (can be removed by adsorption), visible waste materials (can be removed by grids and sieves). To correct this parameter, it is necessary to introduce an oxidizing agent.

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