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"Gheorghe Asachi" Technical University of Iasi, Romania

WASTEWATER CHARACTERISTICS IN TEXTILE FINISHING MILLS

Irina-Isabella Savin[1*], Romen Butnaru [2]

[1] *„Ioan C. Ştefănescu" Technical Highschool, 51-53, Socola Str., 700268, Iaşi, Romania*
[2] *"Gheorghe Asachi" Technical University of Iasi, Faculty of Textile – Leather Engineering and Industrial Management, 53 Mangeron Blvd., Building TEX1, 700050 Iaşi, Romania*

Abstract

The aim of this paper was to accurately analyze the sources of water pollution and loading concentrations in textile finishing mills. A process data collection was performed and integrated with a characterization of the process effluents in terms of treatability and reusability. In order to evaluate properly the wastewater loading, an analysis course was set. The samples have been gathered for two months; instantaneous samples (PI) were drawn from the wastewater, as well as from the painting baths, at the time of the overflow. Based on several daily average values, a general average (PG) has obtained. The experimental data were statistically analyzed and the average values of the investigated parameters for each collecting point corresponding to the sectors of the finishing section were assessed..

Key words: analysis, dye, maximum admissible limit, pollutant, wastewater

1. Introduction

Textile industry is a very diverse sector in terms of raw materials, processes, products and equipment and has very complicated industrial chain. The textile finishing covers the bleaching, dyeing, printing and stiffening of textile products in the various processing stages (fibre, yarn, fabric, knits, finished items). The purpose of finishing is in every instance the improvement of the serviceability and adaptation of the products to meet the ever-changing demands of fashion and function.

The impacts on the environment by textile industry have been recognized for some time, both in terms of the discharge of pollutants and of the consumption of water and energy (Lacasse and Baumann, 2006). Finishing processes can be categorized into purely mechanical and wet processes. The liquid phase for the latter type is primarily water, and - to a lesser extent - solvents and liquefied ammonia gas. Another important medium is steam. To achieve the desired effects, a range of chemicals, dyes and chemical auxiliaries are used.

Environmental problems of the textile industry are mainly caused by discharges of wastewater. The textile sector has a high water demand. Its biggest impact on the environment is related to primary water consumption (80–100 m^3/ton of finished textile) and waste water discharge (115–175 kg of COD/ton of finished textile, a large range of organic chemicals, low biodegradability, colour, salinity). Therefore, reuse of the effluents represents an economical and ecological challenge for the overall sector (Li Rosi et al., 2007). Textile processing employs a variety of chemicals, depending on the nature of the raw material and product (Aslam et al., 2004). The effluents resulting from these processes differ greatly in composition, due to differences in processes, used fabrics and machinery (Bisschops and Spanjers, 2003).

Main pollution in textile wastewater came from dyeing and finishing processes. These processes require the input of a wide range of chemicals and dyestuffs, which generally are organic compounds of complex structure. Because all of them are not contained in the final product, became waste and caused disposal problems.

Major pollutants in textile wastewaters are high suspended solids, chemical oxygen demand, heat, colour, acidity, and other soluble substances (Venceslau et al., 1999; World Bank, 2007).

[*] Author to whom all correspondence should be addressed: savinisabella@yahoo.com, phone 0232 436965, 0729 859522

This paper assesses the characteristics of wastewaters and the average values of the analyzed parameters for each collecting point in the in the finishing mill from a textile factory in Romania.

2. Case study

The technological diagram for wastewater discharging sections from a textile company that processes cotton and cotton-like fabrics was presented together with the wastewater quality parameters, resulted from instantaneous, as well as general samples (Fig. 1) (Savin and Butnaru, 2009). This sector consists of 12 active sections, each of them being provided with monitoring collecting lines, through which the water flows towards the pretreatment plant.

Analysis was carried out for two months and the preliminary conclusions drawn on the basis of the experimental data allowed for a comparison between the concentration of the polluting loading corresponding to some sectors of the Finishing mill and the maximum admissible limits of the analyzed parameters according to NTPA 002/2005 (GD, 2005; Nistreanu et al., 1997; Zaharia, 2008)

The examination of wastewater characteristics is based on the data grouped in Tables 1-6, corresponding to the sections in the finishing sector where the maximum allowable values were exceeded, as well as Tables 7-12, by taking into account the maximum admissible values of the analyzed parameters, according to NTPA 002/2005 (GD, 2005). Some values for Maximum Allowable Concentration are presented in Table 13 (GD, 2005).

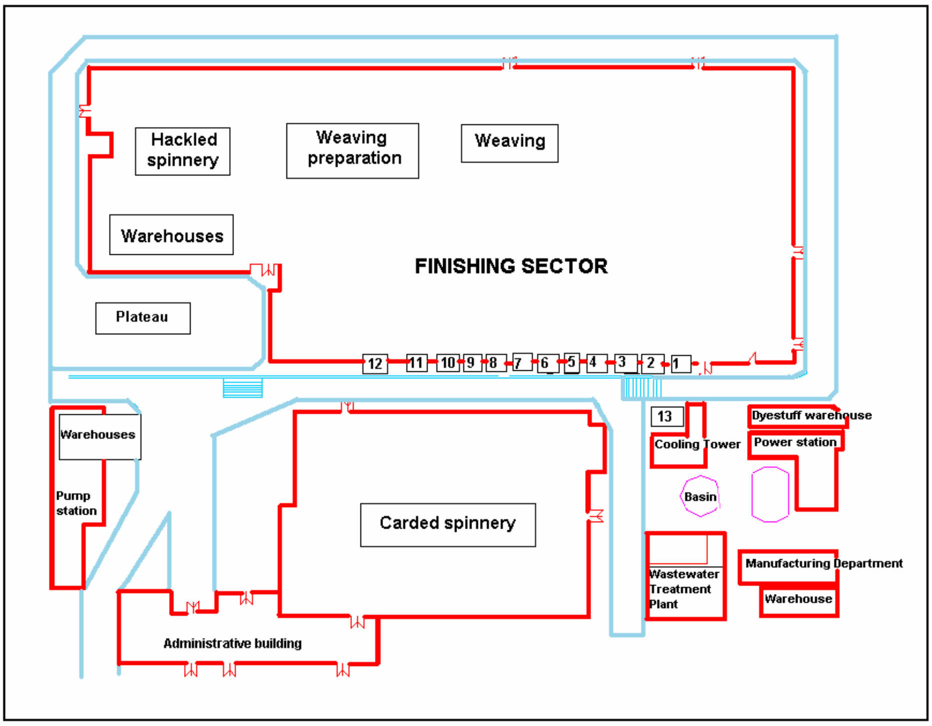

Fig.1. Scheme with the locations of the industrial wastewater sampling points
(1. Burning Sector; 2. CH Station; 3. Bleaching Station; 4. Mercerization Section; 5. Thermofixing section, 6. Chemicals Warehouse, 7. Dyestuff Warehouse; 8. Dyeing Sector; 9. Dyeing Gauge; 10. Printing Sector; 11. Printing Warehouse; 12. Dressing Sector, 13. Wastewater Treatment Plant)
(*Note*: The samples have been drawn upstream the entrance to the sections)

Table 1. Wastewater characteristics for Section 1, corresponding to Burning Sector (instantaneous samples, PI)

Date	*pH*	*NO_3^- mg/L*	*TSS mg/L*	*Chlorides mg/L*	*COD mgO_2/L*	*H_2S mg/L*	*NH_4^+ mg/L*	*NO_2^- mg/L*	*Fixed Residue mg/L*	*BOD_5 mgO_2/L*
14-07	5.2	3	158	169	1749	1.6	7.11	3	992	-
16-07	6.5	1.7	105	64	1512	2.8	3	0.08	4535	675
24-06	5.9	5.3	425	132	2995	1.1	7.9	0.32	3275	800
28-07	5.0	0.025	936	118	3784	2.1	5.7	2.5	6000	-
30-07	5.5	2.1	248	66.8	3106	1.1	3.62	1.2	4400	925
15-08	5.0	2.9	725	180	7802	2.3	6.75	1.75	6920	-
Average	**5.51**	**2.5**	**432.8**	**121.6**	**3491.3**	**1.83**	**5.676**	**1.475**	**4353.6**	**800**

Table 2. Wastewater characteristics for Section 3, corresponding to Bleaching Sector (PI)

Date	*pH*	*NO_3^- mg/L*	*TSS mg/L*	*Chlorides mg/L*	*COD mgO_2/L*	*H_2S mg/L*	*NH_4^+ mg/L*	*NO_2^- mg/L*	*Fixed Residual mg/L*	*BOD_5 mgO_2/L*
14-07	10.5	6.1	219	100	1865	-	15.3	6.1	4231	-
16-07	9.3	2.2	135	2200	966	-	2.5	0.2	4785	-
25-07	12.3	6.3	88	80	2960	0.0	5.0	0.36	6222	*326*
26-07	12.5	5.2	938	830	1261	2.7	6.9	0.4	6000	-
28-07	11	6.1	617	600	6200	8.1	9.1	2.85	6000	-
29-07	12.3	7.1	106	60	2820	9.62	9.16	0.24	7694	*100*
30-07	13.0	5.1	120	120	3441	5.52	7.9	1.1	9600	*188*
01-08	12.4	6.0	85	140	1995	6.7	8.1	0.36	8195	*122*
average	***11.6***	***5.54***	***288.5***	***516***	***2688.5***	***5.44***	***8.0***	***1.45***	***6590.9***	***184***

Table 3. Wastewater characteristics for Section 4, corresponding to Mercerizing Sector (PI)

Date	*pH*	*NO_3^- mg/L*	*TSS mg/L*	*Chlorides mg/L*	*COD mgO_2/L*	*H_2S mg/L*	*NH_4^+ mg/L*	*NO_2^- mg/L*	*Fixed Residual mg/L*	*BOD_5 mgO_2/L*
16-07	10.5	3.3	56	128	2142	3.6	8.7	0.16	3474	-
25-07	11.6	6.4	125	160	3160	0.0	5.6	12.8	3345	500
28-07	7.0	9.4	137	175	6556	0.92	2.150	0.025	3600	520
29-07	12.3	4.1	56	40	1820	0.32	7.62	0.56	3594	100
30-07	11.0	10	147	64	1991	-	8.5	2.8	5600	80
01-08	12.4	4.4	110	150	1060	1.7	18.6	0.32	3650	-
average	**10.8**	**9.4**	**105.2**	**119.5**	**2788.2**	**1.31**	**8.53**	**2.773**	**3877.2**	**300**

Table 4. Wastewater characteristics for Section 8, corresponding to Dyeing Sector

Date	*pH*	*NO_3^- mg/L*	*TSS mg/L*	*Chlorides mg/L*	*COD mgO_2/L*	*H_2S mg/L*	*NH_4^+ mg/L*	*NO_2^- mg/L*	*Fixed Residue mg/L*	*BOD_5 mgO_2/L*
16-07	10.7	8	344	104	3836	-	33.3	1.28	1046	195
24-07	6.3	3.7	72	48	258	0.8	0.48	0.08	548	70
25-07	8.3	6.2	956	141	1185	1.3	11.5	0.92	184	300
26-07	8.05	6.04	147	-	1907.6	-	14.31	0.9	1600	-
28-07	6.5	4.7	820	386	5443	0.8	14.29	-	6800	-
29-07	8.0	8.3	534	601	920	3.3	9.9	0.96	836	140
30-07	8.0	7.4	500	139	860	1.6	14.33	0.89	4400	155
01-08	8.6	4.1	623	100	853	1.9	16.5	1.32	717	-
average	**8.06**	**6.06**	**499.4**	**213.2**	**1907.8**	**1.62**	**14.34**	**0.91**	**2016**	**170**

Table 5. Wastewater characteristics for Section 9, corresponding to Dyeing Gauge Sector (PI)

Date	*pH*	*NO_3^- mg/L*	*TSS mg/L*	*Chlorides mg/L*	*COD mgO_2/L*	*H_2S mg/L*	*NH_4^+ mg/L*	*NO_2^- mg/L*	*Fixed Residue*	*BOD_5 mgO_2/L*
28-07	6.5	4.9	325	230	7561	5.9	18.4	0.21	2000	*410*
30-07	6.5	4.7	-	70	2800	6.2	18.8	0.19	2400	*230*
01-08	12.1	4.8	175	150	458	-	18.6	0.2	2135	-
average	***8.36***	***4.8***	***250***	***150***	***3606.3***	***6.05***	***18.6***	***0.2***	***2178.3***	***320***

Table 6. Wastewater characteristics for Section 12, corresponding to Dressing Sector (PI)

Date	*pH*	*NO_3^- mg/L*	*TSS mg/L*	*Chlorides mg/L*	*COD mgO_2/L*	*H_2S mg/L*	*NH_4^+ mg/L*	*NO_2^- mg/L*	*Fixed Residue mg/L*	*BOD_5 mgO_2/L*
14-07	7	1.6	140	40	1369	9.6	5.06	1.0	610	*180*
25-07	7.3	3.6	544	80	825	7.6	14.8	2.2	66	*60*
26-07	7.11		135	-	1905	-	9.93	1.6	400	-
average	*7.15*	*2.6*	*273*	*60*	*1097*	*8.6*	*9.93*	*1.6*	*358.6*	*120*

Table 7. Sample drawn from the course corresponding to the Burnt Sector (Section 1)

Value	*pH*	*NO_3^- mg/L*	*TSS mg/L*	*Chlorides mg/L*	*COD mgO_2/L*	*H_2S mg/L*	*NH_4^+ mg/L*	*NO^-_2 mg/L*	*Fixed Residue mg/L*	*BOD_5 mgO_2/L*
min.	5.0	0.025	105	64	1512	1.1	3	0.08	992	675
max.	6.5	5.3	936	180	3784	2.8	7.9	3	6000	925
Average(PG)	5.62	2.5	374.4	121.6	2629.2	1.83	5.4	1.475	3840.4	800

Table 8. Sample drawn from the course corresponding to Section 3

Value	*pH*	*NO_3^- mg/L*	*MTS mg/L*	*Chlorides mg/L*	*COD mgO_2/L*	*H_2S mg/L*	*NH_4^+ mg/L*	*NO^-_2 mg/L*	*Fixed Residue mg/L*	*BOD_5 mgO_2/L*
min.	9.3	2.2	85	60	966	0.0	2.5	0.2	4231	*122*
max.	13	7.1	938	2200	6200	9.62	15.3	6.1	9600	*326*
average	*11.6*	*5.54*	*288.5*	*516*	*2688.5*	*5.44*	*8*	*1.45*	*6590.9*	*184*

Table 9. Sample drawn from the course corresponding to the Mercerized sector (Section 4)

Value	*pH*	*NO_3^- mg/L*	*TSS mg/L*	*Chlorides mg/L*	*COD mgO_2/L*	*H_2S (mg/L)*	*NH_4^+ mg/L*	*NO^-_2 mg/L*	*Fixed Residue mg/L*	*BOD_5 mgO_2/L*
min.	7.0	3.3	56	40	1820	0.0	2.15	0.025	3345	80
max.	12.4	10	147	175	6556	3.6	18.6	12.8	5600	520
Average (PG)	10.8	9.4	105.2	119.5	2788.2	1.31	8.53	2.773	3877.2	300

Table 10. Sample drawn from the course corresponding to the Section 8

Value	*pH*	*NO_3^- mg/L*	*TSS mg/L*	*Chlorides mg/L*	*COD mgO_2/L*	*H_2S mg/L*	*NH_4^+ mg/L*	*NO^-_2 mg/L*	*Fixed Residue mg/L*	*BOD_5 mgO_2/L*
min.	6.3	3.7	72	48	258	0.8	0.48	0.08	184	70
max.	10.7	8.3	820	601	5443	3.3	33.3	1.28	6800	300
average	8.06	6.06	499.4	213.2	1907.8	1.62	14.34	0.91	2016	170

Table 11. Sample drawn from the course corresponding to the Dyeing Sector (Section 9)

Value	*pH*	*NO_3^- mg/L*	*TSS mg/L*	*Chlorides mg/L*	*COD mgO_2/D*	*H_2S mg/L*	*NH_4^+ mg/L*	*NO^-_2 mg/L*	*Fixed Residue mg/L*	*BOD_5 mgO_2/L*
min.	6.5	4.8	175	70	458	5.9	18.6	0.2	2000	230
max.	12.1	4.8	325	230	7561	6.2	18.6	0.2	2400	410
Average (PG)	8.36	4.8	250	150	3606.3	6.05	18.6	0.2	2178.3	320

Table 12. Sample drawn from the course corresponding to Section 12

Value	*pH*	*NO_3^- mg/L*	*TSS mg/L*	*Chlorides mg/L*	*COD mgO_2/L*	*H_2S mg/L*	*NH_4^+ mg/L*	*NO^-_2 mg/L*	*Fixed Residue mg/L*	*BOD_5 mgO_2/L*
min.	7	1.6	135	40	825	7.6	5.06	1.0	66	60
max.	7.3	3.6	544	80	1369	9.6	14.8	2.2	610	180
Average (PG)	7.15	2.6	273	60	1097	8.6	9.93	1.6	358.6	60

Table 13. Maximum Allowable Concentrations (MAC) values according to NTPA 002/2005 (GD, 2005)

No.	*Quality indicator*	*Units*	*MAC*	*Analysis method*
1.	Temperature, T	^0C	40	-
2.	pH	pH units	6.5-8.5	SR ISO 10523-97
3.	Suspended solids (TSS)	mg/L	350	STAS 6953-81
4.	BOD_5	mg O_2/L	300	STAS 6560-82
5.	COD (as CCO-Cr)	mg O_2/L	500	SR ISO 6060/96
6.	Nitrogen (as $[NH_4^+]$)	mg/L	30	STAS 8683-70
7.	Total phosphorus (as P)	mg/L	5.0	STAS 10064-75
8.	Total cyanides (CN)	mg/L	1.0	SR ISO 6703/1-98
9.	Sulphides and Hydrogen Sulphide (S_2^-)	mg/L	1.0	SR ISO 10530-97
10.	Sulphites $(SO_3)^{2-}$	mg/L	2	STAS 7661-89
11.	Sulphates $(SO_4)^{2-}$	mg/L	600	STAS 8601-70
12.	Phenols (C_6H_5OH)	mg/L	30	STAS 7167-92
13.	Substances extractable with organic solvents	mg/L	30	SR 7587-96
14.	Biodegradable synthetic detergents	mg/L	25	SR ISO 7875/1.2-96
15.	Lead (Pb^{2+})	mg/L	0.5	STAS 8637-79
16.	Cadmium (Cd^{2+})	mg/L	0.3	SR ISO 5961/93
17.	Total Chromium $(Cr^{3+})+(Cr^{6+})$	mg/L	1.5	SR ISO 9174-98
18.	Hexavalent Chromium (Cr^{6+})	mg/L	0.2	STAS 7884-91
19.	Copper (Cu^{2+})	mg/L	0.2	STAS 7795-80
20.	Nickel (Ni^{2+})	mg/L	1.0	STAS 7987-67
21.	Zinc (Zn^{2+})	mg/L	1.0	STAS 8314-87
22.	Total Manganese (Mn)	mg/L	2.0	SR ISO 6333-96
23.	Free residual chloride (Cl_2)	mg/L	0.5	STAS 6364-78

3. Effluents characterization

Characterization of textile process effluent streams is very important to develop strategies for water treatment and reuse. To optimize treatment and reuse possibilities, textile industry waste streams should be in principle considered separately. When the characteristics of the separate streams are known, it can be decided which streams may be combined to improve treatability and increase reuse options (EWA, 2005; Le Rosi et al., 2007).

Data from Tables 1-12 lead to the following outcomes:

- in **Section 1,** corresponding to the **Burning** sector, the analyzed parameters which exceed the maximum admissible values given in Table 13 are pH, TSS, COD, H_2S, BOD_5;
- in **Section 3,** corresponding to the **Bleaching** sector, the analyzed parameters which exceed the maximum admissible values in Table 13 are pH, COD, H_2S;
- in **Section 4,** corresponding to the **Mercerized** sector, the analyzed parameters which exceed the maximum admissible values in Table 13 are pH, COD, H_2S;
- in **Section 8,** corresponding to the **Dyeing** sector, the analyzed parameters which exceed the maximum admissible values in Table 13 are TSS, COD, H_2S;
- in **Section 9,** corresponding to the **Printing** sector, the following analyzed parameters exceed the maximum admissible values given in Table 13: COD, H_2S, BOD_5;
- in **Section 12,** corresponding to the **Dressing** sector, the analyzed parameters which exceed the maximum admissible values in Table 13 are: COD, H_2S.

These characteristics are dependent on the main activity developed in each sector. A comparison of the textile effluent and the standard for discharge of textile wastewater into receiving waters shows that the wastewaters have to be treated in order to meet the acceptable range of the effluent discharge standards.

If untreated wastewater would be discharged in aquatic environment, some effects could take place, for example:

- Effect of BOD: depletes dissolved oxygen from streams, lakes and oceans; may cause death of aerobic organisms (fish kills etc.); increases anaerobic properties of water
- Effect of TSS: increases turbidity (less light - reduced photosynthesis, causes fish's gills to get plugged up); increases silting (reduces lifetime of lakes, changes benthic ecology)
- Effect of pH: organisms are very susceptible to acids and bases

4. Consideration on water conservation and pollution prevention in textile finishing mills

The value of water resources is universally recognized and water shortage is increasing in many companies. The need to preserve this resource is the driving force behind the identification and exploitation of non-conventional water sources. For industry, in particular textile production, wastewater reclamation appears a technically feasible solution (Bergenthal, 1984; Li Rosi et al., 2007).

Under these concerns a variety of wastewater recycle/reuse technologies have been developed during time to allow these mills to reduce the volume of wastewater and the amount of pollutants discharged.

With most of these technologies, specific technical and economic factors affect their application at a given mill, and thus each application must be considered under its own mill-specific conditions.

The first step in a pollution prevention strategy for water is a thorough audit and characterization of wastewater from textile operations. A program of maintenance, inspection, and evaluation of production practices should be established. Significant reductions in water use can be made by implementing the following: minimizing leaks and spills, maintaining production equipment properly, identifying unnecessary washing of both fabric and equipment, training employees on the importance of water conservation.

5. Conclusions

The results can be used as starting points in order to design the sewage network and to ensure its protection in case of the joint effect of some toxic and corrosive pollutant agents. Certain pollutants in textile wastewater are more important to target for pollution prevention. The organic load (COD as CCO-Cr) is exceeded in all analyzed sectors: Burnt, Bleaching, Mercerized, Dyeing, Printing, Dressing.

Wastewater in Bleaching, Mercerized and Printing sectors requires separate treatment, which can decrease the concentration of polluting agents.

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