REUSE OF EFFLUENT WATER OBTAINED IN DIFFERENT TEXTILE FINISHING PROCESSES

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Abstract:

The use of clean water in textile finishing is both common and very expensive. Effluent water subjected to advanced methods of physical, chemical, and biological treatment could be used for this purpose. However, information obtained from industry and the literature shows that effluent water obtained from different finishing processes may be reused without being totally purified. In this paper, a method is proposed to determine the viability of reusing effluent water obtained from different textile finishing processes of cotton fabrics after just basic treatments. These treatments include; filtering, airing, pH regulating and ion exchange. Effluent water obtained in different textile finishing processes was analysed in terms of pH value, COD (Chemical Oxygen Demand), SS (Suspended Solids), colour, hardness and conductivity. Effluent water for treatment and the process where the treated water was reused were determined by means of the proposed method, based on a multiple criteria decision making approach. A laboratory scale trial was conducted to investigate the efficiency of treatment.

Key words:

Textile effluent, wastewater, treatment, multiple criteria decision making.

Introduction

Dyeing and finishing processes in the textile industry require large amounts of good quality water. The textile industry is one of the most polluting industries because of the high volume of effluent water discharged and the nature of the effluent contaminants. The effluent water generated after dyeing and finishing processes must be treated by a combination of chemical, physical and biological methods before discharge in order to meet legislative requirements. Furthermore, advanced treatment techniques are needed, especially after the dyeing processes, in order to remove residual dyes from the effluent. Therefore, the reuse of effluent water provides an opportunity to achieve environmental and economic benefits.

A literature survey showed that much work has been focused on investigating the effectiveness and feasibility of new advanced technologies that are promising in terms of their performance and cost in the treatment and reuse of textile effluents. These technologies include membrane processes such as; microfiltration, ultrafiltration, nanofiltration, and reverse osmosis, and; advanced oxidation processes, electrochemical processes, adsorption, and ion exchange. They were also found to be more effective for the removal of colour and COD from textile wastewater when compared with conventional methods [1].

Most of the earlier studies have been related to the application of membrane technologies on the basis of laboratory, and/or pilot scale trials, and the quality of the treated water was evaluated with respect to the process water presently in use [2-20]. There have also been studies conducted into investigating the use of membranes in combination with physico-chemical processes for treatment and reuse of textile wastewater [21-22]. In addition, the use of an external membrane bioreactor for the treatment of waste has been researched and its operating conditions determined [23-24]. The treatment of wastewater for reuse in the textile industry by means of other advanced technologies including; ozonation, electroflocculation, and advanced oxidation was also studied in several works [25-30]. Generally, these studies focused on

the removal of colour, and the reuse of the effluents generated by the dyeing process.

Riera-Torres et al., treated dyeing wastewater by means of an electrochemical treatment and then reused the treated water in the dyeing of 100% plain cotton interlock knitting fabrics by using five reactive dyes. They concluded that 70% of the wastewater could be satisfactorily reused by direct bath reuse [31].

In this study, a method is proposed to determine the viability of the reuse of effluent water obtained from the different textile finishing processes of cotton fabrics after some basic treatments including; filtering, airing, pH regulating, and ion exchange in a textile plant. The layout of the plant machinery was also considered as a criterion. The aim of this study is to minimise water consumption and purification costs.

Materials and Method

Effluent waters generated in the textile plant were first divided into two groups as usable and unusable. Effluents of some processes such as dyeing and desizing were declared unusable, as they contain residual dyes and a high chemical content, and therefore would need to be totally purified by conventional or advanced methods, or their combination. The water fed into the processes and the usable effluents were analysed in terms of pH value, COD (Chemical Oxygen Demand), SS (Suspended Solids), colour, hardness and conductivity in accordance with the related standards [32-36].

The method designed for determining the reuse of the effluent water is based on the multiple criteria decision making approach. This method was used to find out which effluent water was suitable to be reused, and to determine the type of treatments necessary.

The first step was to build a hierarchy in order to evaluate the characteristics of the effluent water by comparing one to another. These evaluations were then converted into numerical values and the numerical weight was used as the selection criterion.

Figure 1. Principle of the hierarchical approach.

The principle of such a hierarchical approach is demonstrated in Figure 1.

In order to choose the best alternative, the criteria were converted into numerical values. When a change was needed in the criteria, this was scored as 0, otherwise it was scored as 1. The distance between the finishing processes based on the machinery layout in the plant was determined as a sub-criterion; a relatively long distance was scored as 0, and a short distance was scored as 1. Thus, the alternative with the highest total score was the one selected for reuse.

A microfiltration membrane process and an ion-exchange system were used for the effluent treatment. In addition, airing was performed when it was necessary to lower COD. The microfiltration membrane was used for removal of suspended solids (SS) and also to a considerable extent, colour. For ion-exchange, Na_2Z (resin) was used for softening the effluent water, and in this way, the conductivity and pH of the effluents were also adjusted. The following reactions occur in Na_2Z (resin) ion-exchange system:

In order to confirm the effluent treatment, one of the effluents that was intended for reuse after treatment, was used for hydrogen peroxide bleaching of a cotton fabric sample. The bleaching recipe is as follows:

- 1 ml/ 400 ml H_2O_2
- 0.4 g/ 400 ml Na_2CO_3
- 2 g /400 ml silicate
- 1 ml/ 400 ml wetting agent

Bleaching was performed at 90° C for 1 hour.

The results were evaluated in comparison with a fabric sample bleached by using inflow process water and the degree of whiteness of the bleached fabrics was evaluated by using a spectrophotometer.

Results and Discussion

Analysis of process water and effluents

The results of the analysis of the water fed into the processes, and the usable effluents are given in Table 1.

Selection of effluents for reuse

The minimum treatment process and the shortest distance between the processes were considered as the key parameters for selection of effluents for reuse. The required treatment

processes for obtaining inflow water were determined according to pH, colour, COD, SS, hardness and conductivity of the effluents. In Table 2, the targeted processes for reuse of the effluents and evaluation of different alternatives are shown.

The alternative with the maximum total score was selected for reuse. Thus; Sanfor 1 outflow effluent was selected for reuse in scouring machine no.1, bleaching machine no.1 bath 6 (BENINGER 1) outflow was selected for reuse in Bleaching machine no.2 (BENINGER), THEN 15 Jet Procion / Displacement bath 1 outflow was selected for reuse in JET Dyeing Machine no. 3, and KUSTERS 1 /Bath 6 outflow was selected for reuse in Mercerisation machine no.2.

Evaluation of the reuse of the effluents

After the effluents were selected, the aim was then to evaluate the performance of the effluent during reuse. For this purpose, "Sanfor 1 outflow effluent" was reused in "scouring" after treatment. The cotton fabric sample bleached by using the

Figure 2. % Reflectance of the bleached fabrics. Red line: Fabric bleached by using treated water. Green line: Fabric bleached by using inflow water.

Figure 3. K/S values of the bleached fabrics. Red line: Fabric bleached by using treated water. Green line: Fabric bleached by using inflow water.

Table 1. Analysis of the water fed into the processes, and the usable effluents.

No.	Machine name/effluent type	Total hardness (dF)	pH	COD (mg/l)	SS	Conduc-tivity	Colour (Pt-Co)
1	Inflow water	1.4	8.43	<10	0	380	colourless
2	JET 19 /Dyeing machine cleaning	0.1	7.28	<10	200	190	27
3	BENNINGER1 /Bleaching bath 1	0.1	7.57	228	100	152	87
4	BENNINGER1 /Bleaching bath 2	0.1	7.81	107	200	138	30
5	BENNINGER1 /Bleaching bath 3	0.3	8.54	20	100	265	46
6	BENNINGER1 /Bleaching bath 4	0.1	8.30	76	50	267	38
7	BENNINGER1 /Bleaching bath 5	0.2	7.66	65	100	260	32
8	BENNINGER1 /Bleaching bath 6	0.5	7.16	30	50	266	33
9	BENNINGER2 /Bleaching outflow	0.5	7.00	1093	80	350	80
10	THEN 15 Jet Procion /Displacement bath 1	0.2	9.25	<10	100	186	57
11	THEN 15 Jet Procion / Displacement water after dyeing	0.3	10.45	35	200	263	65
12	THEN 23 Jet /Fibrillation final displacement water	0.1	9.58	<10	100	387	30
13	THEN 23 Jet /Displacement water after enzyme treatment	0.3	9.86	121	200	376	65
14	THEN 23 Jet /Acid bath after prewashing	0.5	5.90	171	100	491	27
15	THEN 20 Jet /Enzyme treatment	1.2	9.34	251	100	863	26
16	THEN 20 Jet /Outflow	0.5	7.60	603	360	416	66
17	THEN 21 Jet /Outflow	0.4	6.40	38	80	241	56
18	THEN 23 Jet /Outflow	2.0	7.00	640	100	944	36
19	JET KUSTERS /Batch washing bath 2	0.1	8.82	91	50	363	72
20	JET KUSTERS /Batch washing bath 3	0.1	8.85	25	200	357	52
21	JET KUSTERS /Batch washing bath 6	0.1	9.21	53	150	184	54
22	KUSTERS 1 /Bath 6	0.4	7.57	30	150	284	29
23	JET KUSTERS /Outflow	2.0	5.70	1510	240	590	34
24	Continue Kusters /Outflow	0.6	7.00	1764	80	233	48
25	Scouring	0.8	7.76	26	150	278	36
26	Stenter 2 /Outflow	2.0	6.20	1390	120	544	44
27	Stenter 4 /Outflow	2.0	4.70	1734	520	1470	45
28	Stenter 6 /Outflow	0.1	5.40	610	40	313	70
29	Stenter 7 /Outflow	0.2	4.90	4520	440	624	44
30	Sanfor 1 /Outflow	0.1	8.00	<10	40	361	29
31	Sanfor 2 /Outflow	1.0	7.40	395	520	351	34

treated effluent was evaluated in terms of whiteness and the results were compared to the whiteness of the cotton fabric sample bleached by using the inflow water.

The results demonstrated in Figures 2 and 3, and Table 3 reveal that the effluent water "Sanfor 1 outflow effluent" was successfully reused for the bleaching process after treatment. This confirms the reliability of the method used for selection of the effluents for reuse, and the processes used for treatment of the effluents.

Conclusion

This research, investigating the reuse of effluent water obtained in different textile finishing processes shows that it is possible to reuse some of the effluents after some simple and low cost

treatment processes, without a negative impact on the product quality. The reuse of effluents will lead to water saving, reduced energy consumption, and lower effluent treatment costs.

In this study, microfilters, which are the cheapest type of membranes, were used to remove SS, COD and colour. Advanced membrane technologies could be used in order to change the hardness and conductivity of the effluent as well as the removal of SS, COD and colour. However, these advanced technologies require a higher investment cost. For this reason, zeolite was used to change the hardness and conductivity of the effluent. Zeolite is a natural mineral that is widely available and therefore, the cost of the proposed effluent treatment method is low.

Finally, the method used for the selection of the effluents for reuse, and the treatment process can be implemented in the

Table 2. Selection of effluents for reuse.

Re-use for:	Scouring machine no.1			
	Effluent water alternatives:			
	30 - Sanfor 1 /Outflow	12 - THEN 23 /Fibrillation final displacement water	7 - BENNINGER1 /Bleaching bath 5	25 - Scouring
pH	1	0	0	0
colour	0	0	0	0
COD	1	1	0	0
SS	0	0	0	0
hardness	0	0	0	0
conductivity	1	1	0	0
distance	1	0	1	0
TOTAL SCORE	4	2	1	0
Re-use for:	Bleaching machine no.2 (BENINGER)			
	Effluent water alternatives:			
	16 - THEN 20 Jet /Outflow	11- THEN 15 Jet Procion / Displacement water after dyeing	8 - BENNINGER 1 /Bleaching bath 6	19 - JET KUSTERS /Batch washing bath 2
pH	1	0	1	1
colour	0	0	0	0
COD	0	1	1	0
SS	0	0	0	0
hardness	0	0	0	0
conductivity	0	0	0	1
distance	0	0	1	0
TOTAL SCORE	1	1	3	2
Re-use for:	JET Dyeing Machine no. 3			
	Effluent water alternatives:			
	10 - THEN 15 Jet Procion /Displacement bath 1	27 - Stenter 4 /Outflow	24 - Continue Kusters /Outflow	5 - BENNINGER1 /Bleaching bath 3
pH	1	0	0	1
colour	0	0	0	0
COD	1	0	0	1
SS	0	0	0	0
hardness	0	0	0	0
conductivity	0	0	0	0
distance	1	0	1	0
TOTAL SCORE	3	0	1	2
Re-use for:	Mercerisation machine no.2			
	Effluent water alternatives:			
	22 - KUSTERS 1 /Bath 6	28 - Stenter 6 /Outflow	17 - THEN 21 Jet /Outflow	29 - Stenter 7 /Outflow
pH	1	0	0	0
colour	0	0	0	0
COD	1	0	1	0
SS	0	0	0	0
hardness	0	0	0	0
conductivity	0	0	0	0
distance	1	1	1	0
TOTAL SCORE	3	1	2	0

Table 3. Numerical expression of the colour values of the bleached fabrics. Standard refers to the fabric bleached by using treated water, batch refers to the fabric bleached by using inflow water.

Parameter	Standard	Batch	Difference
X	107.63	107.54	
Y	113.90	113.81	
Z	115.99	116.40	
L*	105.14	105.11	-0.03
a*	-0.59	-0.60	0.00
b*	3.61	3.31	-0.30
c*	3.66	3.37	-0.29
h	99.30	100.19	0.05
DE*			0.30

textile dyeing and finishing facilities for efficient water and energy use. However, the machine layout is an important criteria and one that should be considered in the selection of effluents for reuse.

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