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Wastewater Reuse for the Minimization of Fresh Water Demand in Coastal Areas—Selected Cases from the Textile Finishing Industry

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ABSTRACT

Availability of water to the industry often becomes prohibitive, both in terms of quality and cost, in coastal areas. This study takes the textile industry and evaluates the prerequisites of water recovery and reuse. In this context, a large spectrum are studied for their water, the general quality of wastewater generated, quality and treatability of reuse wastewater streams, and expected changes in the overall effluent quality after segregation of the recovery wastewater portion.

Key Words: Textile finishing industry; Chemical treatment; Biological treatability; COD fractionation; Wastewater reuse; Coastal areas.

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INTRODUCTION

Coastal areas are generally regarded as environmentally sensitive zones, therefore the land use in these areas should be considered with a careful long-term management strategy. The proper management of coastal areas would propose the controlled development of residential land use, whereas inevitable industrial activities should be minimized. However, the current situation in some countries like Turkey, is the opposite with a dense industrialization in the coastal zones, since this application is beneficial in terms of short-term economics.

Coastal areas are highly attractive sites for the industries, as they offer the ease of raw material supply, transportation, and marketing. This would lead to an increased demand for industrial fresh water that cannot be supplied by the scarce local resources. This unbalanced supply and demand would boost fresh water costs.

Turkey has a high amount of textile production and is among the eight leading textile exporters throughout the world, being the second textile supplier of European Union. Textile industry applications are typical examples for the industrial land use of coastal areas in Turkey.

Industrial wastewater management needs a systematic approach for the minimization of fresh water demand. This approach requires a careful in-plant control strategy with full information on water consumption and pollution profile of each major operation step. The main objective of the article is to review a large spectrum of different textile plants in terms of water demand and quality of wastewater generated. The general reuse perspective was evaluated within the framework of stream segregation for reuse, treatment for the quality improvement of the reusable streams, and additional impact of water recovery on the quality/treatability of the remaining wastewater portion.

CHARACTERISTICS OF THE INVESTIGATED PLANTS

In this study, the wastewaters originating from textile finishing operations have been investigated in terms of their characterization, treatability, and reuse alternatives for the minimization of fresh water demand. Twenty-four different cases covering a wide range of processes from dyeing, printing, desizing, kiering, bleaching, optical brightening to stone bleaching applied to cotton woven fabric, silk woven fabric, wool woven fabric, cotton knit fabric, PES (polyester) knit fabric, cotton/PES blend knit fabric, viscose rayon knit fabric, acrylic fiber, and yarn and wool yarn by the use of desizing enzymes, pumice stone, optical brightener, urea and reactive, acid, pigment, metal complex, disperse, chromium, basic dyes etc., are evaluated. Specifications related to investigated cases are summarized in Table 1. The cases are classified for further evaluation with respect to their material types.

CONVENTIONAL CHARACTERIZATION

The first part of the survey involves characterization of textile finishing effluents in terms of conventional parameters. Evaluation of the data outlined in Table 2 presents that the investigated cases cannot be generally grouped in terms of their conventional wastewater characterization and pollution loads even for cases processing the same materials by using the same agents and operations.

The COD values vary in a wide range between 350 and 4738 $mg\,L^{-1}$, when the extreme value of Case G3 is not considered. An exceptionally high COD value is associated with wastewaters originating from Case G3. This case involves a special type of finishing application named "Tube and item printing" where white spirit with high organic content is used as solvent. Except the Cases G1 (silk–cotton woven fabric) and B3 (cotton knit fabric), all wastewaters cover over 70% soluble organic matter. The SS values in the table differ between 10–3500 $mg\,L^{-1}$. The wastewaters originated from the Cases A1, A2, and A3 have extremely high SS contents due to the usage of pumice stone, in a special type of finishing application called "stone bleaching." The VSS/SS ratios in the analyzed cases varies between 10 to 97% except the stone bleaching having a VSS/SS ratio of only 1% indicating the inorganic nature of the pumice stone used in the process. Depending on the nature of applied processes and used dyes, the pH values of effluents vary from acidic to alkaline character. Generally, the wastewaters investigated may be considered as nitrogen and phosphorus deficient, except the Case G1. As urea is used for printing operations in Case G1, a TKN/COD ratio similar to that of domestic sewage is reported for this case. Another significant feature of the data is that the unit water consumption and organic load are highly variable in a range of 20–231 $m^3\,ton^{-1}$ fabric and 14–236 $kg\,COD\,ton^{-1}$ fabric, respectively. According to the figures given in Table 2, only denim processing cases show a distinct group in terms of unit water consumption and organic load.

TREATABILITY STUDIES

Biological treatment is the most commonly used technology applied to textile industry.[13] Chemical treatment, as a pretreatment application before biological treatment is also an alternative in the treatment scheme, when insoluble disperse dyes are used and removal of toxicity is necessary.[10,14–16] Another application point of chemical treatment may be after biological treatment as a polishing step aiming at the removal of color and the organic matter which cannot be removed biologically.[17–19]

In this study only biological treatment or chemical treatment prior to biological treatment applications are investigated for the evaluation. Within the concept of biological treatability the COD fractions are studied.

Biological Treatability Oriented Characterization

This part of the study covers identification of COD fractions in terms of their biodegradation characteristics. Total COD consists of biodegradable and inert components; both subdivided into further fractions. The total inert COD consists of soluble inert COD, S_{I1}, and particulate inert COD, X_{I1}, both by-passing the system without being affected from biochemical reactions. On the other hand, the

Table 1. Specifications related to investigated cases.

Case	Type of material	Process specification	Applied dye or main specific agent	Reference
A1	Cotton denim fabric[a]	Desizing; stone bleaching	Desizing enzymes; pumice stone	[1]
A2	Cotton denim fabric[a]	Desizing; stone bleaching	Desizing enzymes; pumice stone	[1]
A3	Cotton denim fabric[a]	Desizing; stone bleaching	Desizing enzymes; pumice stone	[2]
B1	Cotton knit fabric	Optical brightening; peroxide bleaching; dyeing	Optical brightener; H_2O_2; reactive dye	[3]
B2	Cotton knit fabric	Optical brightening; kiering; peroxide bleaching; dyeing	Optical brightener; H_2O_2; reactive dye	[4]
B3	Cotton knit fabric	Optical brightening; kiering; peroxide bleaching; dyeing	Optical brightener; H_2O_2; reactive dye	[5]
B4	Cotton knit fabric	Optical brightening; kiering; peroxide bleaching; dyeing	Optical brightener; H_2O_2; reactive dye	[6]
B5	Cotton knit fabric	Optical brightening; peroxide bleaching	Optical brightener; H_2O_2	[6]
B6	Cotton knit fabric	Peroxide bleaching; dyeing	H_2O_2; reactive dye	[7]
B7	Cotton knit fabric	Peroxide bleaching; dyeing	H_2O_2; reactive dye	[6]
B8	Cotton knit fabric	Peroxide bleaching; dyeing	H_2O_2; reactive dye	[2]
B9	Cotton knit fabric	Kiering; dyeing	Soda; reactive dye	[6]

C1	Cotton/PES knit fabric	Peroxide bleaching; dyeing	H_2O_2; reactive dye	[2]
C2	Cotton/PES knit fabric	Bleaching; dyeing	H_2O_2; reactive dye	[6]
D	PES knit fabric	Dyeing	Disperse dye	[2]
E	Wool/PES knit fabric	Dyeing	Metal complex; disperse dyes	[8]
F	Viscose rayon knit fabric	Dyeing	Reactive dye	[6]
G1	Silk[b] + Cotton[c] woven fabric	Bleaching; desizing; kiering; dyeing; printing	H_2O_2; reactive, acid, pigment, disperse dyes; urea	[9]
G2	Cotton knit fabric	Rotation printing	Copolymer; pigment dye	[10]
G3	Cotton knit fabric	Tube and item printing	Ethyleneurea; white sprite; pigment dye	[10]
H	Wool woven fabric	Dyeing	Metal complex; disperse dyes	[8]
J1	Wool yarn	Dyeing	Chromium dye	[8]
J2	Wool yarn	Dyeing	Metal complex; disperse dyes	[8]
K	Acrylic fiber and yarn	Dyeing	Basic dye	[3]

[a]Previously dyed jeans.
[b]80% of the production.
[c]20% of the production.

Table 2. Conventional wastewater characterization.

Type of w astewater	Total COD ($mg\,L^{-1}$)	Soluble COD ($mg\,L^{-1}$)	SS ($mg\,L^{-1}$)	VSS ($mg\,L^{-1}$)	TKN ($mg\,L^{-1}$)	NH_4-N ($mg\,L^{-1}$)	Total P ($mg\,L^{-1}$)	pH	Q [m^3 (tone fabric)$^{-1}$]	COD load [kg COD (ton fabric)$^{-1}$]	Reference
A1	1,910	1,570	10,400	124	31	9.4	18.5	8.0	70	130	[1]
A2	1,940	1,650	11,200	100	32	1.0	35	8.9	70	136	[1]
A3	2,400	1,700	9,700	70	35	5.6	34	9.3	68.4	155	[2]
B1	2,300	1,900	135	80	14	ND	4.5	10.1	ND	ND	[3]
B2	955	675	105	85	ND	ND	ND	9.6	75	72	[4]
B3	1,980	1,210	170	130	25	21	27	10.2	75	148	[5]
B4	1,180	890	100	90	14	ND	13	10.3	75	84.5	[6]
B5	4,738	ND	70	60	45	ND	ND	ND	40	190	[6]
B6	2,100	1,558	700	ND	62	ND	13.6	10.5	ND	ND	[7]
B7	672	ND	48	34	ND	ND	ND	ND	99	67	[6]
B8	1,470	1,165	490	160	110	0.5	4	10.9	80	118	[2]
B9	828	ND	65	32	22	ND	10	ND	91	75	[6]
C1	2,400	1,690	370	180	20	0.2	7	10.2	80	192	[2]
C2	2,070	ND	85	54	34	ND	29	ND	95	197	[6]
D	1,985	1,485	213	22	27	1.7	9	5.8	20	40	[2]

E	1,445	1,320	<10	ND	73	50	ND	7	151	236	[8]
F	728	ND	29	28	16	ND	32	ND	113	82	[6]
G1	1,070	620	105	90	110	62	2	8.2	ND	ND	[9]
G2	785	ND	125	ND	30	20	ND	7.4	ND	ND	[10]
G3	49,170	ND	9,500	ND	1,765	368	ND	8.5	ND	ND	[10]
H	650	ND	30	ND	ND	ND	ND	5.7	231	150	[8]
J1	1,080	ND	3,500	ND	ND	ND	ND	4.1	24	26	[8]
J2	365	ND	1,450	ND	ND	ND	ND	6.2	38	14	[8]
K	1,900	1,590	90	43	72	ND	4.2	4.5	ND	ND	[3]
Organized industrial district[a]	932	580	225	130	54	ND	7.9	8.2	ND	ND	[11]
Domestic sewage	410	140	210	145	43	32	7.2	7.4	ND	ND	[12]

ND: not determined.
[a]Predominantly textile.

subdivision of the total biodegradable COD covers basically two parts: the readily biodegradable COD, S_{S1} and the slowly biodegradable COD, which consists of soluble, S_{H1} and particulate parts X_{S1} based on dual hydrolysis models.[11,20]

As mentioned earlier, raw wastewaters of denim processing cases contain excessive amount of SS due to the use of pumice stone in the stone bleaching operations. Plain settling must be applied prior to biological treatment for such cases and therefore the results of COD fractionation given in Table 3 for denim processing effluents (Cases A1–A3) are obtained after 6 h of gravity settling. Such a gravity settling is reported to have no effect on the COD content of raw wastewaters.[1]

Evaluation of the data presented in Table 3 shows that 2–35% of the total COD consists of inert organic matter, which is predominantly soluble in nature. This characteristic becomes important when stringent effluent discharge limitations are required. The fraction of particulate inert COD is small enough to be neglected. The results outline that the textile wastewaters have a biodegradable fraction varying from 65 to 98%. This fraction involves only a portion of readily biodegradable COD in the range of 7–24%, while the remaining portion is classified as slowly biodegradable COD, predominantly soluble (55–80%) in form.

Effect of Chemical Treatment on Biological Treatability

As mentioned earlier, chemical treatment is a pretreatment step aiming to ease the biological treatment. Chemical treatment is applied to the effluents of two cotton knit fabric processing cases (Cases B4 and B2) with similar process specifications and an acrylic fiber and yarn processing (Case K). The wastewaters of Case B4 are subjected to chemical precipitation with sodium bentonite and ozonation experiments, whereas chemical oxidation with 4 different ozone doses is applied to effluents of Case B2. Oxidation with H_2O_2 and precipitation by the use of $FeCl_3$ are used for the wastewaters of Case K. The results of physicochemical treatability outlined in Table 4, indicate that in Case B4, the optimum COD and color removals of 47 and 69% respectively, are obtained with sodium bentonite. Therefore further biological treatability studies (Table 5) are conducted on the samples chemically precipitated with 2000 $mg\,L^{-1}$ sodium bentonite. This application reduces total COD from 1180 to 630 $mg\,L^{-1}$, a level approximately half of the initial value and provides a soluble COD removal of approximately 60%, whereas the removal of particulate portion remains limited to 12%.

The results show that the readily biodegradable COD is found to be reduced from 118 to 70 $mg\,L^{-1}$ with a removal of 40%, a 70% decrease is observed for the soluble slowly biodegradable COD (S_{H1}) and a 43% removal achieved for the soluble inert COD. X_{S1} removal remains limited to 15% and X_{I1} is not affected from chemical precipitation to a significant extent.

COD fractionation studies for Case B2 are applied for three different utilized ozone doses of 130, 235, and 1385 $mg\,L^{-1}$. At 130 $mg\,L^{-1}$ utilized ozone dose, the effect of ozonation is observed mainly on soluble components, whereas the particulate fractions are reported to be affected with the increased ozone

Table 3. COD fractionation of raw textile wastewaters.

	COD components													
Type of wastewater	C_{T1} ($mg\,L^{-1}$)	S_{T1} ($mg\,L^{-1}$)	X_{T1} ($mg\,L^{-1}$)	S_{S1} ($mg\,L^{-1}$)	S_{S1}/C_{T1} (%)	S_{H1} ($mg\,L^{-1}$)	S_{H1}/C_{T1} (%)	S_{I1} ($mg\,L^{-1}$)	S_{I1}/C_{T1} (%)	X_{S1} ($mg\,L^{-1}$)	X_{S1}/C_{T1} (%)	X_{I1} ($mg\,L^{-1}$)	X_{I1}/C_{T1} (%)	Reference
A1[b]	1,910	1570	340	325	17	1,005	53	240	13	340	18	N	—	[1]
A2[b]	1,940	1,650	290	410	21	1,140	59	100	5	290	15	N	—	[1]
A3[b]	2,400	1,700	700	330	14	1,270	53	100	4	700	29	N	—	[2]
B1	2,300	1,900	400	420	18	1,310	57	170	7	365	16	35	2	[3]
B2	955	675	280	110	12	245	26	320	34	ND	—	ND	—	[4]
B3	1,980	1,210	770	187	9	734	37	289	15	708	36	62	3	[5]
B4	1,180	890	290	118	10	525	44	247	21	227	19	63	5	[6]
B6	2,100	1,558	542	ND	—	ND	—	317	15	517	25	25	1	[7]
B8	1,470	1,165	305	330	23	575	39	260	18	288	20	17	1	[2]
C1	2,400	1,690	710	165	7	1,275	53	250	10	598	25	112	5	[2]
D	1,985	1,485	500	300	15	770	39	415	21	390	19	110	6	[2]
E	1,445	1,320	125	340	24	833	58	147	10	ND	—	ND	—	[8]
Organized industrial district[a]	932	580	352	139	15	411	44	20	2	352	38	N	—	[11]
Domestic sewage	450	155	295	40	9	97	22	18	4	250	55	45	10	[12]

ND: not determined, N: negligible.
[a]Predominantly textile.
[b]After passing through a 6 h of gravity settling.

Table 4. Physico-chemical treatability of raw textile wastewaters.

Case	Physico-chemical method	Agent type	Optimum dose ($mg\,L^{-1}$)	Initial COD ($mg\,L^{-1}$)	COD removal (%)	Color removal (%)	Reference
B4	Precipitation	Sodium bentonite	2,000	1,180	47	69	[6]
B4	Oxidation	Ozone	43[a]	1,180	9	69	[6]
B4	Oxidation	Ozone	62[a]	1,180	13	74	[6]
B4	pH adjustment + oxidation	H_2SO_4 + ozone	14[a]	1,180	18	36	[6]
B2	Oxidation	Ozone	130[a]	955	11	83	[4]
B2	Oxidation	Ozone	235[a]	955	19	92	[4]
B2	Oxidation	Ozone	465[a]	955	21	94	[4]
B2	Oxidation	Ozone	1,385[a]	955	32	94	[4]
K	Oxidation	H_2O_2	1.0[b]	1,900	63	ND	[3]

[a]Utilized ozone.
[b]H_2O_2/COD with 500 $mg\,L^{-1}$ Fe^{3+} and a day of reaction time.

Table 5. COD fractionation of pretreated textile wastewaters.

C_{T1} ($mg\,L^{-1}$)	S_{T1} ($mg\,L^{-1}$)	X_{T1} ($mg\,L^{-1}$)	S_{S1} ($mg\,L^{-1}$)	S_{S1}/C_{T1} (%)	S_{H1} ($mg\,L^{-1}$)	S_{H1}/C_{T1} (%)	S_{I1} ($mg\,L^{-1}$)	S_{I1}/C_{T1} (%)	X_{S1} ($mg\,L^{-1}$)	X_{S1}/C_{T1} (%)	X_{I1} ($mg\,L^{-1}$)	X_{I1}/C_{T1} (%)
Case B4, pretreated with 2000 $mg\,L^{-1}$ optimum sodium bentonite dosage,[6]												
630	375	255	70	11	163	26	142	23	192	30	63	10
Case B2, pretreated with 130 $mg\,L^{-1}$ utilized ozone,[4]												
850	580	270	40	5	240	28	300	35	ND	—	ND	—
Case B2, pretreated with 220 $mg\,L^{-1}$ utilized ozone,[4]												
775	545	230	50	6	200	26	295	38	ND	—	ND	—
Case B2, pretreated with 1,385 $mg\,L^{-1}$ utilized ozone,[4]												
650	480	170	45	7	165	25	270	42	ND	—	ND	—
Case K, pretreated with H_2O_2,[3]												
710	700	10	86	12	596	84	28	4	N	—	N	—

ND: not determined, N: negligible.
*H_2O_2/COD with 500 $mg\,L^{-1}$ Fe^{3+} and a day of reaction time.

Table 6. Reuse criteria for textile dyeing wastewaters.

Parameters	Ref.[21]	Ref.[22]
pH	6.5–8.0	6.5–7.5
Total COD ($mg\,L^{-1}$)	0–160	<50
TSS ($mg\,L^{-1}$)	0–50	<500
TDS ($mg\,L^{-1}$)	100–1,000	—
Total hardness ($mg\ CaCO_3\,L^{-1}$)	0–100	90
Chloride ($mg\,L^{-1}$)	100–300	<150
Total chromium ($mg\,L^{-1}$)	—	0.1
Iron ($mg\,L^{-1}$)	0–0.3	0.1
Manganese ($mg\,L^{-1}$)	<0.05	0.05
Conductivity ($\mu S\,cm^{-1}$)	800–2,200	—
Alkalinity ($mg\,CaCO_3\,L^{-1}$)	50–200	—

doses. Fourteen percent removal of soluble fraction and 4% removal in particulate fraction are associated with $130\,mg\,L^{-1}$ of utilized ozone. The application of $1395\,mg\,L^{-1}$ of utilized ozone reduces particulate COD and soluble COD by 39% and 29%, respectively. The reductions of S_S, S_H, and S_I for utilized ozone of $130\,mg\,L^{-1}$ can be outlined as 64, 2, and 6%, respectively, whereas S_S, S_H, and S_I removals of 59, 33, and 16% are obtained for $1395\,mg\,L^{-1}$ of utilized ozone. The figures given in Table 5, indicate that the application of ozone lowers the S_S fraction, and increases the S_I fraction while maintaining the S_H fraction at the same level. As reported in Lit.[3] the wastewater of Case K is observed to be totally resistant to biological treatment. Therefore chemical oxidation with H_2O_2 is applied previous to biological treatment. The results present that approximately all particulate matter is converted to soluble form and oxidized at a great extend. Wastewater becomes fully soluble in nature, S_{H1} covers 84%, whereas S_{S1} is 12% and S_{I1} is only 4%.

WASTEWATER REUSE APPLICATIONS

The first stage in applying wastewater management that covers wastewater reuse applications for industrial wastewaters is the characterization of segregated streams. The following step is the comparative evaluation of segregated stream characterization with the required reuse criteria. Unfortunately no clearly defined reuse criteria for textile industry is reported in literature as shown in Table 6. Therefore reuse water quality requirements must be identified by considering also the specific demands of the manufacturer. Streams that can comply the reuse requirements directly or after passing through a proper treatment can be defined as potentially reusable portions. The remaining wastewaters after segregating the recovered portion are likely to represent a stronger characteristic containing higher levels of residues.

Evaluation of the data given in Table 7 shows that the application of reuse for Cases B2 and B4 minimizes the fresh water demand by 52 and 22%,

Table 7. Characterization of segregated streams for reuse application.

	Case B2		Case B4	
Parameter	Raw reusable wastewater	Raw remaining wastewater	Raw reusable wastewater	Raw remaining wastewater
Total COD ($mg\,L^{-1}$)	315	1,220	350	1,475
Soluble COD ($mg\,L^{-1}$)	190	850	200	1,215
Color (Pt-Co)	30	770	25	990
TSS ($mg\,L^{-1}$)	60	125	80	115
VSS ($mg\,L^{-1}$)	60	95	80	94
Cl^- ($mg\,L^{-1}$)	275	2,530	320	5,210
TDS ($g\,L^{-1}$)	1.18	ND	1.1	12.5
pH	7.4	9.7	5.2	10.6
Flowrate (%)	52	48	22	78
Reference	[4]		[6]	

ND: not determined.

Table 8. Ozonation of reusable streams.

	Case B2			Case B4
Initial COD ($mg\,L^{-1}$)	315	315	315	350
Utilized ozone ($mg\,L^{-1}$)	145	440	1,350	83
Characterization after ozonation				
Total COD ($mg\,L^{-1}$)	210	205	190	250
Soluble COD ($mg\,L^{-1}$)	205	195	185	ND
Color (Pt-Co)	5	5	5	≈0
TSS ($mg\,L^{-1}$)	<10	<10	<10	ND
TDS ($g\,L^{-1}$)	1.29	1.23	1.18	1.2
Cl^- ($mg\,L^{-1}$)	275	275	270	ND
pH	7.9	7.9	7.9	7.5
Reference	[4]			[6]

ND: not determined.

while increasing all the pollutant levels (e.g., 28 and 25% increase in total COD, respectively).

Ozonation studies are performed on potentially reusable streams for Cases B2 and B4. Results tabulated in Table 8 show that only approximately 30% COD removal is achieved and a colorless reuse stream is obtained with 83 $mg\,L^{-1}$ utilized ozone dose for Case B4.

Experiments on Case B2 show that even with a high utilized ozone dose, it is not possible to reduce the COD level under 190 $mg\,L^{-1}$. The remaining wastewaters are expected to reflect a stronger characteristic. However, biodegradability of the remaining wastewaters is one of the key factors in evaluating the feasibility of a reuse application. In this context, Table 9 presents the COD fractionation of the remaining wastewaters for Cases B2 and B4. Practically the segregation of the

Table 9. COD fractionation of remaining textile wastewaters.

C_{T1} (mg L^{-1})	S_{T1} (mg L^{-1})	X_{T1} (mg L^{-1})	S_{S1} (mg L^{-1})	S_{S1}/C_{T1} (%)	S_{H1} (mg L^{-1})	S_{H1}/C_{T1} (%)	S_{I1} (mg L^{-1})	S_{I1}/C_{T1} (%)	X_{S1} (mg L^{-1})	X_{S1}/C_{T1} (%)	X_{I1} (mg L^{-1})	X_{I1}/C_{T1} (%)
Case B2, untreated remaining wastewater,[4]												
1220	850	370	65	5	410	34	365	30	ND	—	ND	—
Case B4, untreated remaining wastewater,[6]												
1475	1215	260	132	9	776	53	307	21	182	12	78	5

ND: not determined.

reusable portion has no effect on the COD fractionation of Case B4, although a stronger wastewater is obtained. On the other hand, reuse application results in higher soluble inert COD levels for Case B2 that leads difficulties in fulfilling the discharge limitations.

CONCLUSIONS

The significant points derived from this study can be outlined as follows:

(i) The textile plants cannot be easily grouped in terms of their wastewater characterization and treatability; each textile finishing industry must be evaluated as a separate case.
(ii) Specific attention should be devoted to reuse application for minimizing the fresh water demand in textile finishing industries. The most important issue in such applications is the stream segregation.
(iii) Stream segregation for reuse is observed to generate a stronger wastewater which in turn increases the cost of treatment. Therefore feasibility of reuse application should be investigated by considering treatment costs vs. savings on fresh water demand.

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