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Analyses and Treatment of Textile Effluents

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ABSTRACT

The present study was carried out to determine the degree of pollution of textile wastewater and ability of $FeCl_3$ as coagulating agent for its treatment. The wastewater samples were collected from ten different textile industries from city zone of Faisalabad (Pakistan). These samples were analyzed for the parameters like pH, turbidity, EC, TSS, TDS, COD, hardness, chlorides, SO_4^{-2} by standard methods before and after treatment. It was observed that $FeCl_3$ acts as a good coagulating agent for the treatment of textile effluents. The pH, turbidity, EC, TSS, TDS, COD, hardness, chlorides and SO_4^{-2} values of effluents were found to decrease up to level of 0.0 - 30.74, 38.88 - 59.45, 39.50 - 57.86, 63.1 - 82.51, 64.83 - 87.10, 43.87 - 77.68, 33.33 - 73.88, 45.59 - 59.82 and 48.38 - 64.58%, respectively after treatment. It was concluded that the industrial effluents should be treated before to be drained into the natural water bodies so that it may not cause water and soil pollution and $FeCl_3$ might be used for wastewater treatment on industrial scale.

Key Words: Textile effluents; Coagulating agent; Water hardness; Wastewater treatment

INTRODUCTION

Textile industries play very important role in degrading the water quality by releasing their effluents in river, lakes and oceans that harming our planet to the point, where organisms are dying at a very frightening rate (Hanif *et al.,* 2005). Sulphate content of industrial effluents is always high and it should never be discharged into a stream or a point from where water is supplied for drinking as higher concentration of SO_4^{-2} in drinking water cause cathartic action (Agarwal, 1996). In wastewater, chloride content can serve as a pollution indicator when considered together with other parameters and high chloride content in water may harm metallic pipes as well as agriculture crops (Kumar, 1989; Lalove *et al.,* 2000). The quality of water can be assessed by chemical analyses using the parameters like conductivity, alkalinity, hardness, SO_4^{-2}, pH, total dissolved solids, chlorides as well as dissolved oxygen (Makia *et al.,* 1999).

The present study was designed to assess the quality of textile wastewater and its treatment by using $FeCl_3$ as coagulating agent.

MATERIALS AND METHODS

Collection of samples. Wastewater samples were collected from industrial outfalls of various textile units from city zone of Faisalabad, Pakistan in plastic bottles and transferred to laboratory for analysis and treatment.

Analysis of samples. The collected samples were analyzed for the parameters like pH, turbidity, EC, TSS, TDS and COD by using standard methods (Arnold *et al.,* 1992). Hardness of water samples was estimated by EDTA titrametic method (Arnold *et al*., 1992). Chlorides and Sulphates were determined by Argentometric and Volumetric methods, respectively (Rump & Krist, 1992).

Treatment of samples. Textile wastewater samples were treated with commercially available $FeCl_3$ flocculent/coagulant, provided by Sitara Chemical industries Pvt. Ltd. Faisalabad, Pakistan. 100 mL textile wastewater sample was taken in a beaker and 2 mL of $FeCl_3$ was added. Treatment scheme consisted of three sequential stages, i.e., rapid mixing, slow mixing and sedimentation. The wastewater and coagulant was stirred at 100 rpm for 2 min for rapid mixing, followed by slow mixing at 20 rpm for 15 min by magnetic stirrer and finally the flocks were allowed to settle for 30 min without any agitation and then filtered the solution as discussed earlier (Arnold *et al*., 1992).

RESULTS AND DISCUSSION

The wastewater samples were analyzed for the above-mentioned parameters. These wastewater samples were treated with ferric chloride and then again analyzed for the same parameters as mentioned in the Tables I - IX. The results indicated that the concentration of all the parameters decreased to a significant ($P < 0.05$) level.

Table I indicates that pH of textile effluents was in the range of 5.79 - 12.88. It is obvious from the results that most of the samples were highly alkaline and above the permissible limits of Environmental Protection Agency (EPA). After treatment with $FeCl_3$, the pH of samples was found to decrease ($P < 0.05$) up to level of 13.0 - 30.74%

but the pH of sample no 7 remained un-changed even after treatment. Benerji (1993) reported that pH is one of the most important operational water quality parameters. The careful attention should be given to pH control at all the stages of water treatment to ensure the satisfactory water classification and disinfections.

The electrical conductivity (EC) of textile wastewater samples before and after treatment is given in Table II. Before treatment, it ranged between 5.24×10^3 - $33.5 \times 10^3 \mu$ Siemen/cm, which is very high than the permissible limits (1000μ Siemen/cm) (EPA standard), which indicates the highest degree of pollution. After treatment, the EC of samples was found to decrease ($P < 0.05$) up to 41.06 - 57.86%. The maximum decrease in EC was observed in sample no 1 and 2 and least in that of sample no 6. The EC is total parameter for dissociated and dissolved substances and depends upon concentration and degree of dissociation of ions as well as the temperature and migration of ions in the electric field but does not give idea about type of ions present (Rump & Krist, 1992).

The turbidity of textile wastewater was found to be in the range of 61 - 87 and 27 - 46 NTU before and after treatment, respectively (Table III). The turbidity of sample no 8 was found to be minimum and that of sample no 5 maximum. Overall the treatment of $FeCl_3$ decreased ($P < 0.05$) the turbidity of textile wastewater up to level of 38.88 - 59.45%. Abdessemed *et al.* (2002) reported similar findings by treating wastewater samples with $FeCl_3$. Pure water is transparent in nature. As the concentration of different ions, dyes and other polluting agents increases, water becomes more turbid and polluted. So turbidity is a good parameter to measure the degree of pollution of water.

The amount of total suspended solid in different textile wastewater samples was found to be in the range of 1020 - 3680 mg L^{-1} (Table IV). The highest level of TSS was found in sample no 8 and that of minimum in sample no 4, which reflects the highest degree of pollution. After treatment, the decrease in TSS level was found to be in the range of 63.12 - 82.51%. The range of TSS before treatment (1020 - 3680 mg L^{-1}) was significantly ($P < 0.05$) higher than the permissible limit of TSS (150 mg L^{-1}) (EPA standard) in wastewater.

The amount of total dissolved solid in different textile wastewater samples was found to be in the range of 1260 - 3810 mg L^{-1} (Table V). The highest level of TDS was found in sample no 9 and that of minimum in sample no 2, which reflects the highest degree of pollution. After treatment, the decrease in TDS level was found to be in the range of 64.83 - 87.10%. The range of TDS before treatment (1260 - 3810 mg L^{-1}) was found to be lower ($P < 0.05$) than the permissible limit of TDS (3500 mg L^{-1}) (EPA standard) in wastewater. The dissolved solids in wastewater give an idea about pollution strength. The high concentration of TDS may impart taste or odours. Dissolved solid in wastewater destined for agriculture purposes might be as high as 2000 mg L^{-1}, but not more than this limit (Kumar, 1989).

Table I. pH of textile wastewater samples before and after treatment

Sample #	pH before treatment	pH after treatment	Decrease in pH (%)
1	08.25 ± 0.41	6.30 ± 0.32	23.63 ± 1.15
2	10.26 ± 0.51	8.40 ± 0.45	18.12 ± 1.03
3	11.22 ± 0.50	9.26 ± 0.39	17.50 ± 1.10
4	12.88 ± 0.61	8.92 ± 0.47	30.74 ± 1.82
5	09.57 ± 0.26	7.90 ± 0.28	17.45 ± 1.21
6	10.45 ± 0.53	9.02 ± 0.37	13.68 ± 0.67
7	05.79 ± 0.17	5.79 ± 0.13	00.00 ± 0.00
8	07.46 ± 0.23	5.82 ± 0.16	21.99 ± 1.23
9	07.23 ± 0.29	6.29 ± 0.21	13.00 ± 0.70
10	08.79 ± 0.38	6.68 ± 0.20	24.00 ± 0.72

Values (mean ± SD) are average of duplicate samples analyzed in triplicate ($P < 0.05$)

Table II. Electrical conductivity (siemens/cm) of textile wastewater samples before and after treatment with $FeCl_3$

Sample #	Electrical conductivity before treatment	Electrical conductivity after treatment	Decrease in electrical conductivity (%)
1	$7.69 \times 10^3 \pm 0.03 \times 10^3$	$3.24 \times 10^3 \pm 0.01 \times 10^3$	57.86 ± 2.61
2	$6.90 \times 10^3 \pm 0.04 \times 10^3$	$2.92 \times 10^3 \pm 0.01 \times 10^3$	57.86 ± 2.60
3	$6.58 \times 10^3 \pm 0.02 \times 10^3$	$3.47 \times 10^3 \pm 0.01 \times 10^3$	47.26 ± 2.12
4	$9.80 \times 10^3 \pm 0.05 \times 10^3$	$4.52 \times 10^3 \pm 0.02 \times 10^3$	53.87 ± 2.42
5	$8.11 \times 10^3 \pm 0.04 \times 10^3$	$4.78 \times 10^3 \pm 0.01 \times 10^3$	41.06 ± 1.84
6	$5.24 \times 10^3 \pm 0.02 \times 10^3$	$3.17 \times 10^3 \pm 0.01 \times 10^3$	39.50 ± 1.77
7	$10.73 \times 10^3 \pm 0.06 \times 10^3$	$5.60 \times 10^3 \pm 0.02 \times 10^3$	47.80 ± 2.50
8	$7.01 \times 10^3 \pm 0.04 \times 10^3$	$4.00 \times 10^3 \pm 0.02 \times 10^3$	42.93 ± 1.93
9	$33.5 \times 10^3 \pm 0.09 \times 10^3$	$18.02 \times 10^3 \pm 0.04 \times 10^3$	46.20 ± 2.00
10	$5.49 \times 10^3 \pm 0.02 \times 10^3$	$3.04 \times 10^3 \pm 0.01 \times 10^3$	44.62 ± 2.01

Values (mean ± SD) are average of duplicate samples analyzed in triplicate ($P < 0.05$)

Table III. Turbidity (NTU) of textile wastewater samples before and after treatment with $FeCl_3$

Sample#	Turbidity before treatment	Turbidity after treatment	Decrease in turbidity (%)
1	74 ± 4.44	30 ± 1.21	59.45 ± 2.95
2	68 ± 3.89	29 ± 1.32	57.35 ± 3.10
3	72 ± 4.37	34 ± 1.40	52.77 ± 2.80
4	80 ± 3.99	36 ± 1.31	55.00 ± 3.42
5	87 ± 4.21	46 ± 1.27	47.12 ± 3.11
6	67 ± 3.37	41 ± 1.39	38.88 ± 3.21
7	63 ± 3.21	27 ± 1.26	57.14 ± 3.41
8	61 ± 3.35	33 ± 1.38	45.90 ± 3.35
9	85 ± 3.47	36 ± 1.43	57.64 ± 2.91
10	75 ± 4.85	31 ± 1.36	58.66 ± 2.67

Values (mean ± SD) are average of duplicate samples analyzed in triplicate ($P < 0.05$)

The total hardness in different textile wastewater samples was found to be in the range of 450 - 1330 mg L^{-1} (Table VI). The highest level of hardness was observed in sample no 8 and that of minimum in sample no 6, which reflects the highest degree of pollution. After treatment, the hardness was found to be reduced ($P < 0.05$) up to level of

Table IV. Total suspended solids (mg/L) of textile wastewater samples before and after treatment with $FeCl_3$

Sample #	Total suspended solids before treatment (mg/L)	Total suspended solids after treatment (mg/L)	Decrease in TSS (%)
1	2800 ± 4.44	600 ± 30.1	78.52 ± 3.92
2	1600 ± 3.89	590 ± 33.0	63.12 ± 3.51
3	3260 ± 4.29	570 ± 29.1	82.51 ± 3.72
4	1020 ± 3.99	256 ± 12.8	74.90 ± 3.81
5	2400 ± 4.21	560 ± 31.2	76.60 ± 3.09
6	1800 ± 3.37	590 ± 35.1	67.22 ± 3.21
7	2400 ± 3.23	715 ± 41.4	70.20 ± 3.32
8	3680 ± 3.35	837 ± 53.2	77.25 ± 3.97
9	3402 ± 3.45	690 ± 49.5	79.71 ± 3.66
10	2237 ± 4.85	560 ± 27.2	74.96 ± 3.62

Values (mean ± SD) are average of duplicate samples analyzed in triplicate ($P < 0.05$)

Table V. Total dissolved solids (mg/L) of textile wastewater samples before and after treatment with $FeCl_3$

Sample #	Total dissolved solids before treatment (mg/L)	Total dissolved solids after treatment (mg/L)	Decrease in TDS (%)
1	2330 ± 93.2	450 ± 18.1	80.68 ± 4.02
2	1260 ± 50.4	270 ± 13.5	78.57 ± 4.71
3	1300 ± 65.1	205 ± 12.3	84.23 ± 5.05
4	1820 ± 91.7	640 ± 32.1	64.83 ± 3.88
5	2600 ± 98.9	540 ± 27.6	79.23 ± 3.16
6	2400 ± 99.1	309 ± 15.4	87.10 ± 4.35
7	1912 ± 92.3	500 ± 30.2	73.68 ± 2.94
8	2802 ± 108	665 ± 33.2	76.26 ± 3.81
9	3810 ± 223	790 ± 47.4	74.59 ± 2.98
10	3605 ± 191	910 ± 45.5	74.75 ± 3.73

Values (mean ± SD) are average of duplicate samples analyzed in triplicate ($P < 0.05$)

Table VI. Hardness (mg/L) of textile wastewater samples before and after treatment with $FeCl_3$

Sample #	Hardness before treatment (mg/L)	Hardness after treatment (mg/L)	Decrease in Hardness (%)
1	640 ± 82.2	305 ± 15.4	52.34 ± 3.14
2	510 ± 30.4	340 ± 13.6	33.33 ± 1.99
3	840 ± 42.6	415 ± 20.7	50.59 ± 2.52
4	635 ± 31.7	325 ± 13.6	48.81 ± 2.44
5	520 ± 20.1	216 ± 12.9	58.46 ± 3.50
6	450 ± 18.6	155 ± 9.30	65.55 ± 3.93
7	980 ± 49.5	402 ± 24.1	58.97 ± 3.53
8	1330 ± 79.4	426 ± 17.4	67.96 ± 3.39
9	1080 ± 54.7	282 ± 14.5	73.88 ± 3.69
10	692 ± 34.2	182 ± 10.9	73.69 ± 4.42

Values (mean ± SD) are average of duplicate samples analyzed in triplicate ($P < 0.05$)

33.33 - 73.88%. The degree of water pollution was found to be higher than the permissible limit (250 mg L^{-1}). The hardness in textile effluents is due to the presence of divalent metallic cat ions like Ca^{+2}, Mg^{+2}, Sr^{+2} and Fe^{+2} (Abbasi, 1998).

Table VII. Chemical Oxygen Demand (mg/L) of textile wastewater samples before and after treatment

Sample #	COD before treatment (mg/L)	COD after treatment (mg/L)	Decrease in COD (%)
1	650 ± 32.5	330 ± 19.8	49.23 ± 2.46
2	490 ± 24.6	275 ± 16.5	43.87 ± 1.75
3	840 ± 50.3	410 ± 24.6	51.19 ± 3.07
4	506 ± 30.2	215 ± 10.7	57.50 ± 2.30
5	650 ± 26.4	318 ± 12.6	51.07 ± 3.06
6	400 ± 20.1	140 ± 8.40	65.00 ± 3.25
7	920 ± 46.3	270 ± 16.3	70.65 ± 3.53
8	1210 ± 60.5	528 ± 31.5	77.68 ± 3.88
9	880 ± 35.2	412 ± 24.8	53.18 ± 2.65
10	590 ± 23.5	221 ± 8.84	62.54 ± 2.50

Values (mean ± SD) are average of duplicate samples analyzed in triplicate ($P < 0.05$)

Table VIII. Chlorides (mg/L) of textile waster water samples before and after treatment with $Fecl_3$

Sample #	Chlorides before treatment (mg/L)	Chlorides after treatment (mg/L)	Decrease in Chlorides (%)
1	1344 ± 62.2	540 ± 27.1	59.82 ± 2.99
2	1980 ± 99.1	900 ± 45.2	54.54 ± 3.27
3	1662 ± 83.1	755 ± 30.1	54.57 ± 2.67
4	1720 ± 86.2	800 ± 48.4	53.48 ± 3.29
5	2010 ± 99.5	905 ± 45.2	54.97 ± 3.43
6	2200 ± 99.9	940 ± 47.4	57.27 ± 2.32
7	1240 ± 62.5	520 ± 26.3	58.06 ± 3.04
8	1805 ± 98.7	890 ± 35.6	50.69 ± 2.97
9	2460 ± 99.6	1240 ± 49.7	49.59 ± 2.27
10	1500 ± 90.1	755 ± 37.4	49.66 ± 2.48

Values (mean ± SD) are average of duplicate samples analyzed in triplicate ($P < 0.05$)

Table IX. Sulfates (mg/L) of textile wastewater samples before and after treatment with $FeCle_3$

Sample #	Sulfates before treatment (mg/L)	Sulfates after treatment (mg/L)	Decrease in Sulfates (%)
1	650 ± 37.2	327 ± 15.3	49.69 ± 2.48
2	682 ± 39.1	352 ± 14.2	48.38 ± 2.41
3	735 ± 29.4	302 ± 15.2	58.91 ± 2.35
4	596 ± 26.7	262 ± 10.4	56.04 ± 3.36
5	802 ± 28.1	380 ± 13.8	52.61 ± 2.63
6	930 ± 35.8	405 ± 17.6	56.45 ± 3.39
7	710 ± 37.1	290 ± 15.4	58.33 ± 2.91
8	835 ± 32.9	325 ± 13.5	61.07 ± 3.66
9	1040 ± 40.5	427 ± 10.2	58.94 ± 2.35
10	480 ± 21.6	170 ± 5.02	64.58 ± 2.58

Values (mean ± SD) are average of duplicate samples analyzed in triplicate ($P < 0.05$)

The total COD in different textile wastewater samples was found to be in the range of 400 - 1210 mg L^{-1} (Table VII). The highest level of COD was observed in sample no 8 and that of minimum in sample no 6, which reflects the highest degree of pollution. After treatment, the COD was found to be decreased ($P < 0.05$) up to level of 43.87 - 77.68%. The degree of water pollution was found to be higher than the permissible limit (150 mg L^{-1}). COD is a measure of all organic matter in the sample including biodegradable fraction as well as the fraction that survive bacterial attack but is oxidizable by strong chemical oxidants (Abbasi, 1998; Tan *et al.*, 2000; Chiron *et al.*, 2000).

The data in Table VIII indicates that chloride contents of textile effluents were found to be in the range of 1240 - 2460 mg L^{-1} reflecting high degree of pollution. After treatment with $FeCl_3$, the reduction ($P < 0.05$) in chloride contents was found up to level of 49.59 - 59.82%.

The amount of sulphate ions in different textile wastewater samples was found to be in the range of 480 - 1040 mg L^{-1} (Table IX). The maximum amount of sulphate ions was found in sample no 9 and that of minimum in sample no 10. Sample no 10 was found to be lower in its sulphate ions as compared with that of permissible limit (600 ppm); whereas, all the rest of samples showed high degree of pollution in terms of sulphate ions concentration. After treatment, the decrease ($P < 0.05$) in sulphate ions concentration was found in the range of 49.69 - 64.58% that demonstrated ferric chloride treatment as an effective remedy for industrial wastewater. Agarwal (1996) reported that the industrial wastewater containing sulphate ions should not be discharged into any water body from where water is supplied for drinking, as higher concentration of sulphate ions cause cathartic action. The variation in the parameters studied among different samples is attributed to the differences in operations and the chemicals used in different industries.

It was concluded that the industrial effluents should be treated before to be drained into the natural water bodies so that it may not cause water and soil pollution and $FeCl_3$ might be used for wastewater treatment on industrial scale.

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