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Wastewater Recycling In Cotton Textile Wet Processing: An Experimental Study

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Abstract

Textile industry is water intensive industry. Mostly textile wet processing industry use more water for their production. Water is expensive to buy, treat & dispose and as it is becoming a scarce commodity, sustainable developments of the textile industry needs recycling of waste water generated and conservation of water to reduce the water requirements and also dependency on other water sources. As the cost of water supplied to industry keeps increasing, recycling becomes more important. Many textile industries in water scarce areas are installing water recycle plants. Municipal wastewater after treatment is disposed to environment. This abundant water is wasted which can be recycled in to the industry with required amount of treatment. This research paper comprises of experimental analysis of recycling municipal treated wastewater for cotton textile wet processing after a necessary treatment.

Key words: Wastewater recycling, Pilot treatment plant, Whiteness index, k/s value, rubbing index, cost-benefit analysis

Introduction

Last few years inadequate water supply is becoming hurdle in the progress, modernization and diversification of textile industry. Textile industries in are having water sources as ground water source, municipal water and water supplied by private water tankers. Day by day these industries are facing water scarcity problems severely. This water scarcity is becoming more severe because of increased exploitation of ground water, increasing urbanization and civilization. To fulfill the increasing water demand of textile processing units, treated Municipal wastewater can be recycled to utilize it in textile processing units. At present this thousands of liters of treated municipal wastewater is disposed on land and river which can be reutilized with techno-economical treatment.

Conceptual Framework of Wastewater Recycling

In the conceptual framework of wastewater recycling considered here, nearest textile industrial estate can directly use this water with recycling concept as shown in Fig 1. The retreated water can be recycled in to various textile industries in two ways. First option is to provide this all treated water to nearest textile industrial estate. The treated water from recycling plant will be collected in receiving chamber or collection sump. From collection sump it can be supplied to various industries. Water used by this industry is treated in their common effluent treatment plant (CETP) and return the water to wastewater treatment plant (WWTP) as shown option 1 in the Fig 1. Another way is that the water used by textile industry after necessary treatment can be directly returned to wastewater recycling plant as shown in option 2.

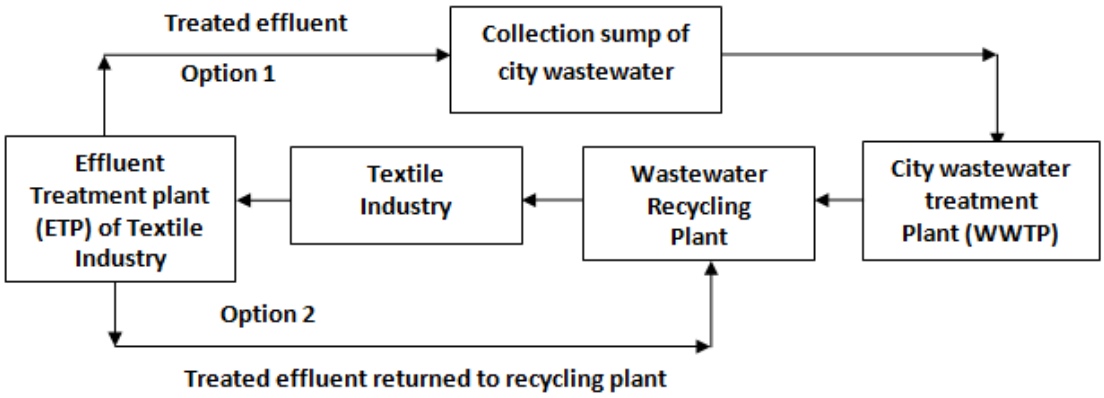

Fig 1 Conceptual framework of wastewater recycling

Pilot treatment plant

Experimental setup of laboratory Scale Pilot Treatment Plant is shown in Fig 2. Pilot treatment plant comprises various treatment processes and units as under-

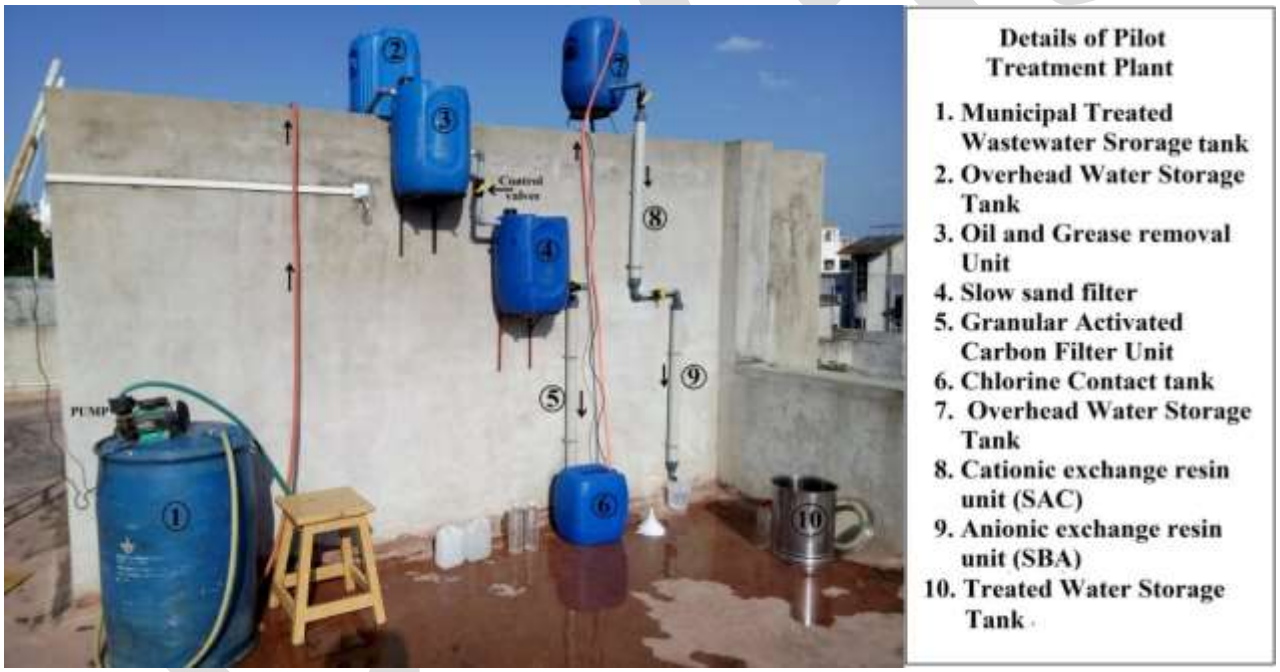

Fig 2 View of Pilot Treatment Plant

1. Municipal treated water storage tank: To store the treated wastewater for further treatments. Also acts as a sedimentation tank.
2. Oil & Grease removal unit: Oil & Grease can be removed with this unit.
3. Slow Sand filter (SSF): Slow sand filter is provided with various layers of sand of different particle size.
4. Granular Activated Carbon filter (GAC): Through this the color and odor from the wastewater is removed.
5. Chlorination unit: This is carried out to disinfect the treated wastewater. For this sodium hypochlorite solution (22 gpl) with various dosages was used.
6. Cationic Exchange Resin (SAC): Here cations like Na^{+}, Mg^{++}, Ca^{++} etc. was exchanged with H+ ions. The cationic exchange resin used was strong acid type

7. Anionic Exchange Resin (SBA): Here anions like $S04^{--}$, $CO3^{--}$, Cl^{-} etc. was exchanged with OH^{-} ions. The anionic exchange rein used was strong base type. It is a strong base anion exchange resin based on polystyrene matrix, containing quaternary Ammonium group.

Experimental analysis

Laboratory analysis has been carried out on the effluent from wastewater treatment plant. The same effluent has been taken to the laboratory scale pilot treatment plant which comprises various treatment processes and units includes slow sand filter (SSF), Granular Activated Carbon (GAC) treatment, Ion exchange processes using cationic exchange resin (SAC), Anionic exchange resin unit (SBA). Detailed laboratory investigation of influent and effluent of pilot plant water is carried out. Results are compared with Indian Standard specifications for water to be used in textile wet processing.

Textile processing units are using municipal tap water or groundwater in processing of fabric. Comparative analysis has been carried out for treated water from pilot plant, tap water and groundwater in processing of cotton fabric. Use of treated water from the pilot plant in textile processing along with various dyes has been analyzed through various laboratory tests. Cotton fabric samples are bleached with groundwater, tap water and pilot plant water. These bleached fabric samples are checked for whiteness index. Detailed experimental analysis has been carried out for testing and analysis of wastewater using pilot treatment plant, including the statistical analysis by 'T-test: Paired Two Sample for Means'.

Properties of cotton fabric processed by using all three types of water as mentioned above has been checked for dying, desizing, scouring and bleaching comprises detailed investigation of K/S values of fabric dyed and whiteness index for bleached fabrics with washing and rubbing fastness investigations of fabric samples by ISO and AATCC method. The results obtained are processed by statistical tools for acceptance or rejections of the values has been carried out by 'Anova: Two-Factor without Replication' method.

On acceptance of the type of water used for process by the statistical as well as quality test, the cost benefit analysis has been carried out and the suitability of the type of water has been finalized.

Results

Recycling of Wastewater in Textile Wet Processing

1. Table 1 shows range of values obtained at outlet of pilot treatment plant. It also shows percentage removal of each parameter and corresponding I.S. standard.

Table 1 Pilot plant water outlet values and I.S. limits for water for Textile Industry

S. N.	Parameters	Range of Inlet values	Range of outlet Values	Average % removal	I.S. Limit for textile (IS 201:1992)
1.	Total Dissolved Solids mg/l	791 to 998	402 to 457	53.91	< 500
2.	Total Hardness mg/l	223 to 270	15 to 31	90.75	< 50 *
3.	Oil and Grease mg/l	73 to 92	0	100	< 1
4.	P^{H}	7.05 to 7.14	7.03 to 7.09	1.24	6.0 to 8.5*
5.	Chlorides mg/l	55 to 78	41 to 59	27.20	< 100*
6.	Nitrates mg/l	0.0124 to 0.027	0.0111 to 0.0154	21.26	< 0.50
7.	Sulphates mg/l	73 to 91	49 to 62	30.58	< 100*

9.	Alkalinity mg/l	153 to 233	123 to 145	30.43	< 150*
12.	Chlorine mg/l	0.1	0.1	00	0.1 to 0.2
13.	Suspended solids mg/l	56 to 123	0	100	< 5
14.	Electrical conductivity	0.73 to 1.01	0.46 to 0.74	30.47	-
15.	Colour	Yellowish	Colourless	100	20 HazenUnits
16.	Odour	Pungent	Odourless	100	-
17.	MPN (/100 ml.)	82 to 126	0	100	-
18.	COD mg/l	56 to 89	12 to 25	74.87	< 50

From the Table it is clear that outlet values of pilot plant water are not violating I.S. standard 201:1992 for water to be used in textile industry. This shows that pilot plant water is suitable for cotton textile wet processing.

2. Treated water from pilot treatment plant was checked for its suitability for the usage in textile wet processing. Comparison between three types of water sample is done for more precision. For analysis Groundwater, Tap Water and pilot plant water were used. Results obtained from all textile related tests shows that pilot plant water is suitable for textile wet processing. Average values various water parameters of ground water, Tap water and Pilot plant water. From this table it is clear that pilot plant water is suitable for textile process usage. From the table it is clear that T.D.S. mg/l, Total Hardness mg/l, Oil and Grease mg/l, P^{H}, Chlorides mg/l, Nitrates mg/l, Sulphates mg/l, Alkalinity mg/l, Suspended Solids mg/l, E.C. (µmhos/cm), M.P.N. (/100 ml.), B.O.D. , C.O.D. and Res. Chlorine (mg/l) are less than other two types and all parameters of pilot plant water are comply with I.S. standard.

3. Whiteness Index of fabric processed with Ground water varies within 59.42 to 63.21. For Tap water it is 58.26 to 62.24 and that of for pilot plant water it varies within 59.42 to 63.21. This shows that pilot plant water gives good whiteness index compared to other two. From study in it is revealed that average whiteness index of cotton fabric bleached with Ground water is 61.832 and that of bleached with Tap Water is 60.158 and pilot plant water 59.144. It can be concluded that average whiteness index of fabric sample is 98.31% of whiteness index bleached with Tap Water which is 60.158 and 95.65% of Ground water which is 61.832. This confirms that pilot plant water gives comparatively good performance in bleaching of cotton fabric in removing impurities. This is because hardness value of pilot plant water is less than other two categories. This shows that pilot plant water is suitable for bleaching of cotton fabric in textile wet processing and with satisfactory whiteness Index.

4. K/s values of cotton fabric dyed with various dyes using Percentage shade in evaluation ranges from 0.5 % to 3.0 % with an interval of 0.5 %. From the results obtained it is clear that k/s values fabric samples dyed by using pilot plant water are more effective than other two types of water. Average dye dearth increase of 5% to 10% can be observed in case of Pilot plant water compared with other two. This ultimately results in saving in quantity of dye of the textile industry.

5. On experimental basis, nine dyes were checked for the processing purpose. These dyes are mostly used in the industry. Cold brand dyes Reactive red M8B, Procion brill Yellow-M4G, Procion blue MG MR show Good –Average rating. All fastness ratings all

samples found above 3. Similarly Hot brand dyes Reactive red HE8B, Procion yellow HE4G, and Reactive Navy blue HER Show fastness rating above 3. Remazol dyes Remazol red RB, Remazol Golden yellow RNL, and Remazol turquoise blue G show good – average performance. Pilot plant water can be utilized in textile wet processing with same quality of fabric received by utilizing fresh water as Ground water or Tap water. Washing Fastness values as per AATCC and ISO-105, rubbing fastness standards as per WET AATCC values and DRY AATCC values and Rubbing Fastness values both ISO-105 DRY and ISO-105 WET are lying between range 3-4 and gray scale standards suggest values between range 1-5.

6. Disinfection: Pilot plant water analyzed for MPN value and found 56/100 ml for first dose of 0.25 mg/l. Residual chlorine found below 0.10 mg/l. At 0.50 mg/l NaOCl dose MPN reduced to 47/100 ml with residual chlorine less than 0.10 mg/l and at 0.75 mg/l NaOCl dose MPN reduced to 12/100 ml with residual chlorine less than 0.15 mg/l. At the dose 1.00 mg/l of NaOCl, MPN value found 0/100ml and continuously observed zero with residual chlorine of 0.20 mg/l. Outlet values of plant show residual chlorine 0.1 mg/l which as per IS standard value between 0.1 to 0.2 mg/l. With proper disinfection Pilot plant water can be utilized without any harm. Additionally most of the textile processes are carried out in hot condition, which is supporting to disinfection process.

7. Cost – benefit analysis: Cost benefit analysis has shown that industry can purchase this pilot plant water at Rs. 18.95 per 1000 liter.

Table 2 Type of water and Cost/day in Rs.

S. N.	Type of water	Cost/day in Rs.	Cost / 1000 liter of water in Rs.
1.	Ground water	Rs. 450000.00	22
2.	Tap water	Rs. 396000.00	25
3.	Pilot plant water	Rs. 341079.50	18.95

From Table 2, Savings or benefit per day in comparison with other two types of waters can be calculated as

1) Ground water = Rs. 396000.00 - Rs. 341079.50 = Rs. 54920.50/day

2) Municipal tap water = Rs. 450000.00- Rs. 341079. 50 = Rs. 108920. 50/day

Conclusion

Analysis of Total Dissolved Solids, Hardness, Oil and grease, P^H, Chlorides, Alkalinity, Sulphates, Nitrates, Suspended Solids, Biochemical Oxygen Demand, Chemical Oxygen demand, Electrical conductivity, Most Probable Number shows that Pilot plant water is suitable for cotton textile wet processing. As per Quality tolerance for water for Textile Industry: Specification (IS 201:1992), specification for water usage in textile wet processing all the values obtained from Pilot Plant are within the prescribed limit.

Overall recycle and reuse by above method helps to reduce the effluent load viz-a-viz effluent treatment cost reduces substantially with saving in quantity of water.

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REFERENCES:

[1] Chae, Y. S., and Hamidi, A. (1997). Environmental Engineers Handbook, Editors-Liu, D. H. F., and Liptak, B. G., Lewis Publishers, New York, 1003-1139.

[2] Cheremisinoff, P.N. (1995). Handbook of water and wastewater treatment technology, Marcel Dekkar, USA, 583-584.

[3] Manivaskam, N. (1995). Water used in textile processing-quality, treatment and analysis, Sakthi Publications, Coimbatore, India, 61-64.

[4] Patankar S.N., (2006), National workshop on Dream of green city at Pune, India. City sewerage and solid waste management, 1-8.

[5] Smith, B., Rucker, J., Water and Textile Wet Processing-Part I, American Dyestuff Reporter, 15-23, 1987.

[6] Sonaje N.P and Chougule M.B., (2012), In-plant recycling of wastewater in textile wet processing –a stochastic analysis of best available technologies (BATS), International journal of contemporary research in India, vol. 2 : issue : 2, 26-35.

[7] Sonaje N.P and Chougule M.B., (2012), Novel techniques of water recycling in textile wetprocessing through best management practices (BMP's), International journal of Applied Science and Advance Technology, Vol. 1, 29-33.

[8] Sonaje N.P and Chougule M.B., (2012), Recycling of wastewater in textile wet processing, International journal of contemporary research in India, vol. 2 : issue : 4, 7-12.

[9] Sonaje N.P and Chougule M.B., (2012), Use of GAC technology and two stage ion exchange technique for recycling of wastewater in textile wet processing, Vol. 4 No.01, International journal of Engineering Science and Technology (IJEST), 50-55,

[10] Sonaje N.P and Chougule M.B., (2013 Experimental analysis of k/s values of cotton fabric processed with recycled wastewater, International journal of or Innovation in Engineering & Management (IJAIEM),Volume 2, Issue 8, 28-31.

[11] Sonaje N.P and Chougule M.B., (2013), , International journal of International Journal of Research in Civil Engineering, Architecture & Design Volume 1, Issue 1, 23-27

[12] Sonaje N.P and Chougule M.B., (2013), Comparison of whiteness index of cotton fabric bleached with recycled wastewater, International journal of Innovative Research in Science, Engineering and Technology, Vol. 2, Issue 8,

[13] Sonaje N.P and Chougule M.B., (2013), Cost- Benefit Analysis of Wastewater Recycling Plant for Textile Wet Processing, International journal of International Journal Of Computational Engineering Research (ijceronline.com) Vol. 3 Issue.1, 27-31.

[14] Sonaje N.P and Chougule M.B., (2013), diagnostic study of various disinfection techniques for recycled wastewater used in textile wet processing, International journal of Industrial Science Vol.1,Issue.1, 1-7.

[15] Sonaje N.P and Chougule M.B., (2013), Evaluation of the Effectiveness of Sodium Hypochlorite for Disinfection of Recycled Wastewater used in Textile Wet Processing, International journal of

[16] Sonaje N.P and Chougule M.B., (2013), Experimental analysis of Washing and Rubbing fastness of cotton fabric processed with recycled wastewater using different dyes, International journal of of Emerging Science and Engineering (IJESE), Volume-1, Issue-10, 29-37.

[17] Sonaje N.P and Chougule M.B., (2013), In-plant recycling of wastewater in textile wet processing- A stochastic analysis of best available technologies (BATs), National Conference NCETETA 2012, D.Y.P.C.O.E., Kolhapur, 577-582.

[18] Sonaje N.P and Chougule M.B., (2014), All India seminar on Innovative Approaches for Low Cost Treatments of Water and Wastewater, February 20-21, 2014, Kolhapur Organized by he Institution of Engineers (India) Kolhapur Local Centre and Department of Technology, Shivaji University, Kolhapur.

[19] Wasif, A.I., Ph.D. Thesis, "Green technology in Textile Processing", M.U.D.C.T., Mumbai (1998), 6-7.

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