International Journal of Current Engineering and Technology
E-ISSN 2277 – 4106, P-ISSN 2347 - 5161

Research Article

Experimental studies on Municipal Wastewater Recycling and Water Conservation in Cotton Textile Wet Processing

N.P. Sonaje[Á] and M.B. Chougule[Ḃ*]

[Á]Deputy Registrar, Shivaji University, Kolhapur, Maharashtra, India
[Ḃ]Textile and Engineering Institute, Ichalkaranji, Maharashtra, India, W.I.T. Solapur, Solapur University, Solapur

Accepted 25 May 2014, Available online 01 June 2014, **Vol.4, No.3 (June 2014)**

Abstract

With advances in technology, wastewater may be treated to meet the most stringent quality requirements and can be used for industries and any purposes desired. The potential uses for reclaimed water are indeed numerous and widely varied. Water recycling and reuse can enable communities to strategically link the distribution and use of locally available water resources with specific water quality and quantity goals, particularly in areas where there are concerns of water. Recycled wastewater is a reliable, valuable, drought proof source of water that must be taken into account in formulating a sustainable water policy. There is a need to encourage planned and appropriate wastewater reclamation and reuse in all countries and to establish safe reuse practice for industries. This paper focuses on use of recycling municipal treated wastewater for cotton textile wet processing after a necessary treatment and water conservation techniques in cotton textile wet processing especially in scouring and bleaching.

Keywords: *Wastewater recycling, water conservation, k/s values, whiteness index, rubbing index, disinfection..*

---

1. Introduction

There are many sources of water, the most common being:"Surface sources, such as rivers, Deep wells and shallow wells, Municipal or public water systems, Reclaimed waste streams. (Smith and Rucker, 1987)

Water is essential natural resource for sustaining life and environment, which is always thought to be available in abundance and free gift of nature (Chae and Hamidi, 1997).

Textile industries are one of the major consumers of water and disposing large volumes of effluent to the environment. The textile industry utilizes abundant water in dyeing and finishing processes. There is need to adopt economical practices for the use of water in textile industries. It has been estimated that 3.5 % of the total cost of running the industry is required for water utilization in textile industry. In India textile units are developed all over the country in the form of small industrial estates (Cheremisinoff, 1995).

Textiles are manufactured to perform a multitude of functions. They are produced to a range of specifications using a variety of fibers, resulting in a complex waste or effluent. Textile waste occurs in a variety of forms throughout production process (Sonaje and Chougule, 2012).

The surface water sources are limited and availability of water from them vary from year to year depending upon monsoon conditions. The underground water resources are also getting depleted with the increasing amount of water drawn from them every year without adequate replenishments. Therefore, the cost of water is rising steeply and the textile mills, which need a large quantity of water, have started taking measures to conserve (Wasif, 1998).

Municipal treated wastewater can be best and sure source of water for textile wet processing.

1.2 Textile wet processing and water usage

Experience has shown that the amount of water required in textile processing varies widely, even between similar wet processing at different sites. The quantities water used for various types of processes is of site-specific nature and various processing situations. Many mills have very high water costs, especially when the water is being purchased from a municipal system. These operations usually are much more conservative with water than others with less costly sources (Smith and Rucker 1987).

The quantity of water required for textile processing is large and varies from mill to mill depending on the fabrics produced and processed, the quantity and quality of the fabric, processes carried out and the sources of water. The longer the processing sequences, the higher will be the quantity of water required. Bulk of the water is utilized in washing at the end of each process. The processing of yarns also requires large volumes of water (Manivaskam, 1995).

---

*Corresponding author **M.B. Chougule** is a Research Scholar and also working as Associate Professor; Capt. **Dr. N.P. Sonaje** is working as Deputy Registrar

The water usage for different purposes in a typical cotton mill & synthetic textile processing mill is given in Table 1, (Sonaje and Chougule, 2012).

Table 1: Water usage in textile mills

Sr.No.	**Purpose**	**Percentage water use**	
		Cotton Textiles	**Synthetic Textiles**
1	Steam generation	5.3	8.2
2	Cooling water	6.4	-
3	Deminerelized water	7.8	30.6
4	Process water (Raw water)	12.3	28.3
5	Sanitary use	7.6	4.9
6	Miscellaneous and Fire fighting	0.6	28.0

1.3 Water recycling in textile wet processing

The textile industry consumes a lot of water, energy and chemicals for the production of textile products, and discharges a significant wastewater, high in volume and in most pollution parameters. Due to increasing water scarcity and costs, there is a need for water savings, reclamation and re-use, and closed water loops in the textile industry. A system analysis in textile processing can help to identify relevant textile processes and water streams with a potential for both direct re-use of waste water and efficient water recycling with membrane technology. Moreover, such an analysis can give the background for a quantification of the potential for water savings and the required investment (Sonaje and Chougule, 2012).

The optimisation of textile processes is of significance for economical use and re-use of water, since an optimised process will produce less waste water and hence reduce costs for recycling of waste water. The direct re-use of waste water in textile industry is possible and very cost-effective, but is mostly restricted to low contaminated textile effluents. Low contaminated waste water is mostly used in rinsing and washing processes of highly contaminated textile products. Recycling of waste water with membrane technology is recognized as a powerful tool for producing clean process water, which can be re-used in textile processing without limitation (Schneider, 2006).

1.4 Wastewater generation in India

Treated municipal water can be recycled into textile wet processing with modern treatment technologies. This will huge amount of water and will overcome the water scarcity problems in textile industries (Sonaje and Chougule, 2012).

As per 2001 census India's population was 1027 million out of which 285 million (27.8%) lived in 5161 towns. Out of this urban population, 37% lived in 35 metropolitan cities and at the rate about 2.3% population growth in urban areas per year, it is expected that 549 million (41%) will be living in urban areas by 2021. Considering intermittent water supply for two to six hours, the urban population having access to the water supply worked out 89% and sewerage and sanitation, 63%. This doesn't indicate the quality of water supply as well as adequate provision for sanitation if compared with required standards. The water pollution is closely connected to the generation of sewage and solid waste.

The rapid growth in population and particularly in urbanization has resulted in sharp increase in generation of these two wastes. In India alone 19000 million litres of sewage is generated every day of which more than 25% is attributed to class I cities. Out of this quantity of sewage 13000 million litres per day (MLD) is collected out of which at the most half is treated to some extent. Table 2 shows values of volume of wastewater generation, collection and treatment. In terms of nutrients and water availability, economic value of this quantity of domestic sewage has been estimated as Rs. One crore per day. As regards industrial wastewater generation, the same is estimated 10000 MLD, 40% is from small scale industries (Patankar, 2006).

2. Materials and Methods

Pilot treatment plant was prepared and treatment was given to treated municipal wastewater. Units in recycling plant comprises Municipal treated water storage tank, Oil & Grease removal unit, Slow Sand filter (SSF), Granular Activated Carbon filter (GAC), Chlorination unit Cationic Exchange Resin (SAC) and Anionic Exchange Resin (SBA).

Treated wastewater from WWTP of Ichalkaranji city of Maharashtra state was used for experimentation (Sonaje and Chougule, 2013).

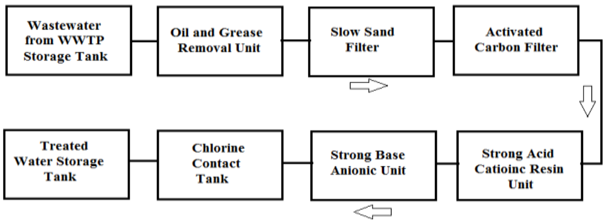

Figure 1: Pilot Treatment Plant

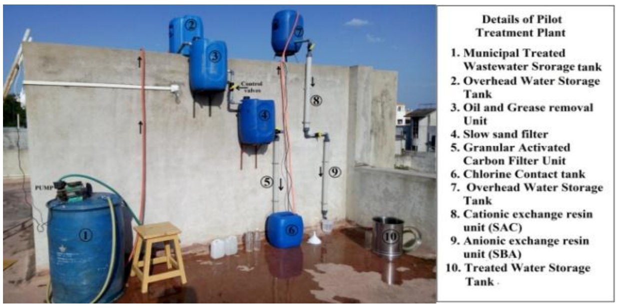

Figure 2: Photograph of Pilot Treatment Plant

2.1 Details of Pilot treatment plant

1. Municipal treated waste 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 sewage. 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. It is a premium quality strong acid cation exchange resin containing nuclear sulphonic acid groups having high exchange capacity, combined with excellent physical and chemical stability and operating characteristics. It is ideally suited for use in a wide range of pH and temperature conditions. It is supplied in hydrogen form for two stages and mixed bed demineralization and in sodium form for softening. It is also used for de-alkalization and chemical processing.

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. It has excellent chemical and operating characteristics along with excellent physical properties due to its crack-free nature. It has a good operating capacity for weak acids like silicic and carbonic along with strong mineral acids, when used in water treatment along with strong acid cation exchange resin. It is ideally suited for use in a wide range of pH and temperatures. It is supplied as moist spherical bead in the chloride form with a particle size distribution to provide good kinetics and minimum pressure drop. Figure 2.1 shows Pilot treatment plant.

Testing and analysis of wastewater treated by pilot treatment plant

Experimentation was carried out for total 12 days. First 4 days plant was utilized only to pass the waste water through the pilot treatment plant.Then different parameters were observed for next 8 days continuously. (Sonaje and Chougule, 2013)

Analysis of Total Dissolved Solids (T.D.S.), Hardness, Oil and grease, P^H, Chlorides, Alkalinity, Sulphates, Nitrates, Suspended Solids (S.S.), Biochemical Oxygen Demand (B.O.D.), Chemical Oxygen demand (C.O.D.), Electrical conductivity (E.C.), Most Probable Number (M.P.N.) and other important parameters is carried out.

2.3 Benefits of recycled wastewater

Recycled wastewater is having many benefits. This benefit analysis can be carried out as economical benefits and societal benefits (Sonaje and Chougule, 2013).

1. Quality of fabric will enhanced with recycled water .At present textile industries are purchasing water of TDS 900 to 1200 mg/l which leads fabric production with less quality.
2. Textile industry facing strong water crisis. These industries are purchasing water at higher cost. Such water recycling projects may give economical solution to the industries.
3. Disposing wastewater on land or any water body may cause harmful environmental effects. The treated wastewater which would have been wasted can be utilized with effective and economical technology.
4. Improvement in fabric rewashing system so that there is economy in water usage in textile industry.
5. There is dye saving in wet processing which is additional benefit to industry.
6. K/s values of dyed fabric found significantly improved.
7. Washing and rubbing fatness of fabric observed with both ISO-105 and AATCC methods are satisfactory.

2.4 K/S Values of Fabric Dyed with various types of Water

Testing and analysis of cotton fabric is carried out after processing with- **(1) Sample A-**Treated water from pilot treatment plant **(2) Sample B-**Municipal Tap water **(3) Sample C-**Ground water or Bore water (Sonaje and Chougule, 2013).

Cotton fabric was used for processing. In experiment cold brand, Hot brand and Remazol dyes were used for analysis. Fabric sample was processed with Treated water from pilot treatment plant, Municipal Tap Water and Ground water or Bore water. Percentage shade in evaluation ranges from 0.5 % to 3.0 % with an interval of 0.5 %.

Dye Category: Cold Brand type of Dye: Reactive Red M8B

Table2: K/s values of cold brand reactive dyes

Sr. No.	% Shade	Fabric Sample		
		A	B	C
1	0.5	11.1308	11.5326	10.5847
2	1.0	16.1548	15.4554	14.5782
3	1.5	22.6528	21.5648	20.2458
4	2.0	24.2358	23.5487	22.1145
5	2.5	28.2546	27.2568	27.4455
6	3.0	33.5568	32.4589	32.2244

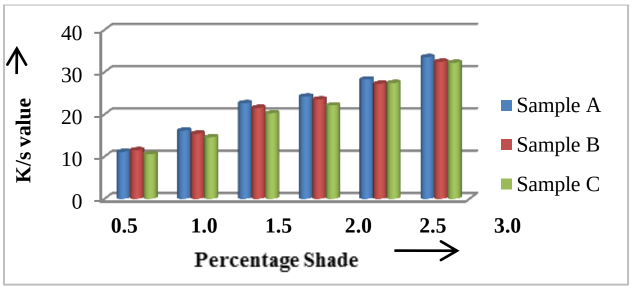

Figure3: Graphical representation of K/s values of cold brand reactive dyes

Improvement in k/s values found in all three fabric samples which are processed with recycled wastewater.

Three types of dye brands used in the experiment i.e. Cold brand dye, Hot brand dye and Remazol brand dye show same improvement in k/s values. Total dissolved solids (TDS) and hardness values are important for better dye fixing on fabric. Total dissolved solids and hardness of recycled wastewater are found lesser than ground water and municipal tap water. K/s values increases with increase in percentage shade of dye. K/s values of cotton fabric dyed using recycled wastewater are found higher than other two samples. Low TDS values and hardness values is the basic reason behind better k/s values of cotton fabric dyed using recycled wastewater. These results show that there is ample scope of using recycled wastewater in textile wet processing.

2.5 Whiteness Index

The evaluation of the whiteness of a product is dependent upon the materials and the application in which it is used. Natural materials, for instance cotton or wool, tend to yield some yellowish tint, so the industry will make modifications to the materials to compensate for this effect. A yellowish tint in a product is most often seen as a quality flaw, e.g., yellowing due to aging or dirt, and businesses will attempt to make the appearance of their products whiter. Bleaching is a process that chemically removes colors from materials and results in a more uniform spectral reflectance. It is the process of removing colored impurities from the griege fabric as efficiently as possible, with minimum or no damage to the fiber and leaving in a perfect white state

Whiteness Index was calculated by Computer Colour Matching (C.C.M.) method. This practice provides numbers that correlate with visual ratings of yellowness or whiteness of white and near white or colorless object-color specimens, viewed in daylight by an observer with normal color vision (Sonaje and Chougule, 2013).

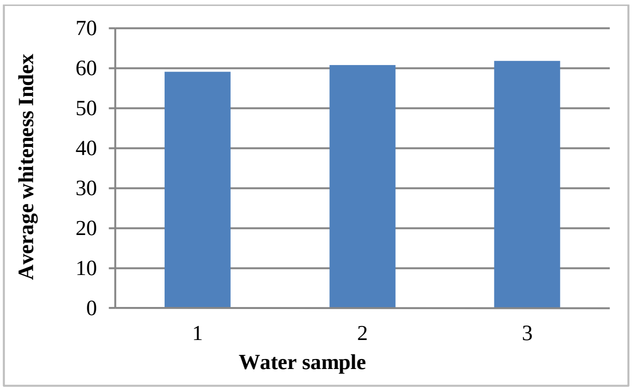

Figure 4: Comparison of Whiteness Index of cotton fabric bleached with three different waters

From experimental study it is revealed that Average whiteness index of cotton fabric bleached with Treated water from pilot treatment plant (Sample A) is 59.144 and that of bleached with Municipal Tap Water. (Sample B) is 60.158 and Ground water or Bore water (Sample C) 61.832. This shows that recycled water gives comparatively good performance in bleaching of cotton fabric by removing impurities. This is because hardness value of recycled wastewater is less than other two categories. It can be concluded that recycled wastewater is suitable for bleaching of cotton fabric in textile wet processing and with satisfactory whiteness Index.

2.6 Washing and Rubbing fastness

Fastness is the resistance of a dye to removal or destruction. In both industrial processing (finishing, for example) and in ultimate use, a textile might meet a range of challenges. Standard laboratory tests put forth by e.g. ISO.

ISO 105 specifies a method for determining the resistance of the colour of textiles of all kinds, including textile floor coverings and other pile fabrics, to rubbing off and staining other materials. The method is applicable to textiles made from all fibres in the form of yarn or fabric, including textile floor coverings, whether dyed or printed. ISO 105 specifies five methods intended for determining the resistance of the colour of textiles of all kinds and in all forms to washing procedures, from mild to severe, used for normal household articles.

This part of ISO 105 is designed to determine the effect of washing only on the colour fastness of the textile. It is not intended to reflect the result of the comprehensive laundering procedure.

Nine dyes were utilized on experimental basis, 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 Average-good rating. All fastness ratings 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 average-good performance. Washing fastness values of all samples have shown satisfactory results as per AATCC and ISO-105.Rubbing fastness values of all samples as per AATCC and ISO-105 in Dry and Wet condition gave good results.Cotton fabric should have better washing and rubbing fastness for its resilience in its normal use. Tests performed here shown good results.

Recycled water can be utilized in textile wet processing with same quality of fabric received by utilizing fresh water as Ground water or municipal tap water. This shows that there is wide scope of utilizing treated wastewater in textile processing, which is water intensive industry (Sonaje and Chougule, 2013).

2.7 Disinfection by Sodium hypochlorite

There is no perfect disinfectant. However, there are certain characteristics to look for when choosing the most suitable disinfectant such as ability to penetrate and destroy infectious agents under normal operating conditions; lack of characteristics that could be harmful to people and the environment; safe and easy handling, shipping, and storage; absence of toxic residuals, such as cancer-causing compounds, after disinfection; and affordable capital and operation and maintenance (O&M) costs. Despite of few drawbacks Chlorine and its compounds are the principal chemical compounds employed for the disinfection of reclaimed water in all parts ofworld. Chlorine is a well-established technology for disinfection because of following points-

1. Presently, chlorine is more cost-effective than other disinfection methods.
2. The chlorine residual that remains in the discharged wastewater can prolong disinfection even after initial treatment and also provides a measure of the effectiveness.
3. Chlorine disinfection is reliable and effective against a wide spectrum of microorganisms.
4. Flexible dosing enables greater control over disinfection since wastewater characteristics vary from time to time and Chlorine can eliminate noxious odors while disinfecting.

Recycled water from pilot treatment plant was disinfected by using Sodium hypochlorite solution (22 gpl). Dosing was kept between 0.25 mg/l to 5 mg/l with the dosing interval of 0.25 mg/l.

Recycled water sample 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. Residual chlorine increased to 0.25 mg/l at NaOCl dose of mg/l. (Sonaje and Chougule, 2013).

Sodium Hypochlorite can easily stored and transported when it is produced on-site. Dosage is simple. Transport and storage of sodium hypochlorite are safe. Sodium hypochlorite is as effective as chlorine gas for disinfection. Sodium hypochlorite produces residual disinfectant.

3. Experimental method for water conservation in cotton pretreatments

Reuse of Scouring Rinses for Desizing The rinse water from the scouring operation is adequate for reuse in other processes such as desizing that do not require water of an extremely high quality. This reuse is particularly true with scouring wastes from synthetic or cotton/synthetic blend fabrics. Scouring rinses may, in certain cases, also be reused to wash floors and equipment. Reuse of Mercerizing or Bleach Wash Water for Scouring or Desizing, Mercerizing or bleaching rinse water can be used in scouring and desizing operations as long as size recovery is not practiced. Generally, the caustic or bleach stream will degrade many size compounds to an extent that they cannot be recovered (NCDEM, 1993). The major factor providing the driving force for the recycle of bleaching rinse water to scouring is the economics of the process. (Porter, 1998)

Water conservation is essential part of water economy. Analysis has been carried out for repeating the bath in Cotton pre-treatment operations. Here these pre-treatment operations considered are scouring and bleaching. Analysis and procedure adopted is given below.

3.1 Selection of material

Table No 3. Fabric details

Sr. No.	Parameter	Details
1.	Fabric type	100% cotton fabric
2.	PPI	66
3.	EPI	85
4.	A. Warp Count	14.7
	B. Weft Count	14.7
5.	GSM	194

Table No. 4: Selection of auxiliaries

Sr.No	Parameter	Grades
1	Wetting agent	LR
2	Caustic soda	LR
3	Hydrogen peroxide (50%)	LR
4	Stabilizer	LR
5	Soda ash	LR
6	Sequestering Agent	LR
7	Scourex	LR

3.2 Testing Equipment

1. Tensile strength tester 2. CCM (Minolta Treepoint system)
3. P^H meter 4. TDS meter

Tests carried out

1. P^H. 2. Alkalinity. 3. Tensile Strength. 4. TDS. 5. TSS. 6. TS. 7. BOD. 8. COD.
9. Carboxylic Acid group content. 10. % NaOH content.

3.3 Desizing

After the weaving process, the sizes have to be removed from the fabric because they interfere with subsequent processing steps. Sizes have, in general, a high biological oxygen demand (BOD) and will contribute significantly to the waste load of the industry effluent. Three methods frequently used in textile processing are acid desizing, enzyme desizing, and oxidative desizing. The goal of these different methods is to hydrolyze the starch.

After getting the grey fabric, the fabric was firstly desized which removes out the starch from the fabric by using following recipe.

Chemical - hydrochloric acid MLR - 1:15

In desizing it is found that the amounts of size add - on was 12 % and desizing liquor was so polluted that it is not possible to reuse it.

3.4 Scouring

Here the fabric is proceeding further for the scouring process. In the scouring process the removal of fatty acids, oils, wax takes place. So the fabric is scoured with the following recipe.

Table No.5: Recipe details for Scouring

Sr.No.	Parameter	Values
1.	NaOH	2 % owf
2.	Na_2CO_3	1 %
3.	Scourex	0.5 %
4.	Wetting Agent	0.5 gpl
5.	Sequestering Agent	0.1 %
6.	Time	90 Minutes
7.	Temperature	95^0 c
8.	MLR	1:20

3.5 Bleaching

After souring the fabric is proceed for the bleaching process. In the bleaching process the natural colouring impurities are decolourised and whiteness is improved. For bleaching process following receipe is followed:-

Table No. 6: Recipe used for bleaching

Sr.No.	Parameter	Values
1.	H_20_2	2 % owf
2.	Soda ash	2 gpl
3.	Stabilizer	1/3rd of H_2O_2
4.	Time	90 Minutes
5.	Temperature	95^0 c
6.	MLR	1:20

3.6 Results of water conservation technique

After the scouring process different tests are carried out for waste liquor. From the results of the tests it is observed that same liquor can be reused for several times.

Table No. 7: Characteristics of Scouring Liquor & Scoured fabric samples

Parameters	Process 1	Process 2	Process 3	Process 4	Process 5	Process 6
P^H	10.8	10.8	10.7	10.6	10.5	9.9
Alkalinity	32.4	32.3	31.6	30.4	29.4	28.9
TDS (ppm)	5100	5900	6500	7150	7980	8500
TSS (ppm)	498	576	675	799	825	866
TS (ppm)	5598	6476	7175	7949	8805	9366
COD(ppm)	901	912	952	1009	1059	1088
BOD(ppm)	355	435	532	657	751	837
CAC Carboxylic Acid	0.9	0.9	0.8	0.9	0.8	0.9
Absorbency	<3sec	<3sec	<3sec	<3sec	<3sec	<3sec
Tensile Strength warp	40	40	41	41	42	42
Tensile Strength Weft	67	67	68	68	68	70

After carrying out of process 1, it is observed that the amount of liquor was decreased because of evaporation and water absorbed by fabric. So while reusing same scouring liquor bath in process 2 hot wash liquor was added to replenish the amount of liquor to be used. Same liquor bath was used for six times. After each scouring process following tests were carried out for the liquor and fabric. The results obtained after each scouring and bleaching process are shown in table 7.

From above result it is observed that the scouring efficiency was very good as in all processes absorbency is less than 3 sec. The fabric damage is also negligible as Carboxylic Acid Content values are in between the desired limit. But the solid content and BOD, COD in the liquor goes on increasing continuously. After sixth process the total solid content increased to a greater extent so the carrying out seventh scouring process was impossible.

After the beaching process different tests are carried out for waste liquor. From the results of the tests it is observed that same liquor can be reused for several times. After carrying out of process 1, it is observed that the amount of liquor was decreased because of evaporation and water absorbed by fabric. So while reusing same bleaching liquor bath in process 2, hot wash liquor was added to replenish the amount of liquor to be used. Same liquor bath was used for six times. The results obtained after each bleaching process are as follows:

Table No. 8: Characteristics of Bleaching Liquor & Bleached fabric samples

Parameters	Process 1	Process 2	Process 3	Process 4	Process 5	Process 6
P^H	9.6	9.6	9.7	9.6	9.7	9.7
TDS	2698	2742	2819	2879	2911	2956
TSS	189	207	212	217	235	239
TS	2887	2949	3031	3096	3146	3195
COD	442	529	637	725	843	949
BOD	159	193	247	299	347	397
Whiteness Index	66.25	65.07	64.11	61.13	59.23	55.2

From above result it is observed that the bleaching efficiency was very good as whiteness index is good i.e greater than 60. But the solid content and BOD, COD in the liquor goes on increasing continuously. After fourth process the whiteness index found to be less than 60 i.e. 59.23 and 55.2 and total solid content increased to a greater extent so the carrying out fifth bleaching process was difficult.

4. Results and Discussion

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 treated water from pilot treatment plant is suitable for cotton textile wet processing (Sonaje and Chougule, 2013).

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 are within the prescribed limit as shown in Table No. 9

Table No.9: Results obtained from pilot plant experimentation

Sr. No.	Parameters	Range of Values	Limits for Textile wet processing*(IS 201:1992)
1	Total Dissolved Solids mg/l	402 to 457	< 500
2	Total Hardness mg/l	18 to 31	< 50 *
3	Oil and Grease mg/l	0	< 1
4	P^H	6.76 to 7.09	6.0 to 8.5*
5	Chlorides mg/l	39 to 59	< 100*
6	Nitrates mg/l	0.0111 to 0.0154	< 0.50
7	Sulphates mg/l	49 to 62	< 100*
8	Aluminium mg/l	0	0.1
9	Alkalinity mg/l	123 to 156	< 150*
10	Iron mg/l	0	0.25*
11	Manganese mg /l	0	0.1*
12	Chlorine mg/l	0.1 to 0.25	0.1 to 0.2
13	Suspended solids mg/l	0	< 5
14	Electrical conductivity (μmhos/cm)	0.46 to 0.74	-
15	Colour	Colourless	20 Hazen Units*
16	Odour	Odourless	-
17	Most Probable Number (/100 ml.)	0	-
18	Chemical Oxygen Demand mg/l	12 to 25	< 50

5. Conclusion

From pilot plant experimentation it is clear that, treated wastewater from pilot plant is suitable for cotton textile wet processing. The potential to use treated municipal wastewater as a water supply for industrial use is of interest as a way to conserve water resources while supporting economic development. Using treated municipal wastewater in industries will help to reduce ground water depletion by providing an alternative supply for non-potable water uses and to provide a reliable and potentially optimum cost water source for industries.

Day by day this increasing cost of water becoming hurdle in the progress of textile industries. Study carried out here shows that there is wide scope of utilizing treated wastewater in textile processing, which is water intensive industry.

From pilot plant experimentation it is clear that, treated wastewater from pilot plant is suitable for cotton textile wet processing. The potential to use treated municipal wastewater as a water supply for industrial use is of interest as a way to conserve water resources while supporting economic development. Using treated municipal wastewater in industries will help to reduce ground water depletion by providing an alternative supply for non-potable water uses and to provide a reliable and potentially optimum cost water source for industries.

Textile wet processing units in Ichalkaranji face water scarcity problem very severely especially during the months of April to May. During this period Textile units procure water from other private sources at very high cost. During industrial visits at Ichalkaranji and Solapur it is found that water cost is increasing every year. In the month of April 2013, these water costs found to be Rs. 60 to 100 per 1000 litre of water. In normal period when water is available it ranges between Rs. 25 to 50 per 1000 litre of water. Cost benefit ratio carried out here shows that recycled water is having cost near to Rs. 20 per 1000 litre of water which is quite less than present water cost used by industries.

Some industries on the bank of river Panchganga are utilizing water from river with additional purifying treatment. From Ground water samples of various locations it is observed that, mostly all water samples are with high hardness and Total dissolved values, water of these locations is not directly useful for textile wet processes.

Small scale industries in textile processing sector are purchasing this water with higher cost and again treating it with required treatment as an additional cost. Day by day this increasing cost of water becoming hurdle in the progress of textile industries. Study carried out here shows that there is wide scope of utilizing treated wastewater in textile processing, which is water intensive industry.

It is possible to reduce the water consumption in cotton pretreatments by reusing the same bath. Same scouring and bleaching bath can be used up to 6 times and 4 times respectively. There is no significant difference between whiteness index values of conventionally bleached and fabric bleached with process 1 to 4. It helps to reduce the effluent load so that the effluent treatment cost is also reduced substantially with saving of water and chemical costs. Conservation of water is achieved by reusing the same bath for several times in cotton pretreatments as scouring and bleaching.

Acknowledgement

Authors are thankful to Prof. (Dr.) S.A. Halkude Principal Walchand Institute of Technology, Solapur, Maharashtra (India) for his constant inspiration throughout this research project. Also we are grateful to Ph.D. Research Centre, W.I.T. Solapur for constant support for this research work.

References

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.

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

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

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

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

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.

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.

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.

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,

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.

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

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,

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.

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.

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

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.

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.

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

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