ENVIRONMENT ANALYSIS OF T.C TERRY TEX LTD

A Dissertation

submitted in partial fulfilment of the requirement

for the award of degree of

Masters in Technology

in

Environmental Science & Technology

Submitted by

Mriduta Sharma

Roll No.601401007

Under the Guidance of

Mr. KS Babu
Assistant Professor

Mr. S.P Aggarwal
H.O.D, ETP
T.C Terry Tex ltd.

SCHOOL OF ENERGY AND ENVIRONMENT
THAPAR UNIVERSITY, PATIALA
(Declared as Deemed-to-be-University u/s 3 of the UGC Act, 1956)

June 2016

DECLARATION

I hereby declare that the project work entitled "Environmental analysis of T.C. Terry Tex Ltd." is an authentic record of my own work carried out at T.C Terry Ltd. as requirements of one year project internship for the award of degree of M.Tech.(EST), Thapar University, Patiala, under the guidance of Mr. S.P Aggarwal and Mr. K..S Babu, during June 22, 2015 to June 14, 2016.

Mriduta Sharma
601401007

Date: 17.07.2016

Certified that the above statement made by the student is correct to the best of our knowledge and belief.

Mr. K.S Babu
Faculty Coordinator

Mr. S.P Aggarwal,H.O.D, ETP
Industry Coordinator

Head
School of Energy and Environment
Thapar University, Patiala

Dean Academic Affairs
Thapar University, Patiala

Acknowledgement

There is a saying “Hard work is key to success”.
This training report gives me an opportunity to thank all those who have helped me to make this training a learning step. I want to pay profound gratitude to Mr. P.S Barnala (Technical head), Mr. Rajesh khanna (Head, H.R.) for providing us an opportunity to do 1 year training in their esteemed organization.

I would also like to thank Mr. Satpal Aggarwal (Head of department of E.T.P) and Mr. K.S. Babu for guiding me in each and every step and helping me in completing my thesis.

It would have not been possible without the help of my friends and family who in one way or another shared their supported me during my training period.
Above all, to Great Almighty, the author of knowledge and wisdom, for his countless love.

Mriduta Sharma

Index

Contents Page No.

<u>List of Tables</u>

List of Figures

List of Flow charts

Abstract

M/S T.C. TERRY TEX LTD. is a large scale textile unit established in April 2008.The industry is engaged in manufacturing 30 TPD Terry towel and 18 TD dyed yarn. The raw material used for manufacturing is cotton with average consumption of 34.5 MTD. Number of workers working in the industry are 983 coming in four shifts i.e. A shift (7.00a.m-3.00p.m), B shift (3.00 p.m-11.00 p.m), C shift (11.00 p.m.-7.00 a.m.) and General shift (9.00a.m.-6.00p.m.).The Industry runs 24 hours a day and 358 days in a year. In the present project, environment analysis of the industry is done with reference to air, water and solid waste. The wastewater is generated mainly from dyeing unit, domestic activities, boilers and other processes like charging and backwashing of soft water system, demineralized plant etc. Hazardous solid waste is generated as ETP sludge, ash from boiler and spent oil from DG sets and non-hazardous waste like .Industry has installed 1850 KLD Effluent Treatment Plant for treatment of wastewater generated from various processes. Also, the industry has installed RO units for recycling and reuse of wastewater. Industry has installed continuous monitoring system for measurement of pH, TDS and flow at the final outlet of ETP with facility of interlocking of TDS meter with RO feed pump. The Industry has also installed continuous monitoring system for measurement of SPM from boiler stack. Industry has 30 acre plantation area in which final outlet of ETP is discharged. Industry has also installed piezometric well in plantation area to ascertain the effect of repeated application of treated wastewater on the groundwater.

Chapter 1: Introduction

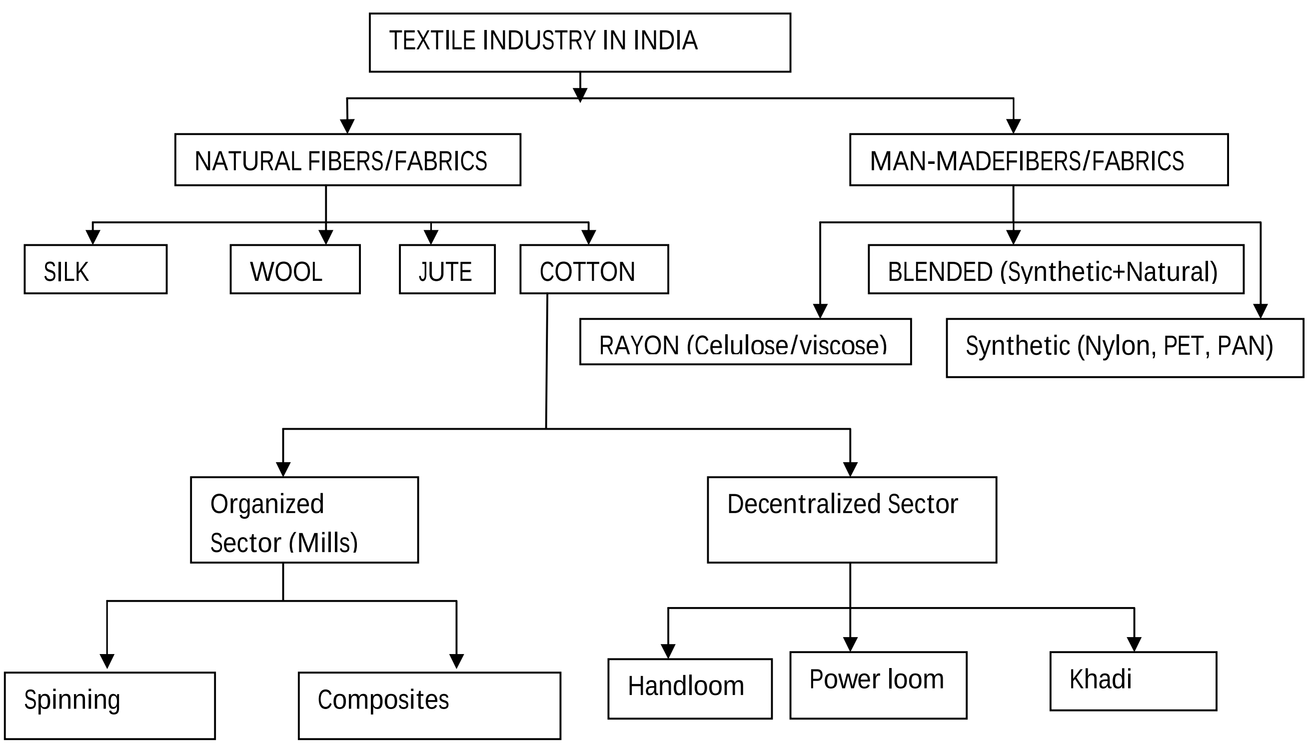
1.1 Structure of Textile Industry: The textile industry is a significant contributor to many national economies. The Indian textile industry is no exception to this. It occupies an unique position in the Indian economy in terms of its contribution to industrial production, employment and exports. It is one of the largest segments of Indian economy accounting for 14% of industrial production and one-third of total exports with only 1-1.5% of import bills. The structure of Indian textile Industry is quite complex. The Indian textile industry ranges from hand-spun khadi and traditional textiles woven on handlooms at cottage industry to the highly capital intensive modern and sophisticated mill sector and synthetic fiber manufacturing units.In between these two extremes lies decentralized power loom,knitting and garment sectors.The Indian textile industry has diversified from the manufacture of traditional items to the manufacture of fashion items for international markets.

Based on the fibers processed, the textile sector can be divided, into two groups:

• Natural fibers such as cotton, wool, silk, jute, etc.

• Man-made fibers, like rayon and synthetics, and their blends.

Out of the total textile production, cotton alone accounts for > 70% followed by man-made (20%) and the rest(10%) which include silk, wool, jute, coir etc.



Flow chart 1.1 – Arbitrary Classification of textile industry in India

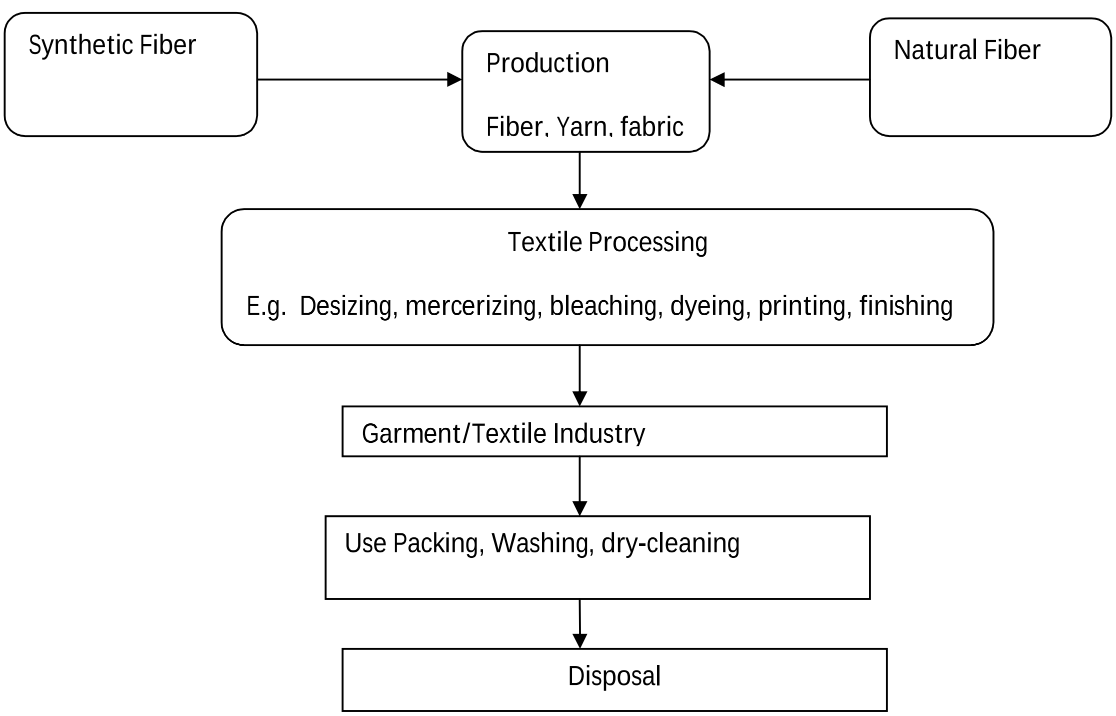
1.2Textile Industry and its Impact on Environment

1.2.1 Environmental legislation

India is the first country which has provided in its constitution the protection and improvement of environment.There are no specific environmental laws for textile sector alone.However,there are industry specific standards,which the textile industry has to comply while setting up or operating an industrial unit.In addition to environmental standards,the Indian textile exporters confronted with social issues like child labour,poor and unhygienic conditions at the work place,low wages etc.It is pertinent to mention the thinking of Europeans regarding Social Accountability Standards(SAS).

1.2.2 Impact on Environment

Any industrial activity causes pollution in one form or the other end and so is the textile industry.The industry covers a wide spectrum of manufacturing activities and is diverse in terms of raw materials and technique employed,chemicals used and the final products.The impact of textile production on the environmental aspects such as air,water,land and human body and the social aspects such as child labour and poor unhygienic working conditions must be considered.Although there are environmental hazards during the entire production chain, the textile wet processing processes possesses serious environmental problems. Large number of chemicals in vast quantities are used in textile wet processing to satisfy consumer's demands as regards aesthetics,handle,imparting desirable properties,etc.Some of these chemicals, such as dyes and finishing agents, remain attached to the textiles, whereas a substantial proportion of these chemicals remain in the processed water causing air and water pollution. Air pollution is also caused during drying and polymerization sequence of finishing operations.



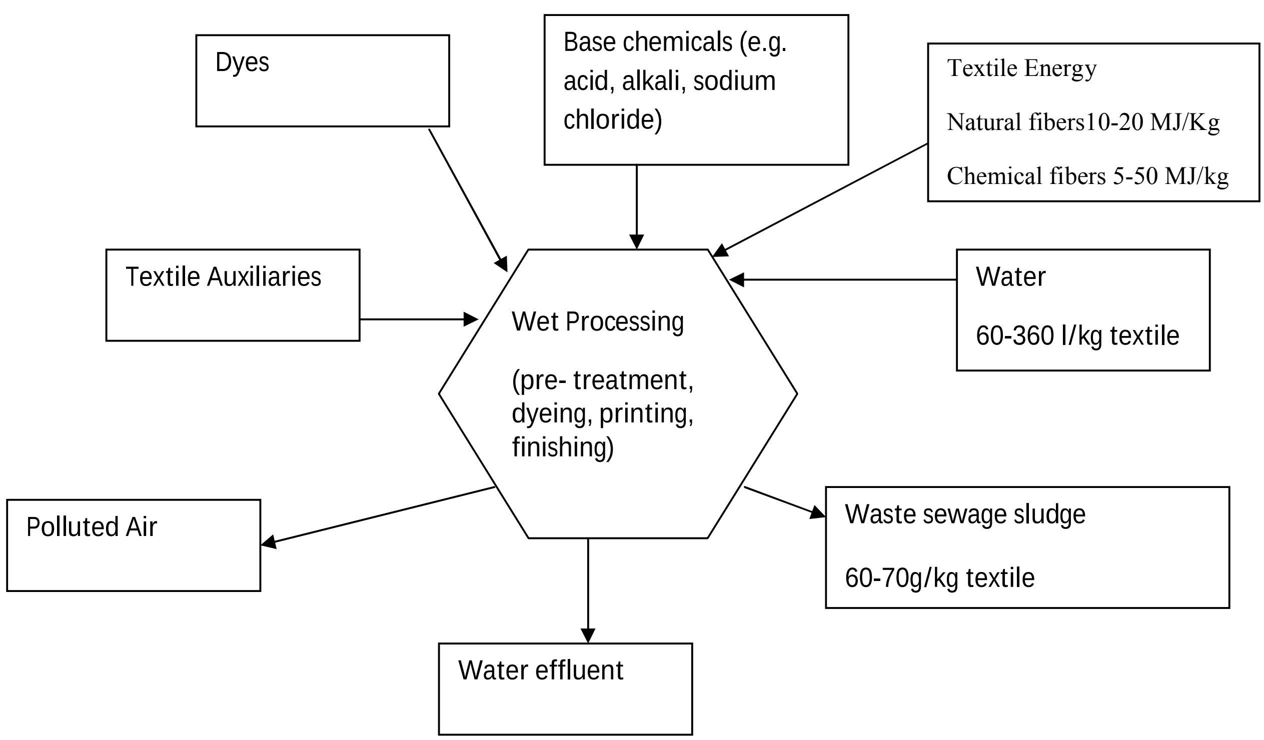
Flow chart 1.2 Manufacturing process in Textile Industry

- Air Emission Sources

Source emissions from textile processes,including boiler emissions,fall into four general categories,such as oil and acid mists,solvent vapors,odor and dust.

- Water Pollution Sources

Textile effluents are generally colored and have high BOD and total dissolved solids(TDS).Natural and added impurities,dyes and pigments,and chemicals used are the main sources of water pollution.Each chemical processes produce effluents with its own distinctive characteristics,e.g. wool effluents are characterized by high BOD,suspended solids and grease content.Cotton effluents have high color content, high BOD,no grease and relatively low suspended solids.Synthetic fiber processing effluents are generally low in volume than those generated in cotton .The pollution load of the effluent can be characterized by the ratio between BOD and COD, which generally represents the degree to which the waste are easy or difficult to biodegrade.Ratio ranging between 1:2 and 1:3 should imply good potential biodegradability. Textile effluent mills are also highly colored due the use of dyes and pigments.Direct discharge of such effluents can lead to significant deterioration in the aesthetic value of downstream water quality.The presence of detergents and surfactants in the effluent would often be a risk to aquatic life and health risk,especially if the receiving water is to be used downstream as drinking water in large population areas.The source of major metal pollutants such as copper,zinc,chromium etc are mainly the metal complex dyes and chromium salts used in wool dyeing or as oxidizing agent in sculpturedyeing. The potential sources for organic pollutants are sizes, organicacids, otherchemicals, carriers used in polyester dyeing, cleaning solvents or scouring agents(trichloroethylene and perchloroethylene), plasticizers, etc.



Flow chart 1.3 Input and outputs in textile industry

- Typical composition of Wastewater generated from various types of textiles is represented in table 1.1.

Property	Standard	Cotton	Synthetic	Wool
pH	5.5-9.0	8-12	7-9	3-10
BOD_5(mg/l)	30-350	150-750	150-200	5000-8000
COD ,(mg/l)	250	200-2400	400-650	10,000-20,000
TDS,(mg/l)	2100	2100-7700	1060-1080	10,000-13,000

Table 1.1 Parameters of wastewater generated from various types of textiles

1.3 Introduction of the Industry

T.C. TERRY TEX LTD. is a large scale textile unit established in April 2008.The industry is engaged in manufacturing 30 TPD Terry towel and 18 TD dyed yarn.The raw material used for manufacturing is cotton with average consumption of 34.5 MTD. Number of workers working in the industry are 983 coming in four shifts i.e. A shift (7.00a.m-3.00p.m), B shift (3.00 p.m-11.00 p.m), C shift (11.00 p.m.-7.00 a.m.) and General shift (9.00a.m.-6.00p.m.).The Industry runs 24 hours a day and 358 days in a year. In the present project, environment analysis of the industry is done with reference to air, water and solid waste. The wastewater is generated mainly from dyeing unit, domestic activities, boilers and other processes like charging and backwashing of soft water system, demineralized plant etc. Hazardous solid waste is generated as ETP sludge, ash from boiler and spent oil from DG sets and non-hazardous waste like .Industry has installed 1850 KLD Effluent Treatment Plant for treatment of wastewater generated from various processes. Also, the industry has installed RO units for recycling and reuse of wastewater. Industry has installed continuous monitoring system for measurement of pH, TDS and flow at the final outlet of ETP with facility of interlocking of TDS meter with RO feed pump. The Industry has also installed continuous monitoring system for measurement of SPM from boiler stack. Industry has 30 acre plantation area in which final outlet of ETP is discharged.Industry has also installed piezometric well in plantation area to ascertain the effect of repeated application of treated wastewater on the groundwater.

The**objectives of this project** is to

- Study various processes of the Industry consuming water and other resources.
- Study Processes of the Industry generating waste in the form of emissions,water,Hazardous and Non-Hazardous waste.
- Environment Analysis of the Industry with reference to air,water and Hazardous and Non-Hazardous waste.

Chapter 2: Review of literature

1. Study has been done for evaluating occupational environment in two textile plants in Northern India with special reference to noise. It was found that noise level in certain section of plant is more than the acceptable limit of 90dbA for 8 hr exposure as stipulated by OSHA. It can be a major reason for occupational hearing loss in workers. (Raman et al.,2006)
2. A high performance polymeric flocculant has been developed by partial alkaline hydrolysis of polyacrylamide grafted carboxymethylstarch (CMS-g-PAM). The laboratory synthesized polymers find potential application as highly efficient flocculant for the treatment of textile industry wastewater.(Gautam et al.,2010)
3. Analysis of trace metals in textile effluents showed elevated levels of Cr, Pb, Ni, Co, Fe, Ca, Na, K and Zn in these media, following the order: soil > effluent > water. Principle component analysis (PCA) of the data showed that the textile effluents are contaminating the soil wherein Cr and Pb were dominant toxic metals having concentrations of 5.96 mg/kg and 4.46 mg/kg, respectively. Other toxic metals such as Co, Cd, Zn, Ni, Mn and Fe, were found to have common origin in the textile effluents.(Manjoor et.al.,2005)
4. Fuel additive containing an oil-dispersible iron compound and an over-based magnesium compound to solid fuel reduces smoke and particulate emissions from steam boilers.(Walter et.al.,2002)
5. Ozonation experiments in a multiple reactor system were conducted to investigate the efficiency of this process in reducing color and chemical oxygen demand of the textile waste effluents. It was observed that decolorization of waste effluents can be achieved in less than 10 minutes. In conjugation with chemical coagulation, the chemical oxygen demand can be consistently reduced up to 70% or more. Ozonation is capable of decomposing the highly structured dye molecules into smaller ones which can be easily biodegraded in an activated sludge process.(Lin et al. , 1993)
6. *Trametes hirsuta* and a purified laccase from this organism were able to degrade triarylmethane,indigoid,azo,and anthraquinonic dyes. Treatment of dyes with the immobilized laccase reduced their toxicities by up to 80%.(Abadulla et al., 2000)
7. Bioassay with daphnids was described to determine the LC50 values of wastewater samples taken from different stages of the finishing textile industry. All effluents were toxic in terms of LC50 and exhibited very high toxicity with acute toxicity unit(ATU) levels between 2.2 and 960.The most toxic contaminant seemed to be ClO- at levels between 0.2 and 6.8 mg/l.(Navarro et al. ,2001)
8. Treatment of wastewater effluent from the secondary wastewater treatment plant of a dyeing and finishing unit is investigated for possible reuse. The treatment system employed consist of an

electrochemical method, chemical coagulation and ion exchange. The electrochemical method and chemical coagulation are intended primarily to remove color, turbity(NTU) and COD concentration of the wastewater effluent while ion exchange is employed to further lower the COD concentration and reduce Fe ion concentration, conductivity and total hardness of wastewater. To enhance the efficiency of electrochemical method, addition of a small amount of hydrogen peroxide is found to be highly beneficial.(Lin et al.,2002)

9. Reuse of wastewater of the textile industry after its treatment with a combination of physico chemical treatment and membrane technologies leads to a COD removal of almost 100%.(Pia et al.,2003)
10. Titanium based dimensionally stable anode (DSA) was used for in situ generation of chlorine in the dye solution. All classes of reactive dyes(100mg/l) showed a complete color removal at a supporting electrolyte concentration of 1.5g/L NaCl and 36.1mA/cm2 current density.(Rajkumar et al.,2005).
11. Investigation of potential of bacteria isolated from textile industries wastewater and drains (textile effluent adapted bacteria) and isolates from a municipal landfill (effluent non-adapted bactria) is done. Effluent adapted strains of Acinetobacter,Bacillus and Legionella with potentials for color removal and strains of Acinetobacter,Bacillus and Psedomonas with chemical oxygen demand (COD) removal activities were discovered.Only strains of Bacillus with potentials for use in color and COD removal were isolated from landfill.(olukanni et.al , 2006)
12. Effectiveness of biological pretreatment involving appropriate microorganisms and suitable support media in a combined process is showed. The combined process consist of biological pretreatment,chemical coagulation and electrochemical oxidation.COD and color were reduced by 95.4% and 98.5% by the combined process respectively.(kim et al. ,2008)
13. A microbial consortium, PDW, was isolated capable of the rapid decolourisation of commercially important textile dyes under anaerobic conditions. Decolourisation was dependent upon the presence of carbon and energy source in addition to textile dyes.PDW was capable of dye colorization when utilizing cheap and readily available carbon sources such as lactose, starch and distillery waste.PDW removed 76% of color from textile plant effluent after 3 days.(Nigam et al.,1996)
14. A photo catalytic approach using semiconductors for degrading several anodynes was developed. Deposition of semiconductor nanoclusters on a conducting glass surface provides a convenient way to manipulate the photo catalytic reaction by electrochemical methods. The thin semiconductor particulate film can be used as a photosensitive electrode in an electrochemical cell.(Kamat et al.,1996)
15. Treatment of wastewater from a textile industry that produces synthetic polyester cloths was studied employing electrochemical techniques. The sample was initially subjected to electro

coagulation to remove suspended solids. Mild steel and aluminum electrodes were tried as anodes; and aluminum was found to be effective for the removal of suspended solids. Using aluminum as anode, the chemical oxygen demand (COD) concentration of the effluent which was initially at the level of 1316 mg L^{-1} could be reduced to 429 mg L^{-1} by electro coagulation. After electro coagulation, the effluent was further subjected to electro oxidation using graphite and $RuO_2/IrO_2/TaO_2$ coated titanium as anodes. During the electro oxidation tests, both COD and chloride ion were simultaneously estimated; and the effect of Cl^- ion is discussed. The measurements have revealed the depletion of Cl^- ion concentration implying the generation of free chlorine during electro oxidation. The depletion of Cl^- ion concentration and the COD removal were observed to be comparatively high in the presence of graphite electrode.(Bhaskar et al. ,2008)

16. The biological breakdown of the chlorolignin residues and the chromophoric groups responsible for the dark coloration of the textile effluent can be accomplished by the use of enzymes from the white rot fungus, Phanerochaete chrysosporium. The siderophores detected from the culture of the organism have been found useful in the decolourization and remediation of the effluent.(Asamudo et al.,2005)
17. Adsorption methods for color removal from wastewater using waste materials activated carbon and activated rice husk as adsorbents. Method was employed for the removal of Safranin-T.The adsorptiom of the dye over both the adsorbents was found to folloe Langmuir and Freundlich adsorption isotherm models.The adsorption of Safranin-T over activated carbon and activated rice husks follows first-order kinetics and the rate constants for the adsorption processes decrease with increase in temperature.(Gupta et al.,2006).
18. The strain Aspergillus fumigates XC6 isolated from mildewing rice straw was evaluated for its ability to decolorize a dye industry effluent. The strain was capable of decolorizing dyes effluent over a PH range 3.0-8.0 with the dyes as sole carbon and nitrogen sources.(Jin et al.,2006).
19. Waste material (carbon slurry),from fuel oil-based generators, was used as adsorbent for the removal of two reactive dyes from synthetic textile wastewater. The study describes the results of Vertigo Blue 49 and Orange DNA13 from synthetic wastewater onto activated carbon slurry. pH 7.0 was found suitable for removal of Vertigo Blue 49 and Orange DNA13.The adsorption isotherms for both dyes were better described the Langmuir isotherm.(Gupta et al.,2007)
20. Phlebia tremellosa decolourised eight synthetic textile dyes by greater than 96% within 14 days under stationary incubation conditions.High Performance liquid Chromatography analysis of culture supernatants indicated that Remazol Black B was degraded by the fungus.(Kirby et al.,2000).
21. An investigation of dye decolorization from synthetic dye solutions using the non-ionic,water soluble,high molecular weight seed gums Ipomoea dasysperma and guar gum as coagulants was

undertaken.The use of galactomannans derived from plants in this system presents a sustainable method of textile effluent treatment.These natural coagulants extracted from plants proved to be a workable alternatives to conventional coagulants as they are biodegradable,safe to human health,are cost effective.(Sanghi e al.,2006)

22. Bacillus cereus isolated from dye industrial waste,that is,effluent and soil samples was screened for its ability to decolourize two reactive azo dye – cibacron black PSG and cibacron red P4B under aerobic conditions at pH 7 and incubated at 35deg Celsius over a five day period.bacteria was able to decolourize cibacron red P4B by 81% using the combination of ammonium nitrate and sucrose,while it decolourizes cibacron black PSG by 75% using yeast extract and lactose.(ola et al. ,2010)
23. The white rot fungus, *Fomes lividus*, was isolated from the logs of *Shorea robusta* in the Western Ghats region of Tamil Nadu, India. The fungus was tested for decolorization of azo dyes such as orange G (50 μM) congo red (50 μM) amido black 10B (25 μM) and also for colour removal from dye industry effluents. The results revealed that the fungus could remove only 30.8% of orange G in the synthetic solution, whereas congo red and amido black 10B were removed by 74.0 and 98.9% respectively. A dye industry effluent was treated by the fungus in batch and continuous mode. In batch mode treatment, a maximum decolorization of 84.4% was achieved on day 4, and in continuous mode a maximum decolorization of 37.5% was obtained on day 5. The colour removal by the basidiomycete fungus might be due to adsorption of the dyes to the mycelial surface and metabolic breakdown. These results suggested that the batch mode treatment of *Fomes lividus* is one of the most efficient ways for colour removal in dye industry effluents.(Selvem et. Al,2003)
24. In recent years, rapid technological advances in the textile and dyeing industry have yielded benefits to society but have also generated new and significant environmental problems. The treatment alternatives applicable for the removal of colour vary, depending upon the type of dye wastewater. A synthetic, simulated mixed dye waste (Basic Yellow 28, Basic Yellow 21, Basic Red 18.1, Basic Violet Red 16, Basic Red 46, Basic Blue 16, Basic Blue 41) representing a known waste from a fibre production factory, was investigated. The biological process of anaerobic digestion has been recognised as a simple and energy-efficient means of treating and stabilising a wide range of organic industrial wastewaters. This study sets out to demonstrate the effect of different loading rates, dye concentrations and hydraulic retention times (HRTs) on colour removal efficiency under mesophilic anaerobic conditions. The reactor was operated under mesophilic conditions at different organic loading rates (OLRs) and HRTs for nine months. The results of this study show that a 2-stage mesophilic anaerobic up-flow packed bed reactor can remove up to 90% of the colour from a mixed cationic dye containing 1000 mg/l of dye. Colour removal efficiency falls as the influent dye concentration increases, but rises with

increased hydraulic retention time and increased organic loading. The primary colour removal mechanism was one of biosorption with subsequent biodegradation. Acetoclastic methanogens were moderately inhibited at low organic loading rates of 0.25 kg COD/m^3 d, at which level, acidogenesis and acetogenesis appeared to be unaffected. Inhibition of acidogenesis became marked at higher OLRs (1 kg COD/m^3 d) and when the HRT was reduced from 5 to 3 days. (talarposhti et al.,2001)

25. To verify whether dyes emitted within the discharge of a dye processing plant were contributing to the mutagenicity repeatedly found in the Cristais River, São Paulo, Brazil, we chemically characterized the following mutagenic samples: the treated industrial effluent, raw and treated water, and the sludge produced by a Drinking Water Treatment Plant (DWTP) located ~6 km from the industrial discharge. Considering that 20% of the dyes used for coloring activities might be lost to wastewaters and knowing that several dyes have mutagenic activity, we decided to analyze the samples for the presence of dyes. Thin layer chromatographic analysis indicated the presence of three prevalent dyes in all samples, except for the drinking water. This combination of dyes corresponded to a commercial product used by the industry, and it tested positive in the Salmonella assay. The structures of the dye components were determined using proton magnetic resonance and mass spectrometric (MS) methods, and the dyes were tested for mutagenicity. The blue component was identified as the C.I. Disperse Blue 373, the violet as C.I. Disperse Violet 93, and the orange as C.I. Disperse Orange 37. The dyes showed mutagenic responses of 6300, 4600, and 280 revertants/μg for YG1041 with S9 respectively. A bioassay-directed fractionation/chemical analysis showed that the C.I. Disperse Blue 373 contributed 55% of the mutagenic activity of the DWTP sludge. We showed that these dyes contributed to the mutagenic activity found in the Cristais River environmental samples analyzed and are indirectly affecting the quality of the related drinking water. Therefore, we believe that this type of discharge should be more thoroughly characterized chemically and toxicologically. Additionally, human and ecological risks associated with the release of dye processing plant effluents should be more fully investigated, especially where the resultant water is taken for human consumption. (Xumbuzeiro et al.,2005)
26. Using a pilot scale continuous system with activated sludge, the effect of the variability of non-pretreated synthetic textile wastewater containing reactive dyes on the pollution bio-removal and on the characteristics of activated sludge (sludge volume index, floc size and shape, filamentous bacteria abundance) has been monitored. Off-line batch respirometry tests have been used in parallel to assess the toxic effects of some of the reactive dyes. Experiments were run by increasing the concentration of a single dye (Run 1) and by feeding with a non-repetitive (Run 2) or a repetitive (Run 3) sequence of dyes. In all runs dyes were added to a synthetic wastewater of constant composition. Although the biomass was significantly upset by some of the dyes, it was

able to cope up with the variations of their chemistry and remained active throughout the experiments and could contribute to COD removal. The dyes were partially adsorbed but not degraded by the micro-organisms. (alinsafi et al., 2006)

27. Narrow-leaved cattails were studied in synthetic reactive dye wastewater (SRDW) under caustic conditions. The effects of the toxic dye were expressed in terms of relative plant growth rate and the appearance of symptoms such as necrosis, and chronic or acute wilting. The dye toxicity was 25.33 mg l^{-1} which was close to approximate the concentration of dye residue from the textile effluent in the public stream. The system pH and % color removal were decreased, indicating that narrow-leaved cattail can treat wastewater. The average system pH decreased from 9 to 7. The maximum color removal was approximately 60% when cultured under soil conditions. The SEM image of narrow-leaved cattail root after treatment with SRDW indicated that the root cortex was damaged and the crystalline sodium salts deposited in the root cells which caused evaporation and transpiration decreased in SRDW. The salinity under caustic conditions also affects the growth of the plants. The maximum sodium removal was approximately 44% and was found in the SRDW under soil conditions within 14 days. A small amount of sodium could enhance the relative growth rate. However, the sodium removal of the plants was limited after the third week of treatment. It should be noted that narrow-leaved cattails are known to avoid the textile dye and salt stress conditions during SRDW treatment through special mechanisms such as salt accumulation in the roots or shedding of older leaves. In addition, elements such as silicon, calcium and iron in plants might help the plant to detoxify by forming complexes with dye molecules. (nilratnisakom et al.,2005)
28. Oxidation of aqueous solutions of a model azo dye pollutant (CI Disperse Orange 25) was studied in a continuous flow reactor, operated at temperatures between 400 and 600 °C and at a fixed pressure of 25 MPa. The parameters used were the temperature, dye concentration, oxidant concentration and flow rate. The initial dye concentrations were in the range of 24.25×10^{-3} and 121.25×10^{-3} mol L^{-1} in terms of chemical oxygen demand (COD). Hydrogen peroxide (H_2O_2) was used as a source of oxygen, and the initial oxidant concentrations were between 36.75×10^{-3} and 183.75×10^{-3} mol L^{-1}. The results demonstrated that the supercritical water oxidation (SCWO) process decreases the chemical oxygen demand up to 98.52% in very short reaction times (at a residence time of 4–12 s). Global rate expression according to wastewater and oxidant concentration was regressed from the complete set of data. The first-order global rate expression was determined with an activation energy of 27.8(±1.2) kJ mol^{-1} and a pre-exponential factor of 34.3(±1.5) s^{-1} to a 95% confidence level. (sogut et al.,2007)
29. The degradation of aqueous solutions of various dyes (e.g., Orange I, Crystal Violet, and Eriochrome Black T) used for the textile industry was performed by means of a special nonthermal quenched plasma technique (i.e., the gliding arc technique, which results from an

electric discharge at atmospheric pressure and ambient temperature). The gaseous species formed in the discharge, and especially the OH radicals, induce strong oxidizing effects in the target solution, so that bleaching of the solution and degradation of the solute result, as evidenced by absorbance and chemical oxygen demand (COD) measurements. The two processes were considered as matching reactions, and overall kinetic data were derived when possible. (Abdelmalek et al., 2005)

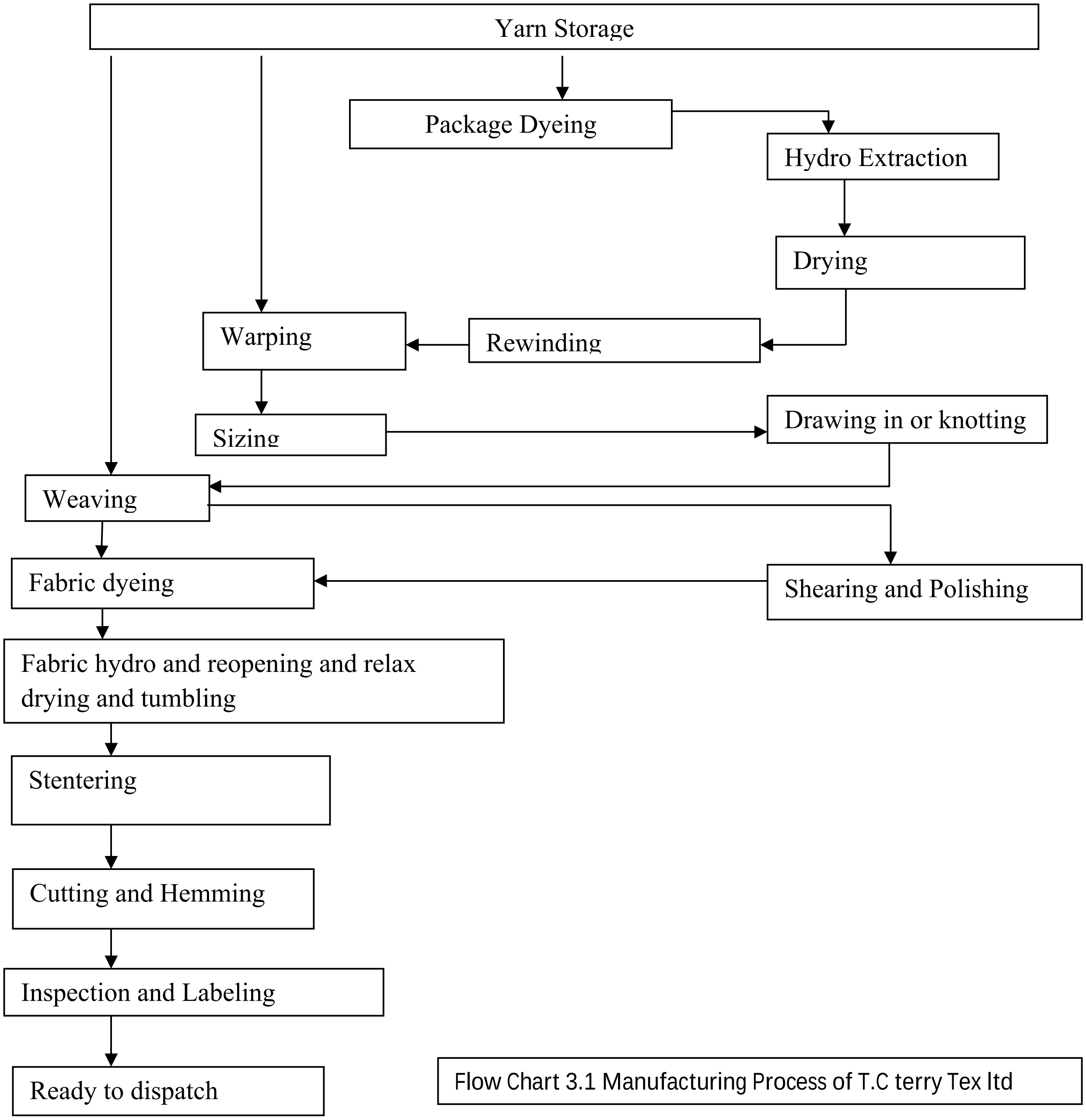
30. Investigations were carried out for possible exploitation of *Cassia javahikai* seeds as potential source of commercial gum for the textile wastewater treatment. Graft copolymerization with acrylamide was done to modify the seed gum for the favorable properties. *C. javahikai* seed gum, and its copolymer grafted with acrylamide were synthesized in the presence of oxygen using potassium persulphate/ascorbic acid redox system. Both *C. javahikai* seed gum (CJ) and its grafted-polyacrylamide (CJG), were found to be good working substitutes as coagulant aids in conjunction with PAC, for the decolorization of all the dyes in varying ratios. CJ and CJG alone could effectively decolorize direct dyes (DBR and DO) and in conjunction with a very low dose of PAC could decolorize all the dyes (DBR, DO, ASR, and PBB) to more than 70%. Grafting also increased the decolorizing ability of CJ gum. (sanghi et al., 2006)
31. This study aimed to evaluate and compare the effectiveness of reverse osmosis (RO) and nanofiltration (NF) membranes in the treatment of biologically treated textile effluent in terms of COD removal, salinity reduction as well as permeate flux. Cross-flow filtration tests of the textile effluent were conducted under various hydrodynamic conditions employing BW30 reverse osmosis and NF90 nanofiltration flat-sheet membranes. The experimental results showed that, under the same operating pressure, the nanofiltration membrane NF90 exhibited higher water permeability and more severe flux decline than membrane BW30 because of its higher porosity and more serious concentration polarization and membrane fouling; while under the same initial flux, the reverse osmosis membrane BW30 experienced more serious flux decline than membrane NF90 due to its tendency towards fouling. Both the membranes could reduce COD to a desirable level of less than 10.0 mg/L. However, the nanofiltration membrane showed better COD removal efficiency compared to the reverse osmosis membrane, possibly due to its sieving removal mechanism. Additionally, the reverse osmosis membrane BW30 reduced salinity to a greater extent than the nanofiltration membrane NF90. The treated water could be recycled back into the process, thereby offering economical benefits by reducing the water consumption and wastewater treatment cost. (Liu et al., 2007)
32. Textile wastewater was treated by means of a fluidized-bed loop reactor and immobilized anaerobic bacteria. The main target of this treatment was decoloration of the wastewater and transformation of the non-biodegradable azo-reactive dyes to the degradable, under aerobic biological conditions, aromatic amines. Special porous beads (Siran®) were utilized as the

microbial carriers. Acetic acid solution, enriched with nutrients and trace elements, served both as a pH-regulator and as an external substrate for the growth of methanogenic bacteria. The above technique was firstly applied on synthetic wastewater (an aqueous solution of a mixture of different azo-reactive dyes). Hydraulic residence time was gradually decreased from 24 to 6 h over a period of 3 months. Full decoloration of the wastewater could be achieved even at such a low hydraulic residence time (6 h), while methane-rich biogas was also produced. The same technique was then applied on real textile wastewater with excellent results (full decoloration at a hydraulic residence time of 6 h). Furthermore, the effluent proved to be highly biodegradable by aerobic microbes (activated-sludge). Thus, the above-described anaerobic/aerobic biological technique seems to be a very attractive method for treating textile wastewater since it is cost-effective and environment-friendly. (geiorgui et al., 2006)

33. In this work, activated carbon was prepared from bamboo waste by chemical activation method using phosphoric acid as activating agent. The activated carbon was evaluated for chemical oxygen demand (COD) and color reduction of a real textile mill effluent. A maximum reduction in color and COD of 91.84% and 75.21%, respectively was achieved. As a result, the standard B discharge limit of color and COD under the Malaysian Environmental Quality act 1974 was met. The Freundlich isotherm model was found best to describe the obtained equilibrium adsorption data at 30 °C. The Brunauer–Emmett–Teller (BET) surface area, total pore volume and the average pore diameter were 988.23 m^2/g, 0.69 cm^3/g and 2.82 nm, respectively. Various functional groups on the prepared bamboo activated carbon (BAC) were determined from the FTIR results (Ahmad et al., 2009)
34. The adsorption of two dyes, namely, Acid Red 57 (AR57) and Acid Blue 294 (AB294), onto acid-activated bentonite in aqueous solution was studied in a batch system with respect to contact time, pH, and temperature. Acidic pH was favorable for the adsorption of these dyes. The surface characterization of acid-activated bentonite was performed using the FTIR technique. The pseudo-first-order and pseudo-second-order kinetic models and the intraparticle diffusion model were used to describe the kinetic data and the rate constants were evaluated. The dynamic data fitted the pseudo-second-order kinetic model well and also followed the intraparticle diffusion model up to 90 min, but diffusion is not the only rate controlling step. The Langmuir and Freundlich adsorption models were applied to describe the equilibrium isotherms and the isotherm constants were determined. The Freundlich model agrees very well with experimental data. The activation energies of adsorption were also evaluated for the adsorption of AR57 and AB294 onto activated bentonite. (ozkan et al., 2004)

Chapter 3: Methodology

3.1. Process Environment Analysis



Flow Chart 3.1 Manufacturing Process of T.C terry Tex ltd

3.1.1 Preparatory Section: The first section in fabric preparation is the preparatory section. Preparatory section includes Warping, Sizing and Weaving.

3.1.1.1 Warping:This is the process used to form the warp beam or sheet formation.There are two types of warping: Direct warping and sectional warping

a. Direct warping: In direct warping the warp threads coming from the creel is directly wound onto the warp beam. The beam is then transferred to for sizing whereas beam from Sectional warping does not require any sizing material.

b. Sectional Warping: Sectional warping is the process where equal length of yarn is wound first in small sections or sheets on a drum, and then it is transferred to the beam from the drum in the form of a sheet. Sectional warping is a two stage procedure which is used to produce fancy fabrics by using color and weave effect. It is also known as pattern warping, indirect warping, drum warping and band warping.Yarn ends supplied from creel are spaced very closely and thus form a warp sheet. This sheet is wound on a beam. The width of the beam between flanges is equal to the loom warp set width of the section sheet. The number of section beams is determined by respective number of ends in the section and the complete warp.Each such sheet of warp ends is called a section. Section of the yarn build of the first section on the reel is obtained by moving the section sheet laterally at a regular rate fitted at one end of reel.When the first section is completed, then the others of its build on the drum is replica of the originall incline sections to the number required for the complete warp are wound on the next section.Fancy warps are prepared by dressing yarn packages in the creel for each section in conformity with warp pattern plan.Section sheets are attached to a beam and withdrawn simultaneously from the reel by rotation of the beam. This unrolling is controlled to provide suitable warp tension for winding the warp on to the beam.As beaming off proceeds, the warp beam is moved laterally at the same rate but in the direction opposite to that of the section during warping. This ensures that the complete warp sheet runs from the reel to between the beam flanges without the necessity for lateral deviation.

3.1.1.2 Sizing

Sizing of yarn is done during beam preparation after winding and warping.It is done by applying various types of size materials on the yarn.During application of size material steam is needed at 2.5Kg/sq cm pressure.Sizing is a protective process.The process of applying a protective adhesive coating upon the yarn surface is called Sizing.Sizing is called the heart of weaving.

Advantages of Sizing include:

- To improve the weave ability of warp yarn by making it more resistance to action of weaving like absorption, friction, tension etc.
- To maintaining good fabric quality by reducing hairiness, weakness and by increasing smoothness and absorbency of yarn.
- Tensile or breaking strength of cellulosic yarn is increased by sizing.
- Elasticity of the yarn is also increased.
- By adding sized material yarn weight is also increased.
- To increase the frictional resistance.
- Projected fibers are removed by this process.

- To reduce electrostatic formation.

3.1.1.3 Weaving

Four major operations are involved in weaving- Shedding, Picking, Beating up (Battening) and taking up and letting off.

- Shedding

  Each alternate warp yarn is raised to insert the filling yarn into the warp to form a shed.

- Picking

  As the warp is raised; the filling yarn is inserted through the shed by a carrier device. Different types of looms are used for carrying the filling yarn through the shed- Shuttle loom, shuttle less looms, circular looms etc.

- Beating

  With each picking operation, the reed pushes or beats each filling yarn against the portion of the fabric that has already been formed. Reed is a comb like structure attached to the looms. It gives the fabric a firm, compact construction.

- Taking up and letting off

With each shedding,Picking, Battening operation, the new fabric must be wound on thecloth beam which is called 'taking up'. At the same time, the warp yarns must be released from the warp beam which is called l 'letting off'. As the shuttle moves back and forth across the width of the shed, a self edge is woven which is called selvage or selvedge. The selvage prevents the fabric from muddling. It is usually more compact and strong than the rest of the fabric. There are different kinds of selvages depending upon the expected use of the fabric- Plain Selvages, Tape Selvages, Split Selvages, Fused Selvages, Leno Selvages and Tucked Selvages.

3.1.2 Grey Fabric Folding

The weaved towels are then checked for faults. The towels are then classified as A grade and B grade on the basis of faults present in them.

A Grade: Crack, Float, Slough off,Reverse Terry,Starting Mark

B Grade:Standard weight,variation percentage, weft crack, float,Defective selvedge,shade variation,oil stain,defectiveborders,Reed mark,hook mistake,uneven pile height,wrong drawing,missing ends,wrong weft,damage terry,Tight end.

3.1.3 Fabric dyeing

Dyeing is the process of adding chemicals and dyes to the fabric. It is the main source of wastewater generation. The Industry has installed 8 soft flow machines of capacity 1200 Kg(2no.),1000 Kg (1no.),800Kg(2no.),700Kg(1no.),400 Kg(1 no.) and 80 Kg(1 no.)

The liquid to fabric ratio for initial wash or single bath is 1:6 and for subsequent bath it is 1:4.5. The process followed in Fabric dyeing is as follows:

a. Desizing: Desizing is the process of removing size material from warp yarn after the fabric is woven. Desizing is done at 60 degree Celsius for 30 minutes and wastewater is generated.
b. Scouring: This is the process to remove impurities from the fabric. It is done at 80 degree Celsius for 1 hour and the wastewater generated is drained out.
c. Hot wash at 80 degree Celsius for 10 minutes.
d. Dyeing

   Different dyes, optical brightening agents, Sodium Chloride, Hydrogen Peroxide are used in dyeing. Dyeing is done at 60 degree Celsius for 40 minutes. However, if the color does not match then the time of dyeing is increased.

   Dyeing is followed by cold wash, acid wash, soaping at 90 degree Celsius for 10 minutes, cold wash and softener.
e. Washing Machine

Open Winch Washing Machine operating at 95 degree Celsius temperature. Machine is used to wash the towel after dyeing.

f. Hydro Extractor

Two number of hydro extractor machine is installedto squeeze the water from towel.Rotate speed of machine is 650 rpm.Time taken is 40 minutes.Machine capacity is 400 Kg. It is based upon centrifugal principle.

g. Rope Opener

To open up the towel after drying rope opener is used operating at 30-40 m/min speed producing 6-7 ton/shift towels.

h. Relax Dryer

To remove the moisture after washing the product is dried in relax dryer.Temperature for cotton is 130 deg Celsius and for polyester is 150 deg Celsius.50% moisture is removed in relax dryer operating at 18-20 m/min speed producing 12 ton/day production.

i. Tumbler Dryer

This removes 15-25% moisture from towel product operating at speed of 15m/min.

j. Hot air stenter

To remove the complete moisture content hot air stenter is used operating at temperature 110deg Celsius-150 deg Celsius having 15 ton/day production.

k. Shearing Machine

This machine is used to remove surface irregularities by passing through cylindrical machine with rotating spiral blades. The machine is operated at 95 degree Celsius producing 1200 MTD production.

3.1.4 Finishing

Finishing includes Length cutting, Length hemming, Cross hemming.

a. Length Cutting: This machine is used for length cutting.This machine cuts the towel in rope form.It operates at 10m/min speed having 2 Kg/square cm pressure.Number of cutters used for bath towel,Wash towel and Hand towel are 4, 8, and 6 respectively.Length cutting has production of 6tonne/shift.
b. Hemming: Machine is used to sew the towel.Two number of machines are used to sew the towel having production of 6 tonne/shift.
c. Cross Hemming: For cross hemming 44 numbers of machines are used.For further cleaning of towels Acetone(For Hard strain) and Petroleum ether(for normal strain) are used.

After the Towels are made they are packaged and classified by different grading system.

S.NO.	Grades	Fault
1	A	No defect
2	B	Mending
3	C	Stitch over terry, wrong stitch cut
4	L	Material that do not dispatch
5 T	Z	No proper size

Table 3.1 Classification of Towel on basis of faults

3.1.5 Winding

In addition to formation of towel industry is also engage in dyeing of yarn threads. Winding is the process to convert smaller package into larger packages Two types of packages are used: Plastic Chesses and Iron Spring Chesses. Plastic cheese is used for dyeing cotton at low temperature. Iron spring cheese used for dyeing PET and P/C blend at high temperature.

3.1.6 Yarn Dyeing

HT/HP machine: This machine consist of a cylindrical carrier having perforation over its surface,over which perforated spindles can be placed, radiating from the surface.The top of the carrier is provided with the hook by which an overhead crane can lower into or raise from an outer cylindrical dry vessel. When in position the cone shaped projection at the bottom of carrier pits into a conical making a leak proof point. The circulation of the dry liquor can be made by wings of a centrifugal pump and direction of the flow can be reversed using a four way stop clock. Windingof the cheese should be of samedensity otherwise uneven dyeing results can take place.

The Industry has installed 13 cone dyeing machines of capacity 1000 Kg(3 no.),600 Kg(1 no.),350 Kg(2 no.),125 Kg(2 no.),45 Kg(2 no.),25 Kg(2 no.) and 12 Kg(1 no.)The process of dyeing the yarn is as follows:

- First of all the yarn are prepared for dyeing process in which chemicals are added.In ready for dyeing process firstly three chemicals Leneto HPLF,Jintexy Eco SQ and Clarite G-100 at 80 degree Celsius for 15 minutes are dosed.
- Then, caustic soda flakes and hydrogen peroxide at 110 degree Celsius for 30 minutes are used for converting grey yarn to ready for dyeing yarn.
- Hot wash is done for removing impurities of dyes and chemicals.
- For neutralization of yarn, three chemicals Green Acid, Jintexy Eco SQ, Jintex OEM SPL are used at 45 degree Celsius for 15 minutes.
- Dyeing of the yarn is done for 3 hours at 60 degree Celsius. For reducing hardness of the yarn Ruoogal RLC-SPL and jintexy Eco SQ 30 are used.Further,Bhawali yellow F3R,Jakazol red ML4BL,Cauozol Black B150,Triple refined salts,caustic soda flakes are used for levelling the yarn.
- Cold wash is done for 10 minutes followed by neutral wash at 60 degree Celsius for 15 minutes.Green acid is used to neutralize the yarn to a pH of 5.5.
- Soaping is done at 90 degree Celsius for 15 minutesfollowed by hot wash at 80 degree Celsius for 10 minutes and cold wash for 10 minutes.
- Color fixation is done by finofex chemical at 45 degree elsius for 15 minutes followed by softener at 45 degree Celsius for 15 minutes.

3.17. Utilities and Services

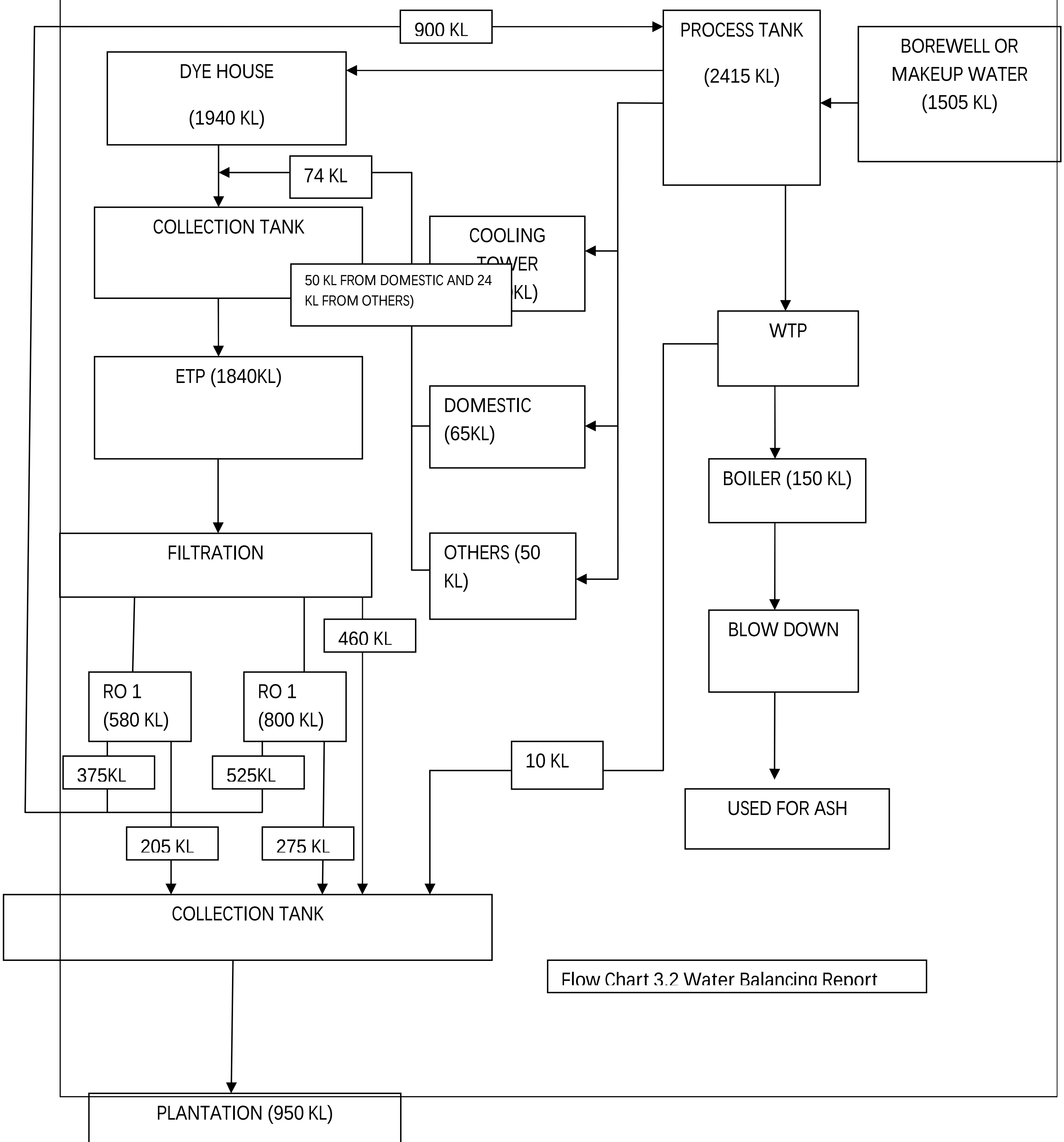
3.1.7.1 Water Supply System

For meeting water requirements for drinking purposes, canteen, washrooms, in process, water is being pumped from two bore wells. At an average 1500 KLD water is pumped from bore well. Electromagnetic flow meters are installed in each bore well to maintain the records of pumped water.

Water Balancing Report is shown in flow chart 3.2 for a single day:

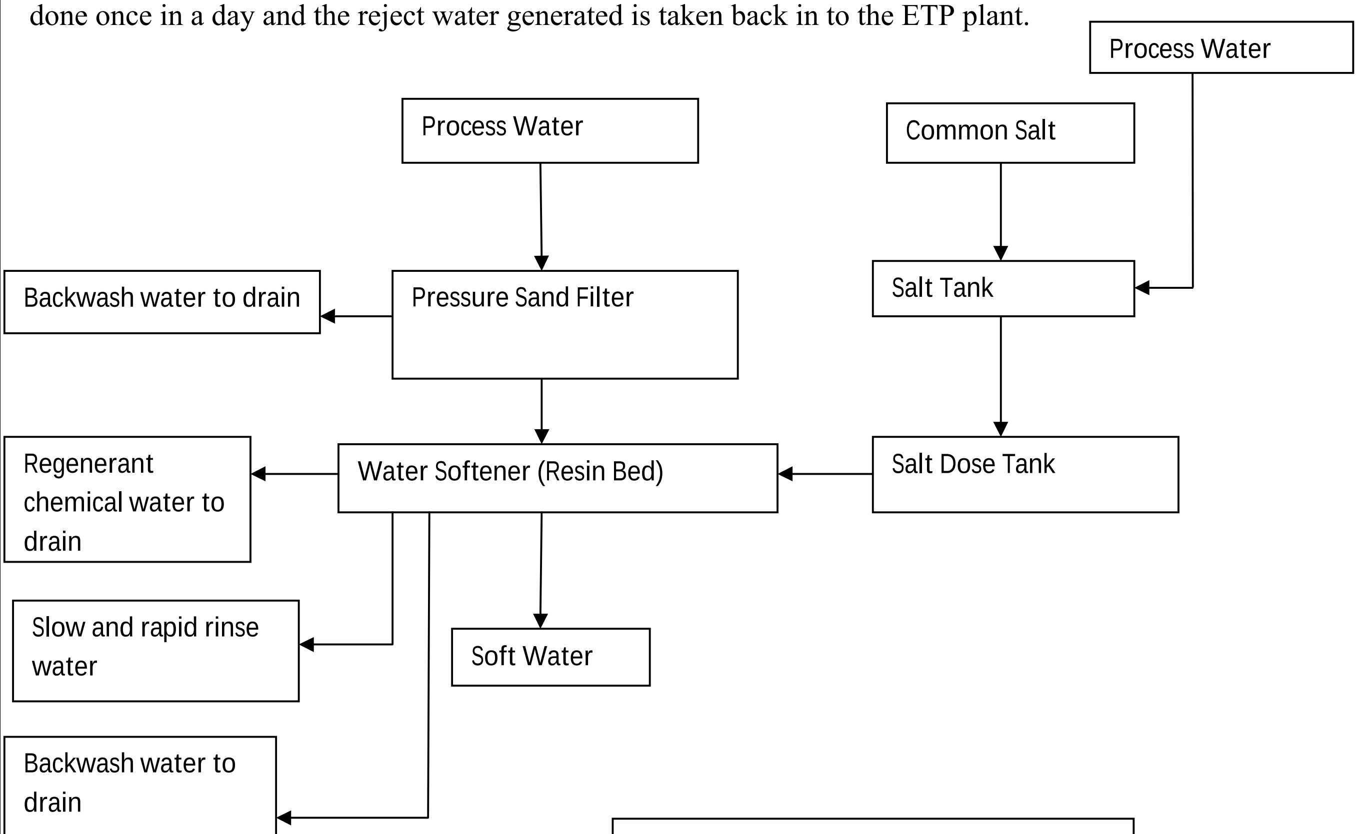
- 1505 KL water is extracted from two bore well and stored in process water tank for meeting water requirements for various purposes like boiler, cooling tower,domestic,dyeing etc.
- 900 KL water is recycled and reuse from reverse osmosis process and feed into the process water tank making the total volume of water 2405 KL.
- From 2405 KL,1940 KL water is used in dye house,200 KL water in cooling tower,65 KL for domestic purposes,50 KL in other processes like in canteen,H.plant etc. and 150 KL water in water treatment plant for use in boiler.
- The wastewater is generated from various processes and drained to effluent treatment plant.1840 KL wastewater reaches the effluent treatment plant which is then treated by various processes.460 KL water after filtration process is feed to reject collection tank and 1380 KL water is feed to reverse osmosis plant.

- A total of 900 KL water is received as RO permit and 480 KL water as RO reject.The RO permit is sent back to process water tank and RO reject to reject collection tank.
- 10KL of water is feed to reject collection tank from water treatment plant of boiler.The blow down water of boiler is used to wash ash.
- A total of 950 KL water is received in reject collection tank which is then discharged to 30 acre plantation area with flow ranging from 30-40 m^3/hr.



Flow Chart 3.2 Water Balancing Report

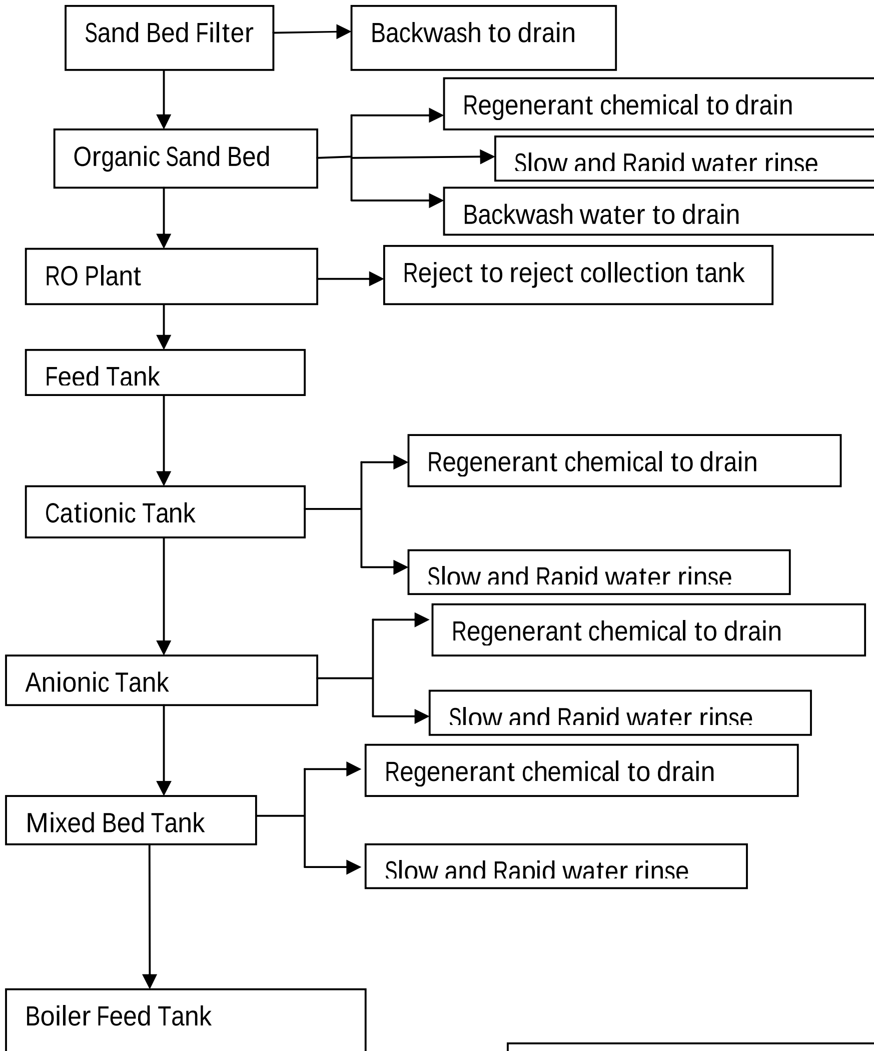
3.1.7.2 Soft Water System: For meeting water requirement in process, water from bore well is passed through softener plant to reduce the hardness of water. Softener plant charging is done by Common Salt (NaCl). Daily dosing of 200 kg common salt is done. Backwashing,Charging,Rinsing of softener plant is done once in a day and the reject water generated is taken back in to the ETP plant.



Flow Chart 3.3 Soft Water Flow System

3.1.7.3 Demineralized Plant

Industry has installed D.M plant of 16000 lt/hr capacity for feeding in to boiler as feed water.Charging of cationic tank is done by hydrochloric acid, anionic tank by Caustic Soda and mixed bed by both the chemicals.Water from DM plant is feed as feed water in boiler. The wastewater generated while charging the plant is sent back to ETP for treatment.



Flow chart 3.4 Demineralized Plant

3.2. Environmental Management

3.2.1 Wastewater Management

Industry has installed Effluent Treatment Plant of 1850KLD capacity. Wastewater generated from various processes is received in ETP plant and treated in following ways:

3.2.1.1 Preliminary Treatment

a. Effluent Receiving Chamber: This unit receives effluent through drains under the effect of gravity. It is equipped with Bar Screens which retains the Fibers coming along with the screen. The Screens are cleaned at regular intervals and the cotton fibers are dumped to garbage area which is then sent to outside to recycling unit.


Fig. 3.1 Effluent receiving chamber

b. Anaerobic Pond: This is a simple water retaining structure having capacity of 3525 KL and retention time of 1.5 days. Anaerobic conditions are maintained in this pond by daily dosing of 10 liter of anaerobic culture. Here, the effluent gets homogenized and cooled. The volatile Organic compounds present in wastewater get converted into carbon dioxide and methane.PH, Total dissolved solids and COD of the effluent gets reduced. At an average 40% COD reduction is achieved through this tank. 4" pump with an average flow of $60m^3/hr$ is installed to pump wastewater from effluent receiving chamber to Anaerobic Pond. Electromagnetic flow meter is installed in inlet of anaerobic pond to monitor flow and thus, quantity of wastewater flowing in the tank. Depth of the tank is 10ft and freeboard provided is 0.5 meter.

Fig 3.2 Inlet and Outlet of Anaerobic pond

c. Collection Tank: dimensions The effluent from outlet of anaerobic tank is feed in to a collection tank of 150KL capacity which is then feed to the next operation by virtue of


Fig 3.3 Collection tank

d. Equalization tank: Aeration is provided in this 730 KL tank to maintain aerobic conditions as dissolved oxygen level is nil in the anaerobic tank.


Fig 3.4 Equalization tank

3.2.1.2 Primary Treatment

a. Flash Mixing Tank: Dosing of various chemicals is done in this tank. Dosing is first prepared in Dosing tanks 3 times a day i.e. per shift and then, feed with the help of dosing pumps. Dosing rate of dosing. Coagulant used is Poly Aluminium Chloride.
b. Flocculator Tank: Mega Plus 101 is a polyamine compound used as flocculant for forming flocs.Solid content of Mega Plus 101 is 40-50% and specific gravity is in between 1-2.Cationic Polymer is used to settle the flocs.

   Dosing of chemicals are calculated on daily basis by Jar test using formula

   Dose in ppm = %age of stock solution*dose (ml)*10^6/volume of solution*100

   On an average 25ppm PAC dosing, 50ppm Mega plus dosing and 2 ppm poly dosing is used.


Fig 3.5 Flash mixing tank

c. Primary Clarifier: Wastewater flows very slowly through 527KL circular primary clarifier consisting of a centre well. Most of the fine settable solids settle down to the tank bottom. Scrapers move the settled solids (sludge) to sumps at one end of the tank.

   Sludge from the sump is then transferred to Sludge thickener for further treatment.


Fig 3.6 Primary Clarifier

3.2.1.3 Biological Treatment

a. Aeration Tank: The effluent is treated biologically. In this unit Bacterial mass is kept alive as an impurity removal agency. Urea, DAP and Jaggery is added to make bacteria alive. Continuos aeration is also provided by Blowers capacity. These Bacteria removes the BOD and COD from the effluent. MLSS concentration (2000-4000mg/l) is maintained in the tank by draining out the excess bacteria whenever required. MLSS concentration is determined by settling process and by dry method. MLVSS concentration is also determined twice in a week. Dissolved Oxygen (1.2-1.4mg/l) is maintained in the tank. Capacity of this tank is 1730KL (864KL*2).Sludge volume index is measured on daily basis which comes out to be in between 80-100.MLVSS/MLSS ratio is in between 0.6-0.7.Total Alkalinity comes out to be <100 mg/lt.

Fig 3.7 Aeration Tank

b. Secondary Clarifier: (capacity 815KL) This tank is provided to retain the Bacterial Sludge by virtue of Gravity Settling Process. And the Clear water is collected from the top and transfer to the next step. 33% of bacterial sludge is recycled back to aeration tank and remaining is taken out as sludge slurry.

Fig 3.8 Secondary Clarifier

c. Clear Water Tank: (Capacity 40KL) Clear Water from secondary clarifier is feed to clear water tank in which Sodium Hypochlorite is dosed to kill any bacteria coming from aeration tank. From this tank the treated water is feed into tertiary treatment.

Fig 3.9 Clear water tank

3.2.1.4 Tertiary Treatment

50% of the water from clear water tank is feed to 1^{st} filtration unit which is comprised of:

a. Sand Bed Filter :(capacity: 18KL) This is a Pressure Sand Bed filter Type filter which removes all the turbidity due to suspended solids. This Unit is filled with silica stones of different size arranged in different layer.
b. Organic Scavenger Bed: This is again a pressure vessel, filled with special type of anionic resin which make treated water fit for feeding it to the membrane based Re-cycling system.

   OSB and SBF is backwashed once in every 24hours. SBF is charged through adding caustic soda and Common salt.OSB is charged by adding HCL. The wastewater generated is sent back to the ETP inlet.

Fig 3.10 Filtration Unit

3.2.1.5 Recycling and Reuse by Reverse Osmosis Process

Industry has installed RO Plants of capacity 1500 KLD capacity.55-65% RO efficiency is maintained in the process. Polyamide thin-film composite RO membrane is used with maximum operating temperature 45 degree Celsius and maximum element pressure drop is 15 psig.

RO cleaning is done once in every 12 hours. Membranes are first washed with Hydrochloric Acid. To avoid damage, it is then cleaned with alkali and caustic soda. Then, Biocleaner and antiscalent is dosed into the membrane.

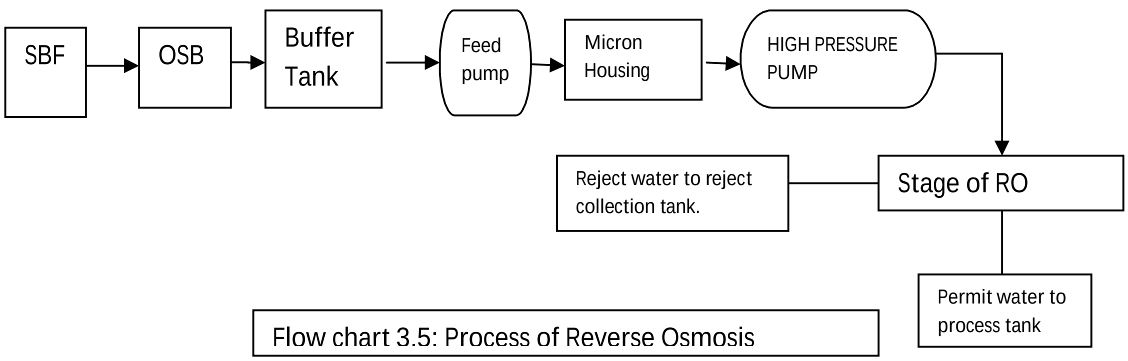
Backwash of RO membrane is done once in 24 hours with water of Clear water tank and the water generated from cleaning and backwashing is discharged to plantation area.

CIP (clean in place) is also done to obtain good cleaning results and subsequently increase the lifetime of reverse osmosis membrane elements.

The process of reverse osmosis carried in the industry is as follows:

• Wastewater from Organic Scavenger Bed is pumped tangentially to a micron housing consisting of 5 micron size filter to remove any suspended particles and microorganisms left in the wastewater. It is used as a pretreatment for Reverse Osmosis process.

• Wastewater with the help of High Pressure Pump is then feed in to RO. Wastewater is treated through Reverse Osmosis process after which permit water is passed to a process tank and reject water to reject collection tank.



Flow chart 3.5: Process of Reverse Osmosis

Fig. 3.11 Reverse Osmosis Units

50% water from clear water tank is feed to second filtration unit and then to reject collection tank. The water from reject collection tank is then discharged to 30 acre plantation area.

Fig 3.12 Reject water discharge in plantation area

Fig 3.13 Online Monitoring System in ETP outlet

3.2.2 Air Pollution Control

Industry is equipped with two numbers of boilers of 8 ton and 12 ton capacity in which rice husk is used as fuel. On an average, 170 ton of steam is generated per day which uses approximately 40 ton of rice husk. Condensate recovery is maintained in between 50%-60%.Number of blow down is 2-Boilers are equipped with separate cyclone separator as Air Pollution Control Device (APCD) with common stack of adequate height and diameter. Id fans suck flue gases and are discharged through stack. Top and bottom diameter of stack is 1.2m and 2.4m respectively.

The Industry has also installed online continuous monitoring meter for measurement of SPM and is connected through CCTV cameras for online surveillance.

Fig 3.14 Online monitoring system for measurement of SPM in boiler stack

3.2.3 Hazardous and Solid Waste Management

3.2.3.1 ETP sludge

Sludge is produced during coagulation/flocculation process which is discharged to a sump. The sludge is then sent to sludge thickener. Then, the sludge is fed to decanter for dewatering process.Cationic polymer is used for dewatering. After dewatering the sludge is dried under sunlight, packed in high density polyethylene bags (HDPE) and stored in (19*14*12 dimension) sludge room. The sludge is sent to Nimbua Greenfields; Derrabassi for further treatment. Although quantification could not be done in the study, as per the management sludge of quantity to a tune 170 kg/day is produced, stored and further sent for the disposal.

Fig 3.15 Decanter   Fig 3.16 Sludge room

3.2.3.2 Ash and Spent Oil

On an average 8TPD Ash is generated from boiler which is sent to authorized dealer.Spent oil (0.2 lt/day) is generated which is stored in sludge room and sent to authorized dealer like Shree Ganesh Udyog.

3.2.3.3 Non-hazardous Solid Waste

The Solid waste generated from the process like yarn cones,cotton fibers,plastics,polybags etc. are disposed to an area covered with fence.From this area,the material is sent outside to a recycling unit.The waste generated from domestic activity is sent to municipal cooperation of that area for treatment.

Chapter 4: Results and Discussion

Environment Analysis of T.C Terry Tex ltd is done during June 2015- June 2016 period.All the environment components (air,water,solid waste) were analyzed and monitored.All standard procedures are followed during analysis.The Results are the averages of various samples analyzed.

4.1 Treated water quality of Demineralized plant

Demineralized water is used as feed water for boiler and the parameters of demineralized water is very important to avoid scaling and other problems in boiler.The Paramteres of demineralized water are checked on daily basis and following results are obtained:

S.No.	Parameter	Method	Results
1.	TDS	TDS meter	<1 ppm
2.	pH	pH meter	6-7
3.	Total Hardness	Standard Method	0ppm
4.	Conductivity	Conductivity meter	<1 microsimens/cm

4.2 Analysis Results of ETP inlet

S.No.	Parameter	Method	Results
1.	pH	IS:3025(P-11)	8.16
2.	TDS(mg/liter)	IS:3025(P-16)	1506
3.	TSS(mg/liter)	IS:3025(P-17)	300
4.	BOD (3 day at 27 degree celsius) (mg/liter)	IS:3025(P-44)	350
5.	COD(mg/liter)	ALPHA 22nd edition	720
6.	MLSS(mg/liter)	Gravimetric Method	3000-4400
7.	MLVSS(mg/liter)	Gravimetric Method	2000-3000
8.	MLSS/MLVSS ratio	-	0.4-0.7
9.	Dissolved Oxygen(mg/liter)	Winkler's method	1.0-1.4

4.3 Analysis of ETP outlet water

S.No.	Parameter	Method	Results	Standard
1.	pH	IS:3025(P-11)	7.15	5.5-9.0
2.	TSS(mg/liter)	IS:3025(P-17)	56	100
3.	TDS(mg/liter)	IS:3025(P-16)	1859	2100
4.	COD(mg/liter)	APHA 22nd edition	90	250
5.	BOD(3 days at 27 degree celsius) (mg/liter)	IS:3025(P-44)	22	30

4.4 Ambient Air Quality Monitoring

Location of Sampling Point:Near Boiler

Duration of monitoring:1446 minutes

Average flow rate of sampling:1.16m^3/min

Volume of air sampled:1559.93 m^3

Average Ambient Temperature:39 degree celsius

S.No.	Parameter	Result	Standard	Method
1.	Sulphur dioxide(microgram/cubicmeter)	28	80	Alpha – Air(Improved West&gaeke method
2.	Nitrogen dioxide(microgram/cubicmeter)	32	80	Modified Jacob&Hochheiser Method
3.	Particulate matter(PM10)(microgram/cubicmeter)	94	100	Gravimetric
4.	Particulate matter(PM2.5) (microgram/cubicmeter)	50	60	Gravimetric
5.	Carbon monoxide(mg/cm^3)	1.8	4	IS:5182(P-10)

4.5 Stack Emission of DG set 1

Sample of Stack emission of DG set was collected and analyzed:

Stack height from roof: 6meter

Diameter of stack:25 cm

Sampling Duration:60 minutes

Flue gas temperature,average:276 degree celsius

Flue gas velocity,average:15.37m/s,

Volumetric Flow rate:2524.68Nm/hr

Ambient Air Temperature:39degree celsius

S.No.	Parameter	Test Method	Results	Standard
1.	Particulate matter(g/kw-hr)	IS : 11255	0.12	0.3
2.	Carbon monoxide(g/kw-hr)	IS : 13270	1.5	3.5
3.	Oxides of nitrogen(NO_2)+hydrocarbons(g/kw-hr)	ALPHA-Air	1.6	4.0

4.6 Stack Emission of DG set 2

Sample of Stack emission of DG set was collected and analyzed:

Stack height from roof: 6meter

Diameter of stack:25 cm

Sampling Duration:50 minutes

Flue gas temperature,average:216degree celsius

Flue gas velocity,average:17.77m/sec

Volumetric Flow rate:2918.90Nm/hr

Ambient Air Temperature:39 degree celsius

S.No.	Parameter	Result	Standard
1.	Particulate matter(g/kw-hr)	0.11	0.3
2.	Carbon monoxide(g/kw-hr)	1.4	3.5
3.	Oxides of nitrogen(NO_2)+hydrocarbons(g/kw-hr)	1.6	4.0

4.7 Stack Emission of Boiler

S.NO.	Test Parmeter	Units	Results	Standards	Test Method
1.	Stack Height	Meter	30		
2.	Stack Diameter	Meter	1		
3.	Ambient Temperature	˚C	18		IS 11255(P-3)2003
4.	Temperature of Stack gases	˚C	107		IS 11255(P-3)2003
5.	Flow rate of stack gases	Nm3/hr	10.05		IS 11255(P-3)2003
6.	Velocity of Stack Gases	m/sec	22273		IS 11255(P-3)2003
7.	Sulphurdioxide(SO_2)	mg/Nm3	45.61	45.61	IS 11255(P-2)2003
8.	Nitrogen Dioxide(NO_2)	ppmv	29.38	710	IS 11255(P-7)2005
9.	Carbon dioxide(CO_2)	%	8		IS 13270(P-7)2005
10.	Particulate Matter(PM)	mg/Nm3	72.26	75	IS 11255(P-3)1985

Chapter 5:Summary and Recommendations

By analyzing all the parameters of water,air,Hazardous and Non-Hazardous waste it has been found that the Industry is in complaince with

- Water (Prevention and Control of pollution) Act,1974
- Air (Prevention and Control of pollution) Act,1981
- Hazardous waste (management and handling) rules,2008

However,the Industry can work on water minimization techniques to minimize the quantum of water produced from the process as wastewater by employing techniques like bioscouring.Dyes and chemicals can be replaced with less harmful chemicals which can result in less toxic wastewater.

The Industry should work on Rainwater Harvesting as the soil has low water retention capacity and rainwater conserved can be reused in various processes.

For conservation of Energy,the Industry should work on more Non-conventional Sources of Energy.

Chapter: 6 References

Tucker, Barbara M. 'The Merchant, theManufacturer, and the Factory Manager: The case of Samuel Slater', Business historyreview, vol.55, No.3 (autumn, 1981), pp.297-313 in JSTOR.

K.Rajkumar, HS Freeman "Environmental chemistry of dyes and pigments", 2005

OD olukami,AA Osuntoki,GO Gbenle "Textile effluent biodegradation potential of textile effluent adapted and non-adapted bacteria",2006

S kim,C park,TH Kim,J Lee,SW Kim "COD reduction and decolorization of textile effluent using a combined process",2008

P Nigam,G Mc Mullan,IM Banat,R Merchant "Decolurisation of effluent from the textile industry by a microbial consortium",1996

DR Kashyap,PK Vohra<S Chopra,R Tewari"Applications of pectinases in the commercial sector",2001

V Khandegar,AK Saroha "Electro coagulation for the textile industry",2001

DT Sponza"Application of toxicity tests into discharge of the textile industry",2003

VK Gupta,A Mittal,R Jain,M Mathur"Adsorption of Safaranin-T from wastewater using waste materials activated carbon and activated rice husks",2006

AK Verma,RR Dash,P Bhunia"A review of chemical coagulation/flocculation technologies for removal of color from textile wastewater",2012

XC Jin,GQ Liu,ZH Xu"Decolorization of a dye industry effluent by Aspergillus Fumigatus"

B.Ramesh Babu;A.k. parande; S.Raghu; and T.Prem Kumar(2007).Textile Technology-cotton textile processing: waste generation and effluent treatment. The journal of Cotton Science 11(2007)141-153.

N Mohan,N Balasubramanian"Electrochemical treatment of simulated textile effluent",2001

C Wang,A Yediler,D Lienert,Z Wang,A Kettrup"Toxicity evaluation of reactive dyestuffs,auxillaries and selected effluents in textile industry to luminescent bacteria Vibrio fischeri",2002

A Alinsafi,M Da Motta,S Le Bonte"Effect of variability on the treatment of textile dyeing wastewater by activated sludge",2006

C Phalakornkule,S Polugumhang,W Tongdaung"Electro coagulation of blue reactive,red disperse and mixed dyes,and application in treating textile effluent",2010

M Ramya,B Anusha,S Kalavathy”Biodecolorizatio and bio degradation of reactive blue by Aspergillus sp.”,2007

SH Lin,CF Peng”A continuos Fenton process for treatment of wastewater”,1995

M Sathiya,S Periyar,A Sasikalaveni”Decolrization of textile dyes and their effluents using white rot fungi”,2007

P Nigam,IM Banat,D Singh,R Merchant”Microbial process for the decolorization of textile effluent containing azo dyes,diazo and reactive dyes”,1996

N Kirby,R Merchant”Decolorization of synthetic textile industry by Phlebia tremellosa”,2000

K Santhy,P Selvapathy”Removal of reactive dyes from wastewater by adsorption on coir pith activated carbon”,2006

Collier, Ann M(1970),A Handbook of Textiles, Pergamon Press,p.258.

R Sanghi,B Bhattacharya,A DixitmV singh”Ipomoea dasysperma seed gum: An effective natural coagulant for the decolorization of textile dye solutions”,2006

D Mantzavinos,E Psillakis”Enhancement of biodegradibilty of industria; wastewaters by chemical oxidation pre treatment”,2004

VK Gupta,I Ali,D Mohan”Equillibrium uptake and sorption dynamics for the removal of a basic dye using low cost adsorbents”,2003

SS Vaghela,AD Jethva,BB Mehta “Laboratory studies of electrochemical tretamnet of industrial azo dye effluent”,2005

B Vander Bruggen,B Daems,D Wilms”Mechanisms of retention and flux decline for the nanofiltration of dy baths from the textile industry”,2001

tctl.in/company-profile

Smelser; Neil J.Social Change in the Industrial Revolution: An application of Theory to the British Cotton Industry(1959).

Sheng H.Lin,Chi M.Lin” Treatment of textile waste effluents by ozonation and chemical coagulation”,1993

Elias Abdullah,Tzanko Tzanov,Silgia Costa “Decolorization and Detoxification of textile dyes with laccase from Trametes hirsute”,2000

A Villegas Navarro,Y Rami,MS Salvador “Determination of wastewater LC50 of the different process stages of the textile industry”,2001

K lin,Vinodgopal,PV Kamat “combined electrochemistry with photocatalysis”,2002

M Pia,A Caetano”Membrane Technology: Application to wastewater”,2003