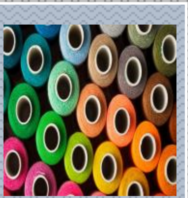




Charter for Water Recycling & Pollution Prevention in Textile Industries in Ganga River Basin

Save Water for Next Generation

Central Pollution Control Board, Delhi

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Charter for Textile industry –
Prevention of pollution in Basin area of River Ganga

Preamble

Textile industry is characterized by the large volume of water required for various operations with variety of chemicals. No doubt, Indian Textile industry is a significant contributor to national economies, by way of large generation of employment as well as earning of foreign exchange. Its pollution impact is a big concern to be reviewed.

In order to reduce impact of pollution especially at Ganga / river Basin area, Central Pollution Control Board formed a team of experts to study & set standard norms for Textile industry which can reduce pollution level of water and mother earth.

Along with statutory requirements, the charter is focused to formulate a system to improve environmental impacts in continuous manner. This charter suggests all stakeholders to utilize three tools for improvements.

1) **BMT (Bare Minimum Technology)** is focused on required minimum technology for running a Textile production house. This will help to reduce pollution level at the end of pipe line. This is mandatory for every industry. This is also focused on control over water consumption and also insisted to reduce water consumption per kg of production by implementation of better technology.
2) **BMP (Best Management Practices)** is optional but it will reduce cost of production along with reduction in use of natural resources. These practices will improve productivity & Quality at lower cost. BMP is a proven technology which can improve the efficiency and help in consistent quality.
3) **CMS (Chemical Management System)** is a system which will reduce pollution at source. It if focused to reduce pollution by selection of right chemicals, suggest using correct procedures during processing. This is a systematic method to reduce pollution by avoiding hazardous chemicals at source.

Textile industry generates many waste streams, including liquid, gaseous and solid wastes, some of which are known hazardous and harmful to human and nature. Several measures for pollution control are discussed in detail including ‘End-of-pipe’ technologies for reduction of pollution level through waste water treatment.

This charter on pollution control in Textile industry is focused on various aspects of pollution reduction by treatment at end of the pipelines as well as also helps in reducing consumption of natural resources & usage of chemicals by proper selection of chemicals & developing green technology. All the three tools will help to reduce ultimate pollution load on mother earth as well as reduce consumption of natural resources. In future this may lead to zero waste concept in Textile industry.

1. Prologue

The Indian textile industry is one of the important and oldest industrial sectors of the country which has shown tremendous growth potential in past few years. Indian textile industry is marked with diversity features. Indian textile industry uses wide variety of raw materials & processing technology which makes difficulty in process of standardization in production process. The industry also uses a wide spectrum of technology, which varies among industries as well as within the industry. The major challenges being faced by Indian textile industry are improvement in resource efficiency, sustaining in global competition, and addressing the environmental issues & challenges. Although, in last decade Indian textile industry has implemented various steps to upgrade technology and implementation of cleaner production initiative leading towards improvement in various indicators such as specific energy consumption, specific water consumption and specific effluent generation, issues of technological obsolescence and lack of standardization in production activity. It is essential to be addressed urgently in a mission mode for the sustainable growth of textile industry along with environmental compliance and in global competition.

During 2012-2013, CPCB implemented a 'Charter for Water Recycling & Pollution Prevention in Textile Industries in Ganga River Basin' in five identified clusters of textile industries located in Uttarakhand and Uttar Pradesh.

New charter is based on basics of reduction of industrial pollution at river Ganga & which can be transferred to other areas in Indian continent. The charter is focused on

a) Participatory approach
b) Bench marking of the processes and waste-minimization /cleaner production options
c) Technology augmentation and process standardization
d) Reduce, recycle and reuse of effluent from various streams without and with treatment (partial or full treatment) for selected processes i.e. management of water utilization and waste water management at ETP.
e) End-of- the- pipe treatment for existing units with retro fitting of recycle and reuse options
f) Effective and continuous monitoring program.

Impact assessment of the charter has shown tremendous improvement in the environmental status of textile industry in the identified clusters. Now it is time to implement the charter for all the textile industries in the Ganga / river Basin states (Uttar Pradesh, Haryana & Delhi)

2. Indian Textile Industry & categories

Textile industry in India are in various forms ranging from small scale hand-looms, to scattered garmenting & in organized clusters, units having automated modern machines for manufacturing fibers to fabrics & garment making. It includes different types of natural fibers such as cotton, silk, wool, synthetic (mainly Polyester, Nylon and Acrylic) as well as mixtures of these fibers are used in Indian textile industry. Processing of textile comprise various processes like –

a) Spinning & Fiber processing
b) Sizing, Weaving, Knitting
c) Processing (Bleaching, Dyeing, Printing & finishing)
d) Industrial Textile / Garmenting

The process flow diagram for a typical textile mill is shown in Figure 1.

On the basis of raw materials to finished products, the textile mills can be grouped as composite mills where final products (Garment or cloth) are produced by the use of raw material (fibers) and these are large units where huge investments are required. In addition to this, there are certain small segments of large industry called as ginning, spinning, weaving, processing, garmenting, laundry etc. Above processes can be further categorized as under depending upon difference in production lines & raw material involved.

1) Cellulosic Material (Woven, Knitting, Non-woven)
2) Technical Textiles Manmade Material (Woven, Knitting, Non-woven)
3) Wool/Silk Material (Woven, Knitting, Non-woven)
4) Cotton/Synthetic Mixed Material (Woven, Knitting, Non-woven)

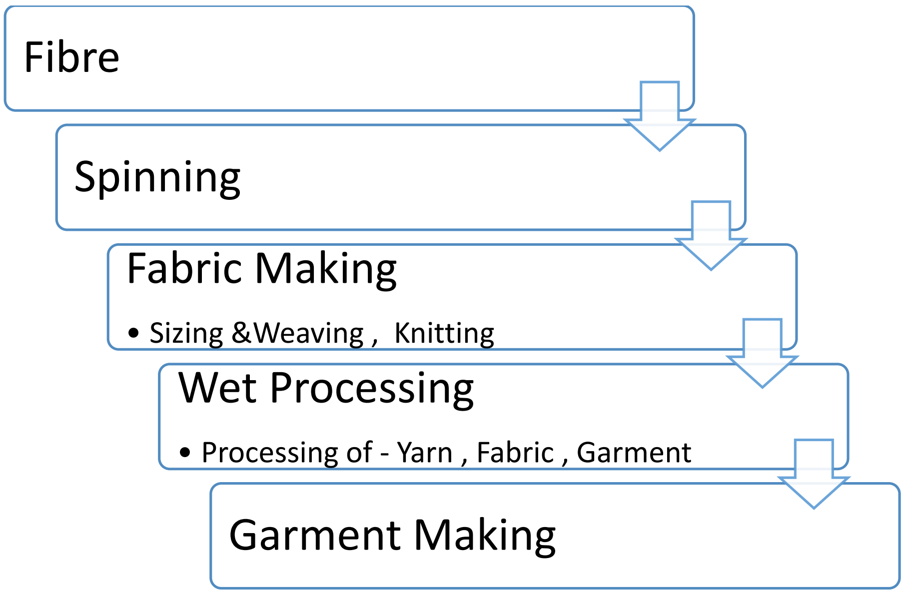


Figure 1. Generalized process flow diagram for a typical textile unit

Above mentioned broad segments may have various processes depending upon the end-product. For example, typical processing steps involved in producing different end-products from cellulosic and man-made fibers and wool and silk can be categorized as given in Table 1 and 2.

Table 1: General Processing Steps for Cellulosic Fiber, Man-Made Fiber, Cellulosic + Man Made Fiber Blend based, Carpet and Technical Textiles					
Steps	**Woven**	**Hosiery**	**Hosiery**	**Carpet / Tech Textile**	**100% Synthetic & others**
Fibers used	**Cellulosic & Man-made Blends**	**Cellulosic**	**Cellulosic & Man-made Blends**	**Mix**	**Polyester / Acrylic/ Others**
Ginning Industry	Ginning	Ginning	Ginning	Ginning	
Spinning Industry	Carding/ Combing Blending	Carding/ Combing	Carding/ Combing Blending	Carding/ Combing Blending	
	Spinning	Spinning	Spinning	Spinning	Spinning
Fabric Making – Loom Shed	Sizing			Weaving	Weaving
	Weaving	Knitting	Knitting	Non-Woven	
Wet Processing Industry / Process-House	De-sizing				
	Scouring / Bleaching	Scouring / Bleaching	Scouring / Bleaching	Scouring / Bleaching	Scouring (Removal of lubricants)
	Dyeing / Printing	Dyeing / Printing	Dyeing / Printing	Dyeing / Printing	Dyeing / Printing
	Finishing	Finishing	Finishing	Finishing	Finishing
Garment industry	Garmenting	Garmenting	Garmenting	End Product	Garmenting
Laundry	Garment washing	Garment washing	Garment washing		Garment washes if required

Table 2: General Processing steps for wool & silk industry	
Fibre cleaning	Scouring De-gumming, Bleaching
Fibre colouring	Dyeing
Spinning	Blending
	Spinning
Fabric making	Weaving/ Knitting
Wet Processing	Scouring / Bleaching
	Dyeing / Printing
	Finishing
Garment industry	Garmenting / End Product
Laundry	Garment washing

The process flow diagrams for various textile mills including carpet units are shown in Figures 2 to 7 given below,

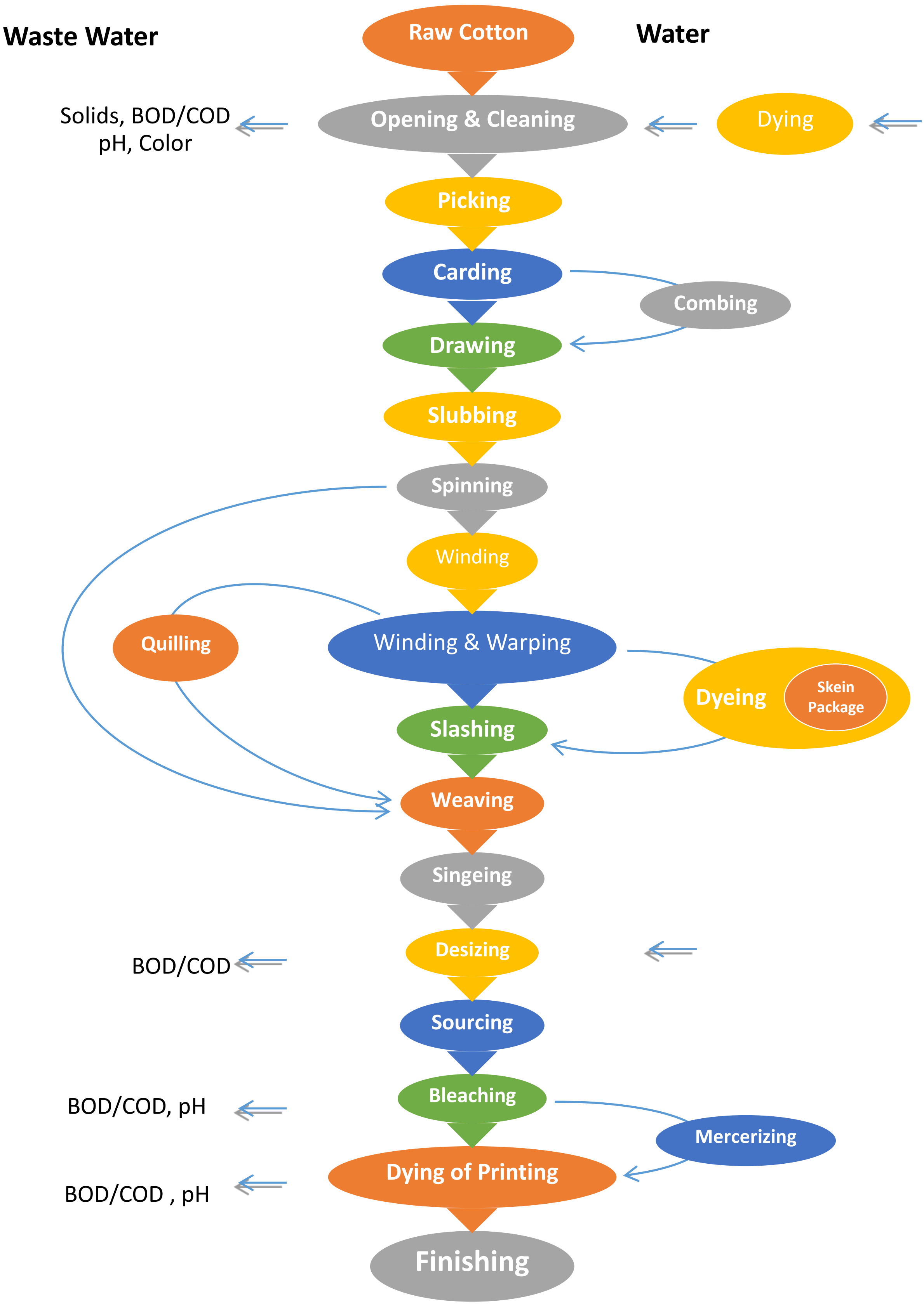


Fig. 2 Schematic flow-sheet of a typical cotton textile mill

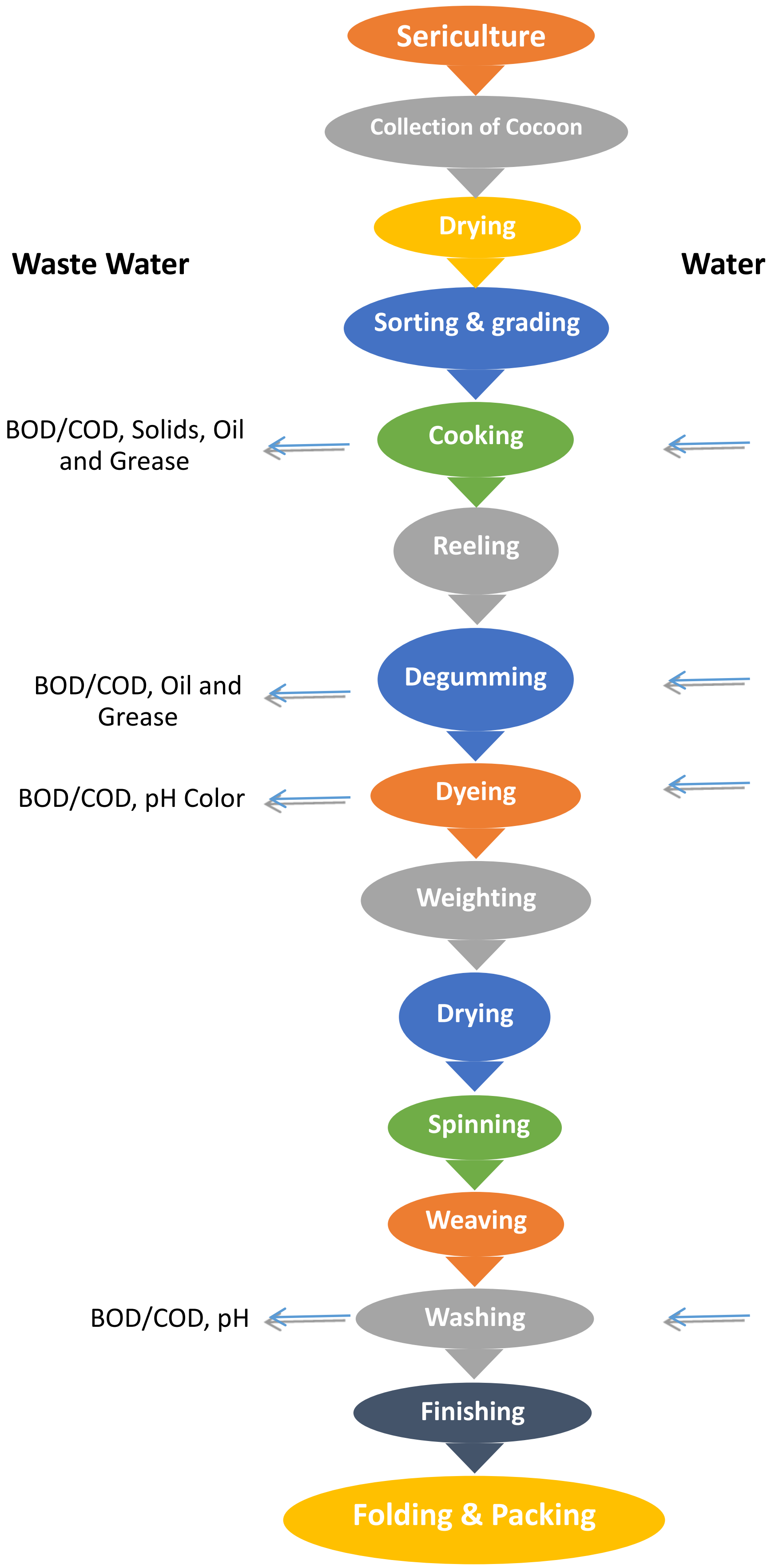


Fig. 3 Schematic flow-sheet of a typical silk textile mill

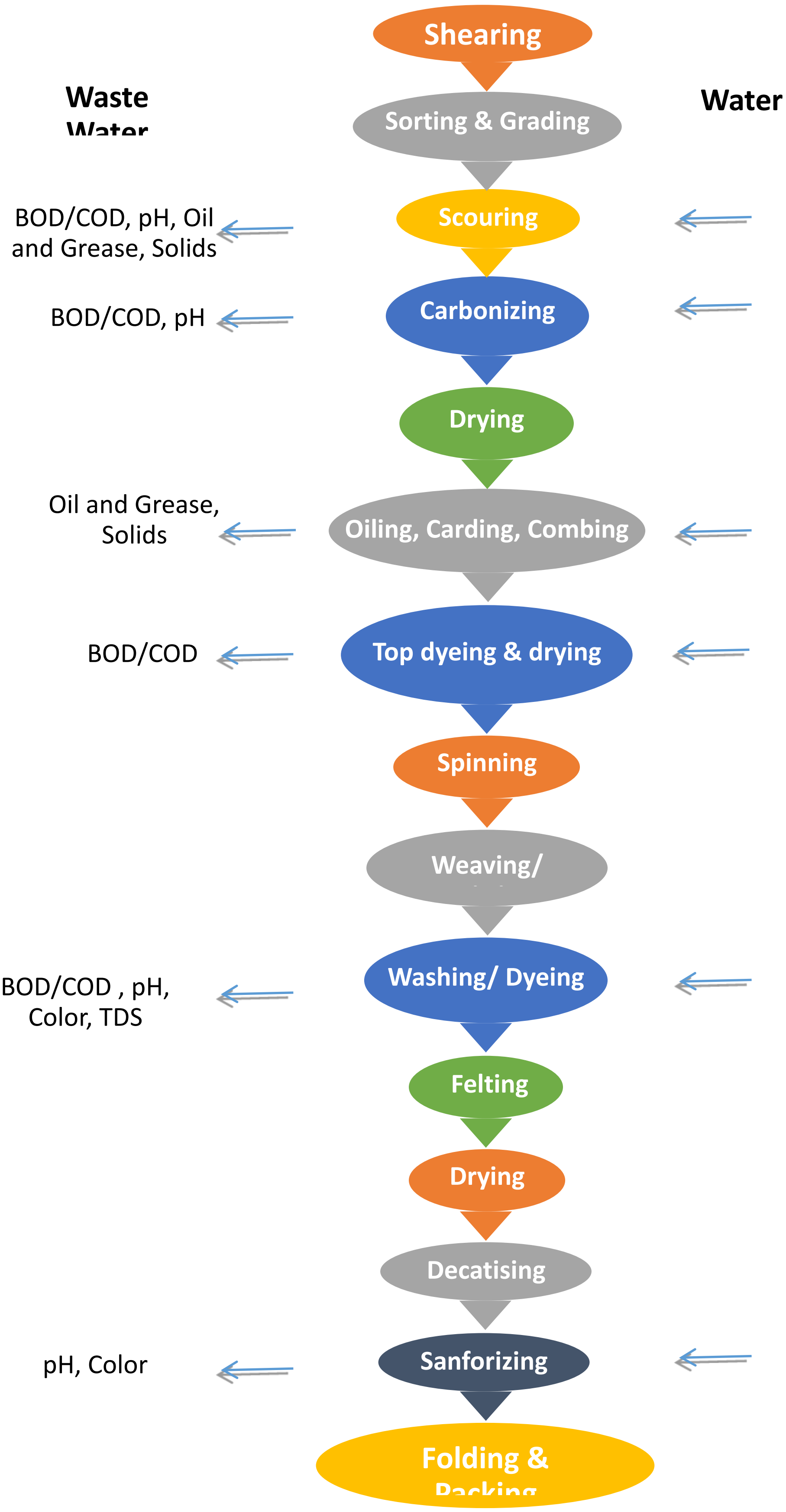


Fig. 4 Schematic flow-sheet of a typical wool fabric manufacture mill

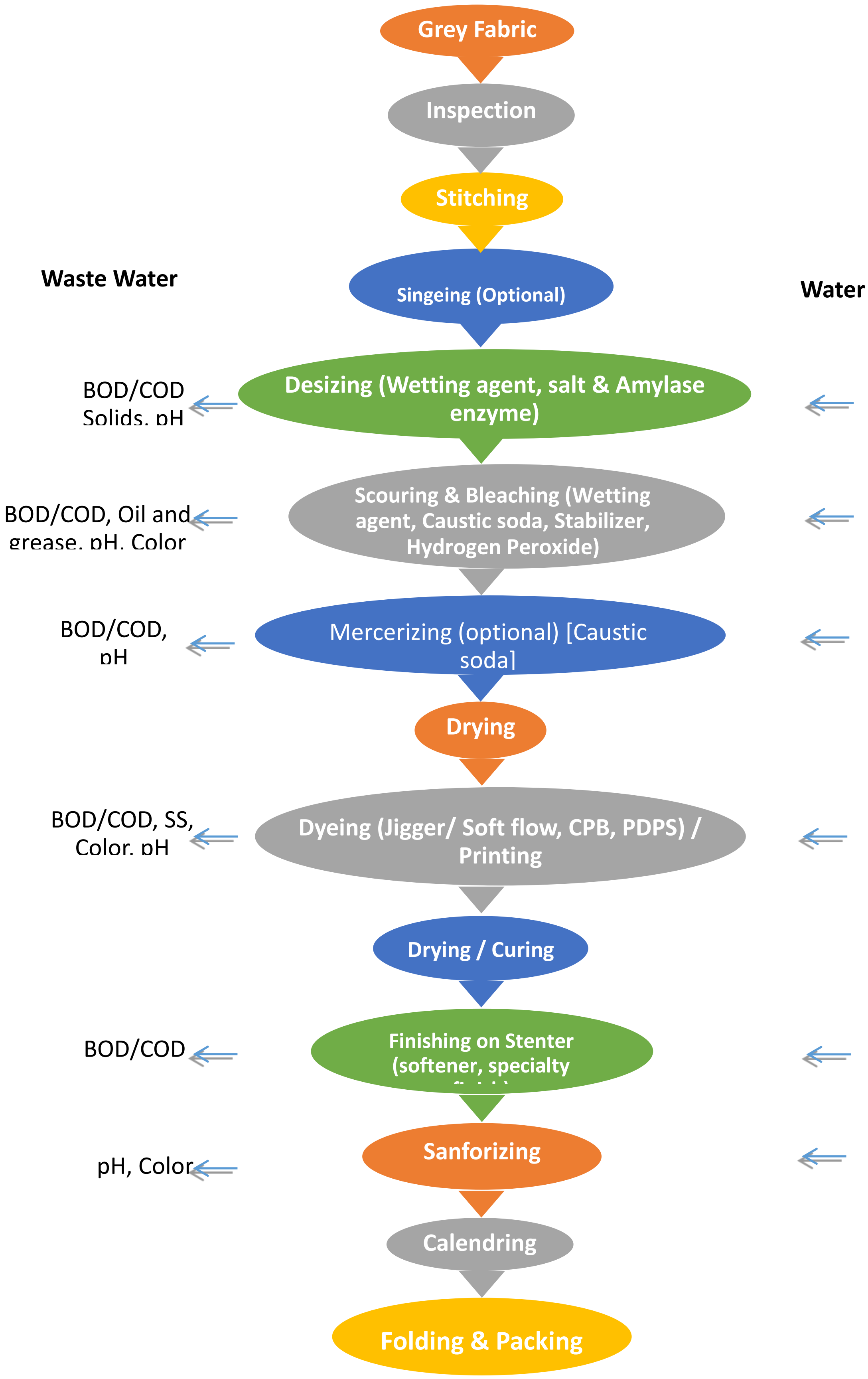


Fig. 5 Schematic flow-sheet of garment manufacture from 100% grey cotton fabric

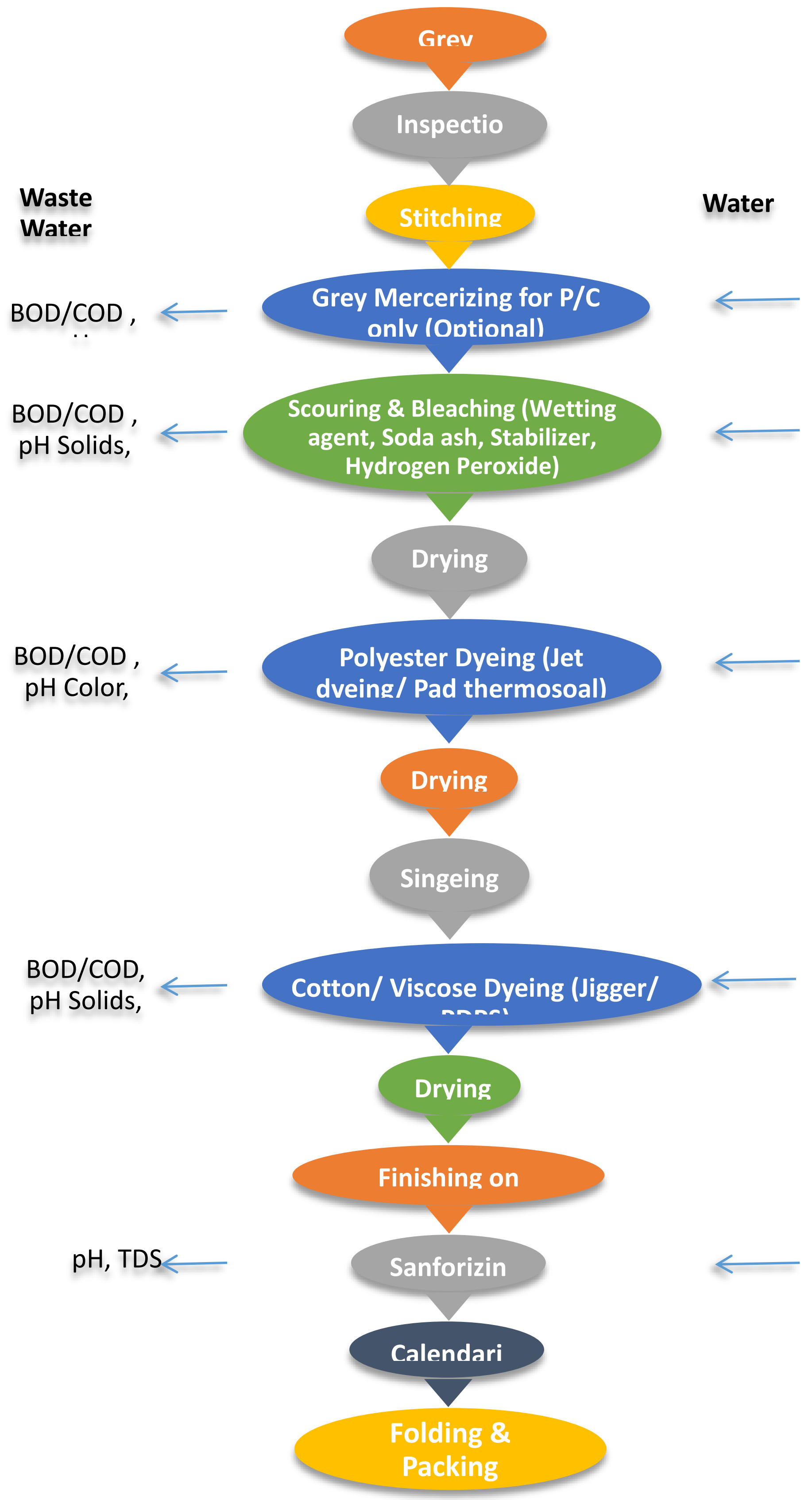


Fig. 6 Schematic flow-sheet of garment manufacture from gray polyester + cotton & polyester +

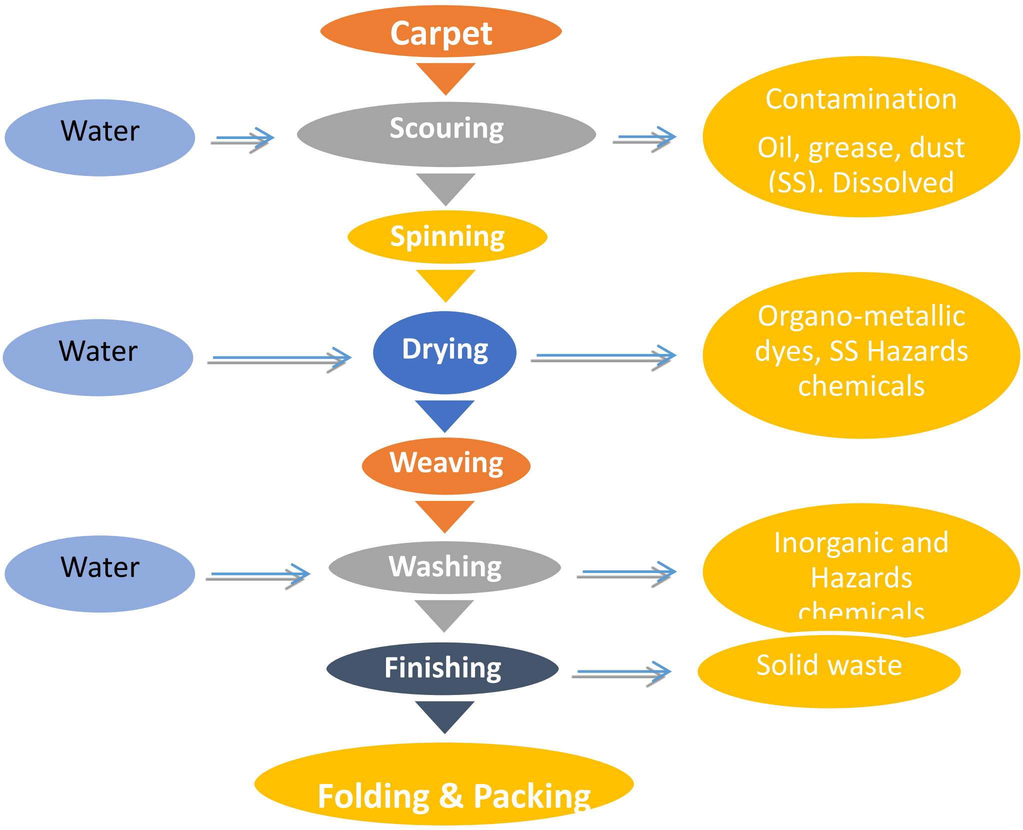


Fig. 7 Schematic flow-sheet of a typical carpet manufacturing process

2.1 Textile Processing Operations

Typical textile processing operations involve over a dozen unit operations (or steps) and require nearly equal number of machines. Table 3 gives the typical list of various unit operations together with their application. Table 4 gives the list of typical machines and the operation for which these are used.

In Table 3 Various Unit Operations in textile processing & their applicability is mentioned in table no 3. All processing units may not essentially follow all the operations. Depending upon end-product & desired quality requirement, some operations may be combined or skipped.

Figures 2 to 4 show the flow diagrams for typical composite Cotton, Silk and Woolen textile mills for processing of raw cotton, silk and wool to finished textile products, respectively. Figures 5 and 6 show the process flow diagrams for garment manufacture from 100% grey cotton fabric and grey polyester + cotton and polyester+ viscose fabric, respectively. Figure 7 shows the typical process flow diagram for carpet manufacture. In each case the operations requiring fresh water and generating wastewater are also indicated.

Table 3 – Various unit operations and the substrates on which they are used		
S. No.	**Process Name**	**Applicability on Substrate**
1.	Desizing (Enzymatic process)	Cotton Fabric / Garments
2.	Desizing (Non enzymatic process)	Cotton Fabric / Garments
3.	Kiering / Scouring	Cotton Grey yarn & fabric
4.	Scouring- cum- bleaching	Cotton Grey Yarn and / Fabric
5.	Mercerizing	Cotton Grey Yarn and / Fabric
6.	Bleaching	Cotton Grey Yarn and / Fabric, Silk Fiber / Yarn , Wool Fiber/Yarn ,
7.	Neutralization / souring	Cotton Fabric / Yarn
8.	Carbonization	Blend Fabric (to burn cellulosic part)
9.	Dyeing	All types of substrates- Cotton , Wool, Polyester, Acrylic, Silk, Viscose
10.	Reduction Clearing	Polyester.
11.	Anti-static finish	Polyester, Acrylic
12.	Soaping	Cotton, Wool, Polyester, Acrylic, Silk, Viscose.
13.	Finishing	Cotton , Wool, Polyester, Acrylic, Silk
14.	Printing (Screen , Rotary , Roller & Block)	Fabric - Cotton , Polyester, Silk, Regenerated cellulose

Table 4 Textile Processing Machines and Operations of their Use		
S. No.	**Machine Name**	**Wet Process Operation**
1	Kier	Kiering, Boiling, Scouring
2	Padding mangle	Desizing
3	Sanforize / Zero- Zero	Anti –shrinkage
4	Jigger	Desizing, Scouring, Washing, Bleaching, Dyeing, Soaping , Dye fixing, Neutralization / souring
5	Continuous Bleaching and / Dyeing Machine	Bleaching and / Dyeing of fabric
6	Winch	Desizing, Scouring, Washing, Bleaching, Dyeing, Soaping , Dye fixing Neutralization / souring
7	Mercerize	Mercerization
8	HTHP – Carrier	Fiber Dyeing, reduction, Soaping, Antistatic
9	HTHP – Package Dyeing	Yarn Dyeing
10	Soft Flow	Fabric Dyeing
11	HTHP – Jet Dyeing	Fabric Dyeing
12	Cabinet Dyeing	Hank Yarn Dyeing
13	Printing	Screen , Rotary , Roller & Block printing
14	Continuous Yarn Dyeing	Denim Yarn Dyeing (Continuous)
15	Stenter	Finishing

Various processes being carried out in above mentioned textile industries that generate liquid pollutants together with their possible impact on receiving water bodies like river Ganga (and its tributaries) are listed in Table 5.

Table 5. Processes Generating Pollution Load and level of their impact on Ambient Water Quality

Process	Steps	Impact	Remarks / Comments
Cleaning of Fiber	Wool, Silk, Jute, Raw cotton package dyeing	Major	Effluent generation
Ginning Industry	Raw cotton mechanical cleaning	Minor	Major solid waste generation
Spinning Industry	Yarn making	Minor	Major solid waste generation
Fabric Making – Loom Shed	Sizing	Major	Effluent generation
	Weaving	None	
Wet Processing Industry / Process-House	De-sizing	Major	Effluent generation
	Scouring / Bleaching	Major	Effluent generation
	Dyeing & Printing	Major	Effluent generation
	Finishing	Minor	Effluent generation
Garment industry	Garment making	Minor	Solid waste generation
Laundry	Garment Washing, Dyeing, Printing	Major	Effluent generation

From Table 5 and Fig. 3 to 7, it is clear that almost all operations of textile industry generate different volumes of wastewater containing various pollutants that are likely to have various levels of adverse impact on water bodies like river Ganga and its tributaries.

From the basic processes discussed above for various textile industries and from the current practices adopted by the Industry it is evident that large volume of water and a variety of chemicals including dyes are used in textile mills at various stages from fiber processing to finished product manufacture. There is a need to understand the characteristics of effluent generated from textile mills to plan for effective and efficient waste water treatment.

Characteristic parameters of typical textile mill waste water are as under:

1) Total Suspended Solids (TSS)
2) Total Dissolved Solid (TDS)
3) pH
4) Temperature
5) Color
6) Chemical Oxygen Demand (COD)
7) Biological Oxygen Demand (BOD)
8) Oil & Grease
9) Sodium Absorption Ratio (SAR)
10) Other Substances such as:

    Total chromium as ‘Cr’

    Sulfide as ‘S’

Phenolic compounds as 'C_6H_5OH'

Ammonical nitrogen as 'N'\

NOTE: The parameters should be as per CPCB guidelines / as per consent to operate document issued to individual industry by SPCB.

The liquid effluent thus generated is required to be treated ~~f~~or recycle and reuse in the process to minimize the volume of discharge. It is also emphasized that efforts have to be made to use best practices and the processes to minimize water consumption besides using appropriate technology for wastewater treatment.

The Central Pollution Control Board has developed specific norms for treated effluent as notified under the Environmental (Protection) Rules 1986 that must be strictly monitored before discharge outside the mill premises

It is understood that Textile Industry is one of the important and growing industries in India. Chemical wet processing of textile consumes approximately 10000 chemicals, dyes and auxiliaries and some of them are banned due to their carcinogenic nature and ~~a~~dverse impact on human health & environment. It is imperative to produce quality goods at economical price but not at the cost of environment and human health and hygiene. Due to hazardous nature of chemicals used in textile production, many adverse impacts are seen on human, animals and nature. This is a matter of high concern.

To overcome this, it is essential to understand the matter in depth especially in textile production areas by using eco-friendly techniques right from fiber procurement and processing (cotton growing, jute growing, sheep rearing, sericulture and synthetic fiber manufacture) to finished marketable products manufacturing. Especially the Indian textile processing industry being major consumer of water for processing and also a major polluter, from pre-treatment to finishing, needs to concentrate on selection of chemicals and process parameters. Self-assessment of chemical inventory and chemical management systems will help further to comply with global chemical legislation, Retailer & Brand Restricted Substance Lists (RSL's) and Manufacturing Restricted Substance Lists (MRSL's) not only in adhering to environmental norms but in getting fair share of global business.

Textiles industries use different chemicals in different processes like De-sizing, Scouring, Bleaching, Dyeing, Printing, Finishing, Softening, Washing, etc. The textiles processing industries consume large quantity of water and produce large volume of effluent from different steps of various processes. Waste water from textile processing and dye containing residues requires appropriate treatment before being released into environment.

Recent consciousness about eco-friendly processing in textile industry has increased awareness of environmental issues. Implementation of effective Chemical Management System (CMS) can help to reduce NPO (Non Productive Output) and hence reduce pollution load on ETP in addition to conforming to the quality of products as per the customers' requirements.

2.2 List of Chemicals used in Textile Industry:

There are various hazardous chemicals used in textile industry. These chemicals are categorized in to 11 priority groups as under;

1) Phthalates
2) Alkyl-phenol Ethoxylates (APEO),
3) Azo Dyes
4) Brominated & Chlorinated Flame Retardants
5) Chloro-phenols
6) Chlorinated Aromatics
7) Chlorinated Solvents
8) Organotin Compounds
9) Short Chain Chlorinated Paraffin's (SCCPs)
10) Heavy Metals
11) Per-fluorinated Chemicals (PFCs)

Process wise list of harmful constituents and related pollution parameter along with their characteristics and level of impact on environment is as given in Table 6.

Table 6
Major Constituents Involved in Various Textile Processes, their Characteristic Parameters and Pollution Impact

Process	Major Constituents	Characteristics	Pollution impact Low, Medium, High
Cleaning of Raw Fibers	- Oil, - Fats Waxes, - Proteins & Pectines	COD, BOD, Turbidity	H
Sizing	- Starch derivatives - Semi-synthetic sizing agents (CMC, CMS) - Synthetic sizing agents (PVAs, polyacrylates) - Additives : - Urea - Glycerin - Waxes and oils - Preserving agents	BOD COD Temperature	H M L M
Desizing	- Acids or Enzymes	BOD (30-40% of total) COD Temperature (60-70ºC)	H H
Scouring	- Saponified waxes, oils, fats - Surfactants - Alkali - High temperature	Oil, fats BOD (30% of total) pH (high) Temperature (70-80ºC)	H H H H H

		Dark colour	
Bleaching	- Residual bleaching agents - Stabilisers - Surfactants - Wetting agents - Mild alkalinity		M
Mercerisation	- Alkali (NaOH) - Surfactants - Dissolved matter	BOD pH (high) TDS	H H H
Dyeing	- Dyestuffs (direct, vat, reactive, sulphur, pigment) - Electrolytes - Carriers - Acids and alkali - Heavy metals - Oxidising agents - Reducing agents - Surfactants and levelling agents	Toxicity BOD Suspended solids pH Strong colour	H H H H H

Pollution load from textile mills differ widely depending upon the nature of Fiber used and the level of processing employed. Organic ingredients in the waste water undergo bio-degradation and reduce dissolved oxygen content (DO) of the receiving water body and thus destroy the aquatic life. Phenolic chemicals impart bad odour and taste to the water mass. The organics should be removed to prevent any chances of stream water becoming unsuitable for agricultural, domestic and industrial use.

Textile mill waste water includes fibrous substrate and processing chemicals. These increases Total suspended solids & reduce oxygen transfer capacity and light penetration and thus affect photo-synthetic activity in the water-bodies.
Soluble inorganic salts may lead to pollute water bodies which are not suitable for domestic and industrial use. Heavy metals are toxic to aquatic life.

Proper treatment of waste water will reduce the concentration of these pollutants as well as their harmful effects and prevent adverse impact on environment. Correctly treated effluent provides opportunities for further use of the treated water back to process. Some measures may also need to be adopted to reduce pollution load (both in terms of concentration and volume) e. g. scouring & bleaching wash water (rinse water) from dye houses may be used for desizing & also back to scouring. Recycling of drain from one process may be used in starting of selected processes whereby, savings of chemicals may take place along with savings in water volume.

After taking all possible steps to reduce pollution load and volume of waste water, the remaining pollutants still do not permit the disposal of wastewater in to a water body. These pollutants may be removed or reduced to an un-harmful level (conforming to the effluent disposal norms) by treating the waste water using a variety of treatment steps and combination of sequences. The best treatment sequence, however, may vary from mill to mill.

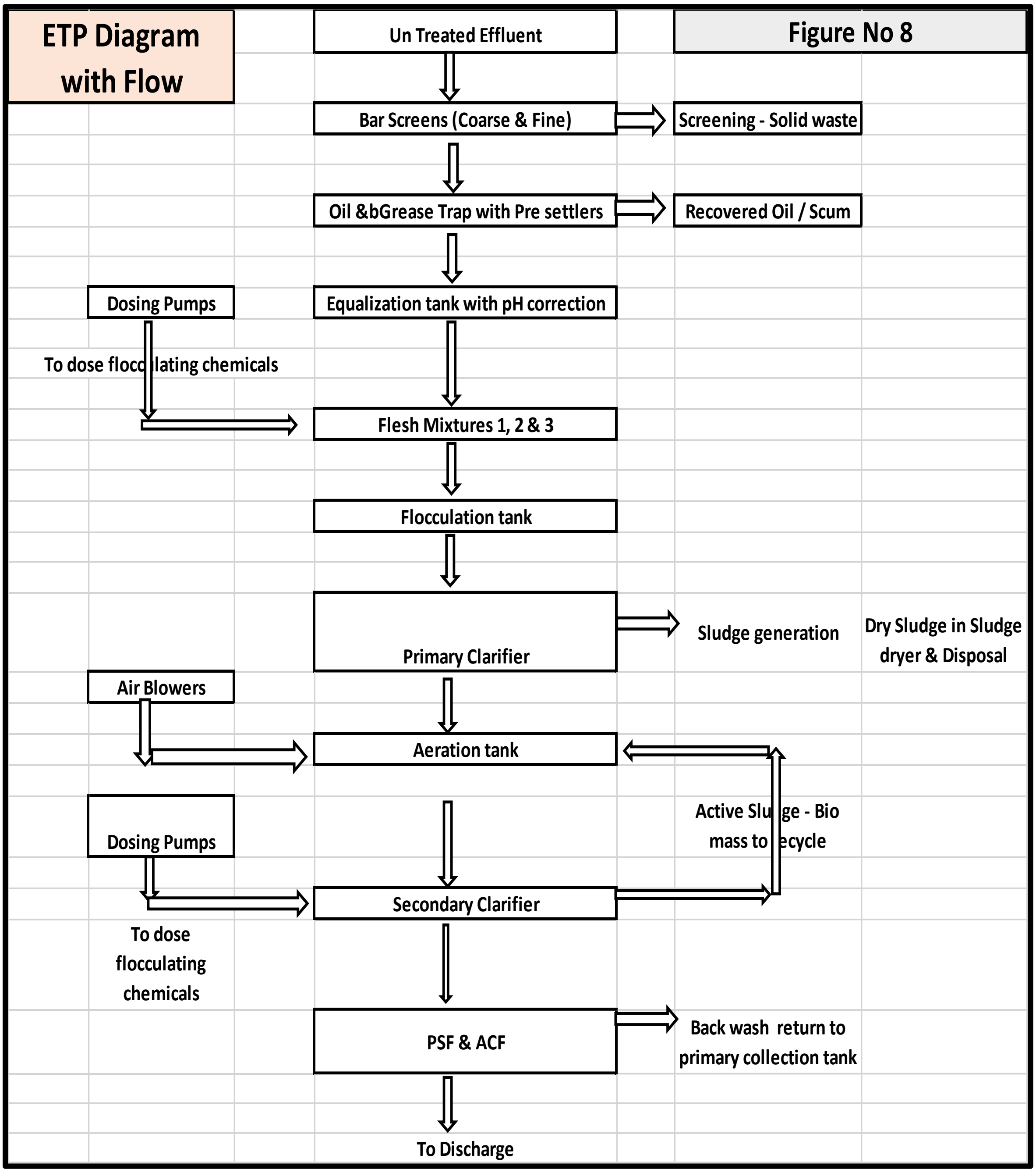
Figure 9 shows a typical treatment scheme for treating waste water from a standard textile mill. The waste water from various sections is brought to primary collection / equalization tank for proper mixing, maintaining even temperature and control of flow for next process. It is then passed across a screen to remove floating substances like Fibers, etc. The screened effluent is then taken to a grit-chamber –cum-primary settling chamber where heavier inorganic and organic solids are removed by settling.

The clarified effluent is then passed to a biological reactor (usually an activated sludge treatment) coupled with a secondary settling chamber. Most of the biodegradable organic pollutants are removed through biological reaction and the excess bio-mass generated is settled out in secondary clarifier. The clarified effluent from the secondary clarifier may be further treated by passing it through a tertiary treatment unit (a series of activated carbon filters + sand bed filters).

The treated effluent may now be discharged onto land or into a receiving water body. If its recycling is required within the plant itself, it may have to be subjected to further treatment using ultra-filtration/nano-filtration/and/or reverse osmosis units. The sludge produced in primary and secondary settlers and tertiary treatments units is separately collected and suitably disposed of after appropriate treatment.

In case it contains toxic chemicals it has to be disposed of at land-fill sites built specially for such wastes. The filtered "OK" water from UF, NF & RO is taken back to process as pure water & highly polluted reject effluent from these filters is taken to Multi Effect Evaporator (MEE).

Figure 8: The treatment scheme for treating waste water from textile mills



3. Problem Analysis

3.1 Focal Problems to be Solved

Textile industries have been put under the categories of 17 highly polluting industries. These industries have high water pollution potential. The major environmental issues related to Indian Textile industries include high volumes of fresh water consumption and waste water discharge, adverse impact on receiving streams due to high pollution load, high color in effluents due to presence of dyes, ETP sludge disposal and management, and poor performance of ETPs. The effluent discharge standards implemented so far are based on the premises that the back ground river water quality is very good and at least 10 times dilution is available. However, these conditions are not being met in most of the Indian rivers in which treated / partially treated / untreated industrial and domestic effluents are being discharged in increasing amounts. As such it is essential that treatment up to tertiary level be made mandatory.

In addition to this, there is a need to reduce water usages in textile industry. This will reduce the requirements of fresh water by the industry which can in turn lead to reduced consumption of natural resources like water, fuel & power.

The reduction of water input can be done by two ways;

1. Optimization of process parameters: Optimization of process parameters will result in reduced water consumption which is quite possible by the use of latest developments in process technology and with low liquor ratio processing equipments, smart washing cycle, and proper controls.
2. Water recycling - Water recycling between several processes is possible, but its potential has not been exploited by textile units. This is possible at two stages:
    - Recycling of water internally in selective processes.
    - Recycling of treated effluent by setting a UF/RO/Nano filters at the end-of- pipe line

Such reduction in fresh water consumption within processing units at various stages will reduce the pollution load on ETP and improve the quality of treated effluent.

Present scenario indicates that, the ETPs of several textile units perform much below the expected level and the effluent discharge norms are violated quite often. Several reasons, including lack of knowledge and expertise to manage the ETPs, are cited by the industry for poor performance of ETPs. It is suggested that each textile unit must have properly qualified trained employees to run and maintain the ETPs. The industry must employ graduates with degrees in Environmental Science or Technology and/or B Tech. (Chemical/Civil/Textile Eng.). The B Tech (Civil/Textile) engineering graduates must have studied courses in environmental pollution control. All such persons should be periodically subjected through refresher courses/workshops/practical training programs of about duration of one week every year.

At present there seems to be inadequate control on the quantity of fresh water used in and waste water discharged from the textile industries due to use of obsolete process technology and age old practices and lack of implementation of polluter pays principle. These coupled with the lack of awareness and typical mind set are the main de-motivating factors responsible for indiscriminate use of precious natural resources in general and fresh water in particular in most of the industries.

It would be appropriate to decide standard norms for usage of water by the textile industry with time bound commitments in a phased manner. The time line for this is described in Table 7 (a &b) give below:

Table 7 (a) - Time Line for Water consumption in Textile Industry			
Process Category	**Average as on current date**	**Target after 1 year of release of charter**	**Target after 2 years of release of charter**
Unit	**L/kg**	**L/kg**	**L/kg**
Raw Wool	250	200	170
Scoured Wool	100	80	68
Polyester	60	48	41
Acrylic	50	40	34
Woven	120	96	82
Raw Silk	200	160	136
Processed Silk	85	68	58
Knit	85	68	58
Canvas	45	36	31
Carpet	50	40	34
Woven cotton	120	96	82
Blend PC	120	96	82
Blend PV	90	72	61
100% Poly	60	48	41
Total	100	80%	68%

Important Note: - The effluent generation will be calculated as 85% of water consumption in all the categories which can be calculated against Table No 7.

Table 7 (b) - Time Line for Effluent Generation in Textile Industry			
Average as on release of charter	**Average as on current date**	**Target after 1 year of release of charter**	**Target after 2 years of release of charter**
Unit	**L/kg**	**L/kg**	**L/kg**
Raw Wool	213	170	145
Scoured Wool	85	68	58
Polyester	51	41	35
Acrylic	43	34	29
Woven	102	82	70
Raw Silk	170	136	116
Processed Silk	72	58	49
Knit	72	58	49
Canvas	38	31	26
Carpet	43	34	29
Woven cotton	102	82	70
Blend PC	102	82	70
Blend PV	77	61	52
100% Poly	51	41	35
Total	100	80%	68%

This chart shows water consumption / Effluent Generations at various stages of textile industries. Water consumption per kg of product for current date has been frozen as upper limit. The next yearly reduction targets have been kept with 20% reduction and at the end of two years of release of charter, reduction targets have been kept with 15% reduction, respectively for reduction in water consumption. **Effluent generation allowance limit will be considered as 85% of water consumed**.

3.2 Root Cause of the Problems

Most of the textile-industries–are using obsolete technologies with average age of equipment/ machines much higher than obsolescence. This has resulted in slow machine speed, high consumption of raw material, energy and water with less efficient operations, causing generation of high volume and increased pollution level of waste streams.

Looking towards years back, most of the textile mills have enhanced their production capacity over the period of time but the augmentation and up-gradation of ETPs have not been adequately addressed. Moreover, most of ETPs have been set up by mills themselves and are quite often based on improper design without being subjected to adequate assessment for performance.

Presently, ETPs consist of two main stages physical and biological treatments and are not adequate to provide requisite level of treatment to the effluent to comply with the prescribed effluent norms and/or to meet the process water quality for wastewater recycling within the process.

The operation and maintenance of ETPs are not always satisfactory. Most mills neither have trained manpower for operating ETP nor proper laboratory facility for measuring and analyzing various performance parameters. Mills also lack proper record keeping and a sound system for monitoring of water consumption and effluent discharge.

SPCBs have inadequate resources for intensive performance monitoring and surveillance activities for compliance verification of these mills. There is a need for strengthening of institutional network to meet the technical requirements of textile industries such as technical knowhow for process and ETP up-gradation, training programs and monitoring.

Most important thing is the mind set of mill owners and ETP officials that needs to be changed. The CPCB and SPCBs need to work hard in this regard.

The up gradation in technology and process is therefore necessary for improved performance and competitiveness through quantifiable increase in productivity, quality improvement with reduced cost, better energy efficiency and environmental compliance. High cost of energy (specially fuel) and the consequent environmental implications, make it imperative for the textile industry to adopt energy efficient and eco–friendly technologies, increase automation and control, optimize process operations, increase reuse and recycling wherever possible of process water and treated effluent, up gradation / modification of ETPs, adoption of Chemical Management System (CMS) and Chemical Recovery System (CRS) for chemical and dye bearing waste water in textile mills (individual / common) and promotion of biotechnological applications.

4. Objectives of the Charter

Central Pollution Control Board (CPCB) has formulated the 'Charter for Water Recycling and Pollution Prevention in Textile industries in consultation with experts from the departments of Chemical Engineering & Technology, IIT (BHU), Textile Engineering, IIT Delhi, Polymer and Fiber Technology, IIT Delhi, Fiber and Textile Processing, ICT, Mumbai, UP Textile Technology Institute, Kanpur and experts from Textile industries, Bombay textile research Association in various brain storming workshops held. A detailed implementation program (DIP) of the Charter has also been formulated.

One of the important objectives of charter is to setup a bench mark for water consumption & optimize the use of water & chemicals in processing.

The nine States – Uttar Pradesh, Uttarakhand, Haryana, NCT of Delhi, Chhattisgarh, Bihar, Jharkhand, and West Bengal, located in the Ganga River Basin are primarily responsible for causing industrial pollution in the Rivers with sizeable contribution from textile mills.

'Charter for Water Recycling and Pollution Prevention in Textile Industries' is specific to textile industries operating in the nine states of Ganga River Basin (here in after referred to as 'the Charter') is formulated, with a view to envisage up gradation of the status of textile industries in terms of process technology, practices and environmental performance, besides substantial reduction in the fresh water consumption and waste water generation and compliance with the prescribed environmental norms, to achieve desired level of environmental protection, zero effluent discharge into the recipient river streams through interception, diversion and disposal of treated effluent for irrigation purposes and to meet objectives of the National Mission for Clean Ganga.

The Charter suggests Bare Minimum Technology (BMT) as an indication of the set of desired technologies or its appropriate alternatives required for implementation by the Textile industries operating in the Ganga River Basin States. The Charter takes a holistic approach for pollution prevention by emphasizing on process technology up-gradation, adoption of best practices, besides desired improvement in effluent treatment including tertiary treatment to reduce fresh water requirement, improve effluent quality and optimize water recycling. Compliance with the prescribed standards is mandatory. There will be no compromise with regard to the industry not meeting the prescribed standards.

4.1 All Time Compliance with Environmental Norms

The Charter envisages up gradation of the status of textile industries operating in the country in terms of process technology, practices and environmental performance to the prescribed level, besides substantial reduction of fresh water consumption, waste water generation and compliance with the prescribed environmental norms on continuous basis. Water consumption, effluent generation and emission limits shall be recorded on the basis of per ton of "product" and not just "textile". Besides, "product" shall include air dry tones of surplus textile produced for short term storage (as wet-lap) or for sale.

4.2 Zero Effluent Discharge into Recipient River Streams

The ultimate objective of the Charter is to envisage the possible reuse & recycling of treated effluent into production process & to minimize fresh water consumption.

4.3 Increased Productivity

The Charter emphasizes on the installation of minimum impact technology to ensure better environmental performance, improved relation between various stake-holders (mills, regulatory authorities and common people), increased productivity, cost savings and competitive market advantages. Increased productivity could ultimately amount to achieving the same production levels with lesser specific consumption of any or all of the resources involved in mill operations.

5. Proposed Strategy

In order to improve the health of the surface water bodies and ambient environment, discharge of pollutants in the river channels needs to be minimized. The effluent, appropriately treated, could be viewed as a source of water that can be used for various processes. Management of water in the textile mills needs a four stage action plan as given in Table 8.

Table 8 Time Frame and Target/Goals for Implementing the Charter.

Objective Hierarchy	Time Frame	Target / Goal
Immediate action	Date of Release of Charter	Meet CPCB guidelines for discharge norms. Plan for installation/ up gradation of ETP/ RO as per CPCB guidelines
Short term objective	After 1 year of release of charter	Meet CPCB guidelines for discharge norms. Reduce Water consumption by 20% per kg of product Completion of installation/ up gradation of ETP/ RO as per CPCB guidelines
Long term objective	After 2 years of release of charter	Meet CPCB guidelines for discharge norms. Reduce Water consumption by 15% in addition to last year's 20% per kg of product Completion of installation/ up gradation of ETP/RO& water recycle as per CPCB guidelines
Ultimate overall objective	Beyond 2 years	Confirmation to recycle 30% water against total input (In other words, water consumption per kg should be reduced by 30% minimum.

1) Immediate plan is to meet the desired levels of effluent discharge as per CPCB norms, exhibit commitment to augment/establish ETP with RO as per CPCB guidelines and also plan to reduce water consumption through process improvement and implementation of recycle and reuse of

water. A strict metering of the water used and waste water generation is recommended. Several technological and process improvement options are available to reduce net water consumption and thereby reduce the amount of effluent generated. Suggested technological up-gradation/measures for reduction in water consumption for achieving the benchmark / overall goal are mentioned in the Charter.

2) Second action plan (after 1 year of release of charter) is to have quantum improvement on the individual ETPs by adding tertiary treatment units. This would result in producing industry grade water from waste water discharged from various processes for reuse in selected processes within the industry. Extensive and regular monitoring protocol is to be followed by regulatory authorities for improved environmental performance. Monitoring and recording of inlet water consumption and reduction by 20% per kg of product up to is mandatory within one year of release of charter.
3) Third action plan (after 2 years of release of Charter) is to have full working of ETP with water recycling system and industry must be able to reduce input water consumption by 15% over and above that of the previous year's achievement of 20% reduction per kg of product.
4) Ultimate goal is to achieve zero liquid discharge of effluent into any stream which meets River Ganga

   Third party involvement is recommended for planning, assessment, design and monitoring of implementation of measures as prescribed in the Charter for process technologies as well as ETP up-gradation. Textile Committee, various Textile Research Associations (may be in this case ATIRA, BTRA, SITRA & NITRA) Local textile mills association (we may include Textile Association of India (TAI) can take initiative. Educational institutes (IITs, ICT, DKTE, SASMIRA-Mumbai etc… can give Technical support for meeting ultimate goal of charter.

Concerned SPCBs and CPCB should act for implementing the Charter in a time bound period and efficient manner.

6. Stake Holders

Several stake holders are involved in environmental pollution control programs. These include central and state level regulatory agencies (pollution control boards and the like). In case of Ganga Basin states, textile manufacturing other stake holders like textile mills, textile mill associations, concerned academic and professional organizations and experts are also to be included as stake holders. Thus the various stake holders concerned with the proper implementation of the Charter are as under:

- National Mission Clean Ganga (NMCG)
- Ministry of Environment, Forests and Climate Change (MoEFCC)
- Central Pollution Control Board (CPCB)
- State Pollution Control Boards (SPCBs) and Pollution Control Committees (PCCs)
- Textile Mills operating in Ganga River Basin States,

- Textile Mills Associations- AICMA, TAI, etc.
- Experts & Resource Institutes (IITs/ ICT, Mumbai / DKTE Ichalkarangi, /ATRA, BTRA, SITRA, NITRA, NEERI/SASMIRA – Mumbai/UPTTI/TITS, Bhiwani/NITS and other consulting organizations)

7. Plan of Activities

For effective and successful implementation of the Charter a set of activities are required to be planned and carried out. This will require phase wise planning of activities, steps to be initiated for the facilitation of the charter, process and technological improvements, water conservation and recycling methodologies, performance assessment of ETPs and their up-gradation, monitoring and surveillance of environmental compliance, strengthening of laboratory facilities, operation and maintenance of ETPs, and creation of environmental management cell. Actions to be taken and steps to be initiated for realizing the goals envisaged under above mentioned activities are elaborated in following tables

During the period of 2 years after release of charter, following objectives as listed in Table 9 must be achieved by the textile mills.

Table 9 Time Frame for realizing Various Objectives

Objective Hierarchy	**Time Frame**	**Target / Goal**
Immediate action	Date as on release of charter	Meet CPCB guidelines for discharge norms. Plan for installation/ up gradation of ETP/ RO as per CPCB guidelines
Short term objective	Completion of 1 year after release of charter	Meet CPCB guidelines for discharge norms. Reduce Water consumption by 20% per kg of product Complete of installation/ up gradation of ETP/ RO as per CPCB guidelines
Long term objective	Completion of 2 years after release of charter	Meet CPCB guidelines for discharge norms. Reduce Water consumption by 15% in addition to last year’s 20% per kg of product Completion of installation/ up gradation of ETP/RO & water recycle as per CPCB guidelines
Ultimate Goal	Beyond Completion of 2 year after release of charter	Confirmation of 30% water recycle against total input (In other words, water consumption per kg should be reduced by 30% minimum.

7.1 Facilitation of Charter

Following actions as enumerated in Table 10 need to be undertaken and completed within the dates (period) as specified by the stakeholders as indicated.

Table 10: List of Activities and Related Action to be undertaken with Dead Line			
S. No	**Activities**	**Action by**	**Completion date**
1)	Self- assessment Identification of third party, such as CTRI, industry associations, etc. by Mills to facilitate the charter implementation and coordination. Give commitments (Intent letter) for meeting the guide lines as per CPCB charter along with recommended areas of improvements' from nominated agency – Third Party. CPCB / SPCB to collect letter of intent & confirm the association of mill & supporting agencies.	Textile Mills Textile Mills SPCB/CPCB	Within 7 days on release of charter
2)	Complete augmentation of ETP/Water recycling project Achieve 20% reduction in Water consumption per kg of product by internal implementation of technology. Monitoring agencies (CPCB, SPCB) to generate detailed reports with all supporting & submit to committee after 6 months (First progress status & finally target completion status)	Textile Mills Textile Mills Submit status report by CPCB / SPCB	Within 1 year of release of charter Within 1 year of release of charter Within 7 days on release of charter & also after 1 year of release of charter
3)	Full working of ETP/RO Project & submit Water Balance reports Reduction in water consumption by further 15% in addition to previous year's saving of 20% (to be calculated in L/kg of product) Commitment for ultimate goal of ZLD & action plan Monitoring agencies (CPCB, SPCB) to generate detailed reports with all supporting & submit to committee after every 6 months (First progress status & finally target completion status)	Textile Mills Textile Mills Textile Mills Submit reports by CPCB / SPCB	Within 2 years of release of charter Within 2 years of release of charter Within 1 year of release of charter Within 2 years of release of charter

7.2 Technological & Process Improvements

Mills will be required to initiate a set of process and technological improvement steps to improve efficiency and reduce chemicals, energy, and water consumption and reduce pollution load. These initiatives and stipulated deadlines are listed in Table 11.

Table 11: Process and Technological Improvement Activities to be initiated with respective Deadlines.

S. No	**Activities**	**Action by**	**Completion date**
1)	**Self-Assessment:** Policy statement with details of inventory of existing process technologies & practices. Identification of augmentation requirements & preparation	Mills	One Month

	of action plan for up gradation with supporting documents & pert chart		
2)	**Third Party Evaluation &Validation:** Evaluation / validation of the reports on inventory, upgradation requirements and action plan	Mills to submit reports from nominated third party.	Two Months
3)	**Implementation of action plan:** Envisaged as per document of individual mills	Mills	As per Schedule
4)	**Monitoring & Assessment:** Submitting status / Progress reports on reduction in water consumption & effluent generation	Mills to submit progress reports to SPCB SPCB to submit verification reports.	Quarterly (Once).
5)	**Verification of Progress** SPCB will assess the progress once in 6 months & submit status reports.	SPCB	Semi-annually (Once)

7.3 Water Conservation & Water Recycling

Measures to conserve water and carryout water recycling wherever possible results in substantial reduction in water consumption and volume of wastewater generation. Table 12 lists a set of activities to be carried out by mills and the time frame for the same.

Table 12
Water Conservation and Water Recycling Practices to be adopted by Mills and their respective Time fames

Sr. No	Activities	Action by	Completion date
1)	Installation of sealed flow meter and running hours meter on bore wells and inlet pipeline of different process section i.e. textile mill, textile production area, boiler etc.	Mills	One Month
2)	Color coding of pipe lines carrying recycled process water and fresh process water	Mills	Two Months
3)	Maintenance of log book to record daily water drawn from bore well and water consumption unit wise after installation of meter. Record of power consumption – meter readings for inlet water pumps	Mills	Daily monitoring & recording
4)	Self-Assessment: Preparation of report of existing water consumption- section wise, reuse/ recycle practices; Preparation of work plan to achieve fresh water requirement targets	Mills	One month

7.4: Assessment, Augmentation and Up-gradation of ETPs for Improved Environmental Performance.

Periodic assessment of ETPS should be routinely carried out. This helps in pinpointing units that are not working properly and deciding about the possible strategies for up-gradation and augmentation of the ETP. The activities to be carried out and responsible organizations with time frame are listed in Table 13.

Table 13 Improved Environmental Performance Parameters through Assessment, Augmentation and Up-gradation of ETPs			
S. No	**Activities**	**Action by**	**Completion date**
1)	**Self-Assessment:** Preparation of ETP adequacy assessment report & proposed augmentation & up-gradation report with design & drawing with monthly pert chart.	Mills	One Month
2)	**Third Party Evaluation & Validation:** Evaluation / validation of adequacy, and proposed augmentation / up-gradation plan, design / drawings	SPCB	Two Months
3)	Implementation of action plan submitted	Mills	As per Schedule
4)	Submission of monthly progress report with evidences	Mills	One Month
5)	Verification of Submission- Progress reports	Third party	Quarterly (Once)
6)	Verification of Progress	SPCB	Quarterly (Once)

7.5 Monitoring & Surveillance of Environmental Compliance

Monitoring and surveillance of the environmental compliance by the textile mills as stipulated in the Charter should be carried out at several levels- such as self-monitoring and periodic report submission by the mills to SPCB or a third party. The strategies to be adopted and the time frame are listed in Table 14.

Table 14: Strategies and Time Frame for Monitoring & Surveillance of Environmental Compliance

S. No	Activities	Action by	Completion date
1)	Self-Monitoring & Reporting: ETP performance monitoring by individual Mills and maintenance of Log Book as per the prescribed format	Mills	Daily
2)	**Submission of the performance report**: Reports to be submitted by Individual mill to third party/ SPCBs	Mills	Monthly
3)	**Review meetings**: Review meetings between Mills / Third party & SPCBs to help mills to improve ETP performance & sample analysis quality	Third party / SPCB	Quarterly
4)	**Regulatory Monitoring:** Periodic / Surprise monitoring and review meetings	SPCB	Quarterly
5)	Monitoring of operational status of CRPs/CCRPs if any mentioned in consent to operate	SPCB	Fortnightly
6)	**Training & Knowledge up gradations:** Organization of training programs on process technology, best practices, ETP operation & maintenance, Sample analysis, Troubleshooting etc….	SPCB / CPCB	Periodically to organize & all mills must send their officials to attend.
7)	**Employment of Trained team: T**o make mandatory requirement - to employ one staff at every ETP with **Environmental Proficiency Certificate** or minimum 5 years of handling ETP plant. CPCB can certify such officials by giving training course on various aspects.	CPCB to take lead	Can decide.

7.6 Environmental Management Cell (EMC) and Laboratory Facility

In view of the importance of resource conservation, water reuse and recycle, and efficient functioning of ETPs it is essential to create an **Environmental Management cell (EMC)** (or strengthen it if already existing) and establish laboratory facilities for evaluating basic pollution parameters capable of indicating the functioning of ETPs will be mandatory.

7.6.1: Setting up of Laboratory Facility at Textile Mills for Effluent Analysis

It would be worthwhile to have basic laboratory facilities for measuring all indicator pollution parameters as stipulated in the norms of CPCB for textile mills. These facilities and instruments will be over and above those incorporated in the continuous online monitoring system.

(a) As per the Environment (Protection) Rules, 1986, pH, DO, TSS, TDS, BOD, COD, Color, Oil & Grease, Total Cr, Phenol, Total Sulfide, Ammoniacal-Nitrogen and SAR (Sodium Absorption Rate) are mandatory to be measured for textile mills. Thus the Mills should have minimum analysis facilities for measuring these parameters. The list of basic laboratory equipment for a standard laboratory coupled with ETP is given in Table 15.

Table 15
List of Equipment for ETP Laboratory

Instruments	No of pieces
pH Meter+ Paper strip	1+ Full set
pH Pen	3
TSS Meter	1
TDS Meter	1
DO Meter	1
BOD testing kits with Incubator	1 set
COD testing kits	1 set
Oven	1
Digital weighing balance: With 0.1 mg accuracy With 10 mg accuracy	 1 1
Necessary Glass ware	As per test procedures mentioned in "Standard test Methods"
Chemical reagents	

(b) The ETP and its laboratory should have properly qualified adequate scientific officials and technical staff for smooth its smooth operation. Details of such staff with their cadre and qualifications are given in Table 16.

Table 16 Scientific and Technical Staff for ETP and Laboratory

Minimum strength in ETP		
Post	**Education / Experience**	**No of employees**
Environment Officer	Graduate in Science / B.E. with 5 years' experience	1
Shift Supervisor cum Lab Technician	Graduate in Science	1

Fitters cum operators	ITI pass	3 (1 per shift)
Helpers	Adult workers	As per requirement
Necessary strength of relievers to be maintained for working on 7 days a week (Continuous process)		

(c) Training of the Staff

It is essential to provide necessary training to each employee with minimum 8 man days per employee in year by professional trainers from reputed organizations.

(d) Frequency of the Analysis

A particular time schedule should have to be followed for measuring various pollution parameters. This frequency of such measurements is listed in Table 17.

Table 17: Frequency of Wastewater Analysis

Parameters	Frequency of Testing
pH	Once in a shift of 8 Hours
TSS	Once in a Shift of 8 hours
TDS	Once in a Shift of 8 Hours
Dissolved Oxygen	Once in a shift of 8 hours
Color visual	Once in a shift of 8 Hours
Treatability study	Once in a Day
MLVSS/MLSS	Once in a Day
COD	Once in a day
BOD	Once in a week

Treatability study: -

Daily once treatability studies to be done

Process -

Collect 10 Ltr of untreated effluent in Bucket.

Add dosing chemicals with correct measurement & check for flocks' generation & settling of flocks with various dosages of chemicals.

Note dosage of chemicals for best generation of flocks & also lowest settling time.

Continue with same amount of dosages for coming 24 hours with intermittent checking in actual process.

7.6.2 Operation & Maintenance of ETP

To achieve the designed performance from ETP, it is necessary to operate it under optimum conditions so as to meet the environmental discharge standards for which regular analysis of various process and pollution parameters and maintenance of records are necessary. For proper and optimum operation of ETPs, the mills should ensure that the plant is well maintained and all equipment is in good working condition. Following guidelines must be religiously followed for proper operation and maintenance of ETP.

Key Guidelines for Operation & Maintenance

- Ensure proper and optimum conditions of each section of ETP as per the designed specification and manufacturer's instruction.
- Avoid fluctuation in effluent flow and pollution load so as to reduce the shock load to bio-mass and the system as a whole.
- Ensure proper addition of nutrients in aeration tank
- Maintain required level of MLSS/MLVSS concentration during biological treatment. It is cheaper, faster and also eco-friendly.
- Maintain desired level of DO in the aeration tank (1.5 to 2.2 mg/l).
- Ensure periodic & timely withdrawal of sludge from the clarifiers & settled bio mass from aeration tanks.
- Ensure proper maintenance of electric motors, pumps & blowers with diffuser system. etc.
- Use power saving technique in ETP operation ~~are~~ as suggested below:
  - ✓ Optimization of blower speed (by VFD) in aeration tank linked with DO in aeration tank
  - ✓ pH control (Dosing of acid) to be linked with pH meter reading of effluent.
- Introduce the practice of proper Documentation & Record Keeping
- Maintain proper record of fresh water consumption, effluent discharge, effluent analysis, and consumption of chemicals in ETP and utility (like steam and power)

For the benefit of Mills formats for daily monitoring & record keeping are provided as under. The Mills are required to prepare a proper log-book using these formats.

Water Consumption, Wastewater & Sludge Generation Data					
Date	**Inlet Water, KL**	**Effluent Generated, KL**	**Sent to CETP, KL**	**Sludge Generated, Kg**	**Sludge Disposal, Kg**
1 Feb					
2 Feb					
3 Feb					

Wastewater and Treated Effluent Characteristics												
Date	**Inlet Effluent at ETP**						**Outlet quality from ETP (To CETP)**					
	pH	**TDS**	**TSS**	**COD**	**BOD**	**Color**	**pH**	**TDS**	**TSS**	**COD**	**BOD**	**Color**
		PPM	**PPM**	**PPM**	**PPM**	**visual**		**PPM**	**PPM**	**PPM**	**PPM**	**visual**
1 Feb												
2 Feb												
3 Feb												

Date	Biological treatment							
	pH	DO	MLSS	MLVSS	COD	BOD	Color*	Effluent flow
		PPM	PPM	PPM	PPM	PPM	visual	KL/h
1 Feb								
2 Feb								
3 Feb								
* Color can be mentioned as Dark, Medium, light, no								

Electric Power & Man Power utilization				
Date	Power consumption in ETP in units		Strength of Man power (staff + operator) Std Strength = ____	
	Meter Reading	Units	Staff	Operators + Helpers
1 Feb				
2 Feb				
3 Feb				

Mill must maintain supporting (date wise) documents for energy strength of work force per day

Chemical Consumption data						
Date	ETP					
	1	2	3	4	5	6
	kg	kg	kg	kg	Kg	Kg
1 Apr 21						
2 Apr 21						
3 Apr 21						

Record of Mal-functional/Non-functional ETP Units								
Date	ETP equipment							
	1	2	3	4	5	6	7	8
	Yes							
1 Feb		No	No					
2 Feb								
3 Feb								

ETP in-charge will be required to maintain data of non-working / under repair status on daily basis. This will help to know the non-functional sections and management can attend same on priority. Moreover, any deviation in outlet results can also be analyzed.

7.6.3 Creation of Environmental Management Cell (EMC)

Every mill will compulsorily setup an Environmental Management Cell (EMC) to effectively monitor the environmental compliance. The Environmental Management Cell will constitute of:

- Unit /Business Head
- ETP In-charge & staff
- Process Operations Heads

- Factory Manager
- Safety officer

Duties of Environmental Management Cell (EMC)

- The Environmental Management Cell (EMC) shall review the water consumption, measures taken and identify the areas for water conservation, resource recovery and pollution reduction every week.
- The detailed minutes of the decisions taken will be recorded and circulated to all members of (EMC) and follow up of the decisions will be monitored by the Unit Head & ETP In-charge.
- Review to be made in case of non-compliance by mill.
- Internal Audit to be done by the EMC on quarterly basis.
- EMC should arrange for External Environmental Audit on an annual basis

8 . Resource Planning and Implementation of Charter

For efficient and proper utilization of wastewater treatment facilities available within the mill or in its vicinity (as a combined effluent treatment unit) will require proper planning and management. The available information on distribution of textile mills, common effluent treatment plants (CETPs) and mills connected to CETPs in Ganga River Basin states is as given in Table 18.

Table 18. Distribution of Textile Mills in the Ganga River Basin 06 States

Table 18. Distribution of Textile GPIS in the Ganga River Basin 06 States			
State	**No of GPI**	**No of Available CETPs**	**No of GPIs Attached to CETPs**
Uttarakhand	03	03	01
Uttar Pradesh	547	09	289
Bihar	03	00	00
West Bengal	03	01	00
Delhi (NCT)	50	13	34
Haryana	319	13	44
Total	**925**	**39**	**368**

Source: As per CPCB TPA inspection 2020.

Implementation of the Charter and the compliance with the prescribed norms / standards shall be the sole responsibility of the Textile Mills. The entire cost towards implementation of the Charter as per the Plan of Activities shall be borne by the individual Textile Mill. Textile Mills shall carry out all the activities related to self-assessment, preparation of action plan, including PERT Chart, implementation of the Charter and self-compliance reporting. Participating mills may take technical / logistic assistance of experts or industry Associations for carrying out various activities as per the Plan of Activities. Some of the activities to be carried out by the individual mills are as under:

1. Preparation of inventory of existing process technologies and practices.
2. Identification of process and technological up-graduation requirements w.r.t. the Charter.
3. Preparation of Action Plan, including monthly PERT Chart for implementation of the Charter for technological and process up-gradation.
4. Implementation of technological up-gradation action plan and submission of monthly progress report.
5. Preparation of ETP adequacy assessment report w.r.t. environmental compliance, actual production, pollution load generation and targeted water consumption; and design, drawing and preparation of proposed augmentation and up-gradation plan, including monthly PERT Chart in accordance with the Charter.
6. Implementation of ETP up-gradation action plan and sub mission of monthly progress report.
7. Installation of sealed flow meter along with running hours meter on inlet water (bore wells/ other source).
8. Installation of flow-meters at individual inlet pipe line of different process operation.
9. Setting up of online effluent monitoring system to monitor final effluent discharge. Those connected to CETP's can have common system installed at CETP discharge.
10. Color coding of pipelines carrying recycled process water and fresh process water.
11. Maintenance of logbook to record daily water drawn from bore wells.
12. Maintenance of log book by individual process unit for recording daily water consumption.
13. Setting up of maximum water consumption targets for individual unit operation.
14. Report preparation of existing water consumption-section wise, reuse / recycle practices, strategies/work plan to achieve fresh water consumption targets.
15. Implementation of water recycling action plan and submission of monthly progress report.
16. Self-monitoring and reporting: Daily ETP performance monitoring and maintain Log Book as per the prescribed format.
17. Participation in periodic review meeting to be held by Third Party (association / SPCB / CPCB).
18. Strengthening of Environmental Cell and Laboratory facilities
19. Organizing training program for their personnel (minimum 32 hours/person/year)

8.2 Third Party: Textile Mills Associations

Textile Institutes/IITs/NITs/ICT/ TRAs

Each of the participating mills may identify either any one of the identified Third Parties or their respective SPCBs / PCCs for evaluation and validation of their technical reports (self-assessment and planning reports: Preparation of inventory, ETP Adequacy & Up gradation, and Action Plans to Implement the Charter), and physical verification of individual mills progress reports under the

Charter implementation program. Third parties, after verification / validation of the progress reports, shall forward these reports to concerned SPCBs & CPCB on quarterly basis. However, regulatory verification shall be carried out by the concerned SPCB/CPCB to ensure timely implementation of the Charter and compliance with the prescribed norms.

Third Party shall play pivotal role in encouraging their member mills in implementation of the Charter and shall facilitate individual mills by arranging technical and logistic supports. Textile Mills Associations / Central Textile Research Institute (TRAs) have been identified as Third Party to facilitate the industry in implementation of the Charter and monitoring.

Textiles committee is an expert organization on Textile Technology under the administrative control of the Ministry of Textiles, Government of India, where as Textile Associations shall engage Expert Institutions like BTRA, IITs/ICT/ NEERI/DKTE/ any other reputed environmental consultants / organizations' or set up Expert Committee (s) for Evaluation & Validation of technical reports submitted by the participating Mills and physical verification of the progress reports.

8.2.1. Third Parties

1. Textiles Committee
2. Department of Textile Technology/ Textile Processing at reputed University or Institute like ATIRA, BTRA, SITRA, NITRA, IIT-Delhi, ICT Mumbai, SASMIRA Mumbai - etc.
3. Indian Textile Manufacturers Association(ITMA)
4 Textile Unit Chapter, Kumaun Garhwal Chamber of Commerce and Industry(KGCCI)
5. Textile Manufacturer Association (TMA), Uttar Pradesh
6. Indian Textile Mills Association
7. Indian Woolen Garments Manufacturers Association
8. Any other R& D organization / local / state / national level industry associations registered as per the established norms, and having at least 10 textile mills as member units.

Participating Mills will have option to select and join any one as the Third Party from the list of third parties. Once joined the selected Third Party, the participating mills shall not be allowed to change their selected Third Party for a period of at least one year.

The Third Party shall perform following activities as per the Plan of Activities:

Engagement of Expert Institutions like BTRA, IITs/NEERI/ICT or any other reputed environmental consultants /organizations or setting up of Expert Committee for Evaluation & Validation of following reports submitted by the participating Mills

- ✓ ETP adequacy assessment report, design / drawings and proposed augmentation / up gradation plan as per Charter

- ✓ Inventory, up graduation requirements and action plan for process up gradation
- ✓ Work plan by mills for reduction in water consumption/ effluent generation

8.2.2 Initial Phase

1. Evaluation & validation of individual mills Action Plan, including PERT Chart for implementation of the Charter for technological and process up-gradation.
2. Evaluation & validation of individual mills ETP adequacy assessment report w.r.t. environmental compliance, actual production, pollution load generation and targeted water consumption; and design, drawing and proposed augmentation and up-gradation plan, including PERT Chart in accordance with the Charter.
3. Evaluation & validation of individual mills assessment report of existing water consumption – section wise, reuse/recycle practices; and their strategies /work plans to achieve fresh water consumption targets.
4. Submission of validated individual mills action plans to concerned SPCBs and CPCB.

8.2.3 Quarterly Activities

Following activities will have to be carried out on quarterly basis:

1. Verification of progress made by individual mills on process technology / ETP upgradation as per their action plans
2. Verification of individual mills fresh water consumption, effluent generation and water recycling achievement, etc.
3. Verification of progress reports submitted by participating mills
4. Compilation of Implementation Status Report for Submission to SPCBs/ CPCB
5. Compilation of ETPs performance report for submission to SPCBs/ CPCB
6. Organizing Quarterly review meetings with participating mills/ SPCBs/ CPCB
7. Organizing quarterly review meetings with participating mills/ SPCBs/ CPCB
8. Periodic organize training/ workshop programs on process technology & Best practices, ETP operation & maintenance, sampling & analysis, etc. for mill officials

Cost of engaging third party / expert will be borne by the member mills. Participating Mills shall pay / reimburse fee to their selected Third Party towards meeting the expenditure for carrying out various activities / responsibilities assigned / to be assigned from time to time to the Third Party under the Charter. Each of the identified Third Parties shall provide the estimated project cost as per the scope of work to member mills willing to join them, who shall also be responsible for ensuring the payment of the services to Third Party.

8.3 State Pollution Control Boards (SPCBs)/Pollution Control Committees (PCCs)

The concerned SPCBs / PCCs shall ensure proper implementation of the Charter by the individual mills. They shall be responsible for monitoring and surveillance activities to ensure environmental compliance. Participating Textile Mills will not be allowed, under any circumstances, for bypassing of ETPs system and discharge of partially / un-treated effluent or episodic discharge. In case of any violation of the prescribed norms, concerned SPCBs will take appropriate actions, including issuance of closure notices, under the Water /Air Acts/ E (P) Act.

Each of the participating mills shall have option to join either any one of the identified Third Parties or their respective SPCBs/PCCs for evaluation & validation of their technical reports (Self-assessment and Planning Reports, Preparation of Inventory, ETP Adequacy & Up gradation, and Action Plans to Implement the Charter), and Physical Verification of their progress reports under the Charter implementation program.

SPCBs/PCCs shall constitute Expert Committee (s) for Evaluation & Validation of following reports directly submitted by the participating Mills to SPCBs/PCCs

- ✓ ETP adequacy assessment report, design / drawings and proposed augmentation / up gradation plan as per Charter
- ✓ Inventory, upgradation requirements and action plan for process up gradation
- ✓ Work plan for reduction in water consumption/ effluent generation

- ➢ **Some of the activities identified for SPCBs/PCCs are as under**:
  - ✓ To ensure proper implementation of the Charter by the individual mills
  - ✓ To carry out monitoring and surveillance activities to ensure environmental compliance
  - ✓ To take appropriate actions under the Water/ Air Acts /E(P) Act in case of any violation of prescribed norms
  - ✓ To participate in evaluation/validation of the status assessment reports, action plan for Charter implementation / process / ETP up gradation
  - ✓ To conduct quarterly review meetings of Mills, Third Parties & CPCB to facilitate mills in timely implementation of the Charter
  - ✓ To constitute Expert Committee for Evaluation & Validation of following reports directly submitted by the participating Mills to SPCBs (Mills have to decide whether to submit the action plans /progress reports to SPCB/ CPCB directly or through the third party).
    - o ETP adequacy assessment report, design / drawings and proposed augmentation / up gradation plan as per Charter
    - o Inventory, upgradation requirements and action plan for process up gradation
    - o Work plan for reduction in water consumption/ effluent generation

- **Surveillance Activities**
  - ✓ Verification of progress reports
    (On quarterly basis in case of direct submission by participating mills, and on random basis in case of submission through Third Party)
  - ✓ Compilation of Implementation Status Report for Submission to CPCB on Quarterly basis
  - ✓ Extensive surprise monitoring

- Organizing Quarterly Review meetings of participating Mills, Third Parties & CPCB to assess status of implementation of Charter and environmental compliance by mills.

8.4 Central Pollution Control Board (CPCB)

The CPCB shall supervise and co-ordinate with stake holders namely participating textile Mills, Third Parties, Expert Institutions, and SPCBs /PCCs. CPCB shall periodically review the progress of implementation of the Charter and carry out environmental compliance assessments. Based on findings of the review meetings, CPCB shall take necessary actions namely modification in the Charter/Action Plan /roles & responsibilities of participating agencies.

Some of the activities identified for CPCB are as under:

1. Participation in review meetings organized by third parties/ SPCBs
2. Organizing quarterly/ half-yearly review meetings of participating mills/ third parties/SPCBs to review the progress of the Charter implementation program
3. To supervise, co-ordinate and provide support to stakeholders
4. To take necessary actions namely modification in the Charter/Action Plan / roles & responsibilities of participating agencies, interpretation of the provisions prescribed under the Charter, approval for any state of the art technology, etc
5. Surprise Monitoring

9 Conditions Necessary for Timely Implementation of the Charter

1. The implementation of the Charter will be considered to be commenced on the date of issuance of directions/instructions from SPCBs/PCCs and the entire action plan will be implemented before Dec 31, 2022. (First phase 31st Dec 2021 & second phase 31st Dec 2022)
2. Participating Textile Mills will submit their time bound action plans in the affidavit format to their respective SPCBs / PCCs for implementation of the Charter as per the Plan of Activities and other Terms & Conditions.
3. Textile Mills shall sign MoUs/ Agreements with their selected Third Parties BTRA / (Associations / CTRI) to participate in the program as per the Plan of Activities and to reimburse the third party expenditure and shall sanction the project as per their mutual agreed ToR.

4. Textile Mill Associations, which have agreed to implement the Charter as per
5. CPCB/SPCBs directives / guidelines will be allowed to achieve short term, and long term objectives as prescribed by the Charter within the agreed implementation period. Participating Textile Mills will not be allowed, under any circumstances, for by passing of ETP systems and discharge of partially /untreated effluent or episodic discharge. In case of any violation, SPCBs/ PCCs will take appropriate actions, including issuance of appropriate directions under the provisions of Water/Air Acts/ Environment (Protection) Act.
6. No regulatory impediments: Any process modification, construction activity or any other action required to be under taken by a mill in pursuit of the objectives of this Charter should obtain necessary clearances from SPCBs with utmost speed. Concerned authorities should set in place a fast-track, single-window clearance mechanism. (SPCB must reply within 15 days from the date of query with suggestion otherwise it will be considered as approved.)
7. Any order/direction prescribed by any Court of Law/Tribunal in respect of individual industrial unit or in general, shall over rule the provisions/norms prescribed under this Charter, and shall be complied by the industry.
8. SPCBs / PCCs may prescribe conditions /norms, etc. stringent than those prescribed under this Charter, and shall be complied by the industry.
9. MoEF /CPCB/ SPCBs /PCCs may issues directions /instructions and /or take up programs for implementation of advanced technological and managerial tools to achieve further higher technological and compliance status in future for prevention, control and abatement of environmental pollution and to meet the objectives of National Mission for Clean Ganga(NMCG).
10. For any clarification and modification in the Charter, Chairman, CPCB will be the sole authority.

10 Industry Specific Standards Notified under the Environment (Protection) Rules, 1986

Under the Environmental (Protection) Rules of 1986, the maximum limit of various pollution parameters as notified for textile mills is given in Table 19. It should be the responsibility of the Mills to maintain & operate their ETP to get a treated effluent conforming to these norms, besides following other guidelines for reducing their energy, raw materials and water consumption.

Table 19 Existing Treated Effluent Quality Standards for Textile Mills

Parameters	Maximum Limits All values in Mg/Ltr (PPM) except pH, Color , SAR
pH	6.5 to 8.5
Suspended Solids (TSS)	100
Color (PCU- Pt-Co. Unit)	150
BOD (3 Days -27° C)	30

Oil & Grease	10
COD	250
Total Chromium as “Cr”	2.0
Total Sulphide as “S”	2.0
Phenolic Compounds as (C_2H_5OH)	1.0
Total Dissolved Solids (TDS)	2100
Sodium Absorption Ratio (SAR)	26
Ammonical Nitrogen (as N)	50

NOTES:

1) In case of direct disposal into rivers and lakes, the Central Pollution Control Board (CPCB) or State Pollution Control Boards / Pollution Control Committees (SPCBs / PCCs) may specify more stringent standards depending upon the quality of the recipient system.
2) Standards for TDS and SAR shall not be applicable in case of marine disposal through proper marine outfall.
3) The treated effluent shall be allowed to be discharged in the ambient environment only after exhausting options for reuse in industrial process / irrigation in order to minimize freshwater usage.
4) Any textile unit attached with the Common Effluent Treatment Plant (CETP) shall achieve the inlet and treated effluent quality standards as specified in serial number 55 of Schedule-I to the Environment (Protection) Rules, 1986 and shall also be jointly and severally responsible for ensuring compliance.
5) The standalone Micro, Small and Medium Enterprises (MSMEs) as per the MSME Development Act, 2006 shall meet the values specified above.
6) The standalone large scale units shall meet the values specified above; however, CPCB or SPCBs / PCCs with the approval of CPCB, may mandate Zero Liquid Discharge in Large scale units in environmentally sensitive / critical areas.
7) The TDS value with respect to treated effluent shall be 2100 milligrams per liter; however, in case where TDS in intake water is above 1100 milligrams per liter, a maximum contribution up to 1000 milligrams per liter shall be permitted provided the maximum value of 3100 milligrams per liter is not exceeded in the treated effluent.”.

11 Charter on Water Recycling & Pollution Prevention in Textile Industry

Textile mills are required to initiate following action plans to meet the requirements of the Charter for water recycling and pollution prevention.

Stage	Action to be taken by mills
1	Plan to reduce water consumption by implementation of new techniques. Immediately (within one week) on release of Charter
2	Plan to start internal recycling methods depending upon selective re-use in process. Within 2 years after release of Charter
3	Mill should plan to reduce water consumption by 30% after completion of 2 years of charter.

11.1 Best Manufacturing Practice (BMP)

The Best Manufacturing Practice (BMP) is indicative of the systems, equipment, processes and practices that are generally considered essential to achievement of the objectives of this Charter.

Technology actually required, or implemented, by individual mills to achieve the same documented level of environmental protection, may differ on account of their unique set of circumstances like scale of operations, equipment and system configuration, product portfolio, raw material mix, etc.

Ultimate aim is to (A) meet specified standards of discharge effluent and (B) Reduce water consumption by selection of technology and recycle of water.

Water saving techniques listed as under which can reduce water consumption (Mill can adopt below techniques & also can identify other methods to save water consumption. Aim is to achieve reduced water consumption target given in Table 20.

Table 20
Action to be taken for Reducing Water Consumption in Various Process Operations

Process	Suggested -Action	Steps to be Taken by Mill
Pretreatment (Desizing, Scouring & Bleaching)	1) Try to recycle internally	○ Can explore possibility to use bleaching water in scouring & desize. ○ Can use water from washes of each process wherever possible through counter current method in washer unit & also by storage in tank & re use.
	2) Avoid overflow rinses	○ Overflow rinses consumes 40% more water as compared to smart washing techniques.
	3) Combined Scouring & Bleaching process (Single bath scouring & Bleaching)	○ This will save water by 40% ○ Use counter current system for washing machines
	4) Use enzyme base technology	○ One can reduce water & energy consumption by reduction in temperature & number of washes.
		○ One can recycle this water back to process by topping-up of chemicals
Dyeing	1) Use single bath dyeing for PC blends	○ Saving of water, power , energy & time
	2) Use low salt dyes, 3) Use high exhaustion dyes, 4) Use of pad dry method instead of exhaustion method.	○ Approx. 20% to 60% water can be saved.
Finishing	1) Use of standing bath for batch wise application of finishing chemicals	○ Can save 15% of water. ○
	2) Can use hi suction slit on stenter	○ Can save 15% of water with compare to padding mangle. This also can reduce energy used in drying.
	3) To recycle cooling water on sanforise finish	○ 80% of water saving (Used in cooling)
New techniques	Use equipment's with low MLR	○ Can save 15% to 20% of water
	Recycle chiller plant water	○ Can save 80% of water

	Auto control of humidification room	○ Can save 25% to 30% of water
	Auto level control in processing machines	○ Can save 30% of water.
	Use nozzle with stop motion at the end of pipe during cleaning	○ Can save 25% of water
	Use of sensor for water flushing in toilets	○ Can save 50% of water.

The Bare Minimum Technology (BMT) is indicative of the systems, equipment, processes and practices that are generally considered essential to achievement of the objectives of this Charter (Mandatory)

BMP (Best Management Practices) is suggestion for overall improvement (Quality, productivity & cost). Industry can decide as an optional (It is not mandatory).

Technology actually required, or implemented, by individual mills to achieve the same documented level of environmental protection, may differ on account of their unique set of circumstances like scale of operations, equipment & system configuration, product portfolio, raw material mix, etc.

Ultimate aim is to A) meet specified standards of discharge effluent and B) Reduce water consumption by selection of technology & recycle of water.

1) Textile is one of the basic & growing industries of India. Chemical wet processing of textile consumes 8000-10000 chemicals, dyes and auxiliaries and some of them are banned due to their carcinogenic and other health impacts. It has been imperative to produce quality goods at economical price but not at the expense of environment, health & hygiene. To combat the difficulties raised by people who are in the business of textile; specially wet processors are compelled to employ eco-friendly wet processing right from pre-treatment to finishing ensuring good quality and reducing overall cost.
2) Textile industries use different chemicals in different processes like Desizing, Scouring, Bleaching, Dyeing, Printing, Finishing, Softening, Washing etc. The textile processing industries consumes large quantity of water and produce large volume of waste water from different steps in various processes. Waste water from textile processing and dyeing containing residues requires appropriate treatment before being released into environment.
3) Interest in eco-friendly processing in textile industry has increased with the awareness of environmental issues. Chemical management System can help to reduce NPO (Non Productive Output) & reduces pollution load on ETP and also conform to the quality of product as per customer's requirements.
4) To overcome pollution issue and reduce its impact on environment, mill technocrats must understand CMS (Chemical Management System) to:
   - ✓ List out total chemicals being used in plant and know its impact on environment.

- ✓ Select chemicals which are less harmful to environment as well as human beings. This can be done by adding environment related check point while selection of new chemical.
- ✓ Follow instructions given in the Manual for Storage, Disposal and Safety (MSDS) and Technical Data Sheet (TDS) of chemical and know their pollution impact.
- ✓ Follow standard process parameters as per TDS for best usage of chemical.

11.2 Chemical Management System (CMS)

The Textile Supply Chain is composed of several tiers as we go
down the ladder from the consumer to the fiber manufacturer. Across this stream, chemicals are used at different stages. Maximum use of chemical and therefore risks – is in the processing section i.e. the garment laundries and the fabric dye-house (Fig.9)

It is essential to manage the chemicals with proper understanding right from purchase, usages & up to disposal.

Looking towards seriousness of subject & need of an hour, CMS is developed. There are many consultants who work on CMS & guide industries for better outputs by reducing NPO's.

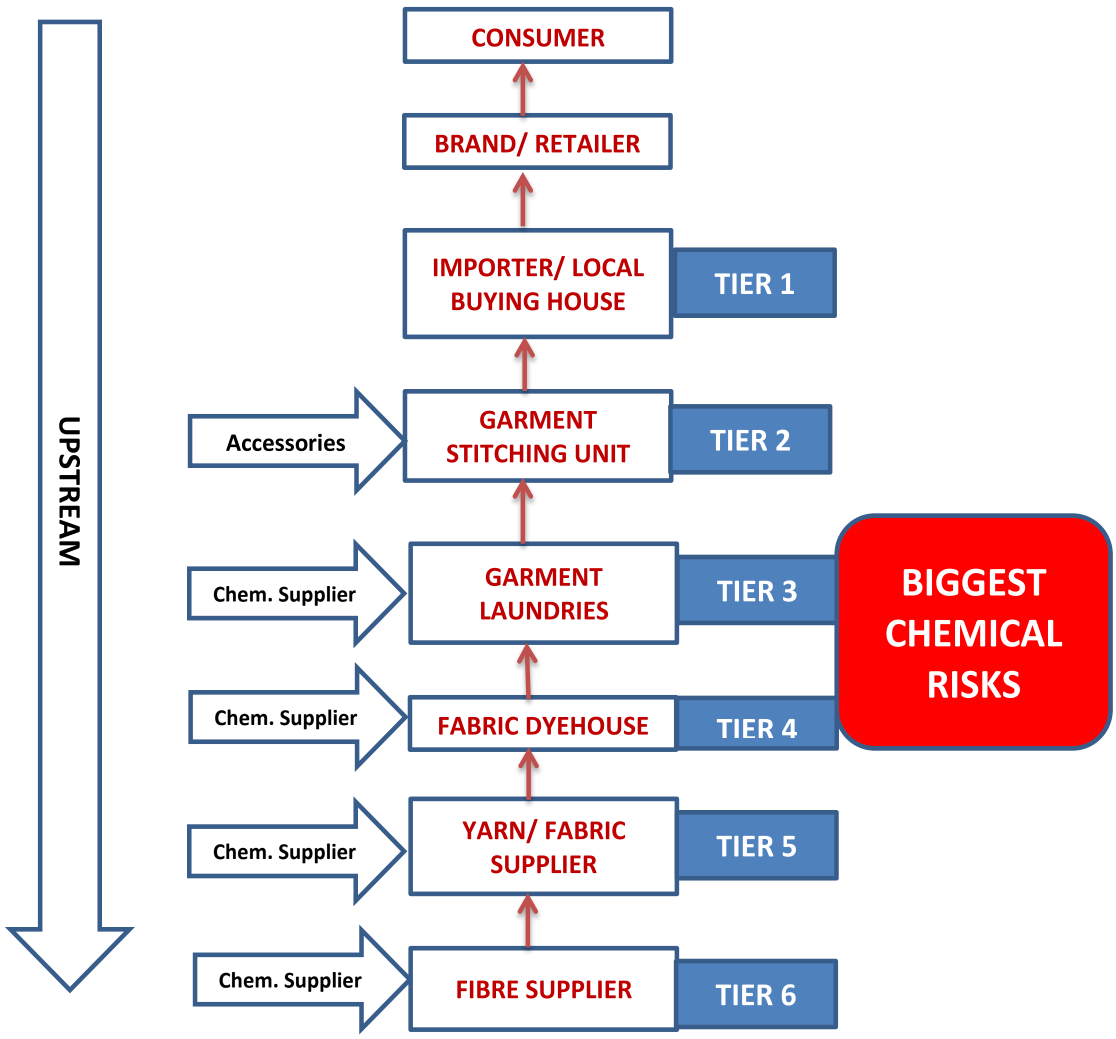


Fig. 9 Textile Supply chain –consumer to giber supplier.

(A) Objectives of CMS

- Quality & performance of end product,
- Compliance to prescribed norms
- Productivity improvements.

(B) Advantages of CMS

- Cost savings
- Improve quality of end product
- Compliance in outputs (Product & effluents)
- Saving in water & Energy
- Reduce accidents & improves Health & Safety

(C) How to Implement CMS

- Commitment for CMS
- Development of CMS team
- Development of CMS Policy
- Deciding authorities & responsibilities of team member from CMS team.
- Training to CMS team & work force
- Providing necessary formats for implementation of CMS in facility
- Development of MIS System - Daily / Monthly check points & reporting system to Top Management
- Self-grading system for future self-assessment.

(D) Examples for action

- Reduce chemical consumption by automation (pH control, Temp control, etc…)
- Use of Enzyme base technology in pre-treatments.
- Techniques to Reduce Salt consumption
- Replace Soda ash by Liquid alkali
- Know chemicals & its parameters for application
- Reuse
  - ✓ Water (standing bath technique, Counter current washing)
  - ✓ Water from Pre-treatments to be reused in to other baths like desizing.
  - ✓ Salt from Dye bath drain by Nano filter technology
  - ✓ Heat from Heat Recovery Unit
  - ✓ Water by using Vacuum slit instead of regular squeezing for better squeezing
  - ✓ Caustic recovery from mercerize wash liquor
  - ✓ PVA recovery system.
  - ✓ Reuse of cooling water at various stages of processing

- ✓ (Cooling water from Sanforize), Cooling towers etc.
- Single bath dyeing of PC blends for selective shades
- Use of Low salt dyes.
- Reduce MLR by various techniques
- Replace overflow rinse by normal washes.
- Use of standing bath for finishing.
- Auto dosing system for chemicals
- Use of laser techniques in place of Potassium Permanganate

11.3 BARE MINIMUM TECHNOLOGY (BMT)

BEST MANAGEMENT PRACTICES (BMP)

BMT is indicative of the systems, equipment, processes and practices that are generally **considered essential to achievement** of the objectives of this Charter in eco-friendly manner. Technology actually required, or implemented by individual mills to achieve the prescribed standards may differ on account of their unique set of circumstances like scale of operations, equipment & system configuration, product portfolio (cellulose, wool/silk/jute, polyester etc.).

However, in addition to the requirement of good manufacturing technology, the mills can also reduce their contribution in pollution load by resorting to Best Management Practices and good house-keeping measures. In the following pages a summary of the Bare Minimum Technologies and Best Management Practices (BMP) are listed for effluent and emission control.

BMP is suggested practices which can reduce the consumption of natural resources like fuel, power & water. It also reduces overall load of pollution. This is **not considered as mandatory** as it can be applied depending upon the availability of technology (equipment & process) & also on quality of end product requirement.

Bare Minimum Technologies (BMT) – Mandatory **Best Management Practices (BMP) - Optional**			
Measures to Be Taken by Facility			
Sl. No.	**Functional Area**	**BMT / BMP**	**Type of Action / Facility(Generic)**
1	**Raw Material Storage**		
1.1	**Storage of raw material**	**BMT**	Covered storage area with proper lighting, ventilation, and access to every stack. The storage area must have all requirements as per the current Factories Act.
1.2	**Storage of Dyes & Chemicals**	**BMT**	• Dyes & chemicals must be stored: - In a covered area – away from direct sun light. - In a place having good ventilation - With proper labeling • All storage / handling & first aid conditions to be maintained as per MSDS guidelines • First aid & firefighting equipment must be located as per the current Factories act.

			• Provision of containment area for storage for every chemical. • Provision of proper drainage lines so that seepage/spills of dyes and chemicals must reach to ETP. • Should follow storage conditions as per the current Factories act. • Correct system to measure mass or volume (kg or Liter). • Proper record of available stocks at any point of time.
		BMP - Optional	• To use stackers for vertical storage of material in racks • To display handling & safety measures for each chemical at storage area. • Display first aid measures in case of accident. • Provision of PPE • Install eye wash & shower with easy approach.
	Water storage	**BMT**	• Covered storage tanks for water with minimum capacity to store for 2 days of water consumption. • Measurement and record of water input & consumption in m^3/d.
		BMT	• To have a separate water tank as a reserve for any accident in premises.

Bare Minimum Technologies (BMT) - Mandatory **Best Management Practices (BMP) - Optional**		
Measures to Be Taken by Facility		
Functional Area	**BMT / BMP**	**Type of Action/Facility (Generic)**
Processing - (Pre-treatment / Cleaning, Dyeing /Printing, Finishing/Laundry etc...) & Laboratory		
Processing		
Pre-treatment / Cleaning	**BMT**	1. All equipment with required inbuilt safety measures 2. Correct weighing balances to measure the material to be processed & also chemicals required to be issued exactly as per issue slip 3. Digital temperature measuring devices. (Optional auto control of temperature) 4. Measurement of water consumption during each process. 5. System to maintain process parameters as per MSDS guidelines / Technical Data Sheet. 6. Use of environmentally hazardous chemicals in process to be avoided (refer MSDS / CPCB guideline of hazardous nature) 7. Availability of PPE & First Aid boxes as per guidelines given in MSDS 8. Must follow the current Factories act guidelines for all equipment
	BMP - Optional	1. To use auto dosing system for dyes & chemicals. 2. pH measuring devices (auto control acid dosing to maintain pH)
Dyeing & Printing	**BMT**	1. Dyeing equipment with required inbuilt safety measures. 2. Correct weighing balances to measure the material to be processed & also chemicals required to be issued exactly as per issue slip 3. Digital temperature measuring devices (Optional auto-control of temperature) 4. Light boxes for shade matching (Optional CCM along with light box) 5. Measurement of water consumption during each process (Optional auto control of water level). 6. System to maintain process parameters as per MSDS guidelines / Technical Data Sheet.

		7. Use of environmentally hazardous chemicals in process to be avoided (refer MSDS for guideline of Hazardous nature) 8. Availability of PPE & First aid boxes as per guidelines given in MSDS 9. Must follow the current Factories act guidelines for all equipment.
	BMP - Optional	1. To use auto dosing system for dyes & chemicals. 2. pH measuring devices (auto control acid dosing to maintain pH)
Finishing	**BMT**	1. Finishing equipment with required inbuilt safety measures. 2. Correct weighing balances to measure the material to be processed & also chemicals required to be issued exactly as per issue slip 3. Digital temperature measuring devices (Optional auto control of temperature). 4. Measurement of water consumption during each process (Optional auto control of water level) 5. System to maintain process parameters as per MSDS / Technical Data Sheet. 6. Use of environmentally hazardous chemicals in processing to be avoided (refer MSDS for guideline of Hazardous nature) 7. Use of PPE & First aid treatment as per guidelines given in MSDS 8. Must follow the current Factories act guidelines for all equipment.
	BMP - Optional	1. To use auto dosing system for dyes & chemicals. 2. pH measuring devices (auto control acid dosing to maintain pH)
Laboratory		
Incoming Raw material	**BMP - Optional**	○ Testing of raw material for Count/Denier, GSM & other necessary parameters ○ Checking for impurities & contaminants in raw material (e.g. Oil % in polyester, size% for woven fabrics etc.…)
Dyes / Chemicals	**BMP - Optional**	○ Testing of % purity of every dye & chemical.
Finished Product	**BMP - Optional**	○ Testing of finished goods for color fastness to washing & rubbing. ○ Testing for home laundering.

Bare Minimum Technologies (BMT) for ETP (Mandatory) Best Management Practices (BMP) for ETP (Optional)		
Measures to Be Taken by Facility		
Functional Area	**BMT / BMP**	**Type of Facility (Generic)**
Effluent Treatment Systems: One of the following combinations of effluent treatment technologies should be used to comply with treated effluent discharge standards notified under the Environment (Protection) Rules, 1986. 1. ETP must have Primary/Secondary & Tertiary Treatment units 2. Capacities of treatment tanks should be as per guide line given in below table for ETP 3. Online measurement for pH, effluent flow, DO, TDS at various treatment tanks (optional online control- auto dosing for pH control & auto control of DO by inverter drive). 4. Proper sludge drying system with separate sludge storage area with containment area. 5. Laboratory for testing of inlet & outlet effluent for pH, TDS, TSS, BOD, COD & flow. These must be recorded on daily basis. 6. Daily record of sludge generation & disposal		
The following individual plants are used for above schemes in different combinations.		
Biogas generation	**BMP - Optional**	• Anaerobic digestion is the biological decomposition of organic matter in absence of oxygen. It is the conversion of organic acid into methane and carbon dioxide by consortium of

		bacteria. This is generally applicable where sizing & desizing processes are carried out. This bio gas can be used in canteen. • COD reduction is around 60 to 70 %. The organic load in the digester is in between 5.0 to 8.0 kg/m^3/day. • One of the following biogas technologies are used as CSTR, UASB, **These processes can be used for treatment of effluent generated from sizing /desizing processes (in a volume)**
Incineration of Bio-Sludge	**BMP - Optional**	• Bio-sludge can be used as fuel along with supporting fuel such as coal, bagasse or other biomass whereas chemical sludge shall be taken to TSDF sites. • Bio sludge is generated in aeration tank & can be used as a fuel along with normal fuel in boilers.
Membrane filtration /Reverse osmosis	**BMP - Optional**	• Advance filtration technique (UF / Nano / RO) has been used commonly for advanced treatment of wastewaters to remove dissolved inorganic solids and some recalcitrant compounds. • The majority of the dissolved salts, low molecular weight organic materials, heavy metals, bacteria, viruses and suspended solids etc. are separated by the series of right membranes and are separated from the system as a brine which can be recycled back to dyeing process & reject to be dried in MEE. In this process, care to be taken in selection of pore size of Nano / RO.

Below is the BMT for each ETP (as per effluent volume generated). Facility should follow the suggestive guidelines mentioned below for getting desired results.

ETP should be operated by trained operators.

Operator should have recognized degree in Environmental Science/Engineering

Industry type	**Function/Description of Equipment**	**Minimum design required depends on effluent generation L/day**		
Water consumption L/day		**Upto 50000 L/day**	**50000- 2 Lac L/day**	**Above 2 lac L/day**
Primary collection tank/ Equalization tank	• To make homogeneous mixing of inlet effluent so that constant quality can be available for further process. • To maintain pH between 6.0 to 8.0 • To maintain the ambient +/- 3ºC temperature	• Minimum tank capacity with retention time of 36 hours with air mixing facility • Chemical Dosing tanks to maintain pH	• Minimum tank capacity with retention time of 30 hours with air mixing facility • Chemical Dosing tanks to maintain pH (Online meter) • Surface aerators can be used to mix the effluent which can help to maintain the temperature.	• Minimum tank capacity with retention time of 30 hours with air mixing facility • Chemical Dosing tanks to maintain pH (Online meter) • Surface aerators can be used to mix the effluent which can help to maintain the temperature.

Flocculation/ Coagulation tank	○ Dosing tanks for 3 chemicals to generate flocks. (de-colorant 1 tank & flocculating/ coagulating chemicals – 2 tanks	○ Tank capacity: for 30 min retention time ○ Low speed stirrer with regulator.	○ Tank capacity: for 30 min retention time ○ Low speed stirrer with regulator.	○ Tank capacity: for 30 min retention time ○ Low speed stirrer with regulator.
Flocks settling Tank	○ Effluent entry from bottom & exit from top. ○ Sludge removal valve at the bottom	○ Tank capacity: for 2 hours retention time.	○ Tank capacity: for 2 hours retention time	○ Tank capacity: for 2 hours retention time
Primary clarifier	○ Clarifier to separate & remove solid chemical sludge from top & bottom.	○ Storage capacity of clarifier should be 6 hours	○ Storage capacity of clarifier should be 4 hours	○ Storage capacity of clarifier should be 4 hours
Aeration tank	○ Aeration tank with biomass dosing system ○ Air blow with diffusers ○ Online DO meter, pH meter	○ Retention time in aeration tank - 24 hours ○ Not required if connected to CETP & fulfilling inlet norms of CETP. ○ Online meters are essential	○ Retention time in aeration tank - 24 hours ○ Spare air blower ○ Online meters are essential	○ Retention time in aeration tank - 24 hours ○ Spare air blower ○ Online meters are essential
Secondary Clarifier*	○ Clarifier to separate & remove Biological sludge from top (scrapper) & bottom.	○ Storage capacity of clarifier should be 8 hours ○ Not required if Aeration tank is not installed.	○ Storage capacity of clarifier should be 8 hours	○ Storage capacity of clarifier should be 8 hours
Pressurized Sand Filter & Activated Carbon Filter	○ Sand Filter is required to remove fine particles from treated effluent ○ Activated Carbon Filter is required to adsorb bad smell gases from effluent.	○ Suitable for effluent volume	○ Suitable for effluent volume	○ Suitable for effluent volume
Micro Filter (Optional)	○ Two Bag Filters first 25 Micron & 5 Micron	○ Not required if connected to CETP	○ As per effluent volume	○ As per Effluent volume
Ultra-Filter (Optional)**	○		○ Sufficient capacity as per design	○ Sufficient capacity as per design

RO (Optional)**	○		○ Sufficient capacity with three stage RO - as per approved design	○ Sufficient capacity with three stage RO - as per approved design
Sludge Settling Tank	○ To settle the sludge from clarifier or drain from any section of ETP. This will thicken the sludge which can be dried quicker.	○ 10000 L	○ 30000 L	○ 50000 L
Sludge Press / Drying System [NOTE: Both should be there- Filter press for primary sludge and sand drying beds for secondary sludge]	○ To get thick sludge which will be dried in sunlight or sludge dryer (Sludge Press / Decanter)	○ Sufficient capacity as per design		
		○ Hazardous sludge should be stored properly in a covered area to avoid contact with rain water / air till the authorized vendor takes it away for final disposal through land fill or incineration		
*. There are various types of clarifiers facility can select any & decide retention time of effluent for treatment.				
**. Auto back wash to be designed to improve life of membrane.				
ETP / Water recycling system must be get approved. Facility officials must meet the desired conditions & standards as per valid consent to operate.				

Settling Chamber	○ To remove coarser particulates from flue gas	Stack dimensions (height and diameter should be as per norms of CPCB to ensure sufficient dilution Settling chamber of suitable size (rectangular cross section) should be close to the ground level.
Multi-cyclone	To remove finer particulates with high efficiency	Dimensions of individual units and number of units in sequence to achieve the required removal efficiency
Bag filters (Alternative to cyclones)	○ To remove finer particulate matter ○ Fabric of bag should be able to bear high temperature	Sufficient capacity and number per bag house as per flow, particulate load and required removal efficiency
Ash ponds	To hold the boiler ash till disposal	Having sufficient capacity to hold ash generated during 2-3 months There should also be a stand by pond.
Fuel & Energy source	○ From renewable sources as much as possible	Facility should switch over to renewable energy source (rice husk, agro-biomass, solar)
		Use of wood should be stopped to avoid/reduce deforestation

It is suggested to keep a control on water consumption depending upon the categories mentioned in chart. Industry should confirm time bound action plan to reduce water consumption per kg of product generated.

12 Scope of Improvement: -

In order to reduce pollution impact of textile industry on human & environment, above protocol is developed. Along with above protocol, CPCB has tried to provide basic understandings on subject matter as a guideline. It is advised that, every responsible official must go through below document. The team of experts has mentioned several systems as Best Management Practices to reduce pollution at discharge level in three stages.

1) Reduce pollution impact by proper selection of Chemicals by avoiding hazardous chemicals in plant activity.
2) Reduce pollution impact by implementing right policies & practices (Procedures) & reduce NPO (Non Productive Outputs). This will help to optimize use of chemicals which ultimately go into drain & reach to ETP. This will also help to reduce cost of production.
3) Reduce pollution impact by adoption of correct procedure at ETP (Effluent Treatment Plant). This will help to meet desired legal norms laid down by PCBs. This will also open possibilities of water recycling along with Recycling of several chemicals from effluent. The right process can reduce overall cost of production in mill.

12.1 Versatility of Textile industry & basic words related to pollution

Textile processing industry is characterized by the large volume of water required for various operations with variety of chemicals. Mostly all industrial activities consume large amount of natural resources & generates pollution in one form or the other and & textile industry is contributing it larger extent. In textile industry, wet processing consumes huge amount of water, chemicals, energy and generating wastes (Non Productive Outputs) at each stage

No doubt, Indian textile industry is a significant contributor to national economies, by way of large generation of employment as well as earning of huge foreign exchange. Textile business is divided into various segments like small medium and large-scale operations.

Textile industry generates many waste streams, including liquid, gaseous and solid wastes, some of which are known hazardous & harmful to human & nature. Several measures for pollution control are discussed in detail including ‘End-of-pipe’ technologies for reduction of pollution level through waste water treatment. In addition to this, it is essential to include Chemical Management System, to reduce generation of Pollutants right from source by proper selection of chemicals, right storage & handling during process & lastly recycling water along with some chemicals back to selected processes.

Main focused areas are Best Management Practices (BMP) Chemical Management System (CMS) & Non Productive Outputs (NPO) Some examples are based on practical aspects during production activity such as water conservation in textile industry, recovery of salt, PVA, Caustic, selection of enzymatic process to reduce consumption of harmful chemicals etc… zero liquid discharge. This may lead to zero waste concept in textile industry. **By implementing above three tools (BMP, CMS & NPO) in right manner can reduce the cost of production with better quality of output leaving clean atmosphere.**

The textile industry is water-intensive. Water is used for cleaning raw material and for the different steps in the textile process. Due to water scarcity and stricter environmental regulations, the cost of freshwater utilization as well as treatment of effluent has increased worldwide. In addition, the textile industry faces pressure from government regulators to move toward sustainability by reducing water consumption, while internal pressures to manage cut-throat competition in costs.

Textile units utilize different amounts of water depending on specific products & processes adopted, such as the fabric used, equipment used and the prevailing management philosophy concerning water usage. Wool and cotton fabric materials processing requires a higher consumption of water than other categories, such as polyester or nylon. The vast amounts of wastewater generated by textile processing facilities create several challenges like effective usage of water, with a focus on energy efficiency. Ultimately, sustainability of textile unit depends upon cost factor focused at consumption of natural resources. Thus center of attention is on water consumption. Solution to these challenges leads to sustainable treatment methods which reduces water consumption & also help in reducing water pollution **-** thereby protecting public health and the surrounding ecosystems. Water is used for cleaning the raw material and for many steps including bleaching, mercerization, dyeing, printing & finishing during entire process. Produced water has to be cleaned from oil, fat, color and other hazardous chemicals, which are used during the several production steps.

It is quite difficult to define standard treatment for treating textile effluent because of the different requirements of each fiber (wool, silk, cotton, polyester etc.), the textile process (e.g., scouring, desizing, dyeing, washing, etc.) and because of the different quality required for the final fabric. Many institutes have started research work on waste water treatment systems & provide good solutions. Many industries have focused on customer requirements & started looking for "Green Products" claiming less harmful to nature & also safer for human being. Later on, it became popular as Eco-friendly processing where by the chemicals used during process are less or not harmful to mother earth & also to human being. This was studied by many experts & ultimately it suggested reducing / eliminating such chemicals from production activities. This system became popular as Chemical Management System (CMS). In CMS, processor should know the pollutant in auxiliaries being used in production & decide optimum dosages. Also must maintain necessary dosages & parameters during process so that, chemical can give best performance. Implementation of CMS can help in reduction of pollution load & also help in cost cutting.

To reduce water consumption per kg of production, one should take initiatives to implement water management practices. Also it is necessary to encourage technical team for adopt various water recycling methods. Various practices are described in Best Management Practices (BMP) whereby industry can reuse water internally in selected processes & reduce water consumption. Treated wastewater can be recycled through advanced filtration techniques. Textile wastewater treatment and reuse is a promising means of conserving available water resources and reducing harmful pollutants being discharged into the environment. This is especially useful for sustainability as companies in this industry move toward pursuing sustainability goals to reduce operational costs and complying with increasingly stricter regulations, it is becoming apparent that water reuse is one of the key components of these initiatives. Water reuse and sustainability is important goal for environmental pollution prevention practices in the textile industry. Textile industry must select & utilize water treatment solutions not only to reduce its operating costs, but also to reduce its water footprint and decrease the ecological impact from its wastewater discharge and generation of solids waste (sludge) on the surrounding atmosphere.

12.2 Textile industry - its impact on pollution - What is Pollution?

The contamination of soil, water, or the atmosphere by the discharge of harmful substances is known as the act or process of pollution. **Generally, pollution is an outcome of human activity & impact of other living animals on natural atmosphere and cycles.** The textile industry is one of the most pollutants releasing industries of the world. ... Besides, 20% of all fresh water pollution is made by textile activity. Pollutants released by the global textile industry are continuously doing unimaginable harm to the environment. It is essential to have sharp focus on pollution & pollutants created by Textile industry.

Impact of pollution is observed on

- Air, Water & Soil.
- Disturb the Natural cycles (seasonal changes) in atmosphere.
- Global warming
- Ozone layer depletion
- Last but not least, it reduces drinking water for living animals including Human.

There are three basic needs that a man possesses food, clothing, and shelter. When we think of pollution, we envision large power plants, coal mines, large fertilizer factories, and raw sewage piped into our waterways. We don't often think of the cloths on our bodies. The global textile and clothing industry is huge, as it fulfills the second basic requirement of man. The consumption of textile products is extremely high & is increasing day by day due to increase of population & fashion. This leads to increase in sq. meter consumption per person. Ultimately the overall impact of textile industry has on our planet is quite large. Fashion is a complicated business involving long and varied supply chains of production, raw material, textile manufacture, clothing construction, shipping, retail, use and ultimately disposal of the garment. It is said that textile is the third largest polluter (after Leather & paper industry) in the world. A general assessment says that, right from the pesticides used in cotton farming, the size used in fabric manufacturing, the toxic dyes used in manufacturing and the great amount of waste generated during disposal of garments. Other supporting systems also generate lots of pollution load which includes coal for steam generation, transportation & packing material. Pollutants released by the global textile industry are continuously doing unimaginable harm to the environment. It pollutes land and makes them useless and barren in the long run. Surveys show that cotton consumes the highest amount of harmful pesticides and fertilizers. Majority of them fall on land while they are sprinkled on the crop. Similarly, textile manufacturing units release hazardous waste into the nearby land.

Categories of Textile industry

Textile industry in India are in various forms ranging from small scale scattered, hand-looms, to garmenting & in organized clusters, units having automated modern machines for manufacturing fibers to fabrics. It includes different types of fiber such as cotton, silk, wool, synthetic (mainly Polyester, Nylon and Acrylic) as well as mixtures of these fibers (such as cotton + synthetic, cotton + wool) are used in the Indian textile units. Processed textile comprise various processes like –

1) Spinning & Fiber processing
2) Weaving, Knitting
3) Processing
4) Industrial Textile / Garmenting

The process flow diagram for a typical textile mill is

Fiber production - Spinning - fabric making (weaving / knitting) – Wet Processing (Loose cotton, yarn, fabric, Garment) – Garment making (Cutting, Bundling, Stitching, Inspection, packing)

On the basis of raw materials to finished products, the textile mills can be grouped as composite mills where final products (textiles) are produced by the use of raw material (fibers) and these are large units where huge investments are required' In addition to this, there are certain small segments of large industry called as ginning, spinning, weaving, processing, garmenting, laundry … etc.

Above processes can be further categorized as under depending upon difference in production lines (e.g. Woven, Non Woven, Knitted etc…. Each production house is a unique & have different raw material, process/Procedure & end- product.

Above mentioned broad segments may have various processes depending upon the end-product to be produced. We will focus at processing industry as it generates more loads on Pollution

Various processes involved in process

- ✓ Desizing
- ✓ Scouring
- ✓ Mercerization
- ✓ Bleaching
- ✓ Dyeing/Printing
- ✓ Finishing
- ✓ Garment washing

Highly polluted textile processing water source and content

Source / process	Typical concentrations
Sizing	Starch, waxes, Carboxyl methyl cellulose-(CMC), Polyvinyl alcohol (PVA) and Wetting agents. Preservatives etc.. High in COD and BOD. Typical water requirements are 1.5 to 5.0 Ltr/kg with an average of 3.5 L/kg.
Desizing	Starch, CMC, PVA, Fats, Waxes, Antistatic compounds, surfactants, Enzymes, mono and di-persulfates for oxidative desizing, surfactants and complexing agents High in BOD, Suspended solids (SS), TDS. Small volume. Typical water requirements are 5.0 to 12.0 L/kg with an average of 8.5 L/kg.
Scouring	Strong alkali (sodium hydroxide -NaOH), alkaline resistant and electrolyte resistant surfactants (fatty alcohols ethloxlyates, alkane sulfonates) enzymes and complexing agents. Typical water requirements are 15 – 30 L/kg with an average of 22.0 L/kg
bleaching	Hydrogen peroxide, sodium hypochlorite, acids, NaOH, surfactants, sodium silicate (Na2SiO3), sodium sulphite, sodium phosphate (Na_3PO_4), enzymes to remove surplus peroxide, short cotton fiber. High in alkalinity, TDS, Suspended Solids and fiber. Low BOD. Bleaching typically requires 15 – 25 L/kg of water
Mercerization	NaOH, ammonia, cotton wax, wetting agents (low molecular alkyl sulfates and alkane sulfonates), antifoaming agents, and complexing agents. Low BOD, TDS and O&G. Typical water requirements are 17 – 25 L/kg with an average of 20.5 L/kg.
Dyeing	Dyes, urea, reducing agents, oxidising agents, acetic acid, wetting agents, solvents, fatty alcohol and alkyl phenol ethyoxylates, aromatic hydrocarbons, chlorinated aromatic compounds, s, naphthalene sulfonic acid, polyamides, formaldehyde, nitrobenzene and other restricted Substances. Stronglycolored, heavy metals, High BOD, TDS, and low Suspended Solids, sulphide.
Padding	Polyacrylates, polyacryl amides, foaming surfactants, co-polymers, ethylene oxide, aryl ether sulfates.
Printing	Pastes, urea, starches, gums, binders, acids, thickeners, alkalis, reducing agents, film forming substances (styrene butadiene co-polymers), polyacrylates, mineral oils, alkyl aryl ethoxylates (APEO), isopropanol, melamine derivatives etc. Highly colored, high BOD, Oily appearance, heavy metals, high SS and slightly alkaline. Very small in volume.
Washes	This process is applied to clean the unwanted chemicals from textile material & generates all kind of pollutants applied in previous process.

Finishing	Resins, formaldehyde, softners, PVA, waxes, silicons, polyethylene etc. High in BOD, COD, Toxic compounds and solvents. Very small volume
Repellent finishes	Fluorocarbon resins, polysiloxanes, aluminum, zirconium and chromium compounds

12.3 Pollution & Pollutants – List of hazardous chemical groups & their adverse impact on human & environment.

A) What is Pollution: -

Generally, pollution is an outcome of human activity & impact of other living animals on natural atmosphere and natural cycles.

The contamination of soil, water, or the atmosphere by the discharge of harmful substances during the act or process of polluting, Pollutants can pollute three major areas as under

- **Water Pollution**

  The toxic chemicals used to produce textiles are major sources of pollution from factory operations. Factories use polyvinyl chloride to size fabrics, chlorine bleach for bleaching, benzidine, toluidine, heavy metals as dyeing agents and APEO – Emulsifiers as auxiliary during process. There are other carcinogenic chemicals (known cancer-causing agents), Other toxic chemicals that are used in everyday operations are formaldehyde, phenolic compounds, heavy metals like lead and mercury. Fabrics & garments are washed and rewashed as they move down the production line to customers. This process releases several pollutants & pollute waterways and groundwater sources.

- **Air Pollution**

  As textiles move through the production process, numerous life-threatening pollutants left untreated can contaminate the air. Factory activities consume lots of steam. Generation of steam is from Boilers which releases nitrous oxides and sulphur dioxides, carbon monoxide from chimney. Certain other operations like sizing, bleaching release chlorine derivatives, and fabric printing releases hydrocarbons and ammonia. Fabric-finishing operations can release formaldehyde into the air without EPA safeguards; these toxic vapors would remain suspended in the air and be carried by the wind to pollute other areas.

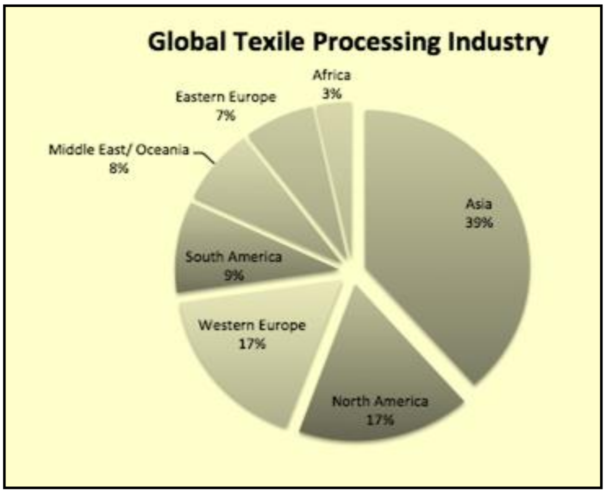
- **Solid-Waste Pollution**

  Textile manufacturing operations create large amounts of toxic and nontoxic solid waste. Fibers, and fabrics are solid waste that are created directly from production lines. The cones, looms and cardboard reels used to hold fibers and textiles during manufacturing add to a factory's solid-waste pollution. Common toxic-solid waste pollutants include the storage drums and plastic containers used to hold hazardous chemicals and solvents. Leftover powdered dyes and dye containers, scrap metal, oily cloths and wastewater sludge can contaminate the soil and groundwater sources if not properly disposed of or released untreated.

12.4 Impact on atmosphere & human beings

The textile industry is one of the most pollutants releasing industries of the world. ... Besides, 20% of world's fresh water pollution is made by textile treatment and dyeing. Pollutants released by the global textile industry are continuously doing unimaginable harm to the environment. It is essential to have sharp focus on pollutants & pollution created by Textile industry.

- Impact of pollution is observed on Air, Water & Soil.
- Disturb the Natural cycles (seasonal changes) in atmosphere.
- Global warming
- Ozone layer depletion



There are three basic needs that a man possesses food, clothing, and shelter. The global textile and clothing industry is really very huge, as it fulfills the second basic requirement of man. Asia is considered as production hub for textiles. The consumption of textile products is very huge & is increasing day by day due to increase of population & also increase in sq. meter consumption per person & fashion. Ultimately the overall impact the apparel industry has on our planet is quite large. Fashion is a complicated business involving long and varied supply chains of production, raw material, textile manufacture, clothing construction, shipping, retail, use and ultimately disposal of the garment. It is said that textile is the third largest polluter (after paper& Textile industry) in the world. A general assessment says that, right from the pesticides used in cotton farming, the size used in fabric manufacturing, the toxic dyes used in processing and the great amount of waste generated during disposal of garments. Other supporting systems also generate lots of pollution load which includes coal for steam generation, transportation & packing material. Pollutants released by the global textile industry are continuously doing unimaginable harm to the environment. It pollutes land and makes them useless and barren in the long run. Surveys show that cotton consumes the highest amount of harmful pesticides and fertilizers. Majority of them fall on land while they are sprinkled on the crop. One must know & accept that; textile manufacturing units release hazardous waste into the nearby land.

12.5 What are Pollutants: -

Here we link this word with chemical pollutants. The substance that pollutes something, especially water or the atmosphere is known as chemical pollutants.

Pollutants are bifurcated by various methods we will see each one in different tables.

i. Pollutants' used & generated during various processes of Textile Processing

The textile industry is water intensive and produces pollutants of different forms. Major environmental issues in textile industry result from wet processing. Wet processes may be carried out on raw cotton form, yarn or fabric. The transformation of raw cotton to final usable form involves different stages.

Many sources of wastewater can be found in a textile processing plant. The effluent can be segregated depending on the degree of pollution into low, medium and high.

Low and medium level polluted water source and its typical content and concentration are given in below table. One can definitely reuse this waste water in selected process & save consumption of fresh water.

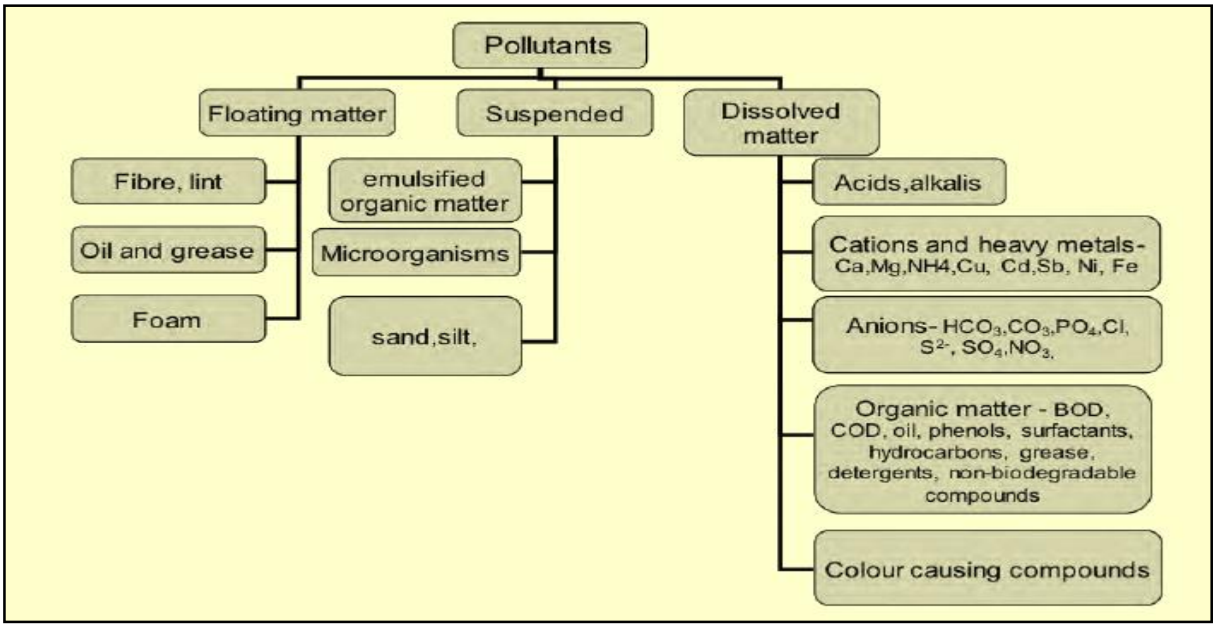
Table 1: - Textile plant -Low and medium polluted water source and content

Degree of Pollutants	Category of Waste water	Source	Typical concentrations
Low	Non-contact cooling water	Heat exchangers, generators and power boiler cooling towers steam trap leaks	Can be low in Total Dissolved Solids (TDS). Ideally needs to be segregated before treatment. Steam condensate - low TDS, sometimes high pH
Medium	Storm water	Parking plots and factory roof drains	Oil and grease (O&G). Storm-water needs to be properly handled set system.
	Clean-up	Raw water treatments- filter backwash	Sodium chloride (NaCl) Dirt
	Boiler blow-down, cooling tower blow-down	Boiler blowdown	High temperature, Boiler blow-down - high TDS and high pH Cooling tower blow-down – high TDS, high SS

High concentrations of contaminants are mainly coming from process wastewater.

1) Flow charts for various processes & its impact on pollution load.

Textile inlet effluent impurities: - categorized in three segments.



In the broad sense, the main pollutants in the textile effluent can be classified into three main categories as floating matter, suspended particles & also dissolved impurities which is well explained in below table. One must set a system of effluent treatment considering below impurities:

Processes Generating Pollution Load and level of their Impact on Ambient Water Quality			
Process	**Steps**	**Impact**	**Remarks / Comments**
Cleaning of fiber	Wool, Silk, Jute, Raw cotton package dyeing	Major	Effluent generation
Ginning Industry	Raw cotton mechanical cleaning	Minor	Major solid waste generation
Spinning Industry	Yarn making	Minor	Major solid waste generation
Fabric Making – Loom Shed	Sizing	Major	Effluent generation
	Weaving	None	
Wet Processing Industry / Process-House	De-sizing	Major	Effluent generation
	Scouring / Bleaching	Major	Effluent generation
	Dyeing & Printing	Major	Effluent generation
	Finishing	Minor	Effluent generation
Garment industry	Garment making	Minor	Solid waste generation
Laundry	Garment Washing, Dyeing, Printing	Major	Effluent generation

Effluent Treatment System of textile units: - As we know, Textile industries in India are highly water consuming industry. The liquid effluent characteristic (quality) and effluent quantity vary according to the processes involved, chemicals used and the scale of operation. Therefore, quality of effluent from one industry varies from the industry. As the textile manufacturing units use different type of raw materials, chemicals and processes, the wastewater treatment also need to be varied.

ii. Below pollutants are considered to measure pollution impact on atmosphere.

- Total Dissolved Solids(TDS),
- Total Suspended Solids (TSS)
- Oil & Grease
- Chemical Oxygen Demand(COD),
- Biochemical Oxygen demand(BOD),
- pH,
- Temperature,
- Total Ammoniacal Nitrogen (TAN),
- Heavy metals like Cadmium(Cd), Chromium(Cr), Copper(Cu), Iron(Fe), Nickel(Ni), Manganese(Mn), Potassium(K), Phosphorous(P), Sodium(Na), Sulphur(S), Zinc(Zn)

iii. Pollutants are categorized by Toxic element

There are various chemicals used in textile industry. These chemicals are categorisedin to 11 priority groups as under;

http://www.afirm-group.com/english-information-sheets/

1) Phthalates
2) APEO
3) Azo Dyes
4) Brominated & Chlorinated Flame retardants
5) Chloro-phenols
6) Chlorinated aromatics
7) Chlorinated solvents
8) Organotin Compounds
9) Short Chain Chlorinated Paraffin's (SCCPs)
10) Heavy metals
11) Per-fluorinated Chemicals (PFCs)

12.6 Impact of Pollutants on Human being & Environment

Since we share everything on Earth with every living thing on the planet, what happens in one area affects everything too, no matter how far away. Pollution or the introduction of different forms of waste materials in our environment has negative impact to the ecosystem we rely on. There are many kinds of pollutions, but the ones that most impact to us are air and water pollution.

It is necessary to know these priorities groups & try to avoid using chemicals to stop poisoning natural water with hazardous, persistent and hormone-disrupting substances. It is a challenge to textile industry to identify & treat them correctly at end of the pipe before discharging to nature. There is another solution to this - Eliminate all hazardous chemicals across production activities & use safe options. This seems to be an easier option

Nearly every activity leaves behind some kind of waste in the environment. Households create ordinary garbage. Cars, trucks, and buses emit exhaust gases while in operation. Industrial and manufacturing processes create solid and hazardous waste. Some wastes contain chemicals that are hazardous to people and the environment. Once these hazardous chemicals are present in the environment, people can become exposed to them. Exposure occurs when people have contact with a chemical, either directly or through another substance contaminated with a chemical.

Chemicals can enter the environment from many different sources such as landfills, incinerators, tanks, drums, or factories. Human exposure to hazardous chemicals can occur at the source or the chemical could move to a place where people can come into contact with it. Chemicals can move through air, soil, and water. They can also be on plants or animals, and can get into the air we breathe, the food we eat and the water we drink.

The different ways a person can come into contact with hazardous chemicals are called exposure pathways. There are three basic exposure pathways: inhalation, ingestion, and skin contact. Inhalation is breathing or inhaling into the lungs. Ingestion is taking something in by mouth. Skin contact occurs when something comes in direct contact with the skin. Ingestion can be a secondary exposure pathway after skin contact has occurred, if you put your hands in your mouth and transfer the chemical from your hands to your mouth.

The Environmental Protection Agency (EPA) has developed informational summaries on selected chemicals to describe how people might be exposed to these chemicals and how exposure to them might affect their health. The summaries also explain what happens to the chemicals in the environment, who regulates them, and whom to contact for additional information.

Some common ways a person may be exposed to hazardous chemicals are:

1) **Water**: Water pollution effects like the air we breathe, water is vital to our survival. It is a precious resource that can easily be polluted and the contamination can transferred to us and affect our health. Exposure can occur when people drink contaminated groundwater or surface water, or accidentally ingest it while swimming or showering. Direct skin contact also is an exposure pathway that occurs during activities like swimming and showering. Water borne diseases such as amoebiasis, typhoid, diarrhea etc. are very common in India due to usage of polluted water. Water pollution affects marine life which is one of our food sources.

2) **Soil, Sediment, or Dust**: People can be exposed to hazardous chemicals in soil, sediment, or dust if they accidentally ingest it, breathe it in, or have direct skin contact. Children are highly susceptible to these exposure pathways. In their daily activities, children have a tendency to have frequent hand-to-mouth contact and introduce non-food items into their mouths.

3) **Air**: We breathe air to live and what we breathe has a direct impact on our health. Breathing polluted air puts you at higher risk for asthma and other respiratory diseases. Air pollutants are mostly carcinogens and living in a pollutant area can put people at risk of cancer. Exposure can occur when people breathe in hazardous chemical vapours or air that is contaminated by hazardous chemicals or dust.

4) **Food**: People can be exposed to hazardous chemicals through the food they eat. Food contamination can occur if the food has come into contact with hazardous chemicals. It can also occur further down the food chain such as through eating contaminated fish. For more information, as a natural flow, effluents are discharged on surface & it reaches to water reservoirs or sea. Fishes come in to contact of hazardous chemicals & absorb – accumulate in fish –tissues. Ultimately, it affects human.

Exposure diagram

Exposure, the chemical getting into or on your body, has to occur to make you sick or cause adverse health effects, or have any effect on your health. If you are not exposed to the chemical, it cannot make you sick. Also, even if exposure has occurred, adverse health effects may not occur.

Adverse health effects are dependent on the following factors of the exposure. Factors that play a part in whether or not adverse health effects may result from an exposure are:

- Type of chemical;
- Toxicity of chemical;
- Amount or dose (the amount or level of a chemical a person was exposed to);LD50
- Concentration level of chemical (LC50)
- Duration (how long did exposure occur); and
- Frequency (how many times the person was exposed).

Also, the occurrence of adverse health effects can depend on the way the chemical enters your body. Some chemicals rapidly absorb through skin, others not at all. Health effects also depend on the toxicity of the chemical that entered your body. Some chemicals are very toxic in small amounts; others are only toxic in large volumes.

For the unborn babies (infants) & child, the adverse health effects from exposure to chemicals can be much greater than for adults. The factors that affect their susceptibility include their stage of development and level of activity in the environment. The fetus is the most susceptible because their developing organs may be permanently damaged. Similarly, children, especially from one to six years of age, are also in a stage of rapid development. During this period, children may take more chemical into their bodies due to body chemistry, level of activity, and relative small body size. As children develop, chemicals introduced into the body can alter many processes essential for proper cell development. As a result, changes can, for example, cause organs within the body to be altered, impairing proper development to a mature organ.

Adolescents may share in the risk due to their increased physical activity and curiosity of the world around them. For more information, see Children's Health Protection.

The human body has the ability to tolerate certain amounts of chemicals and the ability to excrete chemicals from the body. Once a person is exposed to a chemical, it may enter the blood stream, and eventually reach the liver. The liver attempts to detoxify harmful chemicals in the body by converting them to less toxic ones or ones that could be used by the body. The body naturally attempts to eliminate substances that are harmful or are not used. The kidneys filter substances out of the blood and excrete them in urine. Also, chemicals are removed from the body in feces, sweat and exhalation. However, the body may not be able to remove all the chemicals. The amount, type, and length of time you are exposed to harmful substances will determine if you are at risk for adverse health effects.

1) Alkyl phenol Ethoxilates (APEO)

Commonly used alkyl phenol compounds include nonyl phenols (NPs), Octyl phenols and their ethoxylates, particularly nonylphenol ethoxylates. NPs are widely used in the textiles industry in cleaning and dyeing processes. Studies suggest that these compounds persist in rivers, sediment and ground water. They are toxic to aquatic life, persist in the environment and can accumulate in body tissue and bio magnify (increase in concentration through the food chain). Their similarity to natural Oestrogen hormones can disrupt sexual development in some organisms, most notably causing the feminization of fish & than after human being.

- NPEOs or OPEOs biodegrade until they to generate Nonylphenol (NP) and Octylphenol (OP). which is non-biodegradable and more toxic than the original compound. They are bio-accumulative and persist in marine environment.
- Most importantly, NPs are suspected endocrine disruptors, i.e. they mimic female hormones in the human body & disrupt normal body functions. Their structure is similar to the female hormone 17-β Estradiol.

2) Phthalates

Phthalates are a group of chemicals most commonly used to soften PVC (the plastic polyvinyl chloride). In the textile industry they are used in artificial Textile, rubber and PVC and in some dyes. There are substantial concerns about the toxicity of phthalates such as DEHP (Bis (2-ethylhexyl) phthalate), which is repro-toxic in mammals.

The phthalates DEHP and DBP (Dibutyl phthalate) are classed as ‘toxic to reproduction’ in Europe and their use restricted. Under EU REACH legislation the phthalates DEHP, BBP (Benzyl butyl phthalate) and DBP are banned by 2015.

- Phthalates are toxic to reproduction and developmental toxins.
- They affect the health and safety of growing children.
- The toxicity varies depending on the specific phthalate structure.

3) Brominated and chlorinated flame retardants

Many brominated flame retardants (BFRs) are persistent and bio-accumulative chemicals that are now present throughout the environment. Poly-brominated diphenyl ethers (PBDEs) are one of the most common groups of BFRs and have been used to fireproof a wide variety of materials, including textiles.

Some PBDEs are capable of interfering with the hormone systems involved in growth and sexual development. Under EU law the use of some types of PBDE is tightly restricted and one PBDE has been listed as a 'priority hazardous substance' under European water law, which requires that measures be taken to eliminate its pollution of surface waters.

- Tris based flame retardants are semi-durable and leachable
- Tris-based and PBB FRs are proven carcinogenic chemicals
- Bio-accumulative
- Upon incineration, these chemicals release dioxins and furans which are reported to be most toxic pollutants.

4) Azo dyes

Azo dyes are one of the main types of dye used by the textile industry. However, some azo dyes break down during use and release chemicals known as aromatic amines, some of which can cause cancer. The EU has banned the use of these azo dyes that release cancer- causing amines in any textiles that come into contact with human skin.

- Azo Colourants can release one or more aryl amines under reductive cleavage of the azo group (-N=N-). The cleavage of the azo group can occur on the skin, in the intestine and in a body organ. On the skin and in the intestine, this is brought about by bacteria. In the body, for instance, in the liver, azo compounds can be broken down by certain enzyme systems. Non-fixed, water-soluble azo dyes come into contact with skin through perspiration**.**
- These amines are Carcinogenic. Benzidine & 2- naphthylamine are known to cause bladder cancer in workers.
- Azo dyes releasing 26 amines (under certain conditions) are restricted in the EU, China, India, Egypt, Korea, Taiwan and Vietnam.

5) Organotin compounds

Organotin compounds are used in biocides and as antifungal agents in a range of consumer products. Within the textile industry they have been used in products such as socks, shoes and sport clothes to prevent odour caused by the breakdown of sweat.

One of the best-known organotin compounds is tributyltin (TBT). One of its main uses was in antifouling paints for ships, until evidence emerged that it persists in the environment, builds up in the body and can affect immune and reproductive systems. Its use as an antifouling paint is now largely banned. TBT has also been used in textiles.

TBT is listed as a ‘priority hazardous substance’ under EU regulations that require measures to be taken to eliminate its pollution of surface waters in Europe. From July 2010 and January 2012 products (including consumer products) containing more than 0.1% of certain types of organotin compounds will be banned across the EU.

Organotin compounds are Persistent, Bio-accumulative and Toxic (PBT). It has been detected in fish, birds, otters, seals, sharks, porpoises and whales.

They are Mutagenic (chemical agents which changes the genetic material like DNA) and Teratogenic (substance capable of interfering with the development of fetus). High TBT levels were found to have impaired reproduction and causing shell deformities in oysters.

6) Per-fluorinated chemicals

Per-fluorinated chemicals (PFCs) are manmade chemicals widely used by industry for their non-stick and water-repellent properties. In the textile industry they are used to make textile and Textile products both water and stain-proof.

Evidence shows that many PFCs persist in the environment and can accumulate in body tissue and bio-magnify (increasing in levels) through the food chain. Once in the body some have been shown to affect the liver as well as acting as hormone disruptors, altering levels of growth and reproductive hormones.

The best known of the PFCs is per-fluoro-octane sulphonate (PFOS), a compound highly resistant to degradation; it is expected to persist for very long periods in the environment PFOS is one of the ‘persistent organic pollutants’ restricted under the Stockholm Convention, a global treaty to protect human health and the environment and PFOS is also prohibited within Europe and in Canada for certain uses.

Very persistent, Very bio-accumulative (vPvB) and Toxic.

Readily gets absorbed and accumulates in human and animal tissues.

Studies have found small quantities of PFOS and PFOA in the blood samples of humans and wildlife nationwide; indicating that exposure to the chemicals is widespread.

PFOS has been included in 2009 Stockholm Convention on Persistent Organic Pollutants (‘POP’) list.

7) Chlorobenzenes

Chlorobenzenes are persistent and bio-accumulative chemicals that have been used as solvents and biocides, in the manufacture of dyes and as chemical intermediaries. The effects of exposure depend on the type of chlorobenzene; however, they commonly affect the liver, thyroid and central nervous system. Hexa chloro benzene (HCB), the most toxic and persistent chemical of this group, is also a hormone disruptor.

Within the EU, penta-chloro-benzene (PCB) and Hexa chloro benzene (HCB) are classified as ‘priority hazardous substances’ under regulations that require measures to be taken to eliminate their pollution of surface waters in Europe. They are also listed as 'persistent organic pollutants' for global restriction under the Stockholm Convention, and in line with this they are prohibited or scheduled for reduction and eventual elimination in Europe.

8) Chlorinated solvents

Chlorinated solvents - such as tri-chloro-ethane (TCE) - are used by textile manufacturers to dissolve other substances during manufacturing and to clean fabrics. TCE is an ozone-depleting substance that can persist in the environment. It is also known to affect the central nervous system, liver and kidneys. Since 2008 the EU has severely restricted the use of TCE in both products and fabric cleaning.

9) Chlorophenols

Chloro-phenols are a group of chemicals used as biocides in a wide range of applications, from pesticides to wood preservatives and textiles. Pentachlorophenol (PCP) and its derivatives are used as biocides in the textile industry. PCP is highly toxic to humans and can affect many organs in the body. It is also highly toxic to aquatic organisms. The EU banned production of PCP-containing products in 1991 and now also heavily restricts the sale and use of all goods that contain this chemical.

Highly toxic to aquatic systems. It bio-accumulates in organisms.

- Highly toxic to aquatic systems. It bio-accumulates in organisms.
- Harmful to human health.
- Highly persistent in the environment.
- PCP does not meet the Protocol on POPs for water, soil and sediments (Stockholm Convention)
- Technical PCP is contaminated with highly toxic by-products such as Dioxins and Furans.

10) Short-chain chlorinated paraffin

Short-chain chlorinated paraffin's (SCCPs) are used in the textile industry as flame retardants and finishing agents for Textile and textiles. They are highly toxic to aquatic organisms, do not readily break down in the environment and have a high potential to accumulate in living organisms. Their use has been restricted in some applications in the EU since 2004.

11) Heavy metals: cadmium, lead, mercury and chromium (VI)

Heavy metals such as cadmium, lead and mercury, have been used in certain dyes and pigments used for textiles. These metals can accumulate in the body over time and are highly toxic, with irreversible effects including damage to the nervous system (lead and mercury) or the kidneys (cadmium). Cadmium is also known to cause cancer. Though Cr is a vital element for the proper function of human body its oxidative state (Cr^{+6}) is highly toxic even in trace levels.

Uses of chromium (VI) include certain textile processes and Textile tanning: it is highly toxic even at low concentrations, including too many aquatic organisms. Within the EU, cadmium, mercury and lead have been classified as 'priority hazardous substances' under regulations that require measures to be taken to eliminate their pollution of surface waters. In Europe, Uses of cadmium, mercury and lead have been severely restricted in textiles.

- Heavy Metals are Carcinogens, Mutagens and Toxic to Reproduction.
- They could be allergenic and cause dermatitis and eczema

12.7 Effluent treatment & Discharge standards as per Regulatory authorities

Pollution load from textile mills differ widely depending upon the nature of fiber used and the level of processing employed. Organic ingredients in the waste water undergo bio-degradation and reduce dissolved oxygen content (DO) of the receiving water body destroying the aquatic life. Phenolic chemicals impart bad odor and taste to the water mass. The organics should be removed to prevent any chances of stream water becoming unsuitable for agricultural, domestic and industrial use. Solids in textile mill waste waters come from fibrous substrate and process chemicals. This affect oxygen transfer capacity and reduce light penetration affecting photo-synthetic activity in the water-body.

Soluble inorganic salts may make the receiving water bodies unfit for domestic and industrial use. Heavy Metals are toxic to aquatic life.

Proper treatment of waste water will reduce these harmful effects and prevent environmental degradation and provide opportunities for further use of water through recycle. Some measures may also need to be adopted to reduce pollution load such as; Strong rinse waters from dye houses may be used to prepare fresh dye-baths whereas dilute waste waters may be recycled after appropriate treatment within the plant. Saving of chemicals in the first situation may be enough to pay for the cost of treatment in the second situation.

After taking all possible steps to reduce pollution load and volume of waste water, the remaining pollutants still do not permit the disposal of wastewater in to a water body. These pollutants may be removed or reduced to be of safe level (conforming to the effluent disposal norms) by treating the waste water using a variety of treatment steps and combination of sequences. The best treatment sequence may vary from mill to mill.

INDIAN STANDARDS FOR DISCHARGE OF ENVIRONMENTAL POLLUTANTS PART-A : EFFLUENTS is available on web-site http://cpcb.nic.in/GeneralStandards.pdf Even though, industry must follow the discharge norms as per consent to operate document given by state pollution control board.

12.8 ETP details & Basic terms used in ETP

Processes steps used in Effluent treatment plant: -

Wastewater treatment processes can be divided into pre-treatment, primary, secondary and tertiary and advanced treatment which includes zero liquid discharge and salt recovery as shown in below fig.

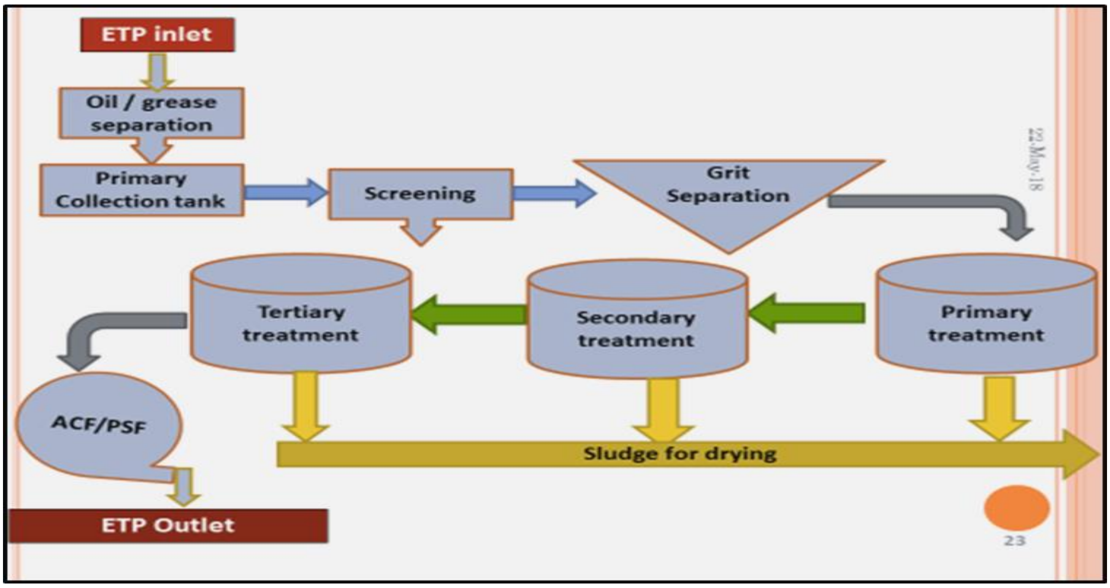
Details of each section of ETP, Quality norms as per regulatory authority. Check points in ETP & impact of pollutants on human being & nature.

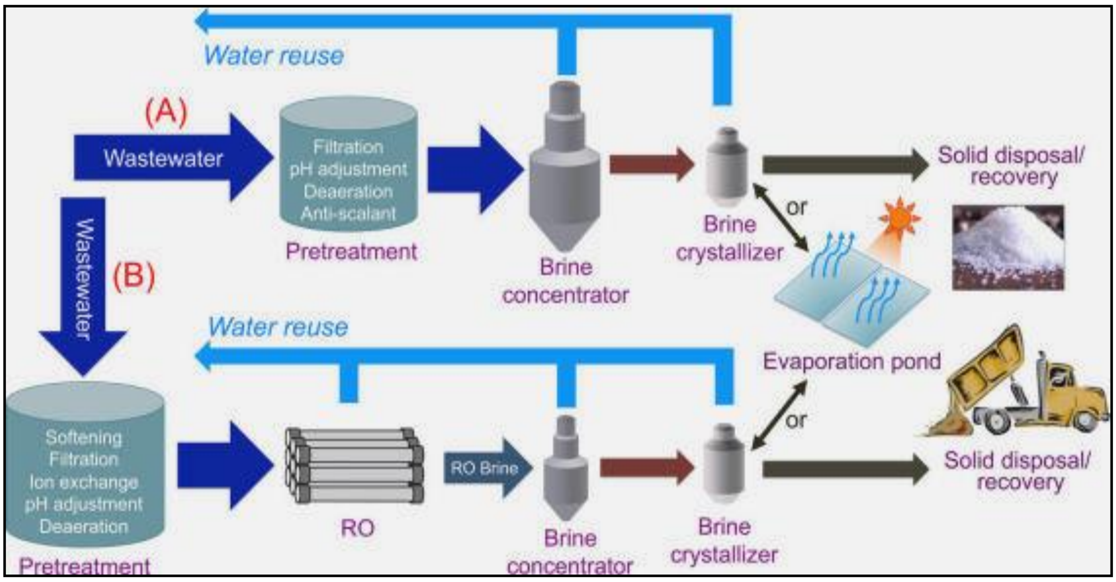
There are various types of treatments in ETP (Effluent Treatment Plant) & after passing effluent through these processes, treated effluent can be recycled after polishing step.

Details of each section of ETP

There are various types of treatments in ETP (Effluent Treatment Plant) & after passing effluent through these processes, treated effluent can be recycled with polishing step.

Process flow of standard ETP





(Recycling of water & salt)

Let us see various treatments involved in basic ETP.

- **Preliminary Treatment**
  - ✓ Screening
  - ✓ Oil & grease removal,
  - ✓ Equalization tank,
- **Primary treatment:**
  - ✓ Chemical dosing & Flocculation
  - ✓ Primary clarifier –settling sedimentation & segregation
  - ✓ pH correction,
- **Secondary Treatment**:
  - ✓ Biological treatment & activated sludge
  - ✓ Secondary clarifier,
- **Tertiary treatment**
  - ✓ Treated effluent collection tank / Ozonation
  - ✓ Pressure Sand Filter
  - ✓ Activated Carbon Filter
  - ✓ Bag Filter
- **Sludge handling**
  - ✓ Sludge collection tank
  - ✓ Concentrating Sludge
  - ✓ Sludge press
  - ✓ Sludge decanter
  - ✓ Sludge dryer
  - ✓ Disposal of sludge
- **Water recycling**
  - ✓ Ultra-Filtration
  - ✓ Nano Filtration
  - ✓ Reverse Osmosis
  - ✓ Multi Effect Evaporator
  - ✓ Recycling of salt / Brine solution

Preliminary treatment

Preliminary treatment is required to remove the coarse solids and other large materials from raw wastewater. Removal of these materials is necessary to enhance the operation and maintenance of subsequent treatment units. A number of unit operations are engaged in the preliminary treatment of wastewater to eliminate undesirable characteristics of wastewater. The operations include use of screens and grates for removal of large materials, pre-aeration for odour control. pH correction and removal of oil & grease. Preliminary treatment done with good manner, improves the performance of ETP.

Primary treatment

Primary treatment is important step in the wastewater treatment process. It involves physical separation of suspended solids from the wastewater using primary clarifiers. This process is helpful in reduction of total suspended solids (TSS), reduces partial COD and prepares the waste for the next step in the effluent treatment process. The objective of primary treatment is to remove of settable organic and inorganic solids by sedimentation and removal of materials that float (scum) by skimming. Approximately 25 to 50% of the COD, 50 to 70% of the total suspended solids (TSS), and 85% of the oil and grease are removed during primary treatment. Some organic nitrogen, organic phosphorus, and heavy metals associated with solids are also removed during primary sedimentation but colloidal and dissolved constituents are not affected. Effective Primary treatment ensures satisfactory performance of subsequent treatments in the plant. Sedimentation chambers are the main units involved but various auxiliary processes such as fine screening, flocculation and floatation may also be used. The second step may be chemical treatment (generally with lime and alum or PAC). The purpose is to remove metals by precipitation but it also removes some associated colloidal COD. The process generates chemical sludge. The primary treatment involves various physical-chemical processes:

- Flocculation-It is a Physico-chemical process that encourages the aggregation of coagulated colloidal and finely divided suspended matter by physical mixing or chemical coagulant aids. Flocculation process consists of a rapid mix tank and a flocculation tank. The process involves mixing of effluent with coagulants in tank, which is then passed on to the flocculation basin where slow mixing of effluent & chemicals occurs & it allows the particles to agglomerate into heavier / more settle able solids. The different types of chemicals used in coagulation include inorganic electrolytes, natural organic polymers and synthetic poly electrolytes. The selection of a specific chemical depends on the characteristics and chemical properties of the contaminants. ($FeSO_4$, Lime, PAC, Alum, decolourant etc.
- Sedimentation- This process is aimed to remove easily settlable solids. Sedimentation chambers may also include baffles and oil skimmers to remove grease and floatable solids from top & also include mechanical scrapers for removal of sludge at the bottom of the chamber.
- Addition of certain coagulants increases the oil removal efficiency of DAF units.
- Clarification- Clarification system uses gravity to provide continuous, low cost separation and removal of particulate, flocculated impurities and precipitates from water gets carried along with free flow of effluent. The clarifier is designed in such a way that entire effluent with precipitates are transferred at the bottom of the circular tank &and clear water floats upward. Mud in a slurry form is accumulated at bottom & can be removed from bottom pipe with gate valve. Clean effluent gets

free flow from top circular trench to next process. In this manner, toxic chemicals which may kill the microbes). Are removed before it reaches to biological treatment.

- Neutralization- Incoming untreated wastewater has a wide range of pH, and it is difficult to treat wastewater with such a high variability of pH. Neutralization is the process used for adjusting pH to optimize treatment efficiency. Acids such as sulphuric or hydrochloric may be added to reduce pH or alkalis such as dehydrated lime or sodium hydroxide may be added to raise pH values. Neutralization may take place in an equalization tank. It can be carried out at the end of the primary treatment also to control the pH of discharge in order to meet the standards.

Secondary treatment

This process involves decomposition of suspended and dissolved organic matter in effluent using microbes. Biological treatment processes mainly used for secondary treatment and are based on microbial action to decompose suspended and dissolved organic pollutants in wastewater. Microbes use the organic compounds as source of energy. Biological treatment can be either aerobic where microbes require oxygen to grow or anaerobic where microbes grow in absence of oxygen or facultative where microbes can grow with or without oxygen. Micro-organisms may be either attached to surface as in trickling filter or be unattached in a liquid suspension as in activated sludge process.

Activated sludge process- It is a continuous flow, **aerobic biological treatment** process that involves suspended growth of aerobic micro-organisms to biodegrade organic contaminants. Influent is introduced in the aeration basin and is allowed to mix with the contents. A suspension of aerobic microbes is maintained in the aeration tank. A series of biochemical reactions in the basin degrade the organics and generate new bio mass. Microorganisms oxidize the matter into carbon dioxide and water using the supplied oxygen. These organisms agglomerate colloidal and particulate solids. The mixture is passed to a settling tank or a clarifier where micro-organisms are separated from the treated water. The settled solids are recycled back to the aeration tank to maintain a desired concentration of micro-organisms in the reactor and some of the excess solids are sent to sludge handling facilities. To ensure biological stabilization of organic compounds, adequate nutrient levels of nitrogen and phosphorous must be available to the bio mass.

The key variables to the effectiveness of the system include:

a) Organic loading which is described as food to micro-organism ratio (F/M) ratio or Kg of BOD applied daily to the system per Kg of biological solids in aeration tank. F/M ratio determines BOD removal, oxygen requirements and bio mass production. Systems designed and operated at lower F/M provide higher treatment efficiency.
b) Sludge retention time (SRT) or sludge age is the measure of the average retention time of solids in the system and the SRT, similar to F/M ratio, affects the degree of treatment, oxygen

requirements and the production of waste sludge. Systems designed and operated at higher SRT provide higher treatment efficiency.

c) Oxygen requirements are based on the amount required for biodegradation of organic matter and the amount required for endogenous respiration of micro-organisms.

The two most common types of biological filters are;

- **Trickling Filters**: In trickling filters treatment is provide by a fixed film of microbes that forms on the surface which adsorbs organic particles and degrades them aerobically. Wastewater is distributed over a bed made of rock or plastic and flows over the media by gravity.
- **Rotating Biological Contractor**: A rotating biological contactor (RBC) consists of a series of discs about 40% of the area is immersed in waste water and the remaining of the surface is exposed to atmosphere, provide a surface for microbial slime layer.
- **Anaerobic Treatment Systems**- These processes are slower than aerobic degradation and when sulphur is present, obnoxious hydrogen sulphide gas is generated. Though the capital cost is high, part of it can be compensated by recovery of bio gas. They are not so commonly used in wastewater treatment systems for ETPs except as a means for sludge stabilization.

Tertiary treatment

- Tertiary treatment may include a number of physical and chemical treatment processes that can be used after the biological treatment to meet the desired objectives. Tertiary treatment is the final cleaning process that improves wastewater quality before it is reused, recycled or discharged to the environment. Tertiary treatment is used for effluent polishing (BOD, TSS), nutrient removal (N, P), toxin removal (pesticides, VOCs, metals) etc.
- Tertiary treatment can also be extensions of conventional secondary biological treatment to further stabilize oxygen-demanding substances in the wastewater, or to remove nitrogen and phosphorus. Tertiary treatment can also involve physical-chemical separation techniques such as activated carbon adsorption, flocculation/precipitation, membranes filtration, ion exchange, de-chlorination and reverse osmosis.
- Some of the common tertiary treatment processes are described below:
- **Granular Media Filtration-** Many processes fall under this category and the common element being the use of mineral particles as the filtration medium. It removes suspended solids mainly by physical filtration. Two common types of these granular media filers are
- **Sand filters** are the most common type which consists of either a fixed or moving bed of media that traps and removes suspended solids from water passing through media.
- **Dual or multimedia filtration** consists of two or more media and it operates with the finer, denser media at the bottom and coarser, less dense media at the top. Common arrangement is

granite base at the bottom, sand in the middle and anthracite coal at the top. Flow pattern of multimedia filters is usually from top to bottom with gravity flow. These filters require periodic back washing to maintain their efficiency.

- **Bag filters**: **-** There are many types of bag filters where different pore size bags are used. Bag filters are used as a protection system to Ultra Filter. Regular cleaning & replacement of bag filters can improve life of UF.
- **Membrane Filtration**– This technique is used to separate particles from a liquid for the purpose of purifying it. In membrane filtration, a solvent is passed through a semi permeable membrane. The membrane's permeability is determined by the size of the pores in the membrane. The size of the pores has to be carefully calculated to exclude undesirable particles, and the size of the membrane has to be designed for optimal operating efficiency. The result is a cleaned and filtered fluid on one side of the membrane, with the removed solute on the other side. Microfiltration, ultra-filtration, Nano-filtration and Reverse Osmosis are some of the examples of membrane filtration techniques.
- **Reverse Osmosis Systems**– This is also a membrane separation method that is used to remove several types of large molecules and ions from solutions through application of pressure to the wastewater on one side of a selective membrane. The result is that the contaminant is retained on the pressurized side of the membrane and the treated waste water is allowed to pass to the other side.
- **Ion Exchange** – Ion exchange is a process of exchange of ions between two electrolytes or between an electrolyte solution and a complex. Ion Exchange can be used in wastewater treatment plants to swap one ion for another for the purpose of demineralization. There are basically two types of ion exchange systems, the anion exchange resins and the cation exchange resins. It can be used for softening, purification, decontamination, recycling, removal of heavy metals from electroplating wastewaters and other industrial processes, polish wastewater before discharging, removal of ammonium ion from wastewaters, salt removal, purify acids and bases for reuse, removal of radioactive contaminants in the nuclear industry, etc.
- **Activated carbon**– Activated carbon is used in a large range of applications in tertiary waste water treatment. Powdered as well as granular activated carbons are generally used for the purpose of de-chlorination of organic compounds. Organic compounds in waste water are adsorbed on to the surface of the activated carbon. A number of factors affect the effectiveness of the activated carbon. These include pore size, composition (Iodine value >1200) and concentration of the contaminant, temperature around 35˚C and pH preferably neutral to slight acidic of the water and the flow rate or contact time of exposure. Activated carbon can be applied on a broad spectrum of organic pollutants and is typically used to remove

contaminants from water such as pesticides, aromatic compounds such as phenol, adorable organic halogens, non-biodegradable organic compounds, colour compounds and dyes, chlorinated/ halogenated organic compounds, toxic compounds, compounds that normally inhibits biological treatments, oil removal in process condensates, halogens, especially chlorine that oxidises downstream processes and organics that have the potential to foul ion exchange resins or reverse osmosis membranes.

- **Ultraviolet (UV) Disinfection** – This technique is primarily employed as a disinfection process that inactivates waterborne pathogens without use of chemicals. Additionally, UV is also effective for residual TOC removal, destruction of chloramines and ozone. Design of the actual treatment system for ETP involves selection of alternative processes based on the ability of individual treatment processes to remove specific waste constituents. UV + Oxidation (Ozone) helps in cracking the pollutant molecule & convert it in to basic molecule.

Treatments in ETP & water recycling are dynamic & daily researches & new inventions brought in to field to improve effluent quality which can be studied & implemented as & when required.

Let us understand the basic terms used in Effluent Treatment plant.

Basic words	Definition
pH	• The pH is equal to −log10 c, where c is the hydrogen ion concentration in moles/ltr. • pH is a figure which express the acidity or alkalinity of a solution on a logarithmic scale on which 7 is neutral, lower values are more acid and higher values more alkaline.
TDS	• TDS is a measure of the combined content of all inorganic and organic substances contained in a liquid in molecular, ionized or micro-granular (colloidal sol) suspended form. • It is measured in ppm (Parts /million
TSS	• Total suspended solids (TSS) is the dry-weight of suspended particles, which are not dissolved, in a sample of water. • TDS can be trapped by a filter & can be measured in PPM.
BOD	• Biochemical oxygen demand (BOD) is a measure of the amount of oxygen that bacteria will consume while decomposing organic matter under aerobic conditions. • The main focus of wastewater treatment plants is to reduce the BOD in the effluent discharged to natural waters. • BOD can be measured in PPM
COD	• Chemical Oxygen Demand (COD) is an indicative measure of the amount of oxygen that can be consumed by reactions in a measured solution. • Chemical oxygen demand is similar to biochemical oxygen demand in that they are both used to calculate the oxygen demand of a water sample. The difference between the two is that chemical oxygen demand measures everything that can be oxidized, whereas biochemical oxygen demand only measures the oxygen demanded by organisms. • Can be measured in PPM
DO	• Dissolved oxygen (DO) is defined as the oxygen dissolved in water available to sustain life, including living bacteria. ... • Ambient temperature, as well as effluent conditions, affect dissolved oxygen readings.

	• It is measured in PPM
MLSS	• Mixed liquor suspended solids (MLSS) is the concentration of suspended solids, in an aeration tank during the activated sludge process, which occurs during the treatment of waste water. ... • Mixed liquor is a combination of raw or unsettled wastewater or pre-settled wastewater and activated sludge within an aeration tank.
MLVSS	• MVLSS is generally defined as the microbiological suspension in the aeration tank of an activated-sludge biological wastewater treatment plant. • The biomass solids in a biological waste water reactor are usually indicated as total suspended solids (TSS) and volatile suspended solids (VSS). • MLSS is used to indicate the concentration of suspended solids in activated sludge. MLVSS represents the concentration of biomass in activated sludge.
Treatability study	It is a jar (Bucket) test by which one can understand how the effluent can be treated & fix chemicals as well as its dosages.
Retention time	It is a measure at an average length of time holding the wastewater in a tank
Grab Sample	It is a sampling method in which a single sample is taken at a specific time
Composite Sample	It is a collection of several individual samples taken at regular intervals over a period of time, usually 24 hours. & combined testing is done
Bio Mass	It is a colony of living Bacteria, which digest many organic and inorganic substances. An essential part of the ecosystem including within human beings
Activated Sludge	Sludge that has undergone flocculation forming a bacterial culture typically carried out in tanks. Can be extended with aeration
Clarifier	A section of ETP equipment used to "clarify" the wastewater, It is a holding tank that allows settling. Used when solids have a specific gravity greater than 1.00
Anaerobic Digester	The breaking down of organic material and other waste biologically by microorganisms in absence of Oxygen. Results in by-products such as methane gas, carbon dioxide, sludge solids and water
Grit Chamber	Usually in ETP, a chamber or tank in which primary influent is slowed down so heavy typically inorganic solids can drop out, such as metals and plastics
Flocculation	The process whereby a chemical or other substance is added to wastewater to trap or attract the particulate suspended solids into clusters -woolly looking mass
Sludge	The solid waste material which settles out in the wastewater treatment process, sometimes it includes bio-solids. This can be dewatered & disposed in government nominated area on chargeable basis. Some research work is exploring possibilities on it can be used for brick making or can be used as a fuel. (prior permission from local statutory agencies are essential for re-use)

Standard parameters for effluent discharge are as per attached regulatory sheet. See annexure-iii

In general, below mentioned parameters are checked & their limit values are to be monitored as per table. However, industry must follow discharge norms as per their consent to operate document.

Industry Specific Standards Notified under the Environment (Protection) Rules, 1986

Existing Treated Effluent Quality Standards for Textile Mills (discharge to inland surface)

Existing Parameters as per standards	Maximum Limits All values in Mg/Ltr (PPM) (except pH, Color , SAR)
pH	6.5 to 8.5
Suspended Solids (TSS)	100
Color (PCU- Pt-Co. Unit)	150
BOD (3 Days -27° C)	30

Oil & Grease	10
COD	250
Total Chromium as “Cr”	2.0
Total Sulphide as “S”	2.0
Phenolic Compounds as (C_2H_5OH)	1.0
Total Dissolved Solids (TDS)	2100
Sodium Absorption Ratio (SAR)	26
Am0nical Nitrogen (as N)	50

Know your effluent: - One must know the characteristics of effluent being collected at primary collection tank. Testing of raw effluent is very important. It is essential to have details of effluent volume (inlet) & its basic tests like COD, TDS, TSS, pH.

Treatability Study: -

A treatability study is a study in which a wastewater /effluent is subject to a physical, chemical, biological, or thermal treatment process to determine:

- Whether the waste is amendable to the treatment process;
- What pre-treatment (if any) is required;
- The optimal process conditions needed to achieve the desired treatment;
- The efficiency of a treatment process for a specific waste or wastes; or
- The volumes and characteristics of residuals resulting from various treatment processes

Phases of treatability study: The phases of a typical treatability study include:

- Identifying treatment and recycling goals.
- Obtaining representative samples for testing.
- Determining analytical methods to evaluate compliance with requirements.
- Developing the necessary testing program to determine if the goals can be met.

In the laboratory for the determination of coagulant dose jar test Apparatus is used. The jar test is a common laboratory procedure used to determine the optimum operating conditions for water or wastewater treatment. This method allows adjustments in pH, variations in coagulant dose, alternating mixing speeds, or testing of different coagulant or polymer types, on a small scale in order to predict the functioning of a large scale treatment operation. A jar test simulates the coagulation and flocculation processes that encourage the removal of suspended colloids and organic matter from the effluent. The jar test is the most common method of determining proper coagulant dosages. When there is a question as to which chemical should be used as a coagulant, it is often necessary to run more than one series of jar tests. Different coagulant chemicals and pH ranges should be used to determine which one produces the most satisfactory results at the lowest cost.

Daily treatability study is to be carried out by ETP operator & decide the dosages of chemicals. This is a good practice & must be done on daily basis.

Treatability study can be carried out as under.

- Take 10 Litre of effluent
- Check pH of same & maintain pH as desired by dosing acid/alkali (Use diluted chemical from dosing tank) write exact chemical required for getting desired result.
- Now you have chemical required for 10 ltrs which can be converted to bulk with proportionate ratio as per flow rate KL/Hour.
- Maintain same dose for next 12 Hours for particular chemical (here dosing rate of chemical is set & measured in Ltr/minute)
- Follow similar procedure for every chemical used in ETP (individual / combination) at various stages.

Let us know few basic terms in details.

A) **BOD: - Biochemical Oxygen demand (BOD):**

The strength of the wastewater is often determined by measuring the amount of oxygen consumed by microorganism like bacteria in biodegrading the organic matter. The measurement is known as the Biochemical Oxygen Demand (BOD). Microorganisms such as bacteria are responsible for decomposing organic waste. When organic matter such as dead plants, leaves, grass clippings, cellulose components, manure, sewage, organic waste like dyes, fats and oils, or even food waste is present in a water supply, the bacteria will begin the process of breaking down this waste. When this happens, bacteria in aerobic process, robbing other aquatic organisms of the oxygen they need to live, consume much of the available dissolved oxygen. If there is a large quantity of organic waste in the water supply, there will also be a lot of bacteria present working to decompose this waste. In this case, the demand for oxygen will be high (due to all the bacteria) so the BOD level will be high. As the waste is consumed or dispersed through the water, BOD levels will begin to decline. Nitrogen and phosphates in a body of water can also contribute to high BOD levels. Nitrates and phosphates are plant nutrients and can cause plant life and algae to grow quickly. When plants grow quickly, they also die quickly. This contributes to the organic waste in the water, which is then decomposed by bacteria. This results in a high BOD level. The temperature of the water can also contribute to high BOD levels. For example, warmer water usually will have a higher BOD level than colder water. As water temperature increases, the rate of photosynthesis by algae and other plant life in the water also increases. When this happens, plants grow faster and also die faster. When the plants die, they fall to the bottom where they are decomposed by bacteria. The bacteria require oxygen for this process so the BOD is high at this location. Therefore, increased water temperatures (35˚C is standard increase may lead to reduce activity & increase BOD) will speed up bacterial decomposition and result in higher BOD levels. When BOD levels are high, dissolved oxygen (DO) levels decrease because the bacteria are consuming the oxygen that is available in the water. Since less dissolved oxygen is available in the water, fish and other aquatic organisms may not survive. Textile Denim plant wastewater possesses a very high BOD like 500 – 2500 mg/l. It is necessary to reduce this BOD value up to a level less than 30 mg/l before discharging them into the environment like canals or rivers. If a water body of high BOD is discharged into the sea or very large river then off course the concentration of BOD decreases due to dilution and have little or no harmful effect on the aquatic life or environment. Therefore if it is possible to discharge a highly toxic effluent in sea or large river no treatment is necessary.

B) Dissolve Oxygen (DO) :

Though it is not mentioned as a basic parameter, dissolved oxygen (DO) is a highly significant parameter to define the BOD or COD of a wastewater. The amount of oxygen present in a certain amount of water in dissolved state is known as DO. It is normally expressed as mg/l. Water may contain DO ranging from 0 to 18 mg/l but in most cases of normal waters, DO lies between 7-9 mg/l. Aquatic lives require certain level of DO to survive in the water. In case of wastewater the microorganisms require oxygen to consume the organic wastes. As a result the DO of water decreases tremendously and becomes a threat to the life of aquatic species. Textile effluents possess very low. In ETPs, DO level in aeration tank (Biological treatment, it is suggested to maintain above 2.0 PPM

C) Chemical Oxygen Demand (COD):

This is a means of measuring the ability of wastewater to sustain aquatic life, essential for the preservation of the environment. It also enables proper assessment of treatment plant performance. Aquatic organisms and animals require dissolved oxygen to flourish. The Chemical Oxygen Demand (COD) test gives an indication of the impact of discharge waters on aquatic life by measuring the oxygen depleting nature of the discharge water. COD is based on the fact that nearly all-organic compounds can be fully oxidized to carbon dioxide with a strong oxidizing agent under acidic condition. COD is another common measure of water-borne organic substances — the process of measuring COD causes the conversion of all organic matter into carbon dioxide. For this reason, one limitation of COD is that it cannot differentiate between biologically active and those which biologically inactive. One major advantage of COD over BOD is that COD can be measured in just three hours whereas BOD measurement takes at least five days. The value of COD is always higher than BOD, this is because BOD accounts for only biodegradable organic compounds while COD accounts for all organic compounds e.g. biodegradable as well as no biodegradable but chemically oxidisable.

D) Total suspended Solids (TSS):

TSS is mainly organic in nature, are visible and can be removed from the wastewater by physical/ mechanical means e.g. screening and sedimentation. TSS is measured by filtering a certain quantity of effluent and then drying the filtrate followed by weighing. TSS is expressed as parts per million or in milligram/litre. The pore size of the filter paper is very important in estimating the TSS, the nominal pore size 1.58 micro meters.

E) Total Dissolved Solids (TDS):

TDS are the solids that are actually in solution, similar for example to mix sugar into hot coffee. Dissolved solids generally pass through the system unaffected. TDS is the sum total of all of the dissolved things in a given body of water. It is everything in the water that's not actually water. It includes hardness, alkalinity, cyanuric acid, chlorides, bromides, sulphates, silicates, and all manner of organic compounds. Every time we add anything to the water, we are increasing its TDS. This includes not only sanitizing and pH adjusting chemicals, but also conditioner, algaecides, and tile and surface cleaners. TDS also includes airborne pollutants and bather waste as well as dissolved minerals in the fill water. TDS is referred to as the total amount of mobile charged ions, including minerals, salts or metals dissolved in a given volume of water, and is expressed in units of mg per unit volume of water (mg/L), or as parts per million (ppm).

Retention Time calculations

The two important parameters for designing an ETP of right capacity and appropriate capability of treating waste water are: (a) Flow rate (b) Pollution load of untreated waste water

(a) Effluent Flow Rate:

Flow rate considered for ETP design (design flow rate) is should be representative of actual flow rate of effluents coming out from the factory processes. Effluent flow from the factory normally fluctuates depending upon the products in-process and type of processing machinery in operation. Flow rates must be measured at different time intervals so that it gives true representation of actual effluent flow. It's a practice to measure flow rate on hourly basis for at least 24 hrs. Spot measurements made over short periods of time generally give inaccurate and misleading data. Through this exercise peak, average and low flow rates are ascertained.

ETP is normally designed with an extra capacity to cater any planned or unplanned expansions in the production processes. Therefore, flow rate considered for ETP design should have at-least 20-25% excess capacity. This excess capacity could be more based on the future expansion plans in the process.

(b) Pollution Load

Pollution load means type and concentration of physical and chemical contaminants in the waste water. These are usually measured or expressed in terms of pH, Chemical Oxygen Demand, Biological Oxygen Demand, Total Dissolved Solids etc.

To ascertain that pollution load is correctly determined for the design, following checks need to be undertaken:

Appropriate parameters contributing to the pollution load and their concentration are considered in the design. This depends on the type of industry and production processes involved. Local legislation for effluent discharge limits should be referred for determining the need for testing of parameters applicable on particular industry.

In absence of clear guidance in the local legislation, it is recommended that waste water stream should be analyzed for at least pH, COD, BOD, TSS, TDS and temperature parameters or help can be taken from Industry

Pollution load must be measured by analyzing Composite Samples of effluent stream for at least 24hrs (Composite Sample: bigger sample composed of individual sub-samples combined together). This is most important factor for each section of ETP. It is essential that, each process gets proper time for its best performance so that, one can reduce cost of treatment. Here are some suggested retention times for various processes of ETP. Retention time can be varied depending upon modification of basic system, effluent quality & size of ETP. To meet desired norms of treated effluent, at ETP outlet one should follow below points during designing of ETP & follow the procedure given by ETP provider (Ultimate requirement for an ETP is "To follow the guidelines suggested in your ETP design which is approved by local statutory authority).

2) Bare Minimum Technology (BMT) in ETP

It is essential to study once again page no 46 onwards & must follow the details mentioned in the charts.

How to calculate Retention time –

1) Total volume of inlet water in ETP. (One can take readings for 30 days & consider maximum volume) Consider factor of safety 30% & use 130% of inlet effluent volume for calculations.
2) Consider 24 hours as running of ETP per day.

   Hence,

   Retention time = Inlet volume*1.3/24

One must know the formulas of calculating volume of tanks.

3) Check points ETP /RO/MEE operations Do's & Don'ts

ETP needs to be assessed in four sections.

- Section 1: Design of ETP
- Section 2: Consented parameters for effluent discharge (as per valid consent to operate)
- Section 3: Test reports (internal & External)
- Section 4: Operation controls

Section 1 - Evaluation of ETP Design

Evaluation of ETP design is very important because plant design is most important factor to meet desired norms once & daily on continual manner. One must study & understand ETP design for any of the following reasons:

- ✓ Before constructing new ETP if the design provided by the supplier can be not correct.
- ✓ If treated water from the ETP is not meeting the discharge limits (indications of under capacity of ETP)
- ✓ Waste water test reports are unreliable or different from the reality.
- ✓ Increase in waste water flow (quantity)
- ✓ Change in effluent characteristics (quality) due to expansion in production processes, change in production techniques, products or new machines etc.

The two important parameters for designing an ETP of right capacity and appropriate capability of treating waste water are:

A) Flow rate

B) Pollution load of untreated waste water

A) Effluent Flow Rate

One can measure flow rate as under;

Flow meters are available to understand flow of effluent. It has to be measured by taking hourly readings & maximum flow rate should be considered as base for deciding ETP design.

In absence of availability of correct flow meters, below method to be considered.

Total Effluent received in ETP (Volume in KL) divided by 24 hours will give average Flow rate of ETP. One must calculate flowmeter readings after every 3 hours & can derive maximum flow rate (same should be considered as actual flow rate).

For designing ETP, flow rate should be 30% higher than actual flow rate. This designed flow rate should be considered for calculation of retention time.

Some standard retention time for each section of ETP is to be studied.

Actual treatability study can be asked to perform.

One should do following checks to ascertain that pollution load is correctly determined for the design:

- ✓ Appropriate parameters contributing to the pollution load and their concentration are considered in the design. This depends on the type of industry and production processes involved. Local legislation for effluent discharge limits should be referred for determining the need for testing of parameters applicable on particular industry.
- ✓ it can be very well confirmed by checking reports / testing of following parameters (as per standard parameters for effluent discharge)
- ✓ Pollution load must be measured by analysing Composite Samples of effluent stream for at least 24hrs (Composite Sample: bigger sample composed of individual sub-samples combined

together). An example of 24-hrs composite sampling for measuring flow rate and analysing concentration of physical & chemical contaminants in the waste water

- ✓ In designing the ETP, 30% factor of safety to be considered. This will take care of shock loads if any.

Section 2: Consented parameters for effluent discharge (as per valid consent to operate)

Section 3: - Achieved results of discharge of effluent.

Section 4: - Operational controls

In addition to this, one must note that, the performance of an ETP cannot be judged just on the basis of test reports of treated effluents. It is equally important that one must check operational controls of ETP. Operational controls include

- ✓ Key parameters (e.g.; pH, Temp, DO level, flow rate etc.) established for all treatment stages.
- ✓ Operating range (upper and lower limits) established for all key parameters. e.g.; Dissolve Oxygen limit in the aerator 1.5 to 2.5 mg/ liter
- ✓ Monitoring or testing frequency (hourly, daily, weekly basis) established for all key parameters.
- ✓ Availability of monitoring devices e.g.; pH meter, DO meter, flow rate meter, energy meter online system for report & analysis. etc.
- ✓ Dosing system for chemicals,
- ✓ Recording of key process parameters
- ✓ Recording of power consumption
- ✓ Flow rate of treated effluent for keeping track of ETP operation on continuous/ regular basis.
- ✓ Water balance system to be checked for factory.

One point to be noted that, ETP having weak operational controls has less chances that treated effluent will meet discharge limits.

- ✓ One should check layout drawings that give route of all waste water streams, drains and ETP bypass in factory premises. (one bye-pass is allowed in case of emergency)
- ✓ One should check physically while taking round in plant. All waste water streams / drain (routine e.g.; production processes and non-routines e.g.; vessel washings, cleaning water after spillage of chemicals etc.) should be connected to ETP.
- ✓ Local legislation should be referred to check the need of treating water from municipal sources/ non-process waste water e.g.; water from wash rooms, kitchen etc.
- ✓ Effluent sampling and testing system. Sampling conditions affect the reliability of the results coming from the laboratory analysis. Some of the basics checks are described below for evaluating sampling and testing routines:
    - The sampling techniques used in wastewater must ensure that representative samples. e.g.; composite samples (Note: There are no universal procedures for sampling: It can

be manual or by automatic devices; sampling programs must be individually tailored to fit each situation.)

- Preservation of samples. e.g.; normally sample must be stored at 4 °C maximum for one day for BOD and COD.
- Check the system of proper labeling on samples to prevent mixing
- Testing procedures (usually standard test methods are followed in the laboratory). Its availability and understanding should be checked.
- Calibration of monitoring and measurement devises
- Initiating preventive or corrective actions on the basis of test analysis.
- Training & competency of operators

Equipment's required for internal lab of ETP can be as under.

(a) Minimum Analysis Facilities for basic tests any ETP lab must have below mentioned instruments.

Instruments	No of pcs
pH Meter	1
pH Pen	3
TSS Meter	1
TDS Meter	1
DO Meter	1
BOD testing kits with Incubator	1 set
COD testing kits with digester	1 set
Oven	1
Digital weighing Balance with 0.1 mg accuracy & 10 gms accuracy	1 each
Necessary Glass ware	As per mentioned in test procedure
Chemical reagents	

(b) Appointment of scientific officials and technical staff for smooth operation of ETP

Minimum strength in ETP		
Post	**Education / Experience**	**No of employees**
Environment Officer	Graduate in Science / B.E. with 5 years' experience	1
Shift Supervisor cum lab technician	Graduate in Science	3 (1 per shift)
Fitters	ITI pass	3 (1 per shift)
Wireman	ITI Pass (Electrician)	1
Helpers	Adult workers	1 per shift
Necessary strength of relievers to be maintained for working on 7 days a week		

(c) Training of the Staff

Necessary training to be given to each employee with minimum 8-man days in year by professional trainers.

(d) Frequency of the Analysis

Parameters	Frequency of Testing
pH	Once in a shift of 8 Hours
TSS	Once in a Shift of 8 hours
TDS	Once in a Shift of 8 Hours
Dissolved Oxygen	Once in a shift of 8 hours
Color	Once in a shift of 8 Hours
Treatability study	Once in a Day
MLVSS/MLSS	Once in a Day
COD	Once in a day
BOD	Once in a week

Operation & Maintenance of ETP

To achieve the designed performance from ETP, it is necessary to operate it under optimum conditions so as to meet the environmental discharge standards for which regular maintenance and analysis of performance parameters is necessary. For proper and optimum operation of ETPs, the mills should ensure that the plant is well maintained & all equipment's are always in working condition.

Key Guidelines for Operation & Maintenance (Do's & Don't's)

Do's

- Ensure proper and optimum conditions of each section of ETP as per the designed specification and manufacturer's instruction.
- Avoid fluctuation in effluent flow and pollution load so as to reduce the shock load to bio-mass and the system as a whole.
- Ensure proper addition of nutrients in aeration tank. Check the health of bio-mass under microscope once in 3 months. The bacteria must not be flat bu tapered from middle portion.
- Maintain required level of MLSS/MLVSS concentration during biological treatment. It is cheaper, faster and also eco-friendly. (Every ETP has different MLSS/MLVSS norms depending upon pollution load, type of bio-mass & no doubt health of bacteria. (Ideally, MLSS – 30% & MLVSS 70% is suggested but it can go down upto 10% of MLSS.) only your DO level should be within limit.
- Maintain desired level of DO in the aeration tank (1.5 to 2.2 mg/l). If possible, install system for auto control of blower speed linked to DO level. This will maintain healthy culture.
- Ensure periodic & timely withdrawal of sludge from the clarifiers & settled bio mass from aeration tanks.
- Proper maintenance of electric motors, pumps & blowers with diffuser system. etc.
- Use of power saving technique in ETP operation are suggested
    - Optimization of blower speed (by VFD) in aeration tank linked with DO in aeration tank
    - pH control (Dosing of acid) to be linked with pH meter reading of effluent.

- Record keeping & Documentation
- Fresh water consumption, effluent discharge, effluent analysis, and ETP chemical & utility (like steam and power) consumption to be properly recorded.

Don't's

- It is essential to maintain constant flow of effluent (preferably flow to bio-mass tank (must be controlled by pumping device.) Never fluctuate effluent flow beyond margin of +/- 10%
- Never allow effluent with alkaline pH to enter in Bio-mass tank (Must be properly neutralize prior)
- Never dose chemicals without treatability study this should be performed daily once)
- Never keep alternate pumps/motors in breakdown condition. (all spare pumps/motors must be in a working condition & must be fixed at its original location)
- Change chemical supplier (especially for ETP) frequently.
- Skip any step in SOP back wash system for filters (PSF, ACF, Bag filters, cartridge filters, membranes)
- Never allow iron, chlorine in membrane.
- Never stop circulation of effluent & air from blower in bio-mass tank as it is food for bacteria & it can develop septic in tank.
- Never use spent acid for neutralization it may be a waste generated from pharma industry & may contain toxic chemicals which are harmful for bio-mass.
- Follow proper SOP while RO is going to be stopped for more than 24 hours.

4) Documentation & Reporting system (MIS)

It is essential to keep records for every process, history card for all equipment & testing reports for each day. Suggested formats for daily monitoring & record keeping are as under

It is also advised to get all parameters / audit of ETP functioning through accredited agency.

Water/Effluent Volume data	Inlet water qty.	Effluent Generated	Sent to CETP	Sludge generated	Sludge disposal
Date	KL	KL	KL	Kgs	Kgs
1 Apr 18					
2 Apr 18					
3 Apr 18					

Effluent Quality data	Inlet Effluent at ETP						Outlet quality from ETP (To CETP)					
	pH	TDS	TSS	COD	BOD	Color	pH	TDS	TSS	COD	BOD	Color
Date		PPM	PPM	PPM	PPM			PPM	PPM	PPM	PPM	
1 Apr 18												
2 Apr 18												
3 Apr 18												

Effluent Quality data	Biological treatment							
	pH	DO	MLSS	MLVSS	COD	BOD	Color*	Effluent flow
Date		PPM	PPM	PPM	PPM	PPM		KL/Hr
1 Apr 18								
2 Apr 18								
3 Apr 18								
* Color can be mentioned as Dark, Medium, light, no								

Mill must maintain supporting (date wise) report for energy & strength of work force/ day.

Utility consumption data	Power consumption in ETP in units		Strength of Man power (staff + operator) Std Strength = ____	
Date	Meter Reading	Units	staff	Operators + Helpers
1 Apr 18				
2 Apr 18				
3 Apr 18				

Chemical consumption data	ETP					
	1	2	3	4	5	6
Date	Kgs	Kgs	Kgs	Kgs	Kgs	Kgs
1 Apr 18						
2 Apr 18						
3 Apr 18						

Equipment non-working data	ETP equipment's working Yes / No							
	1	2	3	4	5	6	7	8
Date	Yes							
1 Apr 18		No	No					
2 Apr 18								
3 Apr 18								

ETP in charge needs to maintain data of non-working / under repair status on daily basis. This will help to know the non-functional sections and management can attend same on priority. Moreover, any deviation in outlet results can be analyzed.

Creation of Environmental Management Cell (EMC)

Every mill will compulsorily setup an Environmental Cell to effectively monitor the environmental compliance. The Environmental Cell will constitute of:

- Unit /Business Head
- ETP In-charge & one officer
- Process Operations Heads
- Factory Manager

Duties of Environmental Management Cell

- The Environmental Management Cell (EMC) shall review the water consumption, measures taken and identify the areas for water conservation, resource recovery and pollution reduction every week.
- Detailed minutes of the decisions taken will be recorded and circulated to all members of (EMC) and follow up of the decisions will be monitored by the Unit Head & ETP In-charge.
- Review to be made in case of non-compliance by mill.
- Internal Audit to be done by the EMC on quarterly basis.
- External Environmental Audit on annual basis.

5) Zero Liquid Discharge (ZLD), Water Recycling & use of Membrane technology

Water recycling requirements & various equipment's used in WRP – Membrane technology. Effluent quality requirement for Membrane safety. Membrane fouling & how to safeguard Membrane life.

The dyeing industry consumes large quantity of dyes & chemicals along with huge quantities of water. Detergents, caustic, soda ash is used to remove dirt, grit, oils and waxes. Hydrogen peroxide is used to improve whiteness and brightness of the end product. Dyes, dye-fixing agents and many inorganic salts are used to provide the brilliant array of colours as per demands from market. Processing of textile generates warm wastewater with heavy colour containing suspended solids, concentrated salt ($NaCl$ / Na_2SO_4).

Dyeing one kilogram of cotton with reactive dyes requires from 70 to 150 litres of water, 0.6 kg of NaCl and 40 g of reactive dye. The effluent generated during textile production need to be treated through various steps like Pre-treatment, anaerobic, aerobic (Biological) treatment, ultra-filtration with reverse osmosis and nano-filtration. At the end of this treatment fresh water &recyclable brine solution is obtained which contains the total salt added in the initial dye bath, which is reusable for further operations. It also generates small volume of concentrated liquor containing hydrolysed reactive dyes and dyeing auxiliaries which is dried to get solid sludge for disposal in scientific manner.

Looking towards today's need, re use of salt & water becomes basic necessity. Let us understand various technologies used to recycle water. Wastewater treatment can be tailored to meet the water quality requirements of a planned reuse.

The need for industrial water recycling and reuse has many drivers, including:

- Industrial and population growth.
- Fresh water costs.
- Regulatory requirements.
- Social responsibility.
- Discharge costs.
- Water scarcity.

Following is the list of various technologies used for waste water recycling:

1. **Softener:** When water contains a significant amount of calcium and magnesium, it is called hard water. Hard water is known to clog pipes and to complicate soap and detergent dissolving in water. Water softening is a technique that serves the removal of the ions that cause the water to be hard, in most cases calcium and magnesium ions. Iron ions may also be removed during softening. The best way to soften water is to use a water softener unit and connect it directly to the water supply.
2. **De-mineralization:** With de-mineralization, all salts dissolved in the water are removed through a combination of strongly acidic cation exchangers and strongly basic anion exchangers. This process can theoretically remove 100 % of salts. Deionization typically does not remove organics, virus or bacteria except through "accidental" trapping in the resin and specially made strong base anion resins which will remove gram-negative bacteria. The raw water passes through two beds filled with small Polystyrene beads, known as Ion-exchange resins. All cations like Sodium, Magnesium, and Calcium etc. are exchanged with Hydrogen ions present in the resin group of the first bed called cation exchanger. Similarly, all anions like chlorides, sulphates etc. are exchanged with Hydroxyl ions present in the resin group of the second bed called Anion Exchanger. Degasser towers are used where the presence of alkalinity is high. The DM water is free from all ions & it is used in:
3. **Electro De-ionization:** A typical EDI unit consists of alternating sheets of cation and anion resins as shown. A spacer is located between each pair of resin sheets to provide a channel between them. Every other channel is filled with mixed (cation and anion) resin beads that are thoroughly mixed together. Every other channel not filled with the beads is the brine channel, where the waste stream flows. A simple way of looking at the set-up is to replace the fresh water channels with the mixed resin beads. The total collection of alternating resin sheets, spacers and resin beads is called a stack. The entire collection is placed between 2 electrodes. When direct current is applied to the electrodes, negatively-charged anions will be attracted to the positively-charged anode, and positively-charged cations will be attracted to the negatively-charged cathode. Feed water is introduced into one end of the channels with mixed resin beads. The undesirable feed water cations in the resin beads migrate through a cation-exchange resin sheet toward the cathode into a brine channel. The undesirable feed water anions in the resin beads migrate through an anion-exchange resin sheet toward the anode into another brine channel. Once a cation or anion has passed through one resin sheet, it cannot pass through the next sheet. Therefore, the undesirable feed water ions are trapped within the brine channels and are carried away as waste stream. Deionized water is removed from the other end of the mixed resin channels. The applied electrical potential will also split water molecules into H^+ and OH^- ions. Both DM & EDI are

removal of all ions from the water & the product water quality is also similar, hence the applications of EDI treated water are also same as that of DM.

4. **Ultrafiltration:** Ultrafiltration is a pressure-driven purification process in which water and low molecular weight substances permeate a membrane while Total suspended solids, Turbidity, colloids, and macromolecules are retained. The primary removal mechanism is size exclusion, although the electrical charge and surface chemistry of the particles or membrane may affect the purification efficiency. Ultrafiltration pore ratings range from approximately 1,000 to 500,000 Daltons. Wherever, total dissolved solids are not a problem, UF can be used. Industries where UF is used include chemicals, steel, plastics & resins, paper & pulp, pharmaceutical and the food & beverage industries, including soft drinks & canned foods, as well as power.
5. **Nano filtration:** The Nano filtration membrane is not a complete barrier to dissolved salts. Depending on the type of salt and the type of membrane, the salt permeability may be low or high. If the salt permeability is low, the osmotic pressure difference between the two compartments may become almost as high as in reverse osmosis. On the other hand, a high salt permeability of the membrane would not allow the salt concentrations in the two compartments to remain very different. Therefore, the osmotic pressure plays a minor role if the salt permeability is high. With a high-pressure pump, feed water is continuously pumped at elevated pressure to the membrane system. Within the membrane system, the feed water will be split into a low saline and/or purified product, called permeate, and a high saline or concentrated brine, called concentrate or reject. Since NF membrane exhibits properties between those of ultrafiltration (UF) and reverse osmosis (RO), both charge and size of particle play important role in NF rejection mechanism.
6. **Reverse Osmosis:** Reverse Osmosis (RO) is among the finest levels of filtration available. The RO membrane generally acts as a barrier to all dissolved salts and inorganic molecules, as well as organic molecules with a molecular weight greater than approximately 100. Water molecules, on the other hand, pass freely through the membrane creating a purified product stream. Rejection of dissolved salts is typically 95% to greater than 99%, depending on factors such as membrane type, feed composition, temperature, and system design. The applications for RO are numerous and varied and include desalination of seawater or brackish water for drinking purposes, wastewater recovery, food and beverage processing, biomedical separations, purification of home drinking water and industrial process water. Also, RO is often used in the production of ultrapure water for use in the semiconductor industry, power industry (boiler feed water), and medical/laboratory applications. Transmembrane pressures for RO typically range from 75 psig (5 bar) for brackish water to greater than 1,200 psig (84 bar) for seawater.
7. **Multi effect Evaporator:** Evaporation is an operation used to remove a liquid from a solution, suspension, or emulsion by boiling off some of the liquid. It is thus a thermal separation, or

thermal concentration, process. Zero-liquid discharge (ZLD) is a water treatment process in which all wastewater is purified and recycled; therefore, leaving zero discharge at the end of the treatment cycle. Zero liquid discharge is an advanced wastewater treatment method that includes ultrafiltration, reverse osmosis, evaporation/crystallization, and fractional electro de-ionization.

8. **Ozonation:** - Ozone is one of the most powerful commercially available oxidants and is commonly used for municipal water and wastewater treatment. In addition to its oxidizing capabilities, it is an environmentally friendly method of treatment. Pollutants, coloured substances, odours and microorganisms are directly destroyed by oxidation, without creating harmful chlorinated by-products or significant residues. Air or pure oxygen is used as the feed-gas source and is passed to the ozone generator at a set flow rate. The energy source for production is generated by electrical discharge in a gas that contains oxygen. Ozone is produced when oxygen (O2) molecules are dissociated by an energy source into oxygen atoms and subsequently collide with an oxygen molecule to form an unstable gas, ozone (O3), which is used to disinfect wastewater. Most wastewater treatment plants generate ozone by imposing a high voltage alternating current (6 to 20 kilovolts) across a dielectric discharge gap that contains an oxygen-bearing gas. Ozone is generated onsite because it is unstable and decomposes to elemental oxygen in a short amount of time after generation.

   After generation, ozone is fed into contact chamber containing the wastewater to be treated. The main purpose of the contactor is to transfer ozone from the gas bubble into the bulk liquid while providing sufficient contact time for degradation/disinfection. The commonly used contactor type's diffused bubble (co-current and counter-current) are positive pressure injection, negative pressure (Venturi), mechanically agitated, and packed tower. Because ozone is consumed quickly, it must be contacted uniformly in a near plug flow contactor.

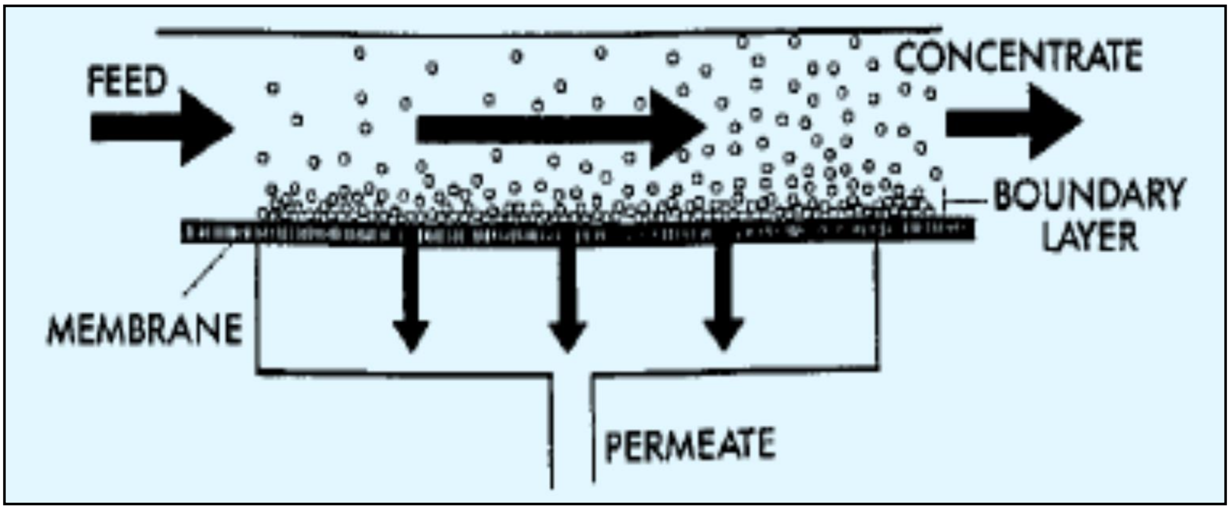
Let us have in-depth understanding about membrane filtration techniques.

MEMBRANE FILTRATION

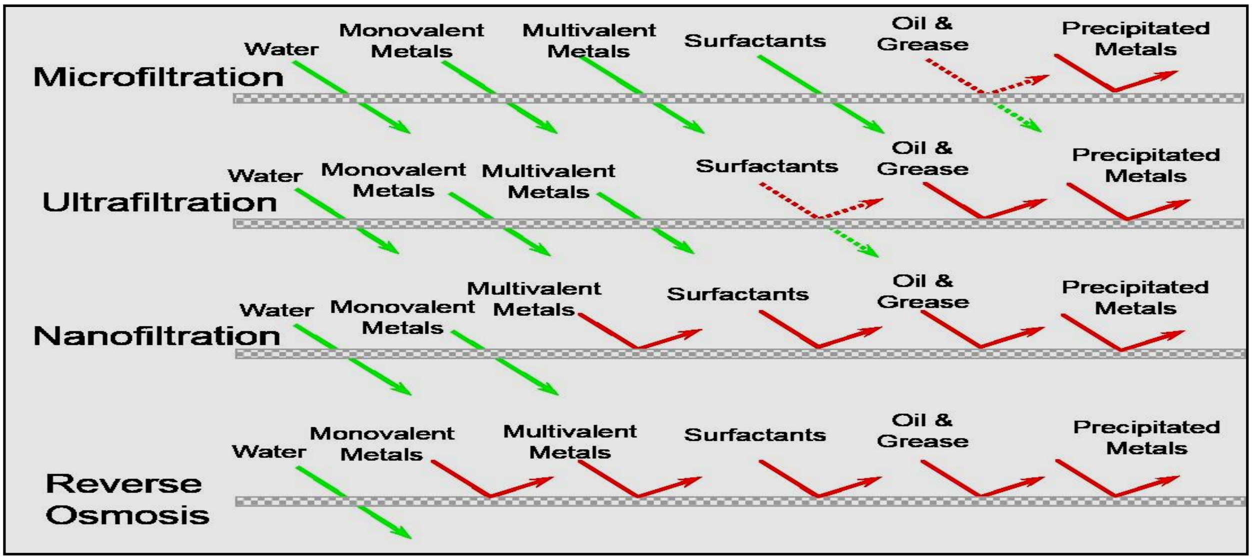
The various filtration technologies which currently exist can be categorized on the basis of the size of particles removed from a feed stream. Conventional microfiltration of suspended solids is accomplished by passing a feed solution through the filter media in a perpendicular direction. The entire solution passes through the media, creating only one exit stream. Examples of such filtration devices include cartridge filters, bag filters, sand filters, and multimedia filters. Microfiltration separation capabilities are generally limited to undissolved particles greater than 1 micron.

For the removal of small particles and dissolved salts, cross flow membrane filtration is used. Cross flow membrane filtration (see Figure 1.1) uses a pressurized feed stream which flows parallel to the membrane surface. A portion of this stream passes through the membrane, leaving behind the rejected particles in the concentrated remainder of the stream. Since there is a continuous flow across the membrane surface, the rejected particles do not accumulate but instead are swept away by the concentrate stream. Thus, one feed stream is separated into two exit streams: the solution passing through the membrane surface (permeate) and the remaining concentrate stream.

Ultra-filtration provides macro-molecular separation for particles in the 20 to 1,000 Angstrom range (up to 0.1 micron). All dissolved salts and smaller molecules pass through the membrane. Items rejected by the membrane include colloids, proteins, microbiological contaminants, and large organic molecules. Most UF membranes have molecular weight cut-off values between 1,000 and 100,000. Transmembrane pressures are typically 15 to 100 psi (1 to 7 bar).

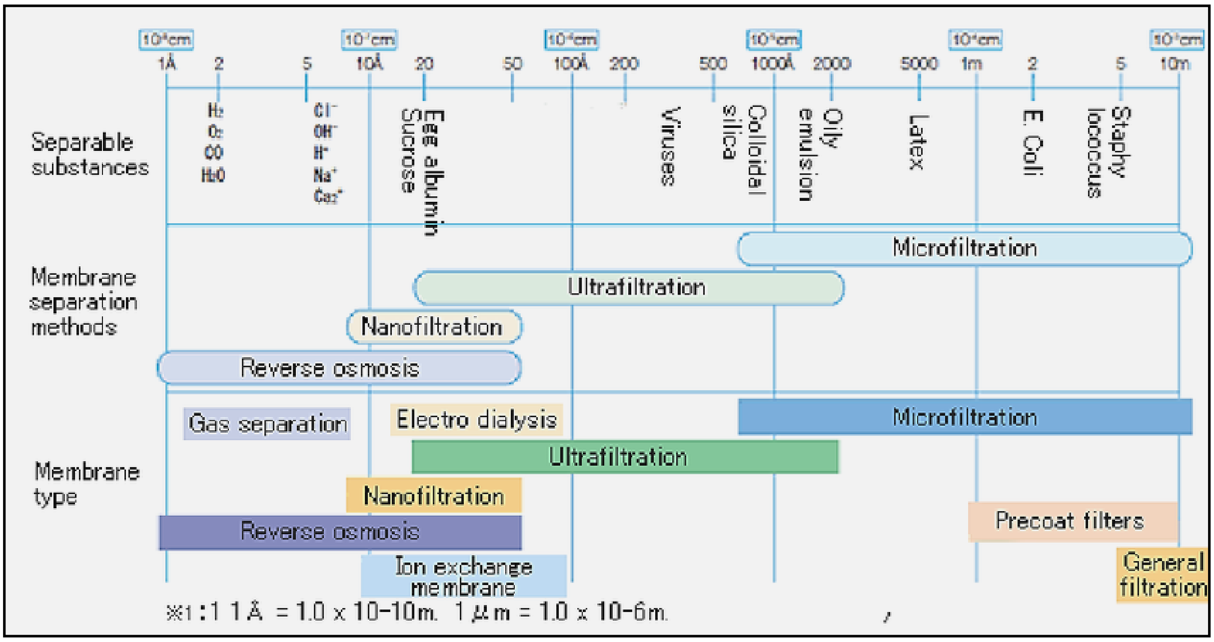


Reverse osmosis is the finest level of filtration available. The RO membrane acts as a barrier to all dissolved salts and inorganic molecules, as well as organic molecules with a molecular weight greater than approximately 100. Water molecules, on the other hand, pass freely through the membrane creating a purified product stream. Rejection of dissolved salts is typically 95% to greater than 99%. Trans-membrane pressures for RO typically range from 75 psig (5 bar) for brackish water to greater than 1,200 psig (84 bar) for seawater.



Ultra Filtration

Ultra-filtration (UF) involves pressure-driven separation of materials from a feed solution. The technology is used to remove particulate and microbial contaminants, but it does not remove ions and small molecules. Pressure drives the process, which typically operates with a feed pressure of 4 to 100 psig. UF plants are automated and have low operational labor requirements. These systems, however, can require frequent cleaning. UF membranes have a service life of three to five years or longer, which is comparable to reverse osmosis membranes. UF modules are commercially available in tubular, hollow-fiber, plate and frame, and spiral wound configurations.



UF membranes reject solutes ranging in size from 0.02 microns and larger. Figure 1 provides a guide to the relationship between common materials, separation processes, and pore size measurements. The UF membrane process separates molecules in solution on the basis of size. The pore size and molecular weight cut-off (MWCO) are often used to characterize a membrane. The pore size is the nominal diameter of the openings or micro-pores in the membrane expressed in microns. The unit of measurement for MWCO is the Dalton (D).

Different membrane materials with the same nominal MWCO may have differing solute rejection. Pore size distribution and uniformity rather than the chemical nature of the membrane material may cause this effect. Because factors other than pore size or MWCO affect the performance of membranes, challenge studies are used to demonstrate membrane performance and benchmark different membranes.

REVERSE OSMOSIS

The application of Reverse Osmosis to the solution of problems in water treatment requires an understanding of the basic mechanisms involved in the process, the limitations of Reverse Osmosis and the pretreatment requirements.

The phenomenon of osmosis occurs when pure water flows from a dilute saline solution through a membrane into a higher concentrated saline solution. A semi-permeable membrane is placed between two compartments. “Semi-permeable” means that the membrane is permeable to some species, and not permeable to others. Assume that this membrane is permeable to water, but not to salt. Then, place a salt solution in one compartment and pure water in the other compartment. The membrane will allow water to permeate through it to either side. But salt cannot pass through the membrane.

As a fundamental rule of nature, this system will try to reach equilibrium. That is, it will try to reach the same concentration on both sides of the membrane. The only possible way to reach equilibrium is for water to pass from the pure water compartment to the salt-containing compartment, to dilute the salt solution.

Figure 1.2 also shows that osmosis can cause a rise in the height of the salt solution. This height will increase until the pressure of the column of water (salt solution) is so high that the force of this water column stops the water flow. The equilibrium point of this water column height in terms of water pressure against the membrane is called osmotic pressure.

If a force is applied to this column of water, the direction of water flow through the membrane can be reversed. This is the basis of the term reverse osmosis. Note that this reversed flow produces pure water from the salt solution, since the membrane is not permeable to salt.

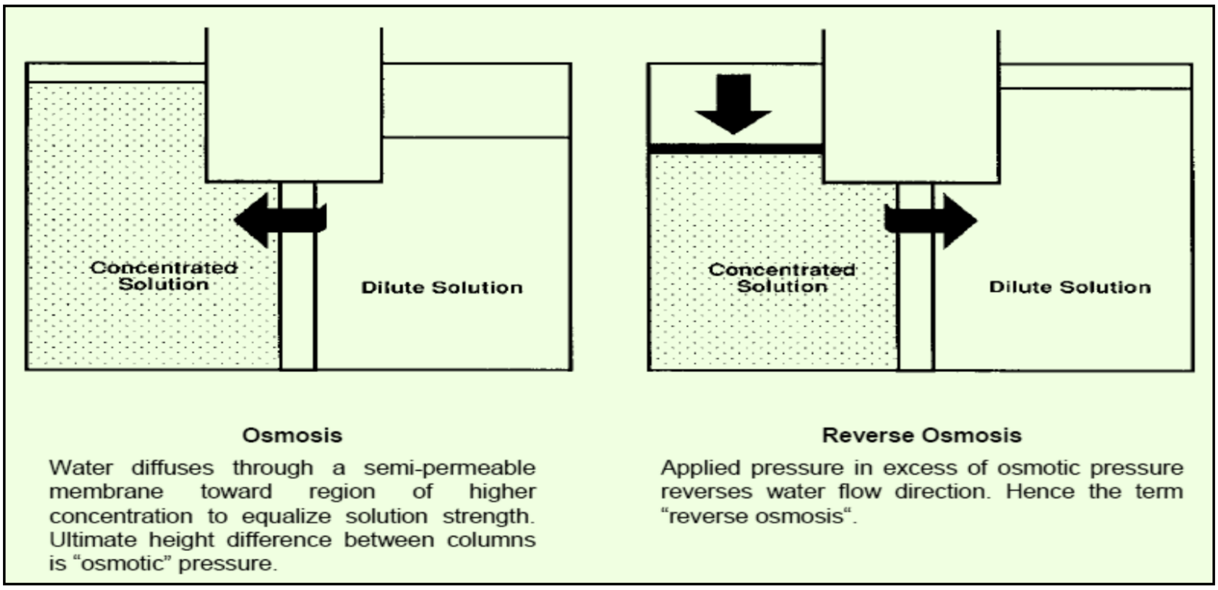


Fig 1.2: Typical Reverse Osmosis flow Diagram

Reverse Osmosis utilizes the unique properties of a semi-permeable membrane to allow fluid to pass while restricting the flow of dissolved ionic material. When pressure is applied to impure water on one side of such membrane material, pure water will pass through, leaving most of the impurities behind. The rejection of the dissolved ionic material is a function of both molecular weight and ionic charge. For example, we can expect a nominal 90% rejection of Sodium chloride, which means that the product water passing through the membrane will have a concentration of salt approximately one-tenth that of the feed water. The rejection of Calcium Carbonate (hardness) will be near 95%, while most metallic salts will be rejected at a rate of 98% to 99%. The rejection of non-jonic or organic material is primarily by mechanical filtration i.e. Pre-treatment of feed water prior to Reverse Osmosis system.

Membrane Safety & How to safeguard Membrane Life

Membrane Fouling

All membranes lose their performance with time. One of the major causes for the loss of performance is due to substances that deposit on the membrane surface. Membrane fouling may have the following several adverse effects:

- Membrane flux decline due to the formation of a low permeability biofilm on the membrane surface.
- Increased differential pressure and feed pressure being needed to maintain the same production rate due to biofilm resistance.
- Membrane biodegradation caused by acidic by-products which are concentrated at the membrane surface. For example, cellulose acetate membrane has been found to be more susceptible to being biodegraded.
- Increased salt passage through membrane and reduced quality of the product water due to the accumulation of dissolved ions in the biofilm at the membrane surface thus increasing the degree of concentration polarization.
- Increased energy consumption due to higher pressure being required to overcome the biofilm resistance and the flux decline.
- Reduced Membrane life

Although the term fouling is used for deposit of any materials on the membrane, the coating of the membrane surface can be due to the following reasons:

- Particulate or Colloidal Fouling
- Inorganic Fouling or Scaling
- Microbial or Bio-Fouling
- Organic Fouling

The International Union of Pure and Applied Chemistry defines fouling as "The process that results in a decrease in performance of a membrane, caused by the deposition of suspended or dissolved solids on the external membrane surface, on the membrane pores, or within the membrane pores".

Particulate or Colloidal Fouling

The source of particulate or colloids in reverse osmosis feed waters is varied and often includes Algae, Bacteria, clay, colloidal silica, and iron corrosion products. Pre-treatment chemicals used in clarification such as alum, ferric chloride, or cationic polyelectrolytes can also cause fouling if not removed in the clarifier or through proper media filtration. In addition, cationic polymers may co-precipitate with negatively charged anti-scalants and foul the membrane.

Inorganic Fouling or Scaling

Inorganic Fouling or scaling is caused by the accumulation of inorganic precipitates like Metallic Hydroxides, & scales on membrane surface or within pore structure. In the reject stream f RO & NF the salt concentrations are very high, hence precipitates are formed when the concentration of chemical species exceeds their saturation concentrations & these chemicals form a concentrated layer in the vicinity of the membrane liquid interface, this phenomenon is known as "Concentration Polarization".

Bio-fouling

Biofouling is the irreversible adhesion on a membrane of microorganisms and the extracellular polymers (ECP). The process of adhesion involves three stages:

- ❖ Bacterial adhesion, which can become irreversible in just hours, even without nutrients present
- ❖ Colony formation
- ❖ Biofilm maturation and the formation of ECP. ECP is a vicious, slimy, hydrated gel. EPS typically consists of heteropolysaccharides & have high negative charge density. This gel structure protects the bacterial cells from hydraulic shear.
- ❖ Bio-fouling has been known as a contributing factor to more than 45% of all membrane fouling and has been reported as a major problem in Nano-filtration (NF) and reverse osmosis (RO) membrane filtration.

Organic Fouling

The adsorption of naturally occurring organic materials to membrane surfaces is frequently cited as the primary cause of chronic fouling of membranes used for both desalting and as pretreatment for membrane desalting in water treatment and wastewater recovery. The characteristics of organic materials that determine their relative propensity to foul membranes appear to include their affinity for the membrane, molecular weight, and functionality, conformation, and membrane characteristics. The adsorption process is favored with high molecular mass compounds when these compounds are hydrophobic or positively charged. A high pH value helps to prevent fouling, because both the membrane and many organic substances assume a negative charge at pH >9. Organics present as an emulsion may form an organic film on the membrane surface. These organics must, therefore, be removed in pretreatment.

Ways to Prevent Fouling

Several methods or indices have been proposed to predict a colloidal fouling potential of feed waters, including turbidity, Silt Density Index (SDI), Langelier Saturation Index (LSI) and Modified Fouling Index (MFI). The SDI is the most commonly used fouling index.

The turbidity of feed water to RO/NF should be less than 1 NTU as one of the minimum requirements of feed water.

It is important to follow membrane manufacturers' recommendations on minimum feed flow, maximum element recovery and maximum element flux. These recommendations are based on the element size and quality of feed water being treated. The concentrations of the dissolved and suspended solids in the boundary layer control the performance of the membrane. Higher concentrations mean higher osmotic pressure, higher tendency of suspended solids to coagulate and coat the membrane surface, and higher likelihood of scaling to take place. Maintaining proper operating conditions for the membrane is the key preventative step to minimize membrane fouling.

Ways to Prevention Organic Fouling

Organics occurring in natural waters are usually Humic substances in concentrations between 0.5 and 20 mg/L TOC. Pretreatment should be considered when TOC exceeds 3 mg/L. Humic substances can be removed by the following:

- Coagulation process with hydroxide flocs
- Ultrafiltration
- Adsorption on activated carbon
- Removal of color from high molecular weight organics is also possible by Nanofiltration membranes.

Coagulation or activated carbon must also be applied when oils (hydrocarbons or silicone based) and greases contaminate the RO feed water at levels above 0.1 mg/L. These substances are readily adsorbed onto the membrane surface. They can be cleaned off, however, with alkaline cleaning agents if the flux has not declined by more than 15%.

In waste water applications, the rejection and concentration of organics is a major objective, hence, it is better to have an UF as a pre-treatment to the RO feed water.

GENERAL WAYS to control Fouling

- **Dispersant Injection**

For suspended or colloidal materials, a dispersant can be injected in the feed water. The usual dosage for a dispersant is 10 ppm. Dispersants keep fine suspended solids from coagulating and coming down on the membrane surface. Proper use of dispersants can minimize fouling due to problem particulates that are difficult to prefilter.

- **Acid Injection**

Adjusting the pH of the feed water is another way to control. The net effect of lowering the feed pH with acid injection is to convert bicarbonate alkalinity to carbon dioxide and thereby prevent the formation of calcium carbonate. For reasons of handling and safety, acid injection is not used for residential or small commercial systems.

- **Reduce Recovery**

Membrane recovery is defined as the ratio of permeate flow to feed flow for that membrane. Recovery can be reduced by increasing the feed flow. Another way to reduce recovery is to decrease the operating pressure. Lower operating pressure produces a lower amount of permeate. If the feed flow can be maintained near the original value, then a lower recovery is obtained.

The effect of lower recovery is to reduce the overall concentration of all substances in the reverse osmosis system. More favorable boundary layer conditions are also achieved by reducing the system recovery.

- **Membrane Cleaning**

Even with all the preventative care given to a reverse osmosis system, some fouling of the membranes will take place. Cleaning of the membranes can improve membrane performance. Membranes can be cleaned using Cleaning Solutions approved by the membrane manufacturer. It is not economical to clean membranes used in the residential reverse osmosis systems.

- **RO membrane cleaning**

The cleaning system is an important part of a desalination installation. Membranes can become contaminated after they have been used for some time, with pollutants such as colloids, bio films and biological matter. These contaminants can absorb to the membrane surface and the pipes of the membrane system and consequentially, the performance of the system will decrease. The system may even be seriously damaged. That is why system needs cleaning periodically.

Cleaning of a Reverse Osmosis system is usually started when the following conditions are in observed:

- The normalized flux has decreased 10-15%
- The normalized salt content of the permeate has increased 10%
- The pressure gradient in a pressure vessel has decreased 15%

- **Chemical Cleaning**

The Chemical cleaning procedure of a Reverse Osmosis system consists of the following process steps:

1. Preparation of the cleaning solutions
2. Replacement of the water contained in the pressure tubes need by the cleaning solution.
3. Low-flow recirculation through the pressure tubes
4. Soaking the membranes in the cleaning solutions
5. Draining the of the pressure tubes
6. Rinsing out the system
7. Restarting up the cleaned system

Ways to Prevent Scaling

An anti-scalant is a pretreatment that gets injected into the feedwater that flows through the RO membrane, preventing the membrane from scaling. RO membrane scaling occurs when particles accumulate on a membrane, causing the membrane's pores to plug. Some common membrane foulants and scalants include calcium carbonate, calcium sulfate, barium sulfate, strontium sulfate, calcium fluoride, Silica etc.

To avoid calcium carbonate and calcium sulphate scaling we use of antiscalants are injected directly into the feed water upstream from the cartridge filter. Dosage of anti-scalant depends on the feed water analysis but usually is between 2 to 5 ppm. In simplified terms, the antiscalants delay the scale formation process. This delay is sufficient to avoid precipitation of calcium carbonate and calcium sulphate on the membrane surface. As this delay is for a finite period, scaling can take place in systems on shut down. For this reason, it is a good practice to flush the membranes with permeate or feed water at shut down. By this flush, the concentrated solution in the membrane is displaced by the permeate or feed water.

Ways to prevent Bio-Fouling

Addition of Sodium Hypochlorite or Chlorine di-oxide at the inlet of RO pre-treatment stage is a common practice. The chemistry and use of chlorine as a disinfectant is widely covered in literature. It is extensively used in industrial and municipal applications due to its relatively low cost and widespread availability. It has significant limitations in terms of application in RO systems; Thin film composite polyamide membranes are sensitive to levels of chlorine with oxidative degradation occurring at between 200-1000 hours of exposure to 1ppm of free chlorine, therefore chlorine must be removed from the feed system prior to entering the membrane, either by activated carbon or dosing Sodium Meta-bisulphite. Therefore, any viable bacterial population or biofilm in the membrane will not be affected. In addition, chlorine breaks down natural organic matter (NOM) present in the feed water to more easily biodegradable products offering a nutrient source to micro-organisms.

Ozonation and/or UV Prior to RO. Because ozone is made of oxygen and reverts to pure oxygen, it vanishes without trace once it has been used. Compare this with other disinfectants. When ozone disinfects or breaks down harmful bacteria or pollutants, there are generally no by-products, unlike most disinfecting agents.

A non-oxidative biocide, 2,2-dibromo-3-nitrilopropioamide (DBNPA), can also be used to minimize and/or eliminate problems due to biofouling accumulation and to ensure long-term performance of a RO system

Most recently, nitric oxide (NO) donor compounds proved very effective at removing both biofilm bacteria cells and ECP. Nitric oxide is toxic to bacteria; the mechanism for this includes DNA damage and degradation of iron sulfur centers into iron ions and iron-nitrosyl compounds.

Membrane Cleaning (CIP) can be used as a method of biofouling control, primarily aimed at disrupting and removing the biofilm layer from the membrane system.

Ways to Prevent Particulate Fouling

Assessment & Prevention of Particulate fouling

Measuring the following indices is an important practice and should be carried out prior to designing a RO/NF pretreatment system and on a regular basis during RO/NF operation (three times a day is a recommended frequency for surface waters).

Sr. No.	Index	Description
1.	Silt Density Index (SDI)	The Silt Density Index (SDI) can serve as a useful indication of the quantity of particulate matter in water and correlates with the fouling tendency of RO/NF systems. The SDI is calculated from the rate of plugging of a 0.45 µm membrane filter when water is passed through at a constant applied gauge pressure. SDI value < 3, which can be considered sufficiently low to control particulate fouling.
2.	Turbidity	Turbidity is an expression of the optical property of water that causes light to be scattered and absorbed rather than transmitted in straight lines through the sample. Turbidity is caused by suspended and colloidal particulate matter such as clay, silt, finely divided organic and inorganic matter, plankton and other microscopic organisms. Turbidity is often used for online control of particle filtration processes. The turbidity of feed water to RO/NF should be less than 1 NTU as one of the minimum requirements of feed water.
3.	Modified Fouling Index (MFI)	The Modified Fouling Index (MFI) is proportional to the concentration of suspended matter and is a more accurate index than the SDI for predicting the tendency of water to foul RO/NF membranes. The method is the same as for the SDI except that the volume is recorded every 30 seconds over a 15-minute filtration period. The MFI is obtained graphically as the slope of the straight part of the curve when t/V is plotted against V (t is the time in seconds to collect a volume of V in liters). MFI value < 1 corresponds to a SDI value < 3, which can be considered sufficiently low to control particulate fouling.

Ways to Prevent Aluminum Fouling

Sources of aluminum fouling are:

- ❖ Flocs carry-over from a pretreatment process using Aluminum based flocculants
- ❖ Post-precipitation of aluminum flocculants due to poor pH control

- Reaction of aluminum with silica, forming aluminum silicates
- Natural mineral silt and colloidal aluminum silicates

Aluminum silicate fouling can be found in the first and last stage of RO/NF plants. Even small aluminum concentrations (like 50 ppb) may result in a performance decline due to several factors:

1. Aluminum reacts with silica. The use of Aluminum based products in the pretreatment increases the risk of aluminum fouling significantly. Therefore, the use of Aluminum based products is not recommended. Iron based products are recommended instead.
2. The solubility of the aluminum is lowest at pH 6.5. This is the pH at which the flocculation should be run. The RO/NF system should be operated preferably at pH 7-9 (dependent on the water analysis since calcium carbonate scaling should be avoided) to keep aluminum in solution.
3. Antiscalants containing polymers (like acrylic Acid based products) are sensitive to the presence of metals like iron and aluminum. It is important to select the right antiscalants. Otherwise, the antiscalants are deactivated (poisoned) and subsequently scaling and antiscalant fouling may occur in the membrane. In addition, the antiscalant fouling can act as a nutrient for microorganisms and biofouling will occur.

Fine clay/sand particles. It is recommended to remove clay and sand particles in the pretreatment by either multimedia filtration, ultrafiltration or microfiltration. It may be necessary to use coagulants in order to form larger particles that can be removed by the subsequent filtration process. To minimize aluminum fouling, it is recommended to keep aluminum in the feed water below 0.05 mg/L.

Maintenance of membrane by regular dosages of chemicals:

(This is general guideline & engineer must follow the process suggested by membrane supplier)

Sr. No.	Chemical	Purpose	Dosage used In PPM	Approx. dosages
For UF system				
1.	Hypochlorite/ ClO2	For UF feed bio-fouling control	2 – 4	5-15 kg/day
2.	NaOH –MC	For Chemic al Maintenance Cleaning	100 – 200	2-3 kg/day
3.	HCL – MC	For Chemical Maintenance Cleaning (MC)	100- 200	0.5-1 kg/day
4.	Hypochlorite – MC	For Chemical MC	200-400	1-2 kg/day
5.	Citric Acid- MC	For Chemical MC	200-400	1-2 kg/day
6.	NaOH – CIP	For UF clean in process	200-400	5-10 kg/month
7.	HCl – CIP	For UF clean in process	200-600	10-25 kg/month
8.	Hypochlorite – CIP	For UF clean in process	500-1000	15 - 25 kg/ month
9.	Citric Acid– CIP	For UF clean in process	500-1000	10- 25 kg/ month

S. No.	Chemical	Purpose	Dosage used In PPM	Approx. dosages
For RO system				
1.	HCL	for RO feed pH correction	20-40	30 -60 kg/day
2.	SMBS	For RO feed ORP control	2-5	6 – 8 kg/ day
2.	Anti-scalent	For RO feed scaling control	4-6	6 - 8 kg/day
4.	NaOH –CIP	For RO clean in process	100-200	15-20 kg/month
5.	HCL – CIP	For RO clean in process	200-400	15-20 kg/month
6.	Acid Cleaner (Citric acid / GE chemicals)	For RO clean in process	500-2000	50-100 kg/month
7.	Alkaline Cleaner (Na4 EDTA/ SDS/ GE chemicals)	For RO clean in process	500-2000	50-100 kg/month
8.	Biocide cleaner	For RO clean in process	100-200	20-30 kg/month

Note: These chemicals consumption and dosing may vary depending on the effluent feed water quality and surrounding conditions. **Always follow the SOP given by membrane manufacturer.**

6) Multi-Effect-Evaporators.

<u>Multi Effect Evaporator & its sections, Quality of salt generated & Reuse.</u>

It is generally a vertical cell in which stainless steel tubes are mounted. Some evaporator systems works on falling liquid film theory which means that the tubes are not filled up with liquid but a liquid film on inner surface of tube is established. To develop such film, the liquid is trickled in the form of drops through a perforation plate in such a way that the drops fall on the internal periphery of tubes and makes a liquid film which moves down throughout the length of the tube. The tuber is heated with the help of steam. This technique is reported to enhance evaporation efficiency. In the evaporation process concentrated liquid is collected at the bottom of evaporator, which is sent to next stage evaporator. Thus the fresh liquor is added only to the first stage evaporator. Similarly, steam is also applied to the first evaporator. The next stage evaporator gets steam from previous one. During evaporation, the liquid is re-circulated till it achieves desired concentration of salt or specific density. The vapors' and spent steam are connected to condenser. Because of the vacuum in evaporators created by condenser, liquid evaporates at low temperature. The operating temperature of a typical Multiple Effect Evaporators is given in below table. Use of evaporators reduces effluent volume. Also, the evaporation leads into increased concentration of salts in the stream making their recovery more viable wherever intended.

Operating conditions of a typical multiple effect evaporation system				
Parameters	**Stage 1**	**Stage 2**	**Stage 3**	**Stage 4**
Temperature (Centigrade)	82	72	62	55
Length of tube (Meter)	6.0	6.0	4.5	4.5
Diameter of tube (MM)	90	90	45	45

The parameters can vary depending on design of MEE.

In the evaporation process, scaling takes place in the tubes as the evaporation proceeds. Higher the scale formation, lower is the heat transfer rate and the evaporation rate is also reduced. After operation of the system for few weeks scale formation reaches at a stage when cleaning appears necessary. Cleaning process involve both chemical and mechanical operations. The inner surface of tube is wetted with cleaning agent usually acid, to loosen the scale. Then a scale cutter, which is mounted on flexible shaft, is used for scaling off the deposition. The cutter is inserted from top end of the pipe and moved down up to bottom which removes scale in the entire length of tube. Then the scale cutter is replaced with a polishing wire brush for giving final cleaning and making tube surface smooth. This process is repeated for descaling of other tubes. Once the entire set of tubes has been cleaned, the evaporator is closed and tested for leaks etc. In the first stage leak test is performed with the soap solution. Then if needed, the evaporator is filled up with water for further leak test. In case any leak is detected it is rectified with refitting of covers and or seal.

Mechanical Vapor Compression

Mechanical vapor compression technique is also used for concentration of effluents. The system is basically a heat exchanger that is an evaporator/condenser. The heat required to evaporate water which flows on one side of a heat transfer surface is supplied through the simultaneous condensation of the distillate-producing vapour on the other side of the surface. That is, the latent heat is exchanged in the evaporation-condensation process within the system. A compressor is the driving force for this heat transfer and provides the energy required separating the solution and overcoming dynamic pressure losses.

Direct contact Evaporation

In direct contact evaporation, a heated gas is used as a heating fluid for bringing about vaporization of liquid (effluent). The gas stream is injected at bottom of the equipment by means of adequate distribution system usually perforated plate or a set of pipes. Since both mass and heat transfer takes place at the gas-liquid interface, the available area in direct contact evaporation fundamentally depends on the bubble size in case gas is inject directly into liquid and the droplet size in case liquid is sprayed into the stream of heated gas. Spraying of liquid in air such as mist evaporation is also used for volume reduction. In the mist evaporation system a mist of small droplets is created by pumping liquid through nozzles mounted around periphery of a duct though which air is blown. The large surface area of the mist results in enhanced evaporation of liquid.

One can use hot exhaust of boiler or DG set for this activity (Need to take prior permission from legal authorities.

Crystallization

Crystallization refers to the formation of solid crystals from a homogeneous solution. It is essentially a solid-liquid separation technique. In order for crystallization to take place a solution must be ‘supersaturated’. Supersaturation refers to a state in which the liquid (solvent) contains more dissolved solids (solute) than can ordinarily be accommodated at that temperature.

This method is used to crystallise salts and recover them from its mother. The crystallizers may be single stage or multi-stage for extracting useful chemicals like sodium sulphate, calcium sulphate, sodium chloride, calcium chloride etc. from process solutions and effluents. One can reuse back to process after necessary test.

Specific Treatments

Textile industry effluent may require specific treatment to remove undesired pollutants based on its end use. For instance, manganese and iron salts are quite available in textile processing. Iron and manganese are expected to be present in effluent which may be due to source of water supply, dyes stuff, chemicals used in process & ETP etc. The textile industry is required to provide aeration system at equalization tanks or holding tank prior to RO system. Iron in the form of ferrous bicarbonate may be removed by aeration when ferric hydroxide is precipitated and carbon dioxide is released into atmosphere. Aeration also helps to raise pH by reducing the content of dissolved carbon dioxide. Manganese bicarbonate also react in the same way for which pH of more than 10 is achieved by addition of lime in physico-chemical treatment plant. If ferrous sulphate ($FeSO_4$ is present in waste water, the insoluble hydroxide of iron or manganese may be formed due to addition of lime. The iron precipitation will occur at 8.5 pH, but the manganese will be precipitated at pH of 9.0 is reached.

$$2Fe^{++} + ½ O_2 + 5 H_2O \rightarrow 2Fe (OH)_3 + 4H^+ \quad Mn^{++} + ½ O_2 + H_2O \rightarrow MnO_2 + 2H^+$$

The iron removal filter can be provided prior to RO to further reduce iron and manganese content. In the filter, manganese zeolite is formed by treating sodium-zeolite with manganous sulphate ($MnSO_4 \cdot H_2O$), and then oxidizing by treatment with potassium permanganate ($KMnO_4$). Higher insoluble oxides of manganese are formed on the surface of zeolite grains, thereby making available oxygen capable of converting the ferrous and manganous ions in water to insoluble oxidized form which can be filtered out using multi-grade filter column.

$$3Fe^{++} + MnO_4 + 7H_2O \rightarrow 3Fe (OH)_3 + MnO_2 + 5H^+ \quad 3Mn^{++} + 2MnO_4 + 2H_2O \rightarrow 5MnO_2 + 4H^+$$

Proper selection and application of individual or combination the advance treatment methods in textile industry can effectively make recovery of water and/or salts from effluent streams for their reuse in production process. Along with the recovery and reuse of water and salt, the advance methods can also be applied to meet stringent environmental or regulatory requirements such as zero effluent discharge. Membrane filtrations can produce treated water with high purity. Treatment system like activated carbon adsorption and Ozonation can be used to make the effluent suitable for use in membrane filtration. Evaporation system can be used for minimizing effluent volume or achieving desired concentration of target pollutant. The evaporation system and crystallizer combination can recover salt. Nanofiltration on other hand allows salt with the permeate, which when used in dyeing process, requires less addition of salt.

Agitated thin film dryer ATFD SYSTEM.

The mother liquor coming from crystallizer and pusher System will be taken in to ATFD for further concentration from 30 % to 90 % TDS and to recover the dry Salt with 8 TO 10 % Moisture.

Recovery of Water and Glauber Salt

The effluent stream bearing high salt i.e. the spent dye bath is segregated and treated with recovery of salt. This effluent stream has low volume and can be treated using a chemical treatment followed by multi-effect evaporation and crystallization. Glauber salt (Sodium Sulphate $Na_2SO_4.10H_2O$) based dyeing enables recovery of the salt. The other effluent stream i.e. wash water can be treated separately by primary/secondary treatment methods followed by RO system to recover water.

7) <u>Costing in ETP & Water Recycling through RO & MEE & Sludge Disposal</u>

Costing of ETP + RO + MEE & Disposal of sludge plays major role in textile water recycling system

Costing in ETP +RO+MEE:

Textile processing industry is versatile & consumes variety of fibers, many more type of dyes & chemicals, various equipment & processes. This is the reason, incoming effluent has different pollution load (quality & volume) It is not possible to have same cost factor for two different units. Even though, I have tried to find a commonality & approximate costs can be as under. Each industry can develop such format & generate costing sheet for individuals.

Details for 100% recycling Typical plant	Cost Rs/KL			Cost
Considering 2000 Kg production / day for Hosiery factory	ETP	RO	MEE	Sludge Disposal
Effluent generated in KL/day	200	190	10	160 Kg/day
Man power cost	5.4	15	50	6.0 Rs/KL of effluent **OR** 7.5 Rs/kg on sludge generation
Chemical Cost	15	9	18	
Electricity cost	13	28	75	
Fuel cost	0	0	480	
Maintenance cost	1.5	3.0	5.0	
Total treatment cost	35	55	628	
Grand Total for 200 KL /Day effluent treatment & 100% water recycling	118.00			6.0

Details for 50% recycling Typical plant	Cost Rs/KL			Cost
Considering 2000 Kg production / day for Hosiery factory	ETP	RO	MEE	Sludge Disposal
Effluent generated in KL/day	200	100	5	160 Kg/day
Man power cost	5.4	22	70	6.0 Rs/KL of effluent **OR**
Chemical Cost	15	15	18	
Electricity cost	13	28	75	
Fuel cost	0	0	510	
Maintenance cost	1.5	3	5	

Total treatment cost	35	68	678	7.5 Rs/kg on sludge generation
Grand Total for 200 KL /Day effluent treatment & 50% water recycling	85.85			6.0

Savings in water recycling system

Detail		50% recycle	100% recycle
Recycling Cost Rs/KL	A	85.85	118
Total Treatment cost for 200 KL/Day Rs/day (200*A)	**B**	**17170**	**23600**
Fresh water requirement (KL/day) against 200 KL/day	C	110	10
Cost of fresh water (Government rates 25 Rs/Day) (25*C)	D	2750	250
Saving in fresh water (200-110)*25	**E**	**2250**	**4750**
Effluent disposal cost to CETP (@ 25 Rs/KL)	F	2500	0
Savings in Effluent discharge cost (5000-D)	**G**	**2500**	**5000**
Salt generated Kg/day	H	500	1000
Recycled salt amount @ 6.0 Rs/Kg Rs/day (F x 6.0)	**I**	**3000**	**6000**
Total saving Rs/Day (E+G+I)	**J**	**7750**	**15750**
Total cost (exp-earning) (B-J)	**K**	**9420**	**7850**
Actual Cost Burden on mill Rs/KL	**L**	**47.10**	**39.25**

These costing figures are derived from a reputed textile mill for a particular quality & volume of effluent & may vary depending upon variable factors.

This cost is more or less equal to total water cost of (Purchase + ETP+ CETP). Increased water consumption will reduce running cost. In addition to this, biological sludge generated can be burnt into boiler (with prior permission from Pollution control board) this will reduce cost of sludge disposal & also it will reduce coal consumption.

12.9 Design Sustainability in Textile industry

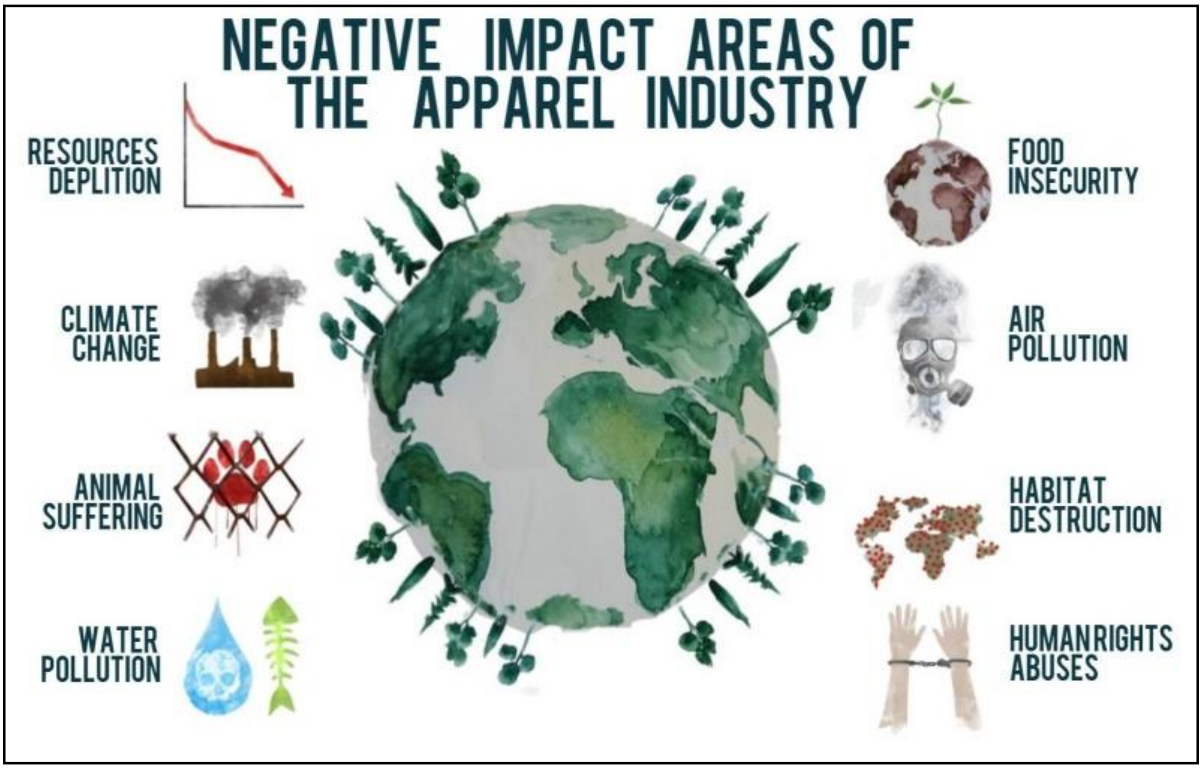
- Best Management Practices (BMP)
- Chemical Management System (CMS)

In today's scenario, it is observed that, textile industry is struggling for sustainability. There are lots of issues related to environmental aspects, awareness among NGO's & villagers' Brands & export houses are imposing stricter environmental norms & that too at competitive rates with higher quality standards. In addition to this, threat from China for cost is always there. Advantages of BMP & CMS

At this stage, one must think – "How to design sustainability."

There are three basic needs that a man possesses food, clothing, and shelter. When we think of pollution, we envision coal power plants, strip-mined mountaintops and raw sewage piped into our waterways.

We don't often think of the cloths on our bodies. The global textile and clothing industry is bound to be huge, as it fulfils the second basic requirement of man. The consumption of textile products is very huge & is increasing day by day due to increase of population & also increase in sq. meter consumption per person. Ultimately the overall impact the apparel industry has on our planet is quite large. Fashion

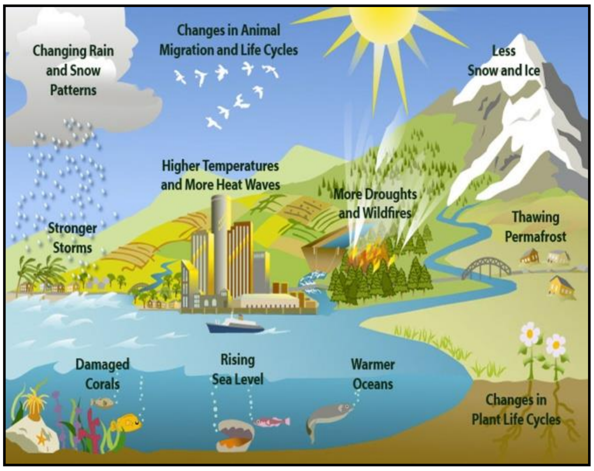


is a complicated business involving long and varied supply chains of production, raw material, textile manufacture, clothing construction, shipping, retail, use and ultimately disposal of the garment. It is said that textile is the second largest polluter (after paper industry) in the world. A general assessment says that, right from the pesticides used in cotton farming, the size used in fabric manufacturing, the toxic dyes used in manufacturing and the great amount of waste generated during disposal of garments. Other supporting systems also generate lots of pollution load which includes coal for steam generation, transportation & packing material. Pollutants released by the global textile industry are continuously doing unimaginable harm to the environment. It pollutes land and makes them useless and barren in the long run. Surveys show that cotton consumes the highest amount of harmful pesticides and fertilizers. Majority of them fall on land while they are sprinkled on the crop. Similarly, textile manufacturing units release hazardous waste into the nearby land.

The combination of all above processes used in textile manufacturing, large volume of water with various pollutants is generated & it needs to be treated in Effluent treatment plant. There are two wars to reduce pollution load

1) By treating effluent in correct manner with correct discharge norms.
2) By avoiding / reducing use of chemical hazards in process.

In second option, one can select green chemicals which are no or less harmful & gets bio-degraded without adverse impact on atmosphere. Green chemistry is a whole new way of thinking or entire new production approach that helps in using the existing knowledge and fundamentals of chemistry and other sciences to decrease the negative impact environment is facing. Green chemistry is different processes and methods that can help in minimizing the effect of pollution or environmental deterioration.



It is a combination of chemistry and chemical engineering for the betterment of the environment. There are several processes in textile production line, that not only add to the environmental pollution but the processes are not cost-effective and harmful to the environment. These processes are the cause of hazardous waste generation. Moreover, disposal of by-product (Sludge) & also garments after usage are dumped & are the cause of environmental pollution. The process should be such that even though the garments or by-products cannot add anything gainful but it should not add to the environmental pollution.

Importance of Green Chemistry

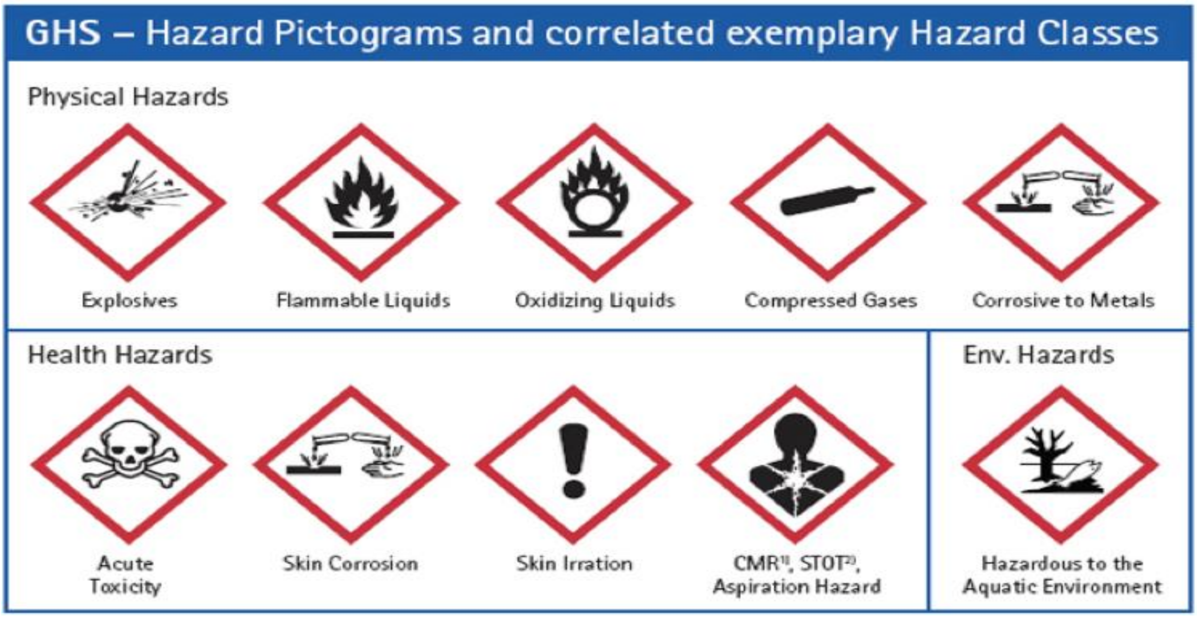
Therefore, it is important to utilize the presently available knowledge to reduce the chemical hazards and also help in developmental activities. This should form the basis of green chemistry. So, what are the measures that need to be taken? For instance, we should be careful while using certain highly toxic organic solvents like toluene, benzene, carbon tetrachloride, etc.

It is fact that, textile industry is highly water consuming industry. In addition to this, the effluent characteristic and effluent quantity vary according to the processes involved, chemicals used and the scale of operation. Therefore, quality of effluent from one industry varies from the industry. As the textile manufacturing units use different type of raw materials, chemicals and processes. As per market demand, textile units change their product mix & lead to variation in effluent characteristics which leads difficulties in treatment at ETP. To avoid use of hazardous chemicals is the only solution for pollution prevention.

There are three types of Chemical hazards:

Type of Chemical Hazard	**Impact of Hazard**	**Precautions to be taken**
Physical hazard	Cause fire	Proper storage of chemicals
	Explosive	

	Corrodes equipment, plant & machinery	
	Causes violent reactions when used with other chemicals in process	
Human health hazard	Skin – eye irritation	Use of proper Personal Protective Equipment's
	Cause allergies	
	Cause cancer	
	Damage organs	
	Affect fertility & reproduction	
	Dusting / Odour	
	Endocrine disruptor	
Environmental hazard (This segment is focused area)	Toxic to aquatic life	Avoid the use of Chemicals
	Toxic to terrestrial life	
	Persistent	
	Bio accumulative	
	Contaminates soil, air & ground water	



It is essential for a technician to know the chemical he uses & its impact on environment. Chemical hazards are further categorized by its chemical nature into 11 priority groups as under;

1) APEO
2) Phthalates
3) Azo Dyes
4) Brominated & Chlorinated Flame retardants
5) Chloro-phenols
6) Chlorinated aromatics
7) Chlorinated solvents
8) Organotin Compounds
9) Short Chain Chlorinated Paraffin's (SCCPs)
10) Heavy metals
11) Per-fluorinated Chemicals (PFCs).

The restrictions on these chemical groups were imposed as & when its severity was identified. Above pic shows the year when particular hazard was banned (Pic is from IKEA brand)

In order to reduce the use and impact of harmful substances in the industry, it is essential to focus on entire supply chain starting from Fiber generation to end consumer to disposal. This includes suppliers of raw material & chemicals, production houses, accessories manufacturers, packaging material suppliers, screen-printers, laundries etc..

RSL & MRSL: -

Restricted Substances are chemicals whose use or presence is banned in a particular end-product such as finished article or garment. Restricted Substances List or RSL is a comprehensive list of all chemicals that are restricted of banned from use on products. RSLs are developed by individually by Brands, Eco-labels or legislations and are continuously updated based on international, federal and local governing bodies. MRSL is a next step to control the use of restricted substances right from manufacturing stage. The MRSL differs from a RSL because it restricts hazardous substances potentially used and discharged into the environment during manufacturing, not just those substances that could be present in finished products. The MRSL takes into consideration both process and functional chemicals used to make products, as well as chemicals used to clean equipment and facilities. It addresses ANY chemical used within the four walls of a manufacturing facility. Thus MRSL has broaden the area of RSL.

A typical RSL manual contains the following:

- Substance name
- CAS Number
- Limit Values of each restricted group
- Terms such as Not Detected and Detection Limit
- Test Method
- Regulations under which the chemical group is restricted.

RSLs Focus on End-Product: Certain chemicals used at different stages of production are released in the environment through waste water, air or sludge. RSLs are focused only on restricted substances in the end product and do not monitor the presence of these chemicals in waste water or sludge. RSL compliance is monitored only through random testing on the samples of finished product. But, this is like solving the problem after the damage has been done! Due to these limitations, Brands have shifted focus from RSLs to Manufacturing RSLs or MRSLs. One need to understand the difference between RSL & MRSL.

RSLs Focus on End-Product where as **MRSL Focus on Usage of Chemicals: -** Certain chemicals used at different stages of production are released in the environment through waste water, air or sludge. RSLs are focused only on restricted substances in the end product and do not monitor the presence of these chemicals in waste water or sludge. RSL compliance is monitored only through random testing on the samples of finished product. But, this is like solving the problem after the damage has been done! Due to these limitations, Brands have shifted focus from RSLs to Manufacturing RSLs or MRSLs. One need to understand the difference between RSL & MRSL.

RSL / MRSL	RSL	MRSL
Definition	RSL is a list of hazardous chemicals that are restricted below a certain threshold in finished textile products.	MRSL is a list of hazardous chemicals that are restricted below a certain threshold in textile, apparel and footwear manufacturing. This list includes process chemicals, which may be used in manufacturing but may not be present in the finished product.
Criteria	Provides threshold limits of hazardous chemicals allowed in finished products	Provides threshold limits of hazardous chemicals allowed in chemical formulations
Identification	Products tested for presence of hazardous chemicals	Chemical formulations tested for presence of hazardous chemicals
Process permissions	Allows hazardous chemicals in manufacturing	Does not allow hazardous chemicals to enter factory gate.
Tool	Tool used to adhere to regulatory requirements	Beyond compliance
Focus	Focus on end-of-pipe	Focus on input chemistry

An important point to consider is that if hazardous chemicals are restricted at the factory gate before they even enter the manufacturing facility, theoretically they will not be present on the finished product. This means

The cost of product testing can be reduced significantly.

Fewer products to test, and less transportation to testing labs saves money.

Fewer garments need to be destroyed which is a requirement for testing.

BMP (Best Management Practices)

Action plan to reduce consumption of NPO (Non Productive Outputs) in textile industry:

NPO can be well explained as - We use raw material, Natural resources (Water, Power & Fuel), Dyes, chemicals & auxiliaries along with man-power to produce end product. This is known as production process. Now, the ingredients' used in production process & not sold along with end product are known as NPO. In this section, we discuss about points related to environmental issues. The action plan to reduce NPO can be as under.

A. Reduction in Water Consumption
B. Reducing Chemical Consumption
C. Reducing Energy Consumption (Power & Fuel)
D. Reducing toxicity of the effluent by adopting correct chemicals & process parameters

A. Reduction in Water Consumption:

All textile industries consume water, which is generally much higher than what they require. The impact of high water consumption includes:

- High wastewater treatment costs at raw water stage & at Effluent treatment stage)
- Higher water bills,
- Increased chemical consumption (as generally chemicals are consumed on GPL basis)
- Increased Fuel costs (Generally Hot / warm water is used in majority of production activity)
- Increased Power costs (Transportation of water from storage tanks to machine & to ETP needs power)

Water consumption can be reduced by implementing simple procedures such as

- Fixing leakages, repair faulty valves,
- Study & reduce diameter of water pipe line
- Use pressurized water spray during cleaning of equipments (Use nozzles at the end)
- While cleaning, one can apply knob to control water volume (On/Off Knob)
- Reduce MLR in batch wise process
- Reduce overflow washing steps & select smart wash system.

- In case of continuous process reduce level of water in selected compartments of m/c & also control pressure of water during overflow.
- Use counter current wash system in washing ranges.
- Internal recycling of process water in selected process, Back wash water of softener plant can be used in preparation of ETP chemicals, floor cleaning, Toilet flushes etc.
- Turn off running taps and hoses (especially in toilets & also at cleaning area of production section)
- Turn off water valves when machines are not running
- Reduce the number of processing steps
- Optimize process water by several trials
- Recycle cooling water
- Re use process water in selected processing steps
- Using water efficient process and equipment
    - Water efficient process
    - ✓ Use enzyme treatment for scouring instead of caustic base.
    - ✓ Use combined process for Bleaching & scouring, use single bath process for PC dyeing (selected shades), avoid full bleaching for shades other than few bright colours & reduce chemicals, water. Consume pressure nozzles & reduce water volume – by spraying water before nip of washing compartments in continuous ranges.
    - ✓ Use direct dyes (high fastness direct dyes) for PC blends & reduce water consumption (these dyes are high exhaustion dyes & reduces consumption of chemicals – salt / alkali.
    - Water efficient equipments
        - ✓ Reduce MLR by proper selection of equipment.
        - ✓ Install level controllers & flow controls in equipments.
        - ✓ Use

B. Reducing Chemical Consumption:

Majority of the chemicals applied in textiles industry are washed off and sent to the drains linked to ETP. Reduction of chemical consumption can lead to a less polluted effluent & lower treatment costs, as well as overall savings in chemical costs during production.

Various options for the reduction of chemical usage arc as follows:

- Recipe optimization
- Control of dosing chemicals
- Pre screen chemicals and raw materials (study MSDS)
- Chemical substitution (by less toxic one)

- Correct storage and handling (Generally chemical has storage instructions & by following storage conditions, one can reduce possibility of degradation on storage
- Chemical recovery and reuse (PVA recovery from desize treatment, Caustic recovery from wash liquor, Salt recovery from dye-bath drain, softener bath drain can be saved by installing standing bath / large tanks & than re-use)
- Process changes
- Improve scheduling of dyeing machines & reduce cleaning of equipment in-between two shades)

C) **Reduce Energy Consumption (Fuel & Power)**:

As with water consumption, reduction in energy use can result in substantial savings and lower emissions from boilers or generating plants.

- Some energy (Fuel) efficient options include the following:
  - Good housekeeping.
  - Maintenances of
    - ✓ Pressure Reducing Valves,
    - ✓ Steam traps,
    - ✓ Escape of energy by Exhaust control of Hot equipments
    - ✓ Auto temperature control devices
    - ✓ Boiler blow-down by linked by TDS
    - ✓ Energy saving by right use of Heat Exchangers
    - ✓ Use of Heat from hot drains from process, Boiler blow off water through feed tank, Pre heating of boiler feed air by hot gases through chimney.
    - ✓ Proper insulation of hot lines (Water, Steam & Condensate steam), Boiler feed tank. Hot water storage tanks Etc...
    - ✓ Auto control of ID/FD fans depending upon O2 level of flue gases through chimney.
    - ✓ Reduce cooling steps in process.
    - ✓ Avoid direct steam by Installing heat exchangers (indirect steam heating)
    - ✓ Energy audit by Boiler engineers & implement suggestions.
- Some energy (Elect power) efficient options include the following
  - Use Invertors drives wherever is possible
    - ✓ Blower speed in aeration tank of ETP
    - ✓ Speed control of stenter motors.
    - ✓ Pumps of Pressurized water line to be regulated by pressure switch.
  - Maintenance & cleaning of all panel boards
  - Energy audit by electrical engineer & implement all suggested options.

- Switch over to power saving lights.
- Auto level controllers for UG & OH water storage tanks

D) Reducing toxicity of the effluent by adopting correct chemicals & process parameters

- Pre screening chemicals using the Material Safety Data Sheets to ensure that chemicals are not toxic
- Test all incoming chemicals for purity & also COD level. Give preference to low COD chemical for consumption. (E.g. Formic acid has COD level of 30% against Acetic acid moreover; its consumption is 30% less against Acetic acid.)
- Identifying sources of pollution and get correct replacements.
- Proper storage & handling can help in reduction of pollution load.
- Improved work practices can reduce chemical wastage & save cost/ pollution load. (chemical spillage can be reduced through improved work practices)
- The reduction of toxicity is a suitable approach to cleaner production. Especially, in the textile industry, compounds that contribute to the aquatic toxicity of textile effluent include salt metals, surfactants, toxic organic chemicals, biocides and toxic anions. Some methods of reducing the use of these compounds are to:
    - Reduce metal content through careful pre screening of chemicals and dyes for metal content and using alternatives where possible
    - Selection of inert tanks for storage of hazardous chemicals)
    - Reduce the amount of salt in the effluent by
        - ✓ Optimizing recipes,
        - ✓ Using low salt dyes,
        - ✓ Reusing salt
        - ✓ Use biodegradable surfactants such as linear alcohol ethoxylates
        - ✓ Replace chlorinated solvents with better alternatives
        - ✓ Replace the use of biocides with ultraviolet light as a disinfectant for cooling towers
        - ✓ Carefully pre screen chemicals for their toxic nature using material safety data sheets (MSDS).

Implement CMS in plant (CMS= Chemical Management System)

Source of pollutants

Restricted Substances in Textile production process.

Process	**Name of Restricted Substance**	**Details**
Natural Fiber Cultivation	APEOs	Emulsifier & wetting agent in formulations of pesticide & insecticide.
	Restricted Pesticides	Pesticide used to protect plant growth

	Heavy Metals (Arsenic)	Preservative, Contaminant in input water
	All Heavy Metals	Contaminants from soil
Synthetic Fiber Production	Heavy Metals (Antimony)	Used as a catalyst in polyester manufacturing
	APEOs	Emulsifier in spin finish, texturing oil
Spinning	APEOs	Spin finish component
	SCCPs	Waxing during yarn winding
Sizing	Un-reacted monomers	Acrylate based size
	Pentachlorophenol	Preservative in size paste
Knitting	APEOs	Emulsifier in Knitting oil and spotting oil
Desizing	APEOs	Wetting Agent
	Pentachlorophenol	Preservative in size paste
	Isothiazolinone	Biocide in enzyme& size formulations
	Unreacted acrylate Monomer	From acrylate based size
Scouring & Bleaching	APEOs	Wetting agents, lubricants, de-aerating agents, scouring agents
	Chlorinated Solvents	Stain removers
	Mercury	Impurity from caustic soda
	EDTA	Chelating agent
Mercerization	Mercury	Impurity from caustic soda
	APEOs	Surfactant and Wetting Agent
Bio-polishing	Isothiazolinone	Preservative in enzymes
Dyeing processes	APEOs	Emulsifiers, Wetting Agents
Dyestuff formulations	SCCPs	De-dusting Oil
Washing process	APEOs	Washing – off chemicals
Reactive Dyeing	Banned Amines	Part of dyestuff
	Formaldehyde	Dye- fixing agent
	Heavy Metals	Part of dyestuff
Disperse Dyeing	Allergenic Disperse Dyes	Dyestuff
	Phthalates	Levelling agents
	Chlorobenzenes	Carrier/Swelling Agent
Acid Dyeing	Carcinogenic Dyes, Banned amines	Dyestuff
Basic Dyeing	Carcinogenic Dyes	Dyestuff
Metal Complex Dyeing	Heavy metals	Part of dyestuff
Direct Dyeing	Banned Amines	Part of dyestuff
	Formaldehyde	Dye-fixing agent
	Carcinogenic Dyes	Dyestuff
Pigment Dyeing	Heavy Metals	Part of Pigments
	Formaldehyde	Fixer
	Unreacted Acrylate monomer	Binder in Pigment Dyeing
Printing processes	APEOs	Emulsifiers, De-aerating Agents
Discharge Printing Process	Heavy Metals (Zinc, Nickel)	Part of Discharging Agent; printing screens, rollers
	Formaldehyde	Discharging Agent
All Printing processes	Unreacted Acrylamide Monomer	Binder
Natural Printing gums	Pentachlorophenol	Preservative used in ptg. Gums
Pigment printing	Formaldehyde	Dye Fixing agent
Washing process	APEOs	Washing-off Aids

Pigment Printing	Banned Amines	Part of a pigment
	Heavy Metals (Lead, Cadmium,)	Part of a pigment,
	Phthalates	Plasticizer in PVC
	Diisocyanates	Binders based on PU or PVC
	Dibutyltin	Catalyst in PVC
Reactive Printing	Banned Amines	Part of Dye-stuff
	Heavy Metals	Part of Dye-stuff
Plastisol Printing	Phthalates	Plasticizer
	Dibutyltin	Stabilizer for PVC
Silicone softener & fatty acid condensates & PE/ Paraffin wax	APEOs	Wetting Agents, Emulsifiers
	Dibutyltin	Catalyst in silicone finishing
Easy care/Anti-crease/ Crease resistant	Formaldehyde	Cross-linking agent
Water, Oil & Stain-repellent Finishing	PFCs (PFOA/PFOS)	Water, Oil and Stain-Repellence
Fire-retardant	Chlorinated and Brominated Flame Retardants	Flame Retardant-finishing agent
Anti-microbial/ Moth-proof Finishing	Tributyltin	Anti-microbial finishing Agent
	Triclosan	Anti-microbial finishing Agent
Antistatic Finishing	APEO	Emulsifier
PVA Emulsion	Phthalates	Stiff finish
Powder Coating	APEOs	Emulsifier
	Benzene	Thickener
	Phthalates	Softener/plasticizer
	Acrylates	Softener/plasticizer
	Vinyl Chloride	Unreacted monomer
	PVC	Coating Material
Polymer Dispersion Coating	Isocyanates	Polyurethane coating
	Free Acrylamide	Unreacted monomer
	Acrylonitrile	Unreacted monomer
	Formaldehyde	Cross-linking Agent
Solvent Based Coating	N-Methylpyrrolidone (NMP)	Solvent
	Di-methyl Formamide (DMF)	Solvent
	N,N-Dimethyl Acetamide (DMAC)	Solvent
	Toluene	Solvent
Tinting/Over dyeing	Heavy Metals	Part of Direct Dyes, Reactive Dyes
	APEOs	Part of Reactive Dyes
Garment Wash Effects	APEO	Soaping Agent, Lubricant
Stain Removal	Chlorinated Solvent	Stain Remover
Packaging and Transportation	Dimethyl Fumarate (DMFu)	Biocide and Fumigant
	PVC	Plastic Packaging Material
	Phthalates	Plasticizer in PVC wrapping
	Formaldehyde	Paper Packaging Material
	Heavy metals (Pb,Cd & Cr)	Cardboard manufacturing

Above list is guidance for possible presence of restricted substances. One can study MSDS & TDS for correct selection of chemicals & dyes in process. Even chemical manufacturer can guide for selection of Dyes & chemicals for restricted substances.

Material Safety Data Sheet (MSDS)

Let us understand important factors in MSDS

MSDS is a document generated by the manufacturer of chemical.

A Material Safety Data Sheet (MSDS) is a document that contains information on the potential hazards (health, fire, reactivity and environmental) and also give information on how to work safely with the chemical product. It is a basic document for development of a complete health and safety program. It also contains information on the use, storage, handling and emergency procedures all related to the hazards of the material. The MSDS contains much more information about the material than the label. MSDSs are prepared by the supplier or manufacturer of the material. It is intended to tell what the hazards of the product are, how to use the product safely, what to expect if the recommendations are not followed, what to do if accidents occur, how to recognize symptoms of overexposure, and what to do if such incidents occur. There are 16 sections in standard MSDS & it can give complete information about hazards (Physical, Health & Environmental.

Standard format of Safety Data Sheets

MSDS should be provided in the official language of the country, where the substance is supplied.

There are total 16 sections in MSDS & should be as under.

1) Identification of the substance/mixture and the company/undertaking
2) Hazards identification (assessment)
3) Composition/information on ingredients
4) First aid measures
5) Firefighting measures
6) Accidental release measures
7) Handling and storage
8) Exposure controls / personal protection
9) Physical and chemical properties
10) Stability and reactivity
11) Toxicological information
12) Ecological information
13) Disposal considerations
14) Transport information
15) Regulatory information
16) Other information

This format is based on GHS recommendations and it is acceptable throughout the world.
For sustainability, one must focus on hazard identification. Same is seen in section no. – 2, 10, 11, 12 & 13. No doubt section no 15 is also important for hazard handling.
The impact of pollution is so high that, Government has laid down stricter norms for discharge of effluent & sludge (CPCB, SPCB) In addition to this, various NGO's, Brands, buying houses are not allowing any industry to do business if they are polluting the atmosphere. The solution to above issue is very simple & is known as CMS that is Chemical Management System.

Chemical Management System (CMS)

To avoid the usage of these RSL / MRSL one must adopt chemical management system (CMS)The Textile Supply Chain is composed of several tiers as we go down the ladder from the consumer to the fiber manufacturer. Across this stream, chemicals are used at different stages. Maximum use of chemical and therefore risks – is in the processing section i.e. the garment laundries and the fabric dye-house (Fig. 9)
It is essential to manage the chemicals with proper understanding right from purchase, usages & up to disposal.
Looking towards seriousness of subject & need of an hour, CMS is developed. There are many consultants who work on CMS & guide industries for better outputs by reducing NPO's.

A) **Objectives of CMS**

Quality & Environmental performance of end product,

- Compliance to statutory prescribed norms
- Improvements in Productivity.

B) Advantages of CMS

- Cost savings
- Improve quality of end product
- Compliance in outputs (Product & effluents)
- Saving in consumption of water & Energy
- Reduce accidents & improves Health & Safety

C) How to Implement CMS

Basic steps for implementation of CMS are as under

- Commitment from TOP management - Generate CMS policy
- Develop a team for implementation
- Development of CMS Policy
- Define responsibilities & authorities of each team member
- Define chemical selection procedure

- Identify hazard of each chemical & make safety procedures for storage, handling & disposal of same.
- Strictly follow safety instructions mentioned in MSDS for transport, storage & handling in mill.
- Strictly follow local & national rules & regulations while storage, use & disposal of any chemical.
- Standardize procedure of testing of raw material, finished product & waste generated during process
- Training to CMS team & work force
- Development of MIS System - Daily / Monthly check points & reporting system to Top Management
- Self-grading system for future self-assessment.

D) Few Examples for action

- Reduce chemical consumption by automation (pH control, Temp control, etc…)
- Use of Enzyme base technology in pre-treatments.
- Techniques to Reduce Salt consumption
- Replace Soda ash by Liquid alkali
- Know chemicals & its parameters for application
- Reuse
  - ✓ Water (standing bath technique, Counter current washing)
  - ✓ Water from Pre-treatments to be reused in to other baths like desizing.
  - ✓ Salt from Dye bath drain by Nano filter technology
  - ✓ Heat from Heat Recovery Unit
  - ✓ Water by using Vacuum slit instead of regular squeezing for better squeezing

- Caustic recovery from mercerize wash liquor
- PVA recovery system.
- Reuse of cooling water at various stages of processing (Cooling water from sanforise), Cooling towers etc….
- Single bath dyeing of PC blends for selective shades
- Use of Low salt dyes.

- Reduce MLR by various techniques
- Replace overflow rinse by normal washes.
- Use of standing bath for finishing.
- Auto dosing system for chemicals
- Use of laser techniques in place of Potassium Permanganate

Ecological foot print of various textile end products

As we know, textile is basic need of human & used in various forms as under.

A) Cotton, viscose, Jute, Linen, Hemp, bamboo, Modal, Ramie
B) Polyester, Acrylic, Nylon Spandex, Rubber,
C) Wool, Silk
D) Gold, Silver, Steel, Copper, Aluminum, Carbon,

Carbon footprint: Today and Tomorrow

Today, textile production is the world's third most polluting industry after the Textile & paper industry. The total greenhouse gas emissions from textile production currently stands at 1.2 billion tonnes annually and this is more than those of all international flights and maritime shipping combined. It is estimated that the fashion industry is responsible for 10 per cent of the global carbon emissions. Manufacturing hubs China and India will increase the footprint further. More than 60 per cent of textiles are used in the clothing industry and a large proportion of clothing manufacturing occurs in China and India, countries which rely on coal-fuelled power plants, increasing the footprint of each garment.

Increasing appetite for fast and disposable fashion

Polyester and cotton are the two most commonly used fabrics in the industry and their production has a considerable ecological impact. Amongst these, polyester along with other synthetic Fibers is the most commonly used fabric, but its production results in more emissions since it is produced from crude oil also consumes more energy & power during production of polyester with compared to Polyester.

According to estimates, 262 per cent more CO_2 is emitted to produce a single polyester T-shirt than a cotton shirt. Moreover, it is further more harmful to environmental aspects due to its non-bio-degradable nature. Cotton is a natural Fiber & its self-degradation property helps nature. Now, looking towards polyester's sustainable property, it can be easily recycled & ultimately, it can reduce adverse impact on nature. Frankly speaking, recycling of man-made products is not happening & cotton is considered as more environmental friendly Fiber. Figures says that, that, the average number of times a garment is worn before it ceases to be used—has decreased by 36 per cent compared to 15 years ago. After use, less than 1 per cent of the material used to produce clothing is recycled into new clothing. It is time to adopt recycling of textile we use.

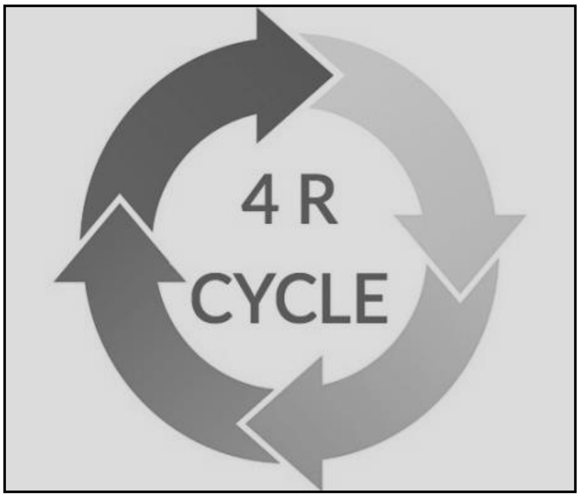
While considering natural Fibers, one can always compare environmental impact (Carbon dioxide and GHG emission) during the production and use of garment.

How to reduce such adverse impacts needs modification in process (Chemical & procedure) Toxic dyes and chemicals used in wet processing of textile goods which are coming in contact with the skin and causing a direct damage to the health like skin cancer, allergy etc. The elimination of hazardous solvents is one of the prime concerns of eco-friendly chemistry. Use of enzymes in wet processing, Reuse of water (popularly known as water recycling), eco-friendly auxiliaries, single step desizing, scouring and bleaching, elimination of carcinogenic dyes and pigments, use of low impact reactive and natural dyes, Use of low MLR equipments for processing, supercritical fluid dyeing (using liquid Carbon dioxide), Ultrasonic and Ultraviolet energy for dyeing, recycling system for organic solvent used in textile pigment printing, avoiding phthalate base pigments in printing, digital printing, heat transfer printing, formaldehyde free finishing and bio-polishing are some of the modified processes consuming lesser or eco-friendly chemicals thereby providing a safer and sustainable environment.

Wet treatment of textiles like desizing, prewashing, mercerizing, dyeing, printing etc. includes a lot of chemical applications on the fibers. Water is used at every stage in fabric manufacturing process application of chemicals, - wash and rinse out those same chemicals to make product ready for next process. Some Fibers need to be bleached with chlorine before dyeing. This causes release of organo-chlorine compounds in the atmosphere, which are very dangerous to the environment. Generally, textile product consumes lot of chemicals (Normally, it takes between 20% and 60% of the weight of the fabric) to produce end product. During the process of wet treatment, huge quantity of fossil fuels is consumed which have carbon content and react with oxygen to form carbon dioxide. This results in acidification, fossil fuel depletion and ultimately global warming. Fabrics take a lot of energy to produce fabrics.

Looking towards the industry’s size and extensive use of raw materials and chemicals need to adopt technologies that are environmentally sustainable. It is observed that, very few textile units, especially - in the processing sector - across the country have failed to meet many environmental laws and regulations. Despite stringent environmental laws and regulations, the compliance level by the textile industry has not been very satisfactory & Effluent Treatment Plants are not able to comply. It is a time to think on this subject & need to decide for reduction in pollution level by use of better technology. Therefore, eco-friendly textile wet processing should be adopted to eliminate/optimize the use of harmful/ hazardous/ carcinogenic chemicals / auxiliaries/ dyestuffs.

A systematic approach including a continuous improvement process can reduce the carbon footprint of textiles. Companies will realize how they can benefit from increasing energy efficiency and thus cutting costs for fuel and electricity. In fact, it can be a triple wins for the textile retailer, supplier and the environmental sustainability can be achieved by looking at the full life cycle of our clothing. Adoption of 3 R concept is now old one & one must add 4th R & follow 4 R concept. i.e. Reduce, Reuse, Recycle & Research.



Reduce: Low carbon foot print processes cut costs by reducing waste of raw materials and energy. Water and energy usage reductions by the textile dyeing and finishing sector can help reduce global carbon dioxide emissions. By saving energy and water, the textile industry can not only save a lot of money, but also help to slow down climate change. The textile industry needs to adopt more energy efficient processes & chemicals. Eco-efficient processes for textile mills can save costs of production and also help to reduce the environmental burden.

Reuse: Industry can reuse water & energy from hot drains. This will help in reduction of production costs.

Recycle: One can always think to recycle water after proper treatment back to process. Many new technologies have been developed to recycle Salt, PVA from size, Caustic from mercerise wash liquor. This will reduce consumption of fresh water & chemicals & ultimately can reduce environmental burden. Used textile material can be converted back into yarn & can generate melange yarn. Same yarns can be re-dyed & produce fresh garments at half the rates. Plastic bottles can be recycled to produce Fiber & used in geo-textiles. Even waste garments (manmade Fiber) can be recycled back to make roads.

Research: Educational & research institutes must apply brain on research activity by environmental burden can be reduced. (Super critical Carbon dioxide process for polyester dyeing is one good example).

Several practical examples will help to develop BMP in textile plant.

Value addition from wastewater treatment, recycling and reuse comes mainly from

1. Recovery of chemicals such as acids
2. Recovery of metals
3. Recovery of energy in the form of biogas, power
4. Recovery of water as fertilizer

Cost reduction techniques in water recycling: -

When we are talking about the water recycling then we should consider the cost reduction in the following aspects i.e.

- Saving of water by recycling in the process itself i.e. generate less amount of effluent
- Saving in the operational cost (electricity and manpower cost) of water recycling in ETP
- Saving in the chemical cost

Saving by generating less amount of effluent: -

This is as like preventive action for the ETP cost reduction. Mills that currently use excessive quantities of water can achieve large gains from pollution prevention. A reduction in water use of 10 to 30 % can usually be accomplished by taking fairly simple measures. A walkthrough audit can uncover water waste in the form of:

- Hoses left running.
- Broken or missing valves.
- Excessive water use in washing operations.
- Leaks from pipes, joints, valves and pumps.
- Cooling water or wash boxes left running when machinery is shut down.
- Defective toilets and water coolers

Addition to the routine audit for the wastages, the Engineer and technocrats in the plant should necessarily think of the below water saving techniques in the textile process house.

Work practices and engineering control

Workers can greatly influence water use. Sloppy chemical handling and poor housekeeping can result in an excessive cleanup. Poor scheduling and mix planning also can require excessive cleanup and lead to unnecessary cleaning of equipment like machines and mix tanks. Leaks and spills should be reported and repaired promptly. Inappropriate work practices waste significant amounts of water. The soft skill training in the work culture and practices will help a lot in this regard.

Every mill should have moveable water meters that can be installed on individual machines to monitor the water use and evaluate improvements. In practice, mills rarely measure water use but rely on manufacturers' claims concerning equipment and water use. The manufacturers' estimates are useful at starting points for evaluating water consumption, but the actual performance of equipment depends on the chemical system used and the substrate. Therefore, water use is situation-specific and should be measured on-site for accurate results. Other important engineering controls are as below;

- Flow control on washers.
- Flow control on cooling water (use minimum necessary).
- Counter current washing.
- High extraction to reduce dragout.

- Recycle and reuse.
- Detection and repair of leaks.
- Detection and repair of defective toilets and water coolers

B) Reusing uncontaminated/first quality water

Perhaps the easiest of all water recycle activities is to reuse non-contact cooling water back to the same process or any other process depending on the water quality. This water requires little or no treatment as it's not contaminated from process chemicals. Also, be sure to stop the cooling water when the machine is stopped and to limit the amount of cooling water when the machine is on. It is very common to find water-cooled bearings, heat exchangers, etc. with very excessive flow rates

Steam condensate water is another example in this category. The steam condensate water is gold water for boiler use as it also increases the feed water temperature by at least 8-10°C. In general, depending on the infrastructure and type of processing. 25-30 % water can be recovered in the form of steam condensate.

C) **Replacing overflow washes by captive washing**

After dyeing or scouring and bleaching cycle, the common practice is to run the overflow washing in the jet or jigger machine. Overflow or running wash consumes a significant amount of the water. To save the water If this overflow wash is replaced by high-temperature captive washes then a considerable amount of water saving can be achieved. Instead of 20 min. overflow wash if two or three captive washes at a higher temp like 80-95°C are incorporated then overflow wash water consumption will be reduced Considerably. This is explained in below table.

D) Reusing wash water by counter current flow washing

Many strategies can be applied for reusing wash water. Three of the most common strategies are counter-current washing, reducing carryover & reusing wash water for cleaning purposes.

The countercurrent washing method is relatively straightforward, simple and inexpensive to use in multistage washing processes. Basically, the least contaminated water from the final wash bath is reused for the next-to-last wash and so on until the water reaches the first wash stage, after which it is discharged. This technique is useful for washing after continuous dyeing, printing, desizing, scouring or bleaching. An important variant of the countercurrent principle is "horizontal" or "inclined" washers arrangement. Horizontal or inclined washing is more efficient because of the inherent countercurrent nature of water flow within the process.

In continuous washing operations, squeeze rolls or vacuum extractors typically extract water between steps. Equipment employing vacuum technology to reduce dragout and carryover of chemical solutions with cloth or yarn is used to increase washing efficiency in multistage washing operations. Use of the vacuum slots will reduce the number of washing compartments from 8 to 3 or 4. Wash boxes with built-in vacuum extractors are available for purchase, as well as washers for prints that combine successive spray and vacuum slots without any bath for the fabric to pass through. Because the fabric is never submerged, bleeding, marking off and staining of grounds is minimized, and water use decreases.

E) Reuse of wash water for cleaning purposes

In many types of operations, wash water can be reused for cleaning purposes. In printing, cleanup activities can be performed with used wash water, including:

- Back gray blanket washing.
- Screen and squeegee cleaning.
- Color shop cleanup.
- Equipment and facility cleaning.

A typical preparation department may also reuse wash water as follows:

- Reuse scour rinses for desizing. This is will save water by 4 lit/kg of the fabric
- Reuse mercerizer wash water for scouring and wherever possible. This will save the use of fresh caustic in scouring, bleaching and also in reactive dye fixation process. One should ensure the adjustment of the caustic concentration.
- Reuse bleach wash water for scouring.
- Reuse water-jet loom wash water for desizing.
- Recycle kier drains to the saturator

F. Final Rinse reuse as Loading Bath for Next Lot: -

One simple technique that saves water and, in some cases, biological oxygen demand loading is to reuse the final bath from one dyeing cycle to load the next lot. This technique works well in situations where the same shade is being repeated or where the dyeing machine is fairly clean.

A good example of this technique is acid dyeing of nylon hosiery. The final bath usually contains an emulsified softener that exhausts onto the substrate, leaving the emulsifier in the bath. This technique can serve as the wetting agent for loading the next batch, thus saving the water, heat, wetting agent and associated BOD.

Similarly, in the case of cotton, viscose and polyester processing of knits and woven fabric on soft, jet dyeing and winch, the technique can be used.

G) Reuse of neutralization bath

In general, the soft flow, jet, yarn dyeing vessel and fiber dyeing machines are operating at the M:L ratio of 1:6-8. As understood, last neutralization bath water is practically clear and is being drained to ETP. This water can be collected back to a separate tank with a filter system and reused for the neutralization process again in another lot. By doing this, a significant amount of the water may be saved per year. Furthermore, acetic acid consumption in the neutralization bath also can be reduced to 50 %. The saving illustration can be as below;

- Total soft flow production per day = 10000 kg
- @M: L ratio 1:6 to 7, water required for neutralization washing = 10000 kg x 5 lit = 50000 lit (Note: - in the wet condition, ML ratio will be 1: 5)
- Per year water saving = 50000 lit x 26 days x12 months x 0.8 = 12480 KL (Note: - It is assumed that after 5 time reusing the water, it can be drained to ETP due to more TDS and suspended solids in it. Hence it is multiplied by 0.8)
- In terms of rupees it is 12480 KL x 60 ₹ = 7, 48,800 ₹ per year = 7 lakhs per year (Note we have considered ETP water treatment and RO recycling cost as 60 ₹ / KL)

After successful implementation of this water reuse, the mill can further think of hot wash bath recycling and reuse. (Hot wash bath of light shades can be considered for reuse).

Below table gives the guideline for water saving by 3R concept (reduce, reuse, and recycle)

S. No.	What to do	Where to do
1	Reduce Water consumption due to wastage	Audit of the process house, Modify the washing process(over flow/running wash to fill-wash and drain technique
2	Re use the uncontaminated/ first quality water as it is	Cooling water, steam condensates etc
3	Re use second-hand quality water (process water) without treatment	Neutralisation baths, counter current washing,
4	Re use second-hand quality water (process water) with filtration or little modification	Neutralisation baths, pastel to light shades post soaping hot wash baths cane reused for the other or same process, cleaning purpose
5	Recycle effluent after partial treatment	Water after Nano filtration can be used for reactive dyeing as it contains the only salt. Also, it can be used for cleaning purpose
6	Recycle after full treatment	RO water suitable for all the process.

SAVING IN THE OPERATIONAL COST (ELECTRICITY, AND CHEMICALCOST) OF WATER RECYCLING IN ETP: -

The electricity, labor and chemical cost can be reduced in the process of water recycling in the ETP. The tips are given process wise

Process in ETP	What to do	Resultant saving
Equalization tank	**Install automatic pH monitoring and dosing system for pH control**	**Reduced manpower and chemical saving**
Biological /aeration tank	**Aeration blower ON /OFF system based on DO monitoring system**	**Reduced manpower and electricity saving**
UF/RO	**The TDS level of the permit to be monitored online and linked to the membrane backwash frequency/program/schedule**	**Saving of electricity and membrane life due to fouling issue.**
Online monitoring of the parameter linked to the activity will reduce manpower and electricity		

Process modifications can substantially reduce the cost of wastewater treatment apart from a change of methodology for foe effluent treatment, land/space requirement, equipment costs and legal binding legislation concerning pollution levels. Such changes are far better than end of pipe solutions in the form of stringent methods of treatment, such as oxidation that are highly energy intensive. Use of easily biodegradable raw materials, fewer refractory pollutants generated for simple simpler treatments and easy recycling and reuse can be potentially attractive options from a cost consideration point of view.
In most cases, chemical industries are located far from the urban areas and often the effluent standards are less strict in these locales. If land is available, conventional biological process can prove to be more economical, especially with the use of lagoon, which offers significant cost reduction due to its simplicity (less capital/land cost), less manpower/processing cost and ease of operation. Temperature/climate can be a major consideration.

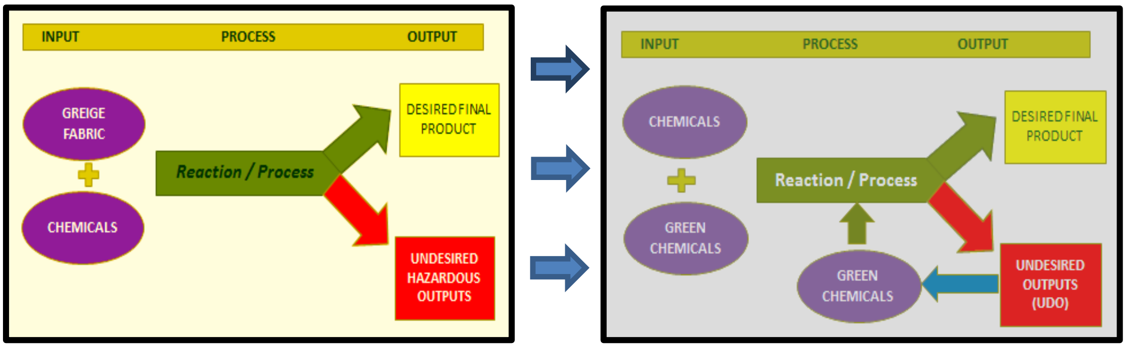
<u>Chemical Management System (CMS) for cleaner production & compliance. Implementation of CMS in factory</u>

A) ABOUT INDIAN TEXTILE INDUSTRY

Textile industry plays an important role in the industrial development of India and is the second largest sector of Indian economy, next to agriculture. As per the recent data published by the ministry of textile, it contributes about 17 percent to industrial production, 7 percent to the GDP, and 25 percent to the country’s export earnings. The textile industry in India is a key sector in terms of employment as it is the second largest employment. It provides direct employment to over 50 million. Textile industry is one of the major polluting industries, which consumes large amount of water for its various operations and generate huge quantity of wastewater which is having high Total Dissolved Solids, Sodium and chloride and is strongly coloured due to utilization of various dye stuff. We know that managing chemicals in our production is not only important but also a challenge. Textile is one of the most polluting industries in the world & the dye-house in charge is always under pressure from all four sides

A) Compliance to regulatory requirements, such as national laws and international agreements.
B) Compliance includes product performance, RSLs and other eco- label standards.
C) Economic considerations in today’s competitive market for sustainability & need to apply each step towards cost saving.
D) Compliance to Social Demands such as NGOs challenging Zero discharge of hazardous chemicals, as also consumers wanting to “green” or “eco-friendly” products

In order to achieve targeted production with fulfillment of all above compliances every industry need to plan a permanent solution that too with eco-friendly methodology.



Normal production cycle New Cycle with Chemical Management

To meet these challenges, Implementation of Chemical Management is the only solution. CMS means to understand the chemicals before use. Chemical management is does not mean pollution prevention. It means prevention of usage of toxic chemicals at source, or treating the generated chemicals which can be recycled up to maximum possible extent.

CMS keeps you aware about WHAT TO USE & WHAT NOT TO USE.

B) **WHAT TODAYS CONSUMER WANTS**?

Today people have started looking for "Green Products" everywhere. In terms of textile products, the purchasing decision of consumers was previously based upon comfort, style, aesthetic appeal, etc., but now more on eco-friendliness of the products. Many clothing companies have started providing clothes made from eco-friendly fabrics, and the demands for these green products are also increasing.

The textile processing stages usually are ‘hidden’ behind the CMT manufacturer or buying agent, and the use of harmful chemicals during these stages could be harmful for the textile workers and may leave traces in the final product and thus appear to the consumer.

C) ABOUT ENVIRONMENTAL REGULATIONS

India is the first country that has integrated the protection and improvement of the environment in its constitution. There are no specific environmental laws for textile industry sector alone.

Industry specific standards, which the textile industry is required to comply with while setting up or operating an industrial unit.

The regulatory authorities are,

- Ministry of Environment and Forests (MoEF)
- Central Pollution Control Board (CPCB) at central level
- State Pollution Control Board (SPCB) at state level.
- Enforcement is done by SPCBs.

Following are the major environmental regulations

- Water (Prevention and Control of Pollution) Act, 1974

- ❖ Air (Prevention and Control of Pollution) Act, 1981
- ❖ Hazardous Waste Management, Handling and Transboundary Movement) Rules, 2008
- ❖ Consent to Establish and Operation Under Air and Water Acts
- ❖ Authorization Under Hazardous Waste (Management, Handling and Transboundary Movement) Rules, 2008
- ❖ The Environmental Protection Act, 1986 (EPA)

<u>Advantages of Chemical Management System</u>

Proper implementation of CMS can lead to following benefits

A) Cost reduction: -

Actions towards reduction of Nonproductive outputs. Wastages can reduce profitability in a large extent. In textile production, wastages can occur due to inefficient storage and handling of chemicals, incorrect weighing and dosing of liquid chemicals, spillages & leakages during transportation and storage, and chemicals lying unused for a long time leading to their expiry. To provide necessary parameters as per process requirements.

B) Reduction on accidents: -

Proper storage & usage with evaluation of hazardous chemicals reduces fire risks.

C) Improvement in worker health and safety: -

Proper display boards with probable hazards & training to handle chemicals improve health & safety in operators**.**

D) Improvement in environmental compliance: -

Proper screening of input chemicals & selecting them based on cost & environmental aspects.

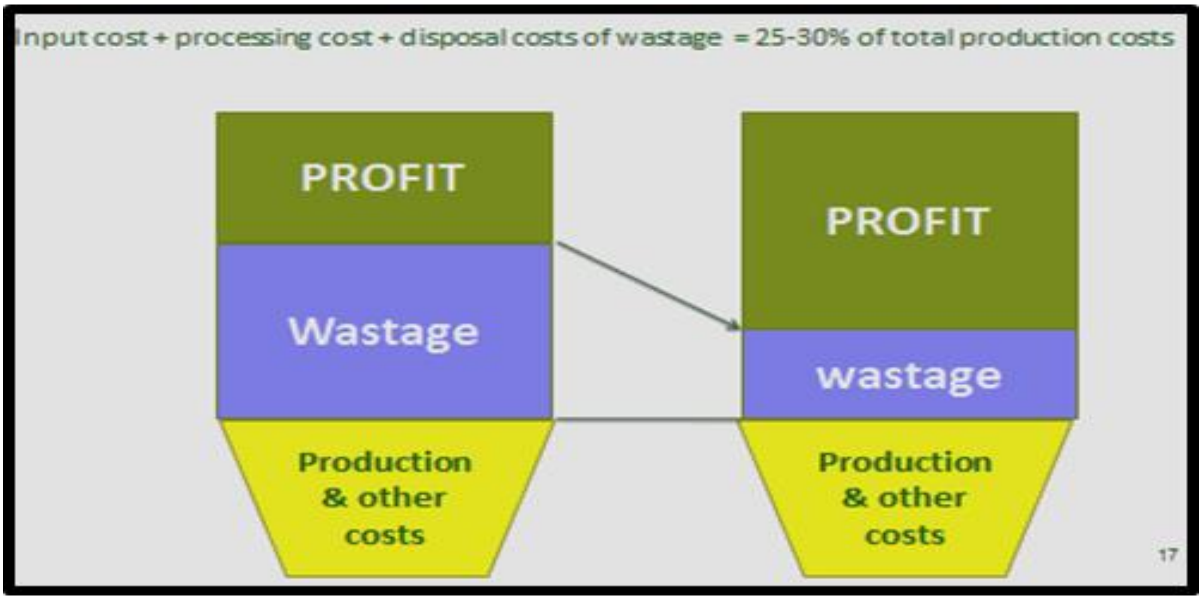
E) Increase in productivity& ultimately increase in profits: -

This is done through proper storage and optimizing smooth chemical flow in the dye house through automated dispensing systems, or by installing simple measures such as electronic weighing balances, a great amount of savings in chemical usage can be brought about. All these measures can lead to improvement in profitability through chemical management systems

Other hidden benefits are as below,

- Improved inventory management,
- Reduced chemical purchase costs,
- Improved data management (MIS)
- Improved delivery targets
- Reduced waste / scrap costs
- Reduced labor costs
- Reduced chemical consumption

- Improved EH&S environmental compliance
- Decreased process downtime / extended tool life



<u>Steps involved in Chemical Management System</u>

Duplication and non- monitoring of chemical consumption is also another cause of profit erosion in a dye-house. This can be tackled through the following steps

1. Prepare a consolidated chemical inventory across various user departments,
2. Documentation & standardization of all the process stages in detail
3. List the chemicals used in each process stage with hazard identification.
4. Document the application and dosage in each process stage

Those chemicals that are being duplicated for the same usage or application can be rationalized and the number of chemicals consumed cans this be reduced. Similarly, software tools can be developed that co-relate the actual chemical usage in a month with a benchmark consumption based on production & dosage of input chemicals. If the actual usage is higher than the theoretical benchmark, it can be concluded that somewhere chemicals have been wasted. A root cause analysis can then be done to monitor and correct the cause to prevent recurrence.

<u>Chemical Management Compliances</u>

The compliances are derived by monitoring three major points:

a) Environmental compliance – which means zero pollution of water, air, soil and less generation of noise and
b) Compliance to Health – which means protection of worker health while handling chemicals, and consumer health while using the end- products
c) Compliance to Physical hazards such as Fire, explosion and corrosion due to chemicals

Types of Chemical Hazards

Physical	Human health	Environment
Cause fire	Skin/eye irritation	Toxic to aquatic life
Explosive	Cause allergies	Toxic to terrestrial life
Corrodes equipment, plant & machinery	Damage organs	Persistent
Causes violent reactions when used with other chemicals in process	Cause cancer	Bioaccumulative
	Affect fertility & reproduction	Contaminates soil, air and/or groundwater
	Dusting / Odour	
	Endocrine disruptor	

Chemicals that impact health and environment are called Restricted Chemical Substances List or RSLs. Many Brands and legislations restrict the use of such chemicals in textile production. A good chemical management system can help to improve compliance to RSLs and reduce failure and rejections of end products. Shown here is a list of the different chemical groups that are restricted for use.

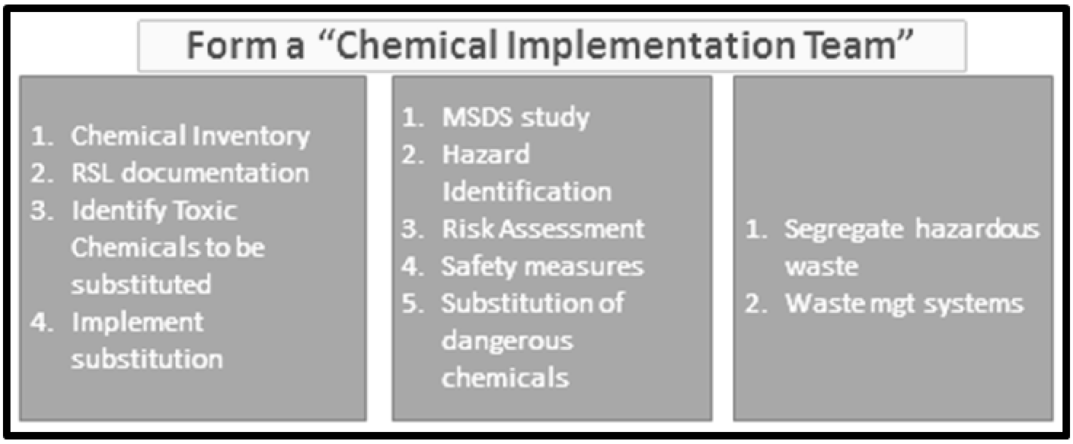
Below mentioned tables show types of Chemical hazards & hazardous chemical list

1. Banned Amines from Azo Dyes	11. PAH
2. Other Carcinogenic Dyes	12. Organotin Compounds
3. Allergenic Disperse Dyes	13. Isocyanates
4. Chlorinated Solvents	14. Flame Retardants
5. Pesticides	15. Chlorinated Aromatics
6. Biocides	16. Dioxins and Furans
7. Chlorinated Phenols	17. Formaldehyde
8. Heavy Metals	18. Unreacted Monomers
9. APEO / NPEO	19. Perfluorinated Compounds
10. Phthalates	

<u>Input Chemical Management comprises of 4 steps</u>:

1) A scientific compilation and documentation on current chemical inventory in a dye house.
2) Documents such as MSDS, labels, technical data sheets, supplier declarations and eco-label certifications need to be studied thoroughly
3) Identification of hazards and risk assessment of all the input chemicals
4) Once this exercise is completed, steps must be taken to

- Substitute toxic chemicals by green alternatives
- Segregate hazardous chemicals for storage and disposal,
- Implement safety measures for worker safety and accident prevention.
- MSDS is most key document of CMS & must be understood correctly.
- In short Chemical Management System needs to follow following points & enjoy the benefits.



CMS leads to improvements in Shop Floor –

- Focus was on health and safety of work force with right Personal Protective Equipment's. Development of Chemical Management Team
- Purchasing practices – Include environmental aspects in purchase procedure of new chemical. Supplier Declarations for compliance
- Chemical hazard labeling – Focus on health and safety at work place.
- Best available technology & practices for Chemical Storage and handling

1) <u>Sustainability & Best Available Technology in Textile industry</u>

The textile industry is one of the most complicated industrial chains in manufacturing industry. There are certain facilities having established work culture & set-up. Whereas there are many SMEs & fragmented setups, there are three main end products mainly driven by customer needs which can be as under.

- Clothing (inner wear, Outer wear, Baby wear & so on.)
- Home furnishing (Carpets, Bed sheets, Curtains etc.)
- Industrial use.
- Technical textiles (Medical use, geo textiles, Packaging etc.)

Asian countries (India, China, Bangladesh etc.) are leading in production activities followed by rest of the world. The consumption of textiles per person is increasing day by day & hence increase in production activities is seen. It is essential that, each facility take care of pollution generated due to entire textile business. It is known that textile is the third largest polluting industry in the world (after Textile & paper industry).

To overcome this issue of pollution generated by these facilities, technocrats have developed MRSLs (Manufacturers'' Restricted Substances List) which are banned or restricted in use during production, packing, transportation & use. The adverse impact of RSLs on human as well as on mother earth is very much known. This matter is well discussed in many research papers & is important. In order to achieve sustainability in business, one must take care of above hazardous chemicals & confirm the end product as "Free from restricted substances." In addition to this, it is essential to take care of natural resources & unwanted use of chemicals. This is popularly known as UDO (Undesired output) or NPO (Non Productive Output)

This concept covers a vast area of savings in Natural resources as well as quality achievement with optimum cost. Focused areas are –

1) Saving in Water consumption,
    - Techniques to optimize water consumption.
    - Internal reuse of water.
    - Water recycling after treatment (ETP / RO)
2) Saving in Power consumption
    - Reduce power consumption
    - Modify process cycle to reduce power utilize
    - Generate power through natural resources (Solar energy, wind energy, Co-generation of power from boiler etc.)
3) Saving in Fuel consumption
    - Reduction in steam consumption by modifying process cycle.
    - Reduction in steam consumption by heat recovery system.
    - Reduction in steam consumption by trapping steam leakages.
    - Condensate recovery & thermal insulation on hot water, steam pipelines.
    - Heat recovery from hot air (Chimney of boiler, DG set exhaust etc.….
    - Testing of smoke from chimney & confirm proper boiler efficiency.
    - Modify process cycle to reduce steam consumption.
4) Saving in chemical consumption
    - Use proper dosages as suggested by chemical supplier.
    - Auto dosing of chemicals
    - Implement Chemical Management System in facility.
    - Avoid leakages & spillages of chemicals
    - Reuse of NPO chemicals back to process. (Mercerize wash liquor in scouring, standing bath for finishing chemicals.

- Recovery of chemicals going into drain. (PVA recovery from sizing-desizing activity, Caustic recovery, Re-use of printing paste for dark shades. Etc.….)

5) Increase efficiency of production house
   - Maintain external parameters during process. (Maintain temperature during dyeing, during stenter finish, during curing etc.…)
   - Reduce rework.
   - Maintain chemical concentration with auto mode (pH neutralization – dose of acid controlled by pH sensor).
   - Training to work force for better output.
   - Explore possibility to recycle packing material.

This list is a dynamic & one can modify depending upon his/her experience in this field.

The main environmental concern in the textile industry is about the Amount of water discharged and the chemical load it carries. Other important issues are energy consumption, air emissions, solid wastes and odors', which can be a significant nuisance in certain treatments.

Industry must have monthly audit on below points

A) Water saving

1) Water leakages
2) Use of running water in production house
3) Reduce overflow rinse during process & modify same by smart washes.
4) Reduce MLR during process
5) Explore possibility of counter current washings in continuous process.
6) Internal reuse of water (selected processes)
7) Combine two processes as far as possible (Combined scouring & Bleaching, Combined Bio polishing & neutralization treatment etc.)
8) Use pressure nozzle with spray for cleaning of printing screens (instead of low pressure water pipe line)
9) Maintain Water balance system in facility.
10) Auto control of water in urinals.
11) Reuse of cooling water.
12) Monitor theoretical use against actual use of water.
13) Rain water harvesting.
14) System to monitor fresh water consumption per kg of product

B) Compressed air saving

1) Audit in a month to find air leakage & have a time bound plan to stop air leakage
2) Different lines for high pressure & low pressure requirement of air.
3) Install water trap in air compressor & maintain it.

C) Power saving

1) Use of inverter drive as far as possible.
2) In ETP, control of air blower speed should be linked with DO meter.
3) Replacement of all V belts of any drive (in case of breaking of any one belt)
4) Maintain correct tension of belts to transfer motion from motor.
5) Electrical audit – once in a 3 month for wastage of power.
6) System to monitor power consumption per kg of product.
7) Explore possibility of power generation by various methods.
8) Modify process to reduce time & ultimately power.
9) Auto back wash system in ETP instruments (PSF, ACF, Water softening plant, Bag filters, UF, RO etc.)
10) Use of power saving lighting system (preferable solar)
11) Training of power saving techniques to every employee.

D) Savings in Chemical consumption (Reduce UDO- Undesired Outputs)

1) Reduce use of chemicals.
2) Recycle used chemicals up to maximum level

Look at below data where yearly approximate chemical consumption is calculated which leads to environmental load

	Good Practice	% Savings			
		Water	Steam	Electricity	Chemicals
Detect Leakages & plug Preventive maintenance	• **Water leakages** • **Steam leakages** • **Condensate steam leakages**	**5.5** **0** **0**	**0** **9.5** **1.5**	**1.5** **0** **0**	
Reuse of water	• **Cooling Tower** • **singeing** • **Air Compressor** • **Preshrink** • **Condensate steam**	**0** **1.5** **2.5** **0..5** **1.0**	**1.6** **0** **0** **0** **5.0**		
Reuse of Process water	• **Bleaching** • **Mercerisation**	**4** **3**			
Heat recovery from Hot drains	• **Recover heat from all drains above 55° C before discharge to ETP.**		**3 to 7**		
Boiler working	• **Pre-screen coal** • **ID/FD fan speed** • **Control Blow off**		**1.5** **2** **1**	**0** **1.5**	
Steam Traps	• **Proper maintenance**		**1**		

Proper Insulations	• **Steam line, Condensate line, Thermic fluid line**		**2**		
Advance Techniques					
Modify process cycle	• **Enzymatic scouring** • **Optimize use of Salt / Soda by graphical method**	**10**			**10** **15**
Automation in process	• **Neutralization by pH control**				**15**
	• **Replace overflow rinse by smart wash**	**15**		**2**	
ETP	• **Blower speed control by D.O. meter**			**30**	
Re-use of chemicals	• **Salt recovery** • **PVA recovery** • **Caustic recovery**				**70** **60** **80**

All above chemicals are contributing in NPO & same to be reduced.

Best Management Practices will lead to reduce consumption of NPO & reduces environmental load.

In nut-shell,

Based shop floor survey emerged a short list of several practical and effective technologies for reducing the NPO in textile processing. Implementation of these technologies required investments ranging from minor to major. & Short term to long term. The technologies fall into the following five categories:

- ✓ Process
- ✓ Dyes & Chemicals
- ✓ Equipment (Modification / new purchase in production activity)
- ✓ Systems, Control, and Management (Lab equipments for testing - analysis & online monitoring systems)
- ✓ Wastewater treatment

Although each technology has been assigned to a category, some technologies apply to more than one category. These technologies can be employed to varying degrees with piece-dyed woven, piece-dyed knits, denim, and yarn-dyeing operations.

These technologies are listed category wise;

Process: -

1) Cold Pad Batch Preparation and Dyeing
2) Continuous Processing of Knits
3) Two-Stage Preparation of Woven
4) Combined Scour and Bleach for Yarns and Knits

5) Foam Dyeing, Finishing, and Coating
6) Right First Time Dyeing

Chemicals and Dyes: -

1. Cationization for Salt-Free Dyeing
2. High-Fixation Reactive Dyeing with Reduced Salt consumption
3. Smart use of chemicals (salt & alkali in reactive dyeing, control Acid consumption by pH control devices,
4. Enzyme Treatment
5. Pre-reduced Liquid Dyes
6. Pigment Pad Application
7. Reuse of printing paste for dark shades

Equipment: -

1. Low-Liquor-Ratio Dyeing Machines
2. Standing bath for selected processes (pH control, finishing etc.)
3. Recovery and Reuse of chemicals (PVA, Salt, Caustic)
4. Insulation of Dyeing, Drying, and Stenter Machines along with pipelines
5. Solar Heating of Water
6. Heat recovery from hot drains
7. Pressurized squeeze before drying (High vacuum slit, High speed Hydro Extractor, Combination of IR & steam for drying- to maintain % moisture in end product)

Systems, Control, and Management: -

1. Automatic Dye and Chemical Dispensing
2. Advanced Equipment and Process Control
3. Various System Approaches to Reduce NPO
4. Empowered Environmental Teams
5. Develop CMS in facility
6. Recording & monitoring system for consumption (Fuel/kg dispatch, Electrical units/Kg of dispatch, water Ltr/Kg of dispatch, man-power/Kg of dispatch, seconds & rags/kg of dispatch)

Wastewater Treatment: -

1. High-Technology Filtration Systems
2. Recycling of Internal Process Water
3. Use or Sale of Wastewater Treatment Sludge for Fuel
4. Physical-Biological, and Activated-Carbon Systems
5. Inverter drive for air blowers in aeration tank (linked with DO)

Testing & Quality control - raw material, finished product / Effluent treatment

What is textile testing? Why it is required? What are the advantages of testing?

"Textile testing is a key in gauging product quality, ensuring regulatory compliance and assessing the performance of textile materials. It is a vital basic tool during the processing of a textile raw material into the production" There are some stages where textile testing can be done; such as, checking raw materials, monitoring production, assessing the Final Product, & effluent, investigation of faulty material, product development and research.

What is quality control? Quality control is a process by which helps to review the quality of all products (Incoming & out going) in an industry.

The quality of a product or process is checked before it is put into large-scale usage. The quality of the product, its performance, and its reliability are the key factors while testing is performed. Testing can be defined as the methods or protocols adopted to verify/determine the properties of a product. It can be divided primarily into two types: regular process testing and quality assurance testing. Routine testing helps to streamline the daily process.

Quality assurance testing helps the process or product in the long run to establish credibility. Testing can also be defined as the procedures adopted to determine a product's suitability & quality.

Textile testing is a gauging product quality, ensuring regulatory compliance and assessing the performance of textile materials. It is a vital basic tool during the processing of a textile raw material into the product. It also helps the distributors and consumer to determine the end product's quality Textile testing refers to the procedures adopted to determine quality throughout the textile product chain (textile fibers, yarns, materials end product & also procedure adopted etc). Mainly it involves the use of techniques, tools, instruments and machines for the evaluation of the properties of these different forms.

Objectives of textile testing:

The main objectives of textile testing are:

- To check the quality and suitability of raw material
- To monitor the production (process control)
- To assess the quality of final product
- To investigate the faulty materials
- To set standards or benchmarks
- For R&D (research and development) purpose
- For new product development
- Cost reduction without harming quality standards

We can elaborate objectives of textile testing in the following ways:

- For researchers, testing results aid the development of new products or new processes, which can save money and resources before production starts on an industrial scale. They also help in the choosing of the best possible route to achieve the end product.
- Testing helps in the selection of the best possible raw materials. “Raw material” is a relative term; for example, fiber is the raw material for spinning, and yarn is the raw material for weaving, Water, chemicals, fuel, are raw materials for process.
- Testing helps in the process control through the use of advanced textile process-control techniques.
- Testing ensures the right product is shipped to the consumer or customer and that the product meets the customer specifications.

Textile testing in particular is affected by the following factors:

Atmospheric conditions affect test results as textile products are greatly influenced by moisture and humidity.

The test method adopted will also cause variation in test results. The testing instrument is also a vital part and, if not properly calibrated, can cause serious variation. Human error is another source of variation. Textile testing starts with textile fibers and goes all the way through to the final product including waste being discharged (Effluent & sludge).

In order to carry out the testing of the textile products, a well-equipped laboratory with a wide range of testing equipment is needed. Well-trained operators are also a prerequisite for the running of the laboratory. The cost of establishing and running the lab is nonproductive at first sight but it pays you back by the way of consistency in quality, Cost reduction & improvements in order level due to customer satisfaction. Testing is carried out at a number of points in a production cycle to improve consistency in quality of the product. Textile testing is a tool to identify fault finding & root cause analysis of particular fault so that it can be avoided in future consignments. It will also help to rectify the running process and enable it to run more smoothly so that the final product accords with the customer’s requirement. It also helps to isolate the faulty part or machine so as to resolve any dispute between the supplier and the producer.

Importance of standards:

The tested textile materials should satisfy certain specifications. Some of these requirements are implicit and others are explicit. The latter are those that indicate a material’s performance in service or whether it will meet its specifications or not. The implicit requirement is that the test is repeatable, that is the textile material will give the same results if it is tested again after some time by another technician or at some other place or the customer’s laboratory. In other words, the test can measure the correct value of the property being assessed. There is no use in testing if it is not reproducible, as it will then count for nothing.

A lack of reproducibility of results can be attributed to the following.

Textile materials have natural variation, for example, fibers obtained from a natural source have variation among their properties.

In the material process from fiber to yarn to fabric, the variations in properties smooth out during process.

The problem of material variation can be rectified with the help of the proper selection of raw material and the use of appropriate process controls. Testing methods (sources of testing standards): Testing is done primarily to test the quality and there are different ways to carry out a test. Hence it is important to standardize the testing methods or procedures. Various national and international organizations have established standards for textile testing. Some of the organizations involved in developing textile testing standards are as follows:

AATCC - American Association of Textile Chemists and Colorists

ASTM - American Society for Testing and Materials

ANSI - American National Standards Institute

ISO - International Organization for Standardization

BSI - British Standards Institute

Sampling procedure

There are two types of sampling especially testing of water (Fresh & ETP)

- Grab sampling allows the analysis of specific types of unstable parameters such as pH, dissolved oxygen, chlorine residual, nitrites and temperature. It is collected at particular time & will give report of effluent / water at that time only
- Composite sampling consists of a collection of numerous individual grab samples taken at regular intervals over a period of time, usually 24 hours. ... It will give an average report of parameters at an average of 24 hours.

Factory can develop standard test method as per any of above five test methods. Standard books are available in market. (BTRA, NTRA have published testing books on textile.)

CPCB has published a Guide manual for water & waste water analysis (available online – http://cpcb.nic.in/openpdffile.php?id=UmVwb3J0RmlsZXMvMjA0XzE1MjQ2NTA4OTNfbWVkaWFwaG90bzEyODI3LnBkZg==)

A simple chart is added as a ready reference

Test Parameters	**Analysis Method**	**Frequency of Test (Minimum)**	**Location of test**
pH	Electrometric - pH Meter / pH paper, pH solution	Once in shift of 8 hours	Primary collection tank, Aeration tank Before final discharge
TSS	Suspended Solids – Gravimetric method Dry at 103 to 105 deg C	Once in shift of 8 hours	Before final discharge Before UF-RO

TDS	Total dissolved solids Gravimetric dried at 180^0 C	Once in shift of 8 hours	Before final discharge
Settable Solids	Gravimetric method Dry at 103^0 C	Once in a day	Aeration tank
BOD	Biological Oxygen Demand 5 days BOD Test	Once in a day	Before final discharge
COD	Chemical Oxygen Demand Open Reflux, Close Reflux Titrimetric method, Closed Reflux (Colorimetric method	Once in a day	Before final outlet
TKN (Total Kjeldahl Nitrogen)	Kjeldahl method	Once in a day	Aeration tank Before final discharge
Sulphide	Methylene blue , Iodometric method	Once in a day	Before final discharge
Oil & Grease	Soxhlet extraction	Once in shift of 8 hours	Primary collection tank Before final discharge
Temperature	Test by Thermo meter (^{0}C)	Once in a shift of 8 Hours	Primary collection tank Aeration tank Before final discharge
Dissolve Oxygen	Check by DO meter (PPM)	Once in a shift of 8 hours	Aeration tank
SVI (Sludge Volume Index)	Measuring Cylinder	Once in a shift of 8 Hours	Aeration tank
Color	Pt-Co Text method	Once in a shift	Before final discharge
Treatability study	Jar Test	Once in a day	Chemical dosing tank

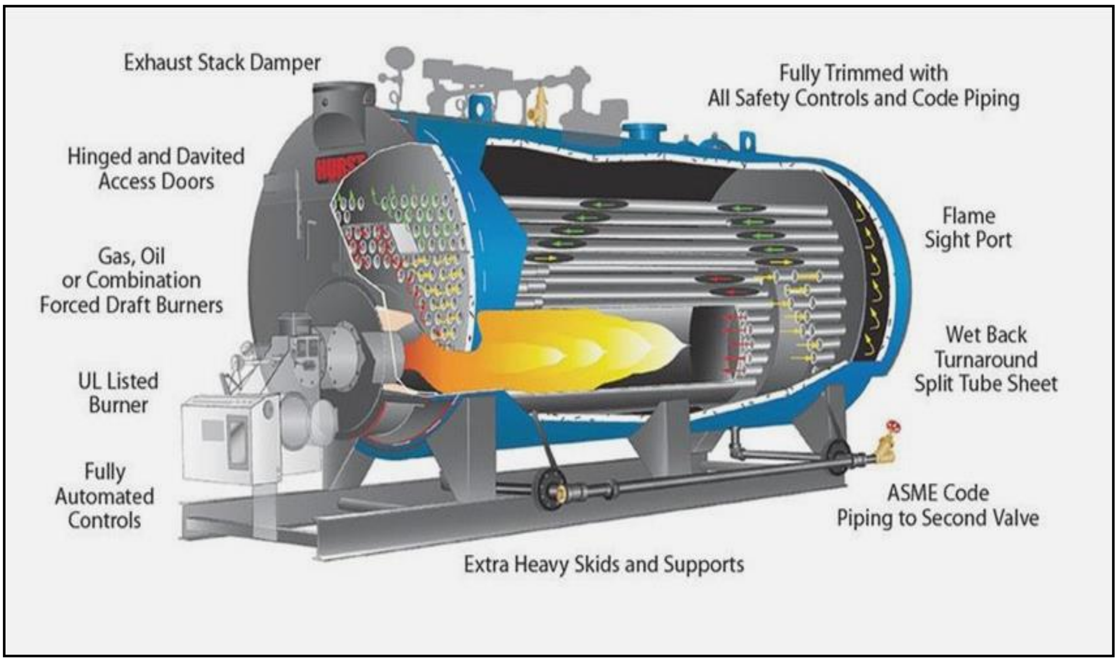
Some quick points for saving of natural resources

Self-Assessment of plant for environmental performance (Steam, Power & Water)

Boiler Check Points

- Preheat combustion air with waste heat before it is exhausted through Chimney.

  (22 ^{0}C reduction in flue gas temperature increases boiler efficiency by 1%).
- Use variable speed drives on large boiler combustion air fans with variable flows.
- Burn wastes if permitted.
- Proper insulation at Boiler hot parts & Feed water tank.



- Clean burners, nozzles, strainers, etc. As per schedule
- Improve oxygen control in furnace.
- Optimize boiler blow-down (check TDS of blow down water & set blow down frequency). Recover heat from blow-down.
- Inspect door gaskets.
- Inspect for scale and sediment on the water side of the tubes (A 1 mm thick scale on the water side could increase fuel consumption by 5 to 8 %.
- Inspect for soot, fly-ash, and slag on the fire side of the tubes (A 3 mm thick soot deposition on the heat transfer surface can cause an increase in fuel consumption to the tune of 2.5%.)
- Optimize boiler water treatment (Maximum use of condensate steam (85% can reduce blow down frequency)
- Establish a boiler efficiency-maintenance program. Start with an energy audit and follow-up, then make a boiler efficiency-maintenance program a part of your continuous energy management program.

Steam System

- Fix steam and condensate leaks (at least 85% of steam consumed should be recycled. A 3 mm diameter hole on a pipe line carrying 7 kg/cm^2 steam would waste 33 kilo litres of fuel oil per year or 70000 kg of coal/year).
- Self-audit & Accumulate work for repair of steam leaks that can't be fixed during the heating season due to system shutdown requirements.
- Use back pressure steam turbines to produce lower steam pressures.

- Install auto devices for temperature control in process equipments.
- Maintain lowest acceptable process steam pressures.
- Reduce hot water direct to drain & try to recycle energy through heat recovery system
- Ensure condensate is returned or re-used in the process (6 ^{0}C raise in feed water temperature by economiser/condensate recovery corresponds to a 1% saving in fuel consumption, in boiler).
  - Recover boiler blow-down.
  - Check operation of steam traps.
  - Systematic remove air from indirect steam using equipments
  - Inspect steam traps regularly and repair malfunctioning traps promptly.
  - Consider recovery of vent steam (e.g. -- on large flash tanks). .
  - Use electric pumps instead of steam ejectors when cost benefits permit
  - Establish a steam efficiency-maintenance program. Start with an energy audit and follow-up, then make a steam efficiency-maintenance program a part of your continuous energy management program.

Furnaces

- Check proper closer of doors & stop heat transfer from doors of furnace.
- Monitor O_{2}/CO_{2}/CO and control excess air to the optimum level.
- Ensure that the furnace combustion chamber is under slight positive pressure.
- Match the load to the furnace capacity (can reduce furnace size in case of constant low load by putting Bricks)
- Retrofit with heat recovery device.
- Investigate cycle times and reduce boiler ON/OFF frequency
- Provide auto temperature controllers.

Insulation

- Repair damaged insulation immediately. (There must be an internal audit for insulation activity) (A bare steam pipe of 150 mm diameter and 100 m length, carrying saturated steam at 8 kg/cm^{2} would waste 25,000 litres furnace oil in a year.)
- Replace wet insulation.
- Use an infrared gun to check for insulation.
- Ensure that all insulated surfaces are cladded with aluminium
- Insulate all flanges, valves and couplings
- Insulate & cover open tanks

(70% heat losses can be reduced by floating a layer of 45 mm diameter polypropylene (plastic) balls on the surface of 90 ^{0}C hot liquid/condensate).

Waste heat Recovery System

It is essential to recover heat from various hot wastages like gases, hot drain, cooling devices etc.

- Recover heat from flue gas, engine cooling water, engine exhaust, low pressure waste steam, drying oven exhaust, boiler blow-down, etc.
- Recover heat from incinerator off-gas / Multi Effect Evaporator in ETP.
- Use waste heat for fuel oil heating, boiler feed water heating, outside air heating, etc.
- Use chillier waste heat to preheat hot water.
- Use thermal wheels, run-around systems, heat pipe systems, and air-to-air exchangers.

ELECTRICAL UTILITIES

Electricity Distribution System

- Optimise the tariff structure with utility supplier
- Schedule your operations to maintain a high load factor
- Shift loads to off-peak times if possible.
- Minimise maximum demand by tripping loads through a demand controller
- Stagger start-up times for equipment with large starting currents to minimize load peaking.
- Use standby electric generation equipment for on-peak high load periods.
- Correct power factor to at least 0.90 under rated load conditions.
- Relocate transformers close to main loads.
- Set transformer taps to optimum settings.
- Disconnect primary power to transformers that do not serve any active loads
- Consider on-site electric generation or cogeneration.
- Export power to grid if you have any surplus in your captive generation
- Check utility electric meter with your own meter.
- Shut off unnecessary computers, printers, and copiers at night.

Motors

- Properly size to the load for optimum efficiency. (High efficiency motors offer of 4 - 5% higher efficiency than standard motors)
- Use energy-efficient motors where economical.
- Use synchronous motors to improve power factor.
- Check alignment.
- Provide proper ventilation

- (For every 10 ^{o}C increase in motor operating temperature over recommended peak, the motor life is estimated to be halved)

- Check for under-voltage and over-voltage conditions.
- Balance the three-phase power supply.
  - (An imbalanced voltage can reduce 3 - 5% in motor input power)
- Demand efficiency restoration after motor rewinding.
  - (If rewinding is not done properly, the efficiency can be reduced by 5 - 8%)

Drives

- Use variable-speed drives for large variable loads.
- Use high-efficiency gear sets.
- Use precision alignment.
- Check belt tension regularly.
- Eliminate variable-pitch pulleys.
- Use flat belts as alternatives to v-belts.
- Use synthetic lubricants for large gearboxes.
- Eliminate eddy current couplings.
- Shut them off when not needed.

Fans

- Use smooth, well-rounded air inlet cones for fan air intakes.
- Avoid poor flow distribution at the fan inlet.
- Minimize fan inlet and outlet obstructions.
- Clean screens, filters, and fan blades regularly.
- Use aerofoil-shaped fan blades.
- Minimize fan speed.
- Use low-slip or flat belts.
- Check belt tension regularly.
- Eliminate variable pitch pulleys.
- Use variable speed drives for large variable fan loads.
- Use energy-efficient motors for continuous or near-continuous operation
- Eliminate leaks in ductwork.
- Minimise bends in ductwork
- Turn fans off when not needed.

Air Blowers

- Use smooth, well-rounded air inlet ducts or cones for air intakes.
- Minimize blower inlet and outlet obstructions.

- Clean screens and filters regularly.
- Minimize blower speed.
- Use low-slip or no-slip belts.
- Check belt tension regularly.
- Eliminate variable pitch pulleys. Use variable speed drives for large variable blower loads. Especially blowers used in ETP should be controlled by dissolve Oxygen in aeration tank.
- Eliminate ductwork leaks.

Pumps

- Operate pumping near best efficiency point.
- Modify pumping to minimize throttling.
- Adapt to wide load variation with variable speed drives or sequenced control of smaller units.
- Stop running both pumps -- add an auto-start for an on-line spare or add a booster pump in the problem area.
- Use booster pumps for small loads requiring higher pressures.
- Increase fluid temperature differentials to reduce pumping rates.
- Repair seals and packing to minimize water waste.
- Balance the system to minimize flows and reduce pump power requirements.

Compressors

- Consider variable speed drive for variable load on positive displacement compressors.
- Use a synthetic lubricant if the compressor manufacturer permits it.
- Be sure lubricating oil temperature is not too high (oil degradation and lowered viscosity) and not too low (condensation contamination).
- Change the oil filter regularly.
- Periodically inspect compressor intercoolers for proper functioning.
- Use waste heat from a very large compressor to power an absorption chiller or preheat process or utility feeds.
- Establish a compressor efficiency-maintenance program. Start with an energy audit and follow-up, then make a compressor efficiency-maintenance program a part of your continuous energy management program.

Compressed air

- Install a control system to coordinate multiple air compressors.
- Study part-load characteristics and cycling costs to determine the most-efficient mode for operating multiple air compressors.
- Avoid over sizing -- match the connected load.

- Load up modulation-controlled air compressors. (They use almost as much power at partial load as at full load.)
- Turn off the back-up air compressor until it is needed.
- Reduce air compressor discharge pressure to the lowest acceptable setting.
- (Reduction of 1 kg/cm^2 air pressure (8 kg/cm^2 to 7 kg/cm^2) would result in 9% input power savings. This will also reduce compressed air leakage rates by 10%)
- Use the highest reasonable dryer dew point settings.
- Turn off refrigerated and heated air dryers when the air compressors are off.
- Use a control system to minimize heatless desiccant dryer purging.
- Minimize purges, leaks, excessive pressure drops, and condensation accumulation.
- (Compressed air leak from 1 mm hole size at 7 kg/cm^2 pressure would mean power loss equivalent to 0.5 kW)
- Use drain controls instead of continuous air bleeds through the drains.
- Consider engine-driven or steam-driven air compression to reduce electrical demand charges.
- Replace standard v-belts with high-efficiency flat belts as the old v-belts wear out.
- Use a small air compressor when major production load is off.
- Take air compressor intake air from the coolest (but not air conditioned) location.
- (Every 5^0C reduction in intake air temperature would result in 1% reduction in compressor power consumption)
- Use an air-cooled after cooler to heat building makeup air in winter.
- Be sure that heat exchangers are not fouled (e.g. -- with oil).
- Be sure that air/oil separators are not fouled.
- Monitor pressure drops across suction and discharge filters and clean or replace filters promptly upon alarm.
- Use a properly sized compressed air storage receiver. Minimize disposal costs by using lubricant that is fully demulsible and an effective oil-water separator.
- Consider alternatives to compressed air such as blowers for cooling, hydraulic rather than air cylinders, electric rather than air actuators, and electronic rather than pneumatic controls.
- Use nozzles or venturi-type devices rather than blowing with open compressed air lines.
- Check for leaking drain valves on compressed air filter/regulator sets. Certain rubber-type valves may leak continuously after they age and crack.
- In dusty environments, control packaging lines with high-intensity photocell units instead of standard units with continuous air purging of lenses and reflectors.
- Establish a compressed air efficiency-maintenance program. Start with an energy audit and follow-up, then make a compressed air efficiency-maintenance program a part of your continuous energy management program.

Chillers

- Increase the chilled water temperature set point if possible.
- Use the lowest temperature condenser water available that the chiller can handle. (Reducing condensing temperature by 5.5 ^{0}C, results in a 20 - 25% decrease in compressor power consumption).
- Increase the evaporator temperature (5.5^{0}C increase in evaporator temperature reduces compressor power consumption by 20 - 25%).
- Clean heat exchangers when fouled. (1 mm scale build-up on condenser tubes can increase energy consumption by 40%)
- Optimize condenser water flow rate and refrigerated water flow rate.
- Replace old chillers or compressors with new higher-efficiency models.
- Use water-cooled rather than air-cooled chiller condensers.
- Use energy-efficient motors for continuous or near-continuous operation.
- Specify appropriate fouling factors for condensers.
- Do not overcharge oil.
- Install a control system to coordinate multiple chillers.
- Study part-load characteristics and cycling costs to determine the most-efficient mode for operating multiple chillers.
- Run the chillers with the lowest energy consumption. It saves energy cost, fuels a base load.
- Avoid oversizing -- match the connected load.
- Isolate off-line chillers and cooling towers.
- Establish a chiller efficiency-maintenance program. Start with an energy audit and follow-up, then make a chiller efficiency-maintenance program a part of your continuous energy management program.

HVAC (**H**eating / **V**entilation / **A**ir **C**onditioning)

- Tune up the HVAC control system.
- Consider installing a building automation system (BAS) or energy management system (EMS) or restoring an out-of-service one.
- Balance the system to minimize flows and reduce blower/fan/pump power requirements.
- Eliminate or reduce reheat whenever possible.
- Use appropriate HVAC thermostat setback.
- Use morning pre-cooling in summer and pre-heating in winter (i.e., before electrical peak hours).
- Use building thermal lag to minimize HVAC equipment operating time.

- In winter during unoccupied periods, allow temperatures to fall as low as possible without freezing water lines or damaging stored materials.
- In summer during unoccupied periods, allow temperatures to rise as high as possible without damaging stored materials.
- Improve control and utilization of outside air.
- Use air-to-air heat exchangers to reduce energy requirements for heating and cooling of outside air.
- Reduce HVAC system operating hours (e.g., night, weekend).
- Optimize ventilation.
- Ventilate only when necessary. To allow some areas to be shut down when unoccupied, install dedicated HVAC systems on continuous loads (e.g., computer rooms).
- Provide dedicated outside air supply to kitchens, cleaning rooms, combustion equipment, etc. to avoid excessive exhausting of conditioned air.
- Use evaporative cooling in dry climates.
- Reduce humidification or dehumidification during unoccupied periods.
- Use atomization rather than steam for humidification where possible.
- Clean HVAC unit coils periodically and comb mashed fins.
- Upgrade filter banks to reduce pressure drop and thus lower fan power requirements.
- Check HVAC filters on a schedule (at least monthly) and clean/change if appropriate.
- Check pneumatic controls air compressors for proper operation, cycling, and maintenance.
- Isolate air conditioned loading dock areas and cool storage areas using high-speed doors or clear PVC strip curtains.
- Install ceiling fans to minimize thermal stratification in high-bay areas.
- Relocate air diffusers to optimum heights in areas with high ceilings.
- Consider reducing ceiling heights.
- Eliminate obstructions in front of radiators, baseboard heaters, etc.
- Check reflectors on infrared heaters for cleanliness and proper beam direction.
- Use professionally-designed industrial ventilation hoods for dust and vapor control.
- Use local infrared heat for personnel rather than heating the entire area.
- Use spot cooling and heating (e.g. -- use ceiling fans for personnel rather than cooling the entire area).
- Purchase only high-efficiency models for HVAC window units.
- Put HVAC window units on timer control.
- Don't oversize cooling units. (Oversized units will "short cycle" which results in poor humidity control.)
- Install multi-fuelling capability and run with the cheapest fuel available at the time.

- Consider dedicated make-up air for exhaust hoods. (Why exhaust the air conditioning or heat if you don't need to?)
- Minimize HVAC fan speeds.
- Consider desiccant drying of outside air to reduce cooling requirements in humid climates.
- Consider ground source heat pumps.
- Seal leaky HVAC ductwork.
- Seal all leaks around coils.
- Repair loose or damaged flexible connections (including those under air handling units).
- Eliminate simultaneous heating and cooling during seasonal transition periods.
- Zone HVAC air and water systems to minimize energy use.
- Inspect, clean, lubricate, and adjust damper blades and linkages.
- Establish an HVAC efficiency-maintenance program. Start with an energy audit and follow-up, then make an HVAC efficiency-maintenance program a part of your continuous energy management program.

Lighting

- Reduce excessive illumination levels to standard levels using switching; delamping, etc.
- Aggressively control lighting with clock timers, photocells, etc.
- Install efficient alternatives to incandescent lighting, mercury vapour lighting, etc. Efficacy (lumens/watt) of various technologies range from best to worst approximately as follows: low pressure sodium, high pressure sodium, metal halide, fluorescent, mercury vapour, incandescent.
- Select ballasts and lamps carefully with high power factor and long-term efficiency in mind.
- Upgrade obsolete fluorescent systems to Compact fluorescents and electronic ballasts
- Consider daylighting, skylights, etc.
- Consider painting the walls a lighter colour and using less lighting fixtures or lower wattages.
- Use task lighting and reduce background illumination.
- Re-evaluate exterior lighting strategy, type, and control. Control it aggressively.
- Change exit signs from incandescent to LED.

Water & Wastewater

- Recycle water, particularly for uses considering quality requirements.
- Recycle water, especially if sewer costs are based on water consumption.
- Balance closed systems to minimize flows and reduce pump power requirements.
- Eliminate once-through cooling with water.
- Fix water leaks.

- Check water overflow pipes for proper operating level.
- Provide proper tools for wash down -- especially self-closing nozzles.
- Eliminate overflow at water tanks by auto level controllers.
- Promptly repair leaking toilets and faucets. Also can explore possibilities of automation to control water consumption.
- Use self-closing type taps in restrooms.
- Consider the installation of a thermal solar system for warm water.
- If water must be heated electrically, consider accumulation in a large insulated storage tank to minimize heating at on-peak electric rates.

Last but not the least....

It is essential to have holistic thinking with commitment with desire to reduce self-contribution on environmental aspects by taking a simple oath.

OATH

"We will take care of mother earth with social responsibility and environmental protection. This is our contribution to a better future for us and for coming generations"

It simply means: Give back what you take!