

**Performance Evaluation of Effluent Treatment
Facilities of Textile Cluster :A Case Study of Narol
Textile Cluster , Ahmedabad , Gujarat.**

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Thapar University**

**In the partial fulfillment for award of the degree of
Master of Technology**

In

Environmental Science and Technology

By

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Declaration

I, the undersigned declare that the research work presented in the M.Tech project entitled **“Performance Evaluation of Effluent Treatment Facilities of Textile Cluster : A Case Study of Narol Textile Cluster , Ahmedabad , Gujarat.”** Has been carried out under the guidance of Dr. Anita Rajor, Assistant Professor, Thapar University and Dr. Bharat Jain, Member Secretary, GCPC. Further, I declare that no part of this Dissertation has been submitted for a degree or any other qualification of any other university or examining body in India/elsewhere.

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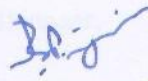
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This is to certify that the thesis report entitled “Performance Evaluation of Effluent Treatment Facilities of Textile Cluster : A Case Study of Narol Textile Cluster , Ahmedabad , Gujarat.” Submitted by Sumitkumar Patel in the partial fulfilment of the requirement for the award of degree of the **Master of Technology in Environmental Science & Technology** to the Thapar University, Patiala is a record of student’s own work carried out by him under my supervision and guidance. The report has not been submitted for the award for the any other degree or certificate in this or any university or Institution.

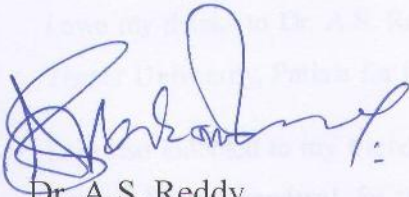


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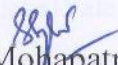
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ABSTRACT

The textile industry is one of the largest segments of Indian industry. It accounts for over 20 % of the value of industrial production and is closely linked with the agricultural and rural economy. This industry occupies a unique place in the national economy through contribution to industrial output, employment generation and foreign exchange earnings. It is the single largest employer in the industrial sector employing about 38 million people. The textile units use a number of dyes, chemicals and other materials to impart desired quality to the fabrics. These units generate a substantial quantity of effluents, the quality of which in most of the cases is unsuitable for further use and can cause environmental problems, if disposed of without proper treatment. Poorly treated wastewater with high levels of pollutants caused by poor design, operation or treatment systems creates major environmental problems when discharged to surface water or land.

Considering the above stated implications an attempt has been made in the present project to evaluate the performance efficiency of ETPs for textile waste. Samples were collected from different points to assess the efficiency of each unit. Parameters analysed for evaluation of performance of ETPs are BOD, COD, TSS, TDS and NH₃-N. All the industry's influent having the range of BOD (268-812 mg/L) and COD (1387 – 3213 mg/L) , and the removal efficiency maximum was observed in industry E which is BOD (85.14 %),COD (86.97 %),TSS (95.41 %),TDS (61.25 %),NH₃-N (89.74 %). Most of the analysed parameter of all industry is above the discharged standard except ammonical Nitrogen. BOD and COD removal throughout treatment plants but final values above the discharged standard (BOD₅ 30 mg/L & COD 100 mg/L). This study also involves identification of problems and for that solution is also provided. Some recommendation suggestions are also provide to improve the performance of ETPs. The proposed CETP is best option available for textile industry which is located in Narol textile cluster.

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CHAPTER 1

INTRODUCTION

1.1 Overview

Rapid growth of industries has not only enhanced the productivity but also resulted in the production and release of toxic substances into the environment, creating health hazards and effected normal operations, flora and fauna. These wastes are potential pollutants when they produce harmful effects on the environment and generally released in the form of solids, liquid effluent and slurries containing a spectrum of organic and inorganic chemicals. Thus pollution is a necessary evil of all development. To combat the plethora of environmental evils of present day society, efficient and environmentally safe organic waste treatment technologies are needed. Financial and technological constraints have led to in efficient conversion processes, there by leading to generation of larger quantities of waste and resulting pollution.

The textile industry is one of the largest segments of Indian industry. It accounts for over 20 % of the value of industrial production and is closely linked with the agricultural and rural economy. This industry occupies a unique place in the national economy through contribution to industrial output, employment generation and foreign exchange earnings. It is the single largest employer in the industrial sector employing about 38 million people. If employment in allied sectors likes ginning, agriculture, pressing, cotton trade jute etc. are added then total employment is estimated at 93 million. The net foreign exchange earnings in these sectors are one of the highest and together with carpet and handicrafts, account for over 37 % of total export earnings at over US \$ 10 billion. Textiles alone, account for about 25 % of India's total foreign exchange. India's textile industry since its beginning continues to be predominantly cotton based with about 65 % of fabric consumption in the country being accounted for cotton. The industry is highly localized in Ahmedabad, Surat, and Mumbai in western part of the country though other centres exist including Kanpur, Kolkata, Indore, Coimbatore and Sholapur. (*ECAC, 2011*)

1.2 Scenario of Textile Industry in Gujarat

Gujarat is one of the leading industrial states in India and textile industry in particular had contributed in a big way to the industrialization of the State. In fact, development of many industries likes, Dyestuff, Chemicals, Engineering/Foundry and Cotton farming is solely dependent on this sector. The State is well known for development of Hybrid Cotton, Ginning, power looms, composite mills, spinning units and independent processing Houses. Overall economic growth of the state is very much dependent on this sector. 24% to 28% of fixed investment, production value and employment of the SSI sector are from textiles alone. Further, 23% of GDP comes out of textiles in the State, 16% of the cultivated land area of the state is for cotton and Gujarat is the largest cotton producer in the country. About 30% of woven fabric from organized sector and 25% of decentralized power loom sector of the country comes from this State alone.

Large Fabric Process Houses are concentrated in Ahmedabad (250) and Surat (350) in the State. The State accounts for 12% share of the total textile exports of the country. A large number of garment units and garment processing units are developed in urban areas of the state. Clusters of processing units are located at Surat, Ahmedabad (Narol) and Jetpur. Though these units fall under decentralized sector, some of them operate on medium scale production capacity having good capability of processing wide range of fabrics.

1.3 Key Environmental Problems in Textile Industry

Water Pollution: Dyeing and bleaching industries are water polluting in nature. Type and concentration of pollutants in the effluent depends on the chemicals used for bleaching and other unit operations, type of dye used and dye fixing chemicals used. Major sources of effluent are intermediate washing carried out in between successive unit operations like mercerising, bleaching, preparation for dyeing etc. Effluent generated from the drying activity is relatively less as compared to other unit operations involved in dyeing and bleaching activities.

Air Pollution: In textile industries steam or heat is one of the major utilities required for dyeing, drying, calendaring and other associated unit operations. For this, industries install either boilers or thermic fluid heaters or both. Type of fuel used in the boilers / thermic fluid

heaters is the major determinants in the concentration of pollutants as far as gaseous emission is concerned.

Soil Pollution: Solid wastes, mainly ETP sludge, its quantity, handling, storage and disposal is one of the most important environmental issues. Improper handling, storage and disposal of these hazardous wastes create several environmental problems like contamination of surface and ground water, air pollution and soil pollution.

1.4 Cleaner Production

Complex environmental issues demand a comprehensive integrated approach to tackle the problems of pollution. Reductions in the use of energy, water and other raw materials along with waste minimisation and elimination, whenever and wherever possible, should be the highest priority. Cleaner production, covering both products and manufacturing processes, is both necessary and beneficial. This implies that all types of resources, along the entire product life cycle, should be used as optimally as possible to reduce environmental impacts. In a textile process, this can mean substituting a nontoxic raw material, reducing water flows, or changing operational parameters and so on. Simple good housekeeping measures can deliver cleaner processes, but a review of the existing process technology may be needed to evaluate the choice of process, a processing sequence and equipment used. Examples of such options include water conservation by counter-current washing, recovery of chemicals such as size, caustic, dyes and grease, replacement of high BOD chemicals by low BOD ones, heat recovery from effluents, etc.

There are three main ways of water reuse can be used, 1) internal wastewater recycling, 2) reuse of treated industrial wastewater in the same process and 3) reuse for other activities such as irrigation, fire protection etc. Implementation of cleaner production techniques at any manufacturing plant can help to reduce effluent characteristics and volume considerably. It will also reduce the overuse of raw materials and energy. The economic advantages gained by implementing cleaner production are twofold: it will reduce both the costs of production and the need for costly end-of-pipe pollution control facilities. At the same time, health and environmental impacts on plant workers and the surrounding community are reduced. (*UNEP Technical Report, (1994)*)

1.5 Gujarat Cleaner Production Centre

Gujarat Cleaner Production Centre (GCPC) has been established by Gujarat Industrial development corporation (GIDC) in the year 1988 and since then the centre is actively engaged in the promotion of cleaner production (CP) /Clean Technology (CT) through its various activities like orientation programme, CP Assessment Projects and C.T. Assessment Projects etc. Gujarat Cleaner Production Centre has been registered under Society Act- 1860 and Trust Act -1950 in August 2008 and now has a separate entity. Along with the Department of Environment and Forests, contribution of GCPC towards promotion of cleaner production in the state to improve the productivity and the environmental problems faced by SMEs of the state is significant.

Some of the milestones are:

- GCPC has been recognized as an ENVIS Centre by MOEF, Delhi.
- GCPC has been appointed as nodal agency for training programme on CP & CT to industrial promotion and investment Corporation of Orissa Ltd and Confederation of Entrepreneurship of Mauritius.
- GCPC is member of Resource Efficient and Cleaner Production –Net which is hosted by UNIDO.

1.6 Objectives

Present study has been conducted to fulfil the following objectives:

- Identification of the sources of the effluent generation from plants.
- Study of existing mode of treatment and disposal of effluent including adequacy of existing ETP of each Industry.
- Identification of operational problems at existing ETPs.
- Monitoring (Sampling and Analysis) of ETPs for efficiency measurement.
- Technical recommendation related to reduction in pollution load generation and improvement in performance of effluent treatment plant.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction to Textile Processing

Textile manufacturing begins with the production of fibers, which can be harvested from natural sources (cotton, linen, jute), manufactured from regenerative cellulosic materials (viscose, acetate), or may be entirely synthetic (nylon, polyester). Fibers then pass through four main stages of processing, including 1. Yarn production, 2. Fabric production, 3. dyeing, and 4. Apparel production.

In yarn production, natural fibers are opened, cleaned, carded, combed, and are converted into yarn or thread. It is followed by fabric manufacturing, which involves either knitting or weaving. The yarn and fabric production steps yield the raw textile material from which most of the textile products are made. Dyeing and finishing represent the third important step. Before dyeing, the gray fabrics undergo various processes, such as washing, scouring, desizing, and bleaching.

Desizing is a preparatory stage of cotton processing, which involves the removal of sizes (starch, polyacrylates, cellulose-derivatives, and polyvinyl alcohol) from cotton fabrics with the help of acids, enzymes, and detergents in order to smooth the fabric for dyeing and finishing. The effluent generated during desizing is characterized by high BOD and COD contents. The scouring process, on the other hand, removes oils, fats, waxes, soluble impurities, and soil particles left over during desizing. The scouring process takes place either in closed vessels known as kiers or in continuous reaction vessels. Scouring effluent has strong yellow-brown colored and is characterized by high COD and pH value (Trotman, 1968).

Cotton fibers have a natural pigment that imparts a dull creamy (yellow-brownish) appearance to the raw fabric (grey fabric), which are required to be bleached in order to remove natural pigment and impurities for targeted whiteness. Hypochlorite was used in older bleaching methods. Over the last many years, hypochlorite is replaced by the hydrogen peroxide as bleaching agent because former produces highly toxic chlorinated by products known as absorbable organically bound halogen (AOX). After bleaching, the cotton fabric is treated with 20-25 % caustic soda solution for improving luster, dye affinity, and tensile

strength. This process is called mercerizing and the resulting effluent is highly alkaline in nature.

In the dyeing process, large quantities of water along with chemicals are used as a medium to transfer dyes to textile substrate. For example, in order to dye one kilogram of cotton fabric using reactive dyes, 0.6–0.8 kg of NaCl, 30–60 g of dyestuff, and 100–150 litres of water are required *Chakraborty et al., (2005)*. The exceptionally high consumption of water owes to intensive washing and rinsing of textile substrate for the complete removal of unfixed dyes. Dyeing can either be carried out in batch machines, including jet, jigger, and package dyeing machines, or in continuous plants, such as pad-batch, pad-steam, or pad-thermo fix. The volume of effluent from a batch process is far greater than that of a continuous dyeing process because batch dyeing process requires multiple rinses (5-10) of fresh water in order to obtain high quality product in terms of fastness properties. The total volume of effluent generated through a dyeing process is a function of liquor ratio (L: R), which is the volume of water required to dye one kilogram of textile material. Depending upon the process, liquor ratio values may range from 1: 0.6 to 1:40 *,Shaikh , (2010)*.

Dyeing Methods

Dyeing methods is main process cause of wastewater in textile industry, which can be divided in two types as follows :

1. Batch wise or discontinuous method that includes all dyeing processes where in dyestuff is exhausted from a quantity of water relatively large in proportion to the material to be dyed. It varies according to method of dyeing. There are many types of the dyeing machines such as Jiggers, Winches, and Jet.
2. Continuous methods are mainly used in the dyeing of textile fibers when they are woven into cloth. The fabric is uniformly impregnated with the required amount of dyestuff and other necessary chemicals by a process called “padding”. This consists of a rapid passage of the fabric at full width through a solution or suspension of dyestuff, thus loosely applied to the fabric, is then fixed usually after intermediate drying, by passage through stream of hot air. It is at this stage the dye diffuses into the fabric interior. A “soaping” treatment to remove unfixed dyestuff, and with certain dyestuff types, to develop true colour and fastness, completes the process.

Table 2.1: Water Consumption and Effluent Generation in Different Wet Processing stages in Textile Industries (Quantity Litre / 100 Kg.)

Sr no.	Activities	Water consumption		Effluent
		Variation	Average	Variation
01	Sizing/slashing	50 - 820	435	50-820
02	Desizing	250 -2100	1175	250 - 2100
03	Kiering/scouring	2000-4500	3250	2000-4500
04	Bleaching			
	1. Yarn (Hypochlorite)	2400-4800	3600	2250 -4600
	2. Yarn (Hydrogen Peroxide)	2400-3200	2800	2250-3050
	3. Cloth (Hypochlorite)	2400-3200	2800	2250-3050
	4. Cloth (Hydrogen Peroxide)	4000-4800	4400	3800-4600
05	Mercerising	1700-3200	2450	1700-3200
06	Dyeing			
	1. Yarn (Light and Medium shades)	3600-17600	10600	3500-17500
	2. Yarn (Dark shades)	3600-4800	4200	3500-4700
	3. Yarn (Very Dark shade)	4800-6400	5600	4700-6300
	4. Cloth (Light and Medium Shade)	6600-8800	7700	6500-8700
		7800-9600	8700	7700-9500
	5. Cloth (Dark shade)	10400-12800	11600	10300-12700
	6. Cloth (Very Dark shade)	14300-17600	15950	14200-17500

Source: ECAC, (2011).

2.2 Environmental issues of Textile industries:

Textile manufacturing operation may generate solvent vapours during dyeing, printing and curing of dye or colour pigments. Dust emission is associated with natural fibre and synthetic processing. Other than these process operations, textile mills have coal or oil fired boilers and thermic fluid heaters which are point emission sources. Approximate quantity of effluent

generated from each of the unit operations and the average characteristic of the effluent in terms of common parameters like pH, TSS, BOD are mentioned below.

1. Sizing / Slashing: It is the process by which yarn is sized with starch or polyvinyl alcohol (PVA) or carboxy methyl cellulose (CMC) to give necessary tensile strength and smoothness required for weaving. The water required for sizing varies from 0.5 to 8.2 litre / per kg. of yarn with an average of 4.35. The effluent discharged through this process is the same quantity of water used in the process. The sizing effluent has a pH of 7.0 – 9.5, 8500 – 22500 mg/l of Total Solids and 620 – 2500 mg/l of BOD.

2. Desizing: In this process, sizing components (rendered water soluble during sizing) are removed from the cloth to make it suitable for dyeing and further processing. This can be done either through acid (sulphuric acid) or with enzymes. The required water at this stage is varied from 2.5 to 21 l/Kg. with an average of 11.75. The entire water consumed during this process is discharged as effluent and it contains 6 – 8 pH, 16000 – 32000 mg/l of Total Solids and 1700 – 5200 BOD.

3. Scouring / Kiering: To remove the natural impurities such as greases, waxes, fats and other impurities, the desized cloth is subjected to scouring. This can be done either through conventional method (kier boiling) or through modern techniques (continuous scour). Kiering liquor is an alkaline solution containing caustic soda, soda ash, sodium silicate and sodium peroxide with small amount of detergent. The water required for this process varies from 20 – 45 l/Kg. with an average of 32.5. The volume of effluent generated through this process is the same as the water intake. Effluent contains 10 – 13 pH value, 2200 – 17400 Total Solids and 100 – 2900 of BOD.

4. Bleaching: For removing the natural colouring materials and to render the cloths white, bleaching is undertaken. Alkaline hydrochloride or chlorine is used for bleaching cotton textiles. Normally for bleaching the good quality fibre, peroxide is used. The chemicals used in peroxide bleaching are sodium peroxide, caustic soda, sulphuric acid and certain soluble oils. The water and chemical requirement and the effluent generation normally varies based on the type of operation and the material (yarn / cloth) to be processed. Bleaching the yarn both through hypo-chloride and hydrogen peroxide methods require same quantity of water

and it varies between 24 to 32 l/kg. But in the cloth bleaching, the water requirement is much higher and it fluctuates between 40 - 48 litre/kg. The effluent discharged from the bleaching processes is slightly lower than the water intake and its quality changes according to the process. Chlorine bleaching effluent contains the pH value of 6, TSS of 6500 mg/ l , TDS of 22,000 mg/l and chloride of 3600 mg/l . In peroxide bleaching, the pH value goes up to 10.5. But the TSS, TDS and chloride values are reduced to 430, 2390 and 560 respectively.

5. Mercerising: Mercerisation provides lustre, strength, and dye affinity and abrasion resistance to fabrics. It is generally carried out for cotton fabrics only for easy dyeing. Mercerisation can be carried out through cold caustic soda solution followed by washing with water several times. The water required for this process varies between 17 to 32 l/Kg. with an average of 24.5. The formation of effluent is the same volume of water used. Mercerising effluent contains 12 -13 pH value, 430 – 2700 TSS, 10940 – 31700 TDS and 150 – 280 BOD.

6. Dyeing: Dyeing is the most complex step in wet processing which provides attractive colour for the product. Dyeing is carried out either at the fibre stage, or as yarn or as fabrics. For dyeing process, hundreds of dyes and auxiliary chemicals are used. In brief, the water requirement for dyeing purpose (include all types and shades) varies from 36 – 176 litre/kg with an average of 106. The effluent generation during dyeing process is slightly lower than the water intake and fluctuates between 35 to 175 l /kg with an average of 105. This effluent contains pH of 10.5, TSS of 10200, TDS of 29800, COD of 1490 and chloride of 1800. *ECAC, (2011).*

Table 2.2: Water Pollution Problems in Textile Industry

Colour	Presence of colour in the waste is one of the main problems in textile industry. Colour is easily visible to human eyes, even at very low concentration. Hence, colour from textile wastes carries significant aesthetic importance. Most of the dyes are stable. They are also not easily degradable by the conventional treatment methods. Removal of dyes from the effluent is major problem in most of textile industries
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Dissolved Solids	Dissolved solids contained in the industry effluents are also a critical Parameter. Use of common salt and glauber salt etc. in the processes, directly increase total TDS level in the effluent. TDS are difficult to be treated with conventional treatment systems. Disposal of high TDS bearing effluents can lead to increase in TDS of ground water and surface water. Dissolved solids in effluent may also be harmful to vegetation and restrict its use for agricultural purpose
Toxic metals	Wastewater of textiles is not free from metal contents. There are mainly two sources of metals. Firstly, the metals may come as impurity with the chemicals used during processing such as caustic soda, sodium carbonate and salts. For instance, caustic soda may contain mercury if produced using mercury cell processes. Secondly, the source of metal could be dye stuffs like metalized mordent dyes. The metal complex dyes are mostly based on chromium.
Residual chlorine	The use of chlorine compounds in textile processing, residual chlorine is found in the waste stream. The wastewater (if disposed without treatment) depletes dissolved oxygen in the receiving water body and as such aquatic life gets affected. Residual chlorine may also react with other compounds in the wastewater stream to form toxic substances
Others	Textile effluents are often contaminated with non-biodegradable organics termed as refractory materials. Detergents are typical example of such materials. The presence of these chemical results in high chemical demand (COD) value of the effluent Organic pollutants, which originate from organic compounds of dyestuffs, acids, sizing materials, enzymes, tallow etc. are also found in textile effluent. Such impurities are reflected in the analysis of BOD and COD. These pollutants are controlled by use of biological treatment processes. In many textile units, particularly engaged in synthetic processing, low BOD/COD ratio of effluent is observed which makes even biological treatment not a ready proposition The wastewater of cotton based textile units is usually alkaline, whereas synthetic and woollen fabric processing generates acidic effluent.

Source: RSPCB, (2011)

2.3 Characterisation of Textile Wastewater

The textile industry uses high volume of water throughout its operation, from the washing of fibers to bleaching, mercerizing, dyeing, and printing and washing of finished products *Imtiazuddin et al., (2012)*. The textile industries can be divided into drying processes and wet processing from a stand point of water usage. The drying process uses a small amount of water and contributes an insignificant load to wastewater generation. On the other hand, the wet processing involves many operations such as preparation, dyeing, printing and finishing which consume large quantities of water and is, therefore, the major source of textile industry wastewater. *Charoenlarp et al., (2009)* Wastewater discharged from a textile wet processing plant contains various types of impurities depending on the type of dyes, chemicals, auxiliaries and process used

The Characteristics of textile waste water can be described as follows *Rott and Minke (1999)*:

- Intense colouring, caused by large number of unfixed remaining dyes.
- High temperatures, since many reactions require high temperatures.
- Pollution with organic materials (such as starch, carboxy methyl cellulose, surfactants etc.) in average to the pollution of domestic water.
- A large amount of refractory COD, caused by high-molecular synthetic textile
- Auxiliaries (TAs) and dyes.
- High conductivity due to salt character of many TAs.
- High AOX-, sulphide- and heavy metal concentrations due to chlorinated bleaching agents and halogen-, sulphur- or heavy metal contained in dyes in some cases.
- High phosphate contents, when pyrophosphates are added because of the use of hard process water.

Ali et al., (2006) the present study was carried out study to determine the degree of pollution of textile wastewater and ability of FeCl_3 as coagulating agent for its treatment. The wastewater samples were collected from ten different textile industries from city zone of Faisalabad (Pakistan). These samples were analyzed for the parameters like pH, turbidity, EC, TSS, TDS, COD, hardness, chlorides, SO_4^{-2} by standard methods before and after treatment.

It was observed that FeCl₃ acts as a good coagulating agent for the treatment of textile effluents. The pH, turbidity, EC, TSS, TDS, COD, hardness, chlorides and SO₄⁻² values of effluents were found to decrease after treatment. It was concluded that the industrial effluents should be treated before to be drained into the natural water bodies so that it may not cause water and soil pollution and FeCl₃ might be used for wastewater treatment on industrial scale.

Krishnaswamy et al (2009) monitored the Wastewater from textile processing units contains a complex mixture of dyes, which are highly Resistant to convention treatment technology.

Deepali et al., (2010) investigated the metals concentration in the effluents and associated soil land groundwater samples collected from textile and tannery industries located near Haridwar. The physico-chemical analysis for metallic parameters was conducted by using Atomic absorption spectrometer and spectrophotometer. The results showed that all metals such as Cr, Fe, Mn, Cu, Pb and Cd exceeded the standard limits in effluents of textile and tannery industries and associated soil samples; the findings also indicate that the Cr contamination was more than other metals. The estimated metal levels in the water and soil were compared with the safe limits laid down by World Health Organization.

Imtiazuddin et al.,(2012) studied the characterisation of textile effluent. The samples were collected during four months from different textile mills and analyzed for various parameters such as Total Dissolved Solids, Chemical Oxygen Demand, Biochemical Oxygen Demand, pH, Electrical Conductivity, and heavy metals like Cadmium, Chromium, Copper, Iron, Manganese, Nickel, Potassium, Phosphorous, Sodium, Sulphur, Zinc were found to be present within the permissible limits. Concentrations of all these metal ions in the effluent were above the recommended standards. It was therefore concluded that textile effluents were highly polluted.

Paul et al., (2012) Studied the Textile effluent from these selected industries is collected and characterized for major pollution indicator parameters namely BOD, COD, TDS, sulphide, sulphate, chloride, hardness, alkalinity, calcium and magnesium. The effluent is dark coloured with alkaline pH. The values of BOD and COD, TDS are found to be higher than prescribe standard the effluent also contains high concentration of sulphate, sulphide, chloride, calcium and magnesium, which are responsible for higher hardness of waste water. Based on these characteristics, it is suggested that the effluent is not be suitable for discharge into environment without treatment.

2.4 Dyes Used in Textile Industry

Pollution due to dyes

A dye is a synthetic chemical used to impart colour to materials of which it becomes an integral part. The large variety of chemicals used in bleaching and dyeing process render them very complex. These chemicals are used in an attempt to make more attractive popular shades of fabrics for a competitive market. Worldwide over 10,000 different dyes and pigments are used in dyeing and printing industries. The total world colorant production is estimated to be 8, 00,000 tons per year and at least 10% of the used dyestuff enters the environment through wastes *Krishnadevi et al., (2011)*.

Dyes are carbon based organic compounds while pigments are normally inorganic compounds, often involving heavy toxic metals. The nature of pollution that accompanies the dyeing industry is primarily due to the non biodegradable nature of the dyes along with the strong presence of appreciable amounts of toxic trace metals, acids, alkalis and carcinogenic aromatic amines in the effluents *Balakrishnan et al., (2008)*.

Dyeing is the process of imparting colours to a textile material in loose fibre, yarn, cloth or garment form by treatment with a dye. Dyeing is also the process of colouring textile materials by immersing them in an aqueous solution of dye, called dye liquor. Normally the dye liquor consists of dye, water and an auxiliary. To improve the effectiveness of dyeing process, heat is usually applied to the dye liquor.

Table 2.3: Pollutants associated with some of the very popular dyes.

Class	Fiber	Nature of Pollution
Direct dye	Cotton	Salt, unfixed dyes, copper salts, cationic fixing agents
Reactive dye	Cotton	Salt, unfixed dyes, Alkali
Vat dye	Cotton	Alkali, oxidizing agent, reducing agent
Sulphur dye	Cotton	Alkali, oxidizing agent, reducing agent, unfixed dyes
Acid dye	Wool	Unfixed dyes, organic dyes
Disperse dye	Polyester	Carriers, reducing agent, organic acids
Metal complex dyes	Wool	Metals, organic acids

Source: *Balakrishnan et al.,(2008)*

Table 2.4: Dye Fixation Characteristics

Dye class	Fibre type	Fixation degree, %	Loss in effluent, %
Acid	Polyamide	80-95	5-20
Basic	Acrylic	95-100	0-5
Direct	Cellulose	70-95	5-30
Disperse	Polyester	90-100	0-10
Metal complex	Wool	90-98	2-10
Reactive	Cellulose	50-90	10-50
Sulphur	Cellulose	60-90	10-40
Dye-stuff	Cellulose	80-95	5-20

2.5 Wastewater Treatment Technologies for Textile Industry

The treatment of textile wastewater is very complex, because the raw materials processed and the intermediate products manufactured vary greatly in their nature and composition. The composition of waste varies even in same industry as a result of transition from one raw material to another and continual changing of process lines and also due to type of fabric manufactured. Before treatment, a separation of different types of wastewater into following group takes place:

- Concentrated liquids (e.g., dyeing, finishing, printing)
- Medium polluted wastes (e.g., washing, rinsing)
- Low to zero polluted wastes (e.g., cooling water).

2.5.1 Preliminary Treatment

Primary treatment includes processes such as screening, neutralisation, equalisation and gravity sedimentation. The purpose of primary treatment is to remove suspended matter (including oil and grease) and to achieve uniform flows and concentrations. As the suspended matter is removed, the BOD or COD is also reduced. The initial stage in the wastewater treatment process (following collection and influent pumping) is preliminary treatment. Raw influent entering the treatment plant may contain many kinds of materials (trash). The purpose of preliminary treatment is to protect plant equipment by removing these materials

that could cause clogs, jams, or excessive wear to plant machinery. In addition, the removal of various materials at the beginning of the treatment process saves valuable space within the treatment plant. Preliminary treatment may include many different processes. Each is designed to remove a specific type of material a potential problem for the treatment process. Processes include: wastewater collections (influent pumping, screening, shredding, grit removal, flow measurement, Preaeration, chemical addition, and flow equalization).

2.5.2 Physio-Chemical Treatment

Chemical coagulation has been used for decades to destabilize suspensions and to effects precipitation of soluble metal species, as well as other in organic species from aqueous streams ,thereby permitting their removal through sedimentation or filtration,alum,lime and/or polymers have been the chemical coagulants used. These processes, however,tend to generate large volumes of sludge with high bound water content that can be slow to filter and difficult to dewater. The process of destabilization is known as coagulation and agglomeration of neutralized particles to form the bigger flocs is known as flocculation.The neutralization of the negative surface of the colloids is accomplished by the addition of cations in the case of inorganic coagulants.The trivalent ions are ten times more effective than the divalent ion. Trivalent iron and aluminium salts are widely used in all the water coagulation treatments.

Coagulation is promoted by addition of an inorganic polyelectrolyte eg. Polyaluminium chloride. These particles are then separated by floatation or sedimentation. Some features of this technology are: 1.it responds quickly to operational factors and therefore automation is simple; 2. the equipment requires less space than the biological lagoon but the equipment is more expensive; 3. removal of 90% of suspended solids and about 10 to 50% COD can be achieved; 4. overdoses of polyelectrolyte lead to residual concentration of polyelectrolyte in the effluent, which has a detrimental effect on the nitrification process; 5.the main problem of the colour in the solid phase remains, although removal from aqueous phase may be up to 90%; and 6. sludge produced is dependent on the nature of the flocculants used. Chemical oxidation using ozone, chemical oxidation using hydrogen peroxide at elevated temperatures and different membrane processes depending on desired application (nanofiltration, microfiltration, ultra filtration and reverse osmosis operating at different pressure) have proven to be highly efficient in removing solids, BOD and COD from textile effluents.

2.5.3 Biological treatment

Biological method (aerobic and anaerobic) is used for decreasing the BOD, COD and TOC of Textile wastewater. These treatments are different depending on the presence or absence of oxygen. 'Activated sludge' is a common process by which rates of elimination by oxidizable substances of the order of 90% can be realized. Because of the low biodegradability of most of the dyes and chemicals used in the textile industry, their biological treatment by the activated sludge process does not always achieve great success. It is remarkable that most of these dyes resist aerobic biological treatment, so adsorbents, such as bentonite clay or activated carbon, are added to biological treatment systems in order to eliminate non-biodegradable or microorganism-toxic organic substances produced by the textile industry

Biological aerated filters (BAF) involve the growth of an organism on media that are held stationary during normal operation and exposed to aeration. In recent years, several BAF-based technologies have been developed to treat wastewater. . *Babu et al., (2007)*

2.5.4 Oxidation Treatment

Oxidants decolourise dyes by breaking down the dye molecule. Commonly used processes are ozone and Fenton's Reagent.

Ozone is one of the strongest oxidizers commercially available and popular for disinfection of potable water. Besides this it has multiple applications. Large, complex organic molecules, detergents, phenols etc. can be broken into simpler compounds by Ozonation. Among the industrial applications, oxidation of organic and inorganic, deodorisation and decolourisation are the main usages. Ozone is an unstable gas at temperature and pressure encountered in water and waste water treatment plants. For most industrial applications ozone has to be produced at the site. Although, there are several methods by which ozone can generated, the corona discharge method is widely used procedure. An ozone generation unit incorporates a series of electrodes fitted with cooling arrangements mounted in a gas tight container. When the source gas (air or oxygen) is passed through narrow gap separating electrodes, the oxygen gets converted into ozone. Ozone is applied to waste water by means of diffuser tubes or turbine mixers. Ozone doses in level of 2 mg/l have been reported to result in virtually

complete removal of colour and hard pollutants such as detergents. The treated water after sand filtration becomes clean and sparkling.

Fenton's Reagent consists of ferrous salt (usually sulphate) and hydrogen peroxide. The reaction is carried out at a pH of 3 and involves the oxidation of ferrous ion to ferric ion with the simultaneous production of the hydroxyl radical. This radical is a powerful oxidising agent and will attack organic compounds and cleave the bonds. In the case of dye molecules, this would lead to decolourisation. A disadvantage (in terms of costs for the discharger) is the production of ferric hydroxide sludge, but it is thought that this sludge is advantageous to the biological treatment system. Other oxidation methods include the use of ultraviolet light in conjunction with a photo catalyst (titanium dioxide), or other chemical agents such as hypochlorite (the use of which is not encouraged as chlorinated organic species may be formed which are themselves toxic to the environment).

Al-Kdasi et al., (2005) carried out a study on treatment of textile wastewater by advanced oxidation processes. Conventional treatment such as biological treatment discharges will no longer be tolerated as 53% of 87% colours are identified as non biodegradable. Advanced Oxidation Process represents a powerful treatment for refractory and toxic pollutants in textile wastewater.

The main drawback of these above methods is that it is not known what degradation products are formed from the oxidation process and it may be the case that these end products, although colourless, may be more toxic than the original dye molecules

2.5.5 Electrochemical technologies in wastewater treatment

Electrochemical technologies are efficient, easy to operate and their facilities are compact. Electrochemical wastewater treatment technologies are electrode position, electro coagulation (EC), electro flotation, electro oxidation (electrochemical oxidation) (EO), electro disinfection and electro reduction. In this thesis, focus is on electro coagulation and electro oxidation because it has been shown that they can have a good potential to remove harmful contaminants from wastewater.

Electro coagulation

Electro coagulation can remove suspended solids, heavy metals, dyes, organic material, fats, oils and greases, ions and radio nuclides from the water. In addition, other contaminants can be removed from the water through the applied electric field, which then react with other molecules and then ionization, electrolysis, hydrolysis and free-radical formation can take place. There is a wide range of possible contaminant removal mechanisms in the electro coagulation process. The features of contaminants affect their interactions and removal path in the electrochemical cell. For example, charged suspended solids are usually adsorbed onto the charged coagulant and ions are electro precipitated. *Lehmonen E. (2012)*

Cerqueira et al., (2009) studied viability of the electro flocculation process for chemical oxygen demand, turbidity and color removal from a raw effluent originated from textile industry. The best removal efficiencies obtained were 93% for color, 99% for turbidity and up to 87% for COD using an aluminium electrode, the initial pH was 5, the cell time operation was 30 min and current density was 15 A/m². These results indicate that, under the studied operational conditions, electro flocculation of these effluents may constitute a viable alternative for COD, turbidity and colour removal.

Electro oxidation

Electrochemical oxidation/electro oxidation can be a one way to meet the strict wastewater treatment requirements and health quality standards set by legislation. Electro oxidation is environmentally friendly technology, which can degrade non-biodegradable organic compounds and remove nitrogen species. This technology has been researched since the late 1970s. The efficiency in oxidizing various contaminants on different electrodes, the catalytic activity and stability of electrode materials, the factors affecting the process performance and the mechanisms and kinetics of contaminant degradation have been as research subjects. The electro oxidation of the organic compounds can occur by two different oxidation mechanisms. One mechanism is direct oxidation or direct anodic oxidation, where the compounds are degraded at the anode surface. Another mechanism is indirect oxidation, where oxidizing agents (HClO, H₂S₂O₈ and others) are electrochemically generated and they operate the oxidation.

Miled *et al.*, (2010). studied the indirect electrochemical oxidation process for the textile wastewater treatment .Electrochemical degradation process was performed using graphite as anode and stainless Steel as cathode .The best removal of organic compounds contained in the waste has been obtained at pH 13, low electrolyte concentration and current density (0.1 M and 200 Ma, respectively . cod and colour removal were 75 % and 43 % respectively.

2.5.6 Adsorption

The adsorption process is used to removes colour and other soluble organic pollutants from effluent the process also removes toxic chemicals such as pesticides, phenols, cyanides and organic dyes that cannot be treated by conventional treatment methods. Dissolved organics are adsorbed on surface as waste water containing these is made to pass through adsorbent. Most commonly used adsorbent for treatment is activated carbon. It is manufactured from carbonaceous material such as wood, coal, petroleum products etc. A char is made by burning the material in the absence of air. The char is then oxidized at higher temperatures to create a porous solid mass which has large surface area per unit mass. The pores need to be large enough for soluble organic compounds to diffuse in order to reach the abundant surface area. Typical properties of commercially available activated carbon are given in Table 2.5.

Table 2.5: Properties of typical activated carbon

Parameter	Value
Base material	Lignin
Real Density	1.9 g/cm ³
Apparent density	0.244 g/cm ³
Surface area	750 m ² /g
Iodine value	93
Effective pore size	2 p

The activated carbon once it is saturated. Needs replacement or regeneration can be done chemically or thermally. The chemical regeneration can be done in within the column itself either with acid or other oxidizing chemicals. This normally effects partial recovery of activity and necessitate frequent recharging of carbon. For thermal regeneration, the exhausted carbon is transported preferable in water slurry to regeneration unit where it is dewatered and fed to furnace and heated in controlled conditions. This process volatilizes and oxidizes the impurities held in carbon. The hot reactivated carbon is then quenched with water and moved back to the site this results in almost complete restoration of its adsorption. There are some other materials such as activated clay, silica; fly ash, etc are also known to be promising adsorbents. *CPCB, (2007)*.

2.5.7 Membrane Filtration

2.5.7.1 Reverse Osmosis

The process of reverse osmosis is based on the ability of certain specific polymeric membranes, usually cellulose acetate or nylon to pass pure water at fairly high rates and to reject salts. Reverse osmosis can be used as end-of-pipe treatment and recycling system for effluent. After primary, secondary and/or tertiary treatment, further purification by removal of organics and dissolved salts is possible by use of reverse osmosis. RO membranes are susceptible to fouling due to organics, colloids and microorganism. Scale causing constituents like hardness, carbonate. Silica, heavy metals, oil etc has to be removed from the feed. As the membranes are sensitive to oxidizing agents like chlorine or ozone, they should also be absent.

2.5.7.2 Ultra filtration

This process is similar to reverse osmosis. The difference between reverse osmosis and ultra filtration is primarily the retention properties of the membranes. Reverse osmosis membranes retain all solutes including salts, while ultra filtration membranes retain only macromolecules and suspended solids. Thus salts, solvents and low molecular weight organic solutes pass through ultra filtration membrane with the permeate water. Since the membrane does not retain salts, the osmotic pressure differences across ultra filtration membrane are negligible. Flux rates through the membranes are fairly high, and hence lower pressures can be used.

Ultra filtration membranes may be made from cellulose acetate, polyelectrolyte complexes, nylon and inert polymers. Hence, acidic or caustic streams may also be treated.

2.5.7.3 Nano filtration

Nano filtration can be positioned between reverse osmosis and ultra filtration. Nano filtration is essentially a lower pressure version membrane where the purity of permeate water less important. This process is used where the high salt rejection of reverse osmosis is not necessary. The nano filtration is capable of removing hardness elements such as calcium or magnesium together with bacteria, viruses and color. Nano filtration operated on lower pressure than reverse osmosis and as such treatment cost is lower than reverse osmosis treatment. Nano filtration is preferred when permeate with TDS but without color, COD and hardness is acceptable. Feed water to nano filtration should be of similar qualities as in case of reverse osmosis. Turbidity and colloids should be low. Disinfection of feed may also necessary to remove microorganism. *RSPCB, (2011)*.

2.5.7.4 Microfiltration

Microfiltration is suitable for treating dye baths containing pigment dyes as well as for subsequent rinsing baths. The chemicals used in dye bath, which are not filtered by microfiltration, will remain in the bath. Microfiltration can also be used as a pretreatment for nanofiltration or reverse osmosis. *Babu et al., (2007)*

Table 2.6: Filtration Spectrum of Different Membranes

Filtration type	Pore size (micron)	Molecular weight	Used for removal of pollutant
Micro filtration	0.007 – 2.00	> 1,00,000	Bacteria, pigments, oil etc
Ultra filtration	0.002 – 0.10	1,000 – 2,00,000	Colloids, virus, protein etc
Nano filtration	0.001 – 0.07	180 – 15,000	Dyes,pesticides,divalent ions etc
Reverse osmosis	< 0.001	< 200	Salts and ions

Source: RSPCB,(2011)

Table 2.7: Treatments for textile wastes and their associated advantages and disadvantages

Processes	Advantages	Disadvantages
Biodegradation	Rates of elimination by oxidizable substances about 90%	Low biodegradability of dyes
Coagulation–flocculation	Elimination of insoluble dyes	Production of sludge blocking filter
Adsorption on activated carbon	Suspended solids and organic substances well reduced	Cost of activated carbon
Ozone treatment	Good decolourization	No reduction of the COD
Electrochemical processes	Capacity of adaptation to different volumes and pollution loads	Iron hydroxide sludge
Reverse osmosis	Removal of all mineral salts, hydrolyzes reactive dyes and chemical auxiliaries	High pressure
Nanofiltration	Separation of organic compounds of low molecular weight and divalent ions from monovalent salts. Treatment of	-
Ultrafiltration–microfiltration	Low pressure	Insufficient quality of the treated wastewater

Source: Babu et al., (2007)

2.6 Environmental Impacts of Textile Industries

Water pollution from textile dyeing industry becomes a matter of concern owing to significant organic matter and dyeing agents that produce colours. The textile industry, a major consumer of water for its different wet processing operations, is also a major producer of effluent wastewater containing organic surfactants, salts, acids, alkalis, solvents and the residual dyes. On account of the high BOD, the untreated textile wastewater can lead to rapid depletion of dissolved oxygen, while directly discharged into the surface water body. The textile wastewater with high amount of COD is also found to be toxic to biological life. The intensive color causes problems to the aquatic life and makes the water unfit for use at the downstream side of the disposal point. To prevent the above adverse effects, the textile

industry wastewater needs to be treated and discharged as per the standards laid down under Central Water (Prevention and Control of Pollution) Act, 1974, legislated by the Government of India. Colour removal from textile effluents has been the target of great attention in the last few years, not only because of its potential toxicity, also due to aesthetic inconvenience. *Mazumder (2011)*

The textile effluent contains organic and inorganic chemical species which have adverse effect on water quality and growth of all plants and animals. The water containing textile effluent used for irrigation contains heavy metals (Cd, Cr, Cu, Hg, Ni, Pb, Zn etc.), which accumulate in various parts of plants that result in various clinical problems in animals as well as in human beings including hepatic and renal system damages, mental retardation and degradation of basal ganglia of brain and liver *Kumar et al., (2012)*. Many azo dyes which cause intensive colour in the wastewater of textile industry effluent have been found to mutagen/carcinogen/toxic to aquatic organisms *Selcuk et al., (2006)*

The high alkalinity and traces of chromium which is employed in dyes adversely affect the aquatic life and also interfere with the biological treatment processes. Dyes with striking visibility in recipients may lead to reduced light penetration in aquatic environment which will significantly affect the photosynthetic activity. The high concentration of nitrogen in the textile industrial effluents can cause the eutrophication of closed water bodies. In addition, coloured water is objectionable as it can spoil the beauty of water environments *Palamthodi et al. (2011)*

Kumar et al.,(2012) Carried out the analysis of textile effluent and its effect on water quality of ganga canal. The Samples collected from before confluence and after confluence with textile effluent at different distance. The water quality index rating of sub canal water was of medium and after discharge of textile effluent it turned to very bad. Thus, the textile effluents considerably deteriorated the quality of sub canal water.

Ahmad et al., (2012) investigated the contaminated soil sample (directly textile effluent used for irrigation) and uncontaminated soil sample. Soil sample are tested for different physiological parameter and result revealed that all the parameter have great variability and continuous application of effluent appears to deteriorate soil quality in the area.

Awomes et al., (2010) carried out study on water samples from a stream polluted by a textile industry were collected at twelve sampling points with sampling intervals of 50 m . Zero values of DO observed at these sampling points showed that the stream was heavily polluted and may not likely support aquatic lives. Metal values of the stream were generally low. This study also revealed that the values of most water parameters were higher than international permissible standards in drinking water, thereby, rendering the stream useless for domestic, agriculture and industrial purposes.

2.7 Waste Minimization

UNEP, (1994). Described the waste minimization consists of source reduction and recycling. Source reduction is usually preferable to recycling from an environmental perspective. Source reduction is any activity that aims to eliminate the generation of waste at its point of origin, while recycling is the reusing, recycling, or reclaiming of materials and waste, including processes that regenerate a material or recover a usable product from it. Waste minimization involves the use of raw material, processes or operating practices in a manner that prevents the creation of pollutants or wastes at their source, and those practices that reduce the use of hazardous and non-hazardous materials, energy, water or other resources. Waste minimization can be illustrated in Figure 2.1.

2.8 Wastewater Minimization

Saeedi et al., (2006) presented four general approaches to wastewater minimization as follows:

1. Process change: Process changes can reduce the inherent demand for water. An example is the replacement of wet cooling towers by dry air coolers.

2. Water reuse: Wastewater can be reused directly in other water using operations when the level of previous contamination does not interfere with the water using operation. This reduces both freshwater and wastewater volumes but leave the mass load of contaminant essentially unchanged.

3. Regeneration reuse: Wastewater can be regenerated by partial or total treatment to remove the contaminants that would otherwise prevent reuse and then can be reused in other water using operations. The regeneration is any operation that removes the contaminants that prevent reuse and could be filtration, pH adjustment, carbon adsorption, and other processes. Regeneration reduces both freshwater and wastewater volumes and decreases the mass load of contaminant.

4. Regeneration recycles: Wastewater can be regenerated to remove contaminants and then the water recycled. In this case, regenerated water may enter the water using operations in which the water stream has already been used. Also, recycle can sometimes create a build up of undesired contaminants not removed in the regeneration process.

Babu et al, (2007.) suggested three ways to reduce pollution

1. Use of new, less polluting technologies;
2. Effective treatment of effluent so that it conforms to specified discharge requirements; and
3. Recycling waste several times over before discharge which is considered the most practical solution.

Ncehn (1993) recommended for in-plant reuse without treatment is given for each of the major operations as follows;

1. Good housekeeping: Good housekeeping in textile industries is a program of maintenance, inspection, and evaluation of production practices should be established. Implementing the following can make significant reductions in water use:

- Minimizing leaks and spills
- Maintaining production equipment properly
- Identifying unnecessary washing of both fabric and equipment, and
- Training employees on the importance of water conservation.

2. Reuse of water in scouring and bleaching: It is the clearer wastewater from the later washes in a bleaching sequence can be reused in some of the earlier washed where water quality is not so important.

3. Reuse in mercerizing: On the mercerizing range, the scope for water conservation and reuse lies in adopting a counter current flow pattern. The water requirement can be reduced, if most of this water can be recovered as steam condensate from the multiple effect evaporators of the caustic recovery plant provided suction in the evaporations is carefully controlled to avoid boiling over.

4. Reuse in dyeing: Small saving can be effected if running washes are replaced by static ones wherever possible. Further, the batching or wetting water need not be drained out. It can be retained for use in the next operation like dyeing .

5. Reuse in printing and finishing: This section uses water for various cooling and washing operation and reuse steam condensates in boilers.

6. Reuse of soaper wastewater: The colored wastewater from the soaping operation can be reused at the backgrey washer, which does not require water of a very high quality. Alternatively, the wastewater can be used for cleaning floors and equipment in the print and color shop.

7. Reused of mercerizing or bleach wash water for scouring or desizing: Mercerizing or bleaching rinse water can be used in scouring and desizing operations, as size recovery is not practiced. Generally, the caustic or bleach stream will degrade many size compounds to an extent that cannot be recovered.

8. Counter current washing: Counter current washing is an employed frequently on continuous preparation and dye range. Clean water enters at the final wash box and flow counter to the movement of the fabric through the wash boxes. Thus, when the fabric enters these the actual wash process, the most contaminated wash water contacts it first, and, later, the cleanest water contacts the cleanest fabric. It can be applied at desize washers, scour washers, mercerizing washers, bleach washers, dye ranges, and print house soaper range.

9. Use of automatic shut-off valves: An automatic shut-off valve set to time, level, or temperature will control the flow of water into a process unit. One plant estimated that a reduction in water use of up to 20% could be achieved with thermally controlled shut-off valves.

10. Use of flow control valves: A flow or pressure reduction valve can significantly reduce the quantity of water used in a wash or clean-up step. These valves are particularly useful in cleaning areas where operators are not always aware of the need for water conservation.

UNEP (1994) recommended the reusing of wastewater could be done by:

1. Recycle/reuse of water jet weaving wastewater: The jet weaving wastewater can be reused within the jet looms. Alternatively, it can be reused in the desizing or scouring process, provided that in-line filters remove fabric impurities and oils.

2. Reuse of pressure filter backwash water: Easily settleable suspended solid is the main pollutant in the pressure filter backwash. By collecting this in a pond with a minimum hydraulic retention time of 12 hours the supernatant free from suspended solids can be reused for gardening purposes. Periodically the retained suspended solids will be removed from the pond and disposed of as solid waste in a landfill site.

3. Reuse of wastewater from the dyeing and finishing department: Fresh water is used for quenching hot ash from the boiler house before disposal. It is feasible to reuse the hard to treat wastewater from the dyeing department, instead of fresh water, for quenching purposes. It was also confirmed that due to adsorption of colour/dyes on the ash particles, there would be about 20% reduction in BOD content in the reused dye-house wastewater.

4. Reuse of wastewater from sizing activities: To avoid spontaneous combustion and to reduce the fine loss, fresh water is used for wetting coal in the yard. By collecting the low volume high organic strength wastewater from the sizing operation in a pond with facilities to prevent septicity, the entire wastewater arising can be used for coal wetting.

2.9 Performance Evaluation of Effluent Treatment Plant

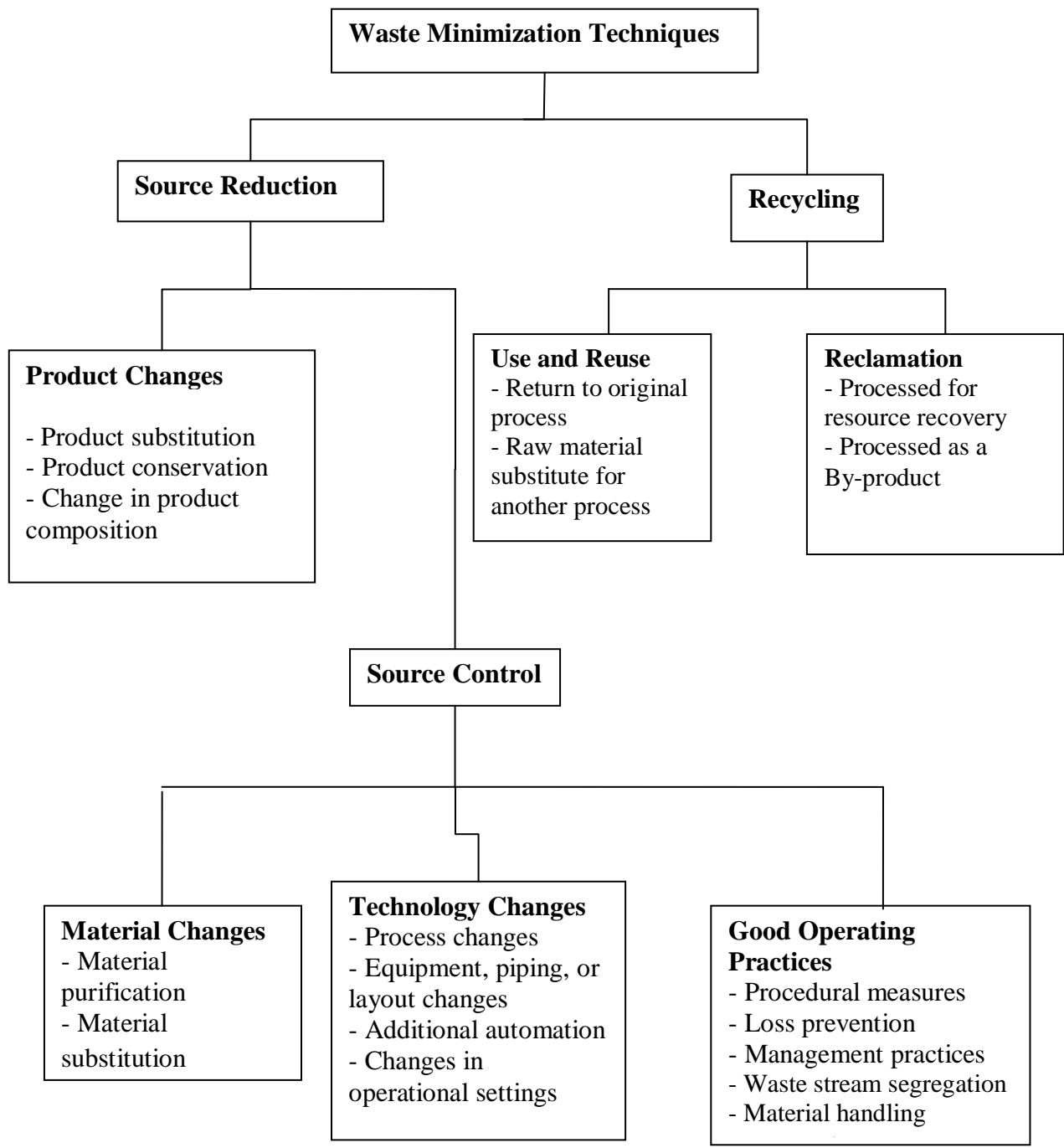
Performance evaluation has the benefit of assessing the performance of the wastewater treatment plant after commissioning the plant based on the removal efficiency of major parameters such as BOD, COD, TSS and TDS. Suitable remedial measures can be adopted to improve the performance of treatment plant.

Waskar et al., Carried out the study on evaluating efficiency of the treatment plant by studying water samples, which were collected at different stages of treatment units. Parameters like BOD, COD, TSS and TDS were studied. Performance efficiency of each unit was calculated, which is the evidence that CETP has been working with the norms of MPCB and meeting the standard discharge limits.

Govindasamy et al., (2006) carried out to evaluate performance efficiency of the treatment plant. Water samples were collected at different stages of treatment units and analysed for the major water quality parameters, such as pH, BOD, COD, TSS and TDS. The performance efficiency of each unit in treating the pollutants was calculated. The generated data presented evidence to that the common effluent treatment plant has been working with the norms of TNPCB and meeting the discharge standard limits.

Teli et al., (2008) evaluate the performance of central wastewater treatment plant in terms of BOD₅, COD, TSS, TDS, oil and grease and ammonical nitrogen removal. Moreover, the performance of the CWWTP related to pre treatment of wastewater in those industries, so performances of pre treatment were also included in this study. samples of wastewater were collected from the CWWTP This study revealed that average concentrations of BOD₅, COD, TSS, TDS, oil and grease, and ammonical nitrogen in the effluent of CWWTP which did not meet the effluent standards for BOD₅, COD and TSS.

Vasudevan et al., (2012) study the performance of CETP for tannery effluent in terms of BOD, COD, TSS, TDS, . ETP showed a removal efficiency of BOD-66%, COD- 21%, TSS- 21% and TDS-5%. The study revealed that ETP has to be redesigned based on the characteristics of influent wastewater in order to meet the Pollution Control Board prescribed standard limits for ETP.



Source: <http://www.niir.org/g/c/ni-76//1.jpg>

Figure 2.1: Waste Minimization Techniques

Desai et al.,(2011) evaluate the performance efficiency of an Effluent Treatment Plant of a textile industry located in kagal-Hatkanangale MIDC area, Kolhapur (Maharashtra). An effluent treatment plant is operating on biological treatment method (Fluidized Aerobic Bio-

Reactor) with an average wastewater inflow of 2 MLD .The wastewater is analyzed for the major water quality parameters, such as pH, BOD, COD and TDS. The effluent samples were collected on a daily basis for a period of one month. The raw wastewater pH was highly alkaline it was then bringing down to neutral which was helpful for biological treatment. The BOD, COD of the treated effluent reduced significantly, where as very small reduction was observed in dissolved solids. Most of all the parameters were within the permissible limits of Maharashtra Pollution Control Board, India.

Oliveira et al., (2011) analyses the performance of 166 wastewater treatment plants operating in Brazil, comprising six different treatment processes: septic tank, anaerobic filter, facultative pond, anaerobic pond, facultative pond, activated sludge, UASB reactors alone, and UASB reactors followed by post-treatment. The study evaluates and compares the observed effluent quality and the removal efficiencies in terms of BOD, COD, TSS, TN, TP and FC with typical values reported in the technical literature. In view of the large performance variability observed, the existence of a relationship between design/operational parameters and treatment performance was investigated. From the results obtained, no consistent relationship between loading rates and effluent quality was found. The influence of loading rates differed from plant to plant, and and the effluent quality was dictated by several combined factors related to design and operation.

CHAPTER 3

METHODOLOGY

3.1 Introduction

In this chapter the methods followed for the study are discussed. For achieving objectives of the study the work planned on the following work elements:

1. Selection of Industry
2. Getting Background information on the ETPs of Textile Wet Processing Industry.
3. Monitoring and analysis of Sample.
4. Efficiency Evaluation Study.
5. Problems identified in the ETPs.
6. Recommendation for Improvement of Existing ETP.

Using the monitoring data both at plant level and at the individual unit level, performance evaluation of the ETPs was done. Performances of the individual units were assessed against the parameters for which the units were used. Performance evaluation was also done for the coincidental removal of pollutants from the wastewater. By knowing the inlet and outlet concentration of different parameters, Plant removal efficiencies for various parameters were calculated.

3.2 Getting Background information of the ETP

The ETPs in Question were visited, surveyed and the people working there were consulted for understanding the scheme of treatment and for obtaining Dimensional, capacity and other details. Sampling location, parameters to be analysed at each of the sampling location were also decided on the basic of the survey.

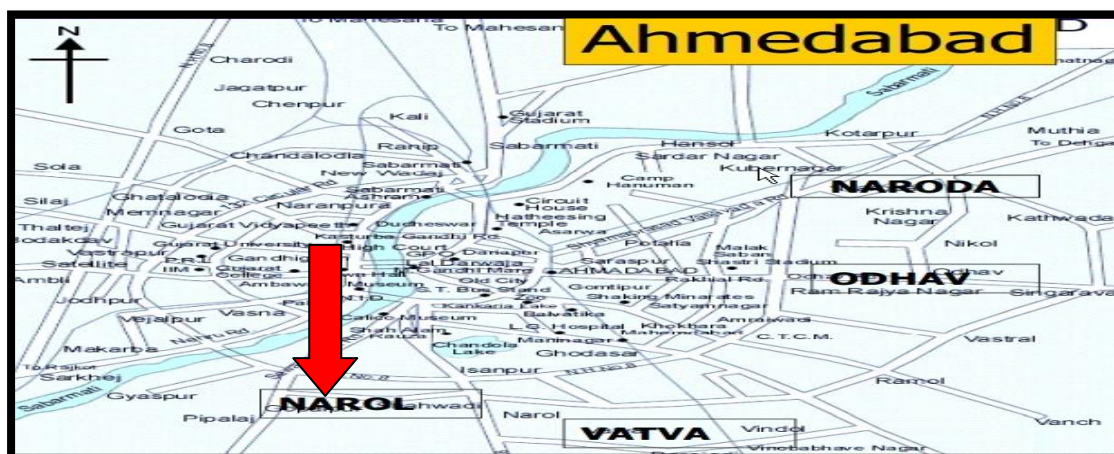
3.3 Monitoring of the ETPs and Efficiency Evaluation

Monitoring was done to understand the performance evaluation of the ETPs. For facilitating this, the sampling location were identifies and the for which the samples should be analysed were decided .It involves Collection of composite samples (at an hour intervals over Eight hours) 9.30 am to 5 .30 pm, at the following different Sampling locations of the ETPs and analyzing them for the different major physiochemical parameters The results obtained from

the monitoring and evaluation studies were compared with the effluent standards prescribed in order to assess compliance. Even pH of the Collected samples was measured on site , The samples from different sampling location were collected in plastic bottles. Until the analysis was over the samples were stored in deep freeze.

3.4 Description of Study area:

The Narol Industrial Cluster is spread over an area of about 500 hectares in Narol, Shahwadi, Isanpur and Piplaj areas in Ahmedabad district and fall under the Ahmedabad Municipal Corporation limits. River Sabarmati flows towards West while industrial area of Vatva is located towards East. Towards its North is the Ahmedabad city while to the South is the villages of Lambha and Jetalpur. Narol Industrial Cluster is an agglomerate of 224 industries in processing of cotton & blended fabrics, dyeing and processing of textiles, denims and synthetic textiles The members of Narol Industrial Cluster process about 2800 million meters of fabric every year and Dyes & chemicals. The total direct employment within these units is about 40,000, while indirect employment is estimated at 100,000 persons. The members of Narol Textile Cluster process about 2800 million metres of fabric every year, generating total revenues in excess of Rs. 25 billion. The exports from this cluster is significant at about Rs. 7 billion, most of it being to places like Europe, USA, Middle East, China, Thailand, Turkey, Brazil, etc. directly or indirectly.



3.5 Characteristics of wastewater Samples:

Characterization of different samples from ETPs was done according to the method given in *APHA (2005)*.

pH

Measurement of pH is one of the most important and frequently used tests, as every phase of water and wastewater treatment and waste quality management is pH dependent. It is measured on site with the help of pH Paper and pH meter. It indicates the nature of wastewater either alkaline or acidic wastewater based on type of wastewater further treatment given.

Biological Oxygen Demand

Biochemical Oxygen Demand (BOD) refers to the amount of oxygen that would be consumed if all the organics in one litre of water were oxidized by bacteria and protozoa. It was estimated by the method 5210 B (*APHA*).

TSS and TDS

Solids were dried at 105°C till constant weight according to the method no. given 2540 B, 2540 C, 2540 D respectively for TS, TDS and TSS. (*APHA*)

Chemical Oxygen Demand

The Chemical Oxygen Demand (COD) is used as a measure of the oxygen equivalent of the organic matter content of a sample that is susceptible to oxidation by a strong chemical oxidant. It was estimated by the method no. 5220 C closed refluxed titration method. (*APHA*)

Ammonical Nitrogen

Wastewater containing Ammonical nitrogen is becoming more important in the alleviation of environmental problems including Eutrophication, corrosion and fouling. Preliminary distillation step, titrimetric method used for analysis of ammonical nitrogen in wastewater sample. It is estimated by method no. 4500 B & C. (*APHA*).

3.6 Mega pipeline for treated effluent:



Photo: Outlet of mega pipeline into Sabarmati river

Mega pipeline of 27 km is provided for treated effluent of industrial cluster Vatva, Naroda, Odhav and Narol. Mega pipeline from Naroda to Pirana has carrying capacity of 90 MLD. At present, the treated effluent from industrial units of this cluster is discharged into mega pipeline and mixed with treated sewage coming from Pirana sewage treatment plant of Ahmedabad municipal corporation before final discharge into river Sabarmati. The mega pipeline has, since last few years, carrying excess of capacity and as a result, frequent overflows in upstream locations is being observed. The textile units in Narol are registered to discharge around 114 MLD as effluent but at present about 265 MLD, of industrial effluents is generated by textile units in Narol alone posing serious survival questions for water bodies in the vicinity.

Table 3.1: Inlet norms for mega pipeline (GPCB)

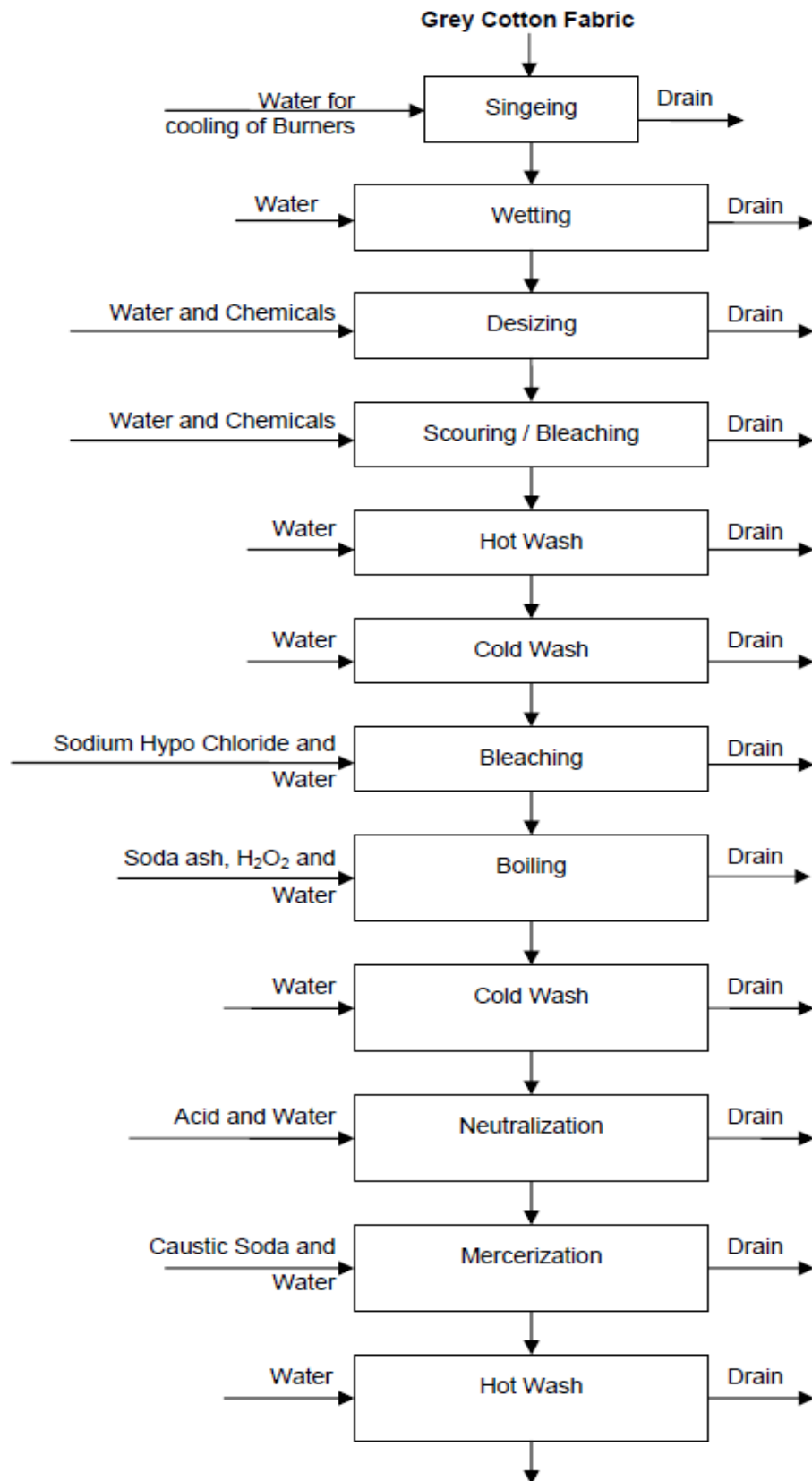
Parameters	Permissible Limit
p ^H	6.5-8.5
Temperature	40°C
Colour	100 Units
Suspended Solid	100 mg/L
Oil & Grease	10 mg/L
Ammonical Nitrogen	50 mg/L
BOD (5 Days at 20 ⁰ C)	30 mg/L
COD	100 mg/L
Chlorides	600 mg/L
TDS	2100 mg/L
Sulphates	1000 mg/L
Total dissolved Solids	2100 mg/L

Table 3.2: Proposed CETP Inlet Norms (Narol Textile Infrastructure & Enviro. Management)

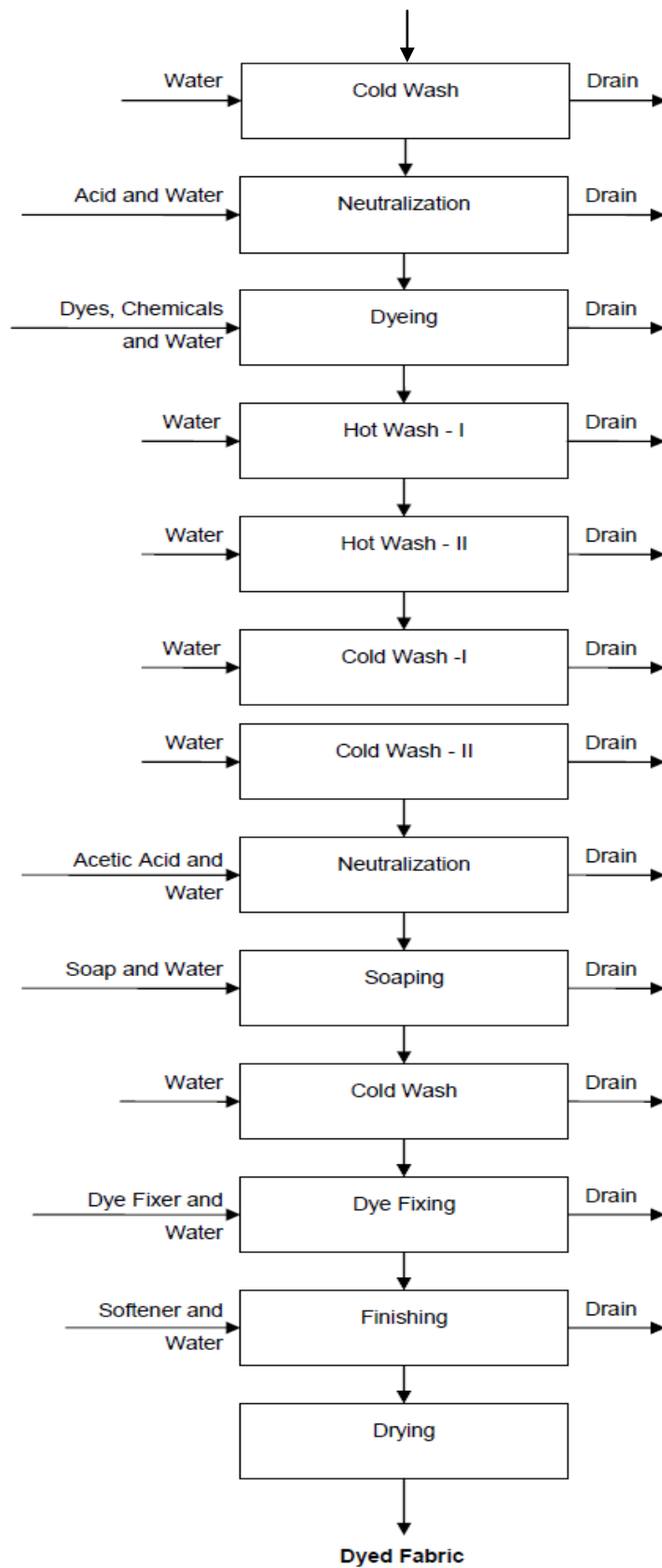
Sr.	Parameter	Unit	Inlet Norms
01	pH	#	6.5-8.5
02	COD	mg/L	1200
03	BOD ₅	mg/L	500
04	TSS	mg/L	300
05	Ammonical nitrogen	mg/L	50
06	Oil & Grease	mg/L	20

Source: gpcb.gov.in/pdf/NAROL_TEXTILE_INFRASTRUCTURE_EIA.PDF

Figure 3.1: Manufacturing Process of textile wet processing Industry



Continued



Source : Guide for assessment of effluent treatment plants in EMP/EIA reports for textile industries, (2008).

3.7 Effluent Treatment Plants Being Studied

All the treatment plant included the following units and facilities which are common and some units are present into one or two industry:

1. Collection cum Equalisation tank
2. Flocculation Tank
3. Primary Settling Tank
4. Primary clarifier
5. Clariflocculator
6. Aeration Tank
7. Secondary Clarifier
8. Treated Effluent sump
9. Sludge Drying Bed
10. Filter Press
11. Activated Carbon Filter
12. Pressure Sand Filter

Generally textile wet processing industry which is located at Narol, Ahmedabad mostly are small scale industry & medium scale industry. They operate their ETPs up to primary treatment or secondary treatment or some may be operate up to tertiary treatment also. In ETPs of textile industry wastewater coming from different process are collected in to the collection sump and from the collection sump it passed into the neutralisation cum equalisation tank where pH is bring down to neutral and flow is equalised for the further treatment and after that effluent is passed into the chemical reaction tank where chemical dosing is applied mainly coagulant is applied for coagulation and flocculation process. After coagulation and flocculation it passed into primary settling for sludge settlement and supernatant passed into the aeration tank for biological treatment and air is supplied by means of blower and after providing sufficient HRT in aeration tank it drained into the secondary clarifier for further sludge settling and treated effluent is discharged into mega pipeline. Some industry also install tertiary treatment units (Pressure sand filter & Activated carbon filter) for treatment of effluent after secondary clarifier which also help to reduction in physiochemical parameters, and treated effluent from filtration process is finally discharged into mega pipeline and 10 -15 % of treated effluent used in washing purpose in printing area.

3.7.1 ETP at Industry: A

The ETP was already over loaded since it started operation in 1990 and today the wastewater generated is more than 1500 m³/day. The daily effluent discharge limit to mega pipeline is 156 m³/day. Installation of Tertiary treatment is just for eye watch .Dimensional and capacity detail of various units and facilities of the ETP are given in table 3.3 and process flow diagram of the ETP with sampling location is schematically shown in figure 3.2.

Table 3.3: Detail of Treatment Units

Sr. No	Name of Unit	Size(m)				capacity, m ³	Retention time, hrs.	
		No.	L×B×H		Free Board			Hopper
1.	Oil and grease trap	1	2.0 × 2.0 × 2.5		0.3	-	10.0	0.16
2.	Collection cum neutralization tank	1	3.75 × 2.7 × 1.7		0.3	-	17.21	0.27
3.	Primary settling Tank	1	5.4 × 4.4 × 1.9		0.7	1.3	45.14	0.72
4.	Primary Clarifier	1	7.0 × 5.0 × 4.0		0.4	-	140.0	2.24
5.	Aeration tank	1	8.6 × 4.6 × 6.4		0.4	-	253.18	4.05
6.	Secondary Clarifier	1	6.5 Ø × 2.5		0.3	0.22	82.96	1.3
7.	Holding sump	1	4.0 Ø × 4.8		0.6	-	60.32	-
8.	Pressure sand filter	1	2.0 Ø × 1.5		-	-	-	-
9.	Activated Carbon filter	1	2.5 Ø × 2.0		-	-	-	-
10.	Sludge pit	1	3.0 × 3.0 × 1.5		0.2	-	13.5	-
11.	Sludge drying beds	1	1.9 × 1.0 × 0.4		0.2	-	2.28	-
12.	Filter press	1	0.6	0.6	21 Plates		-	-
13.	Sludge Storage Room	1	10.5 × 3.5 × 3.0		-	-	110.25	-

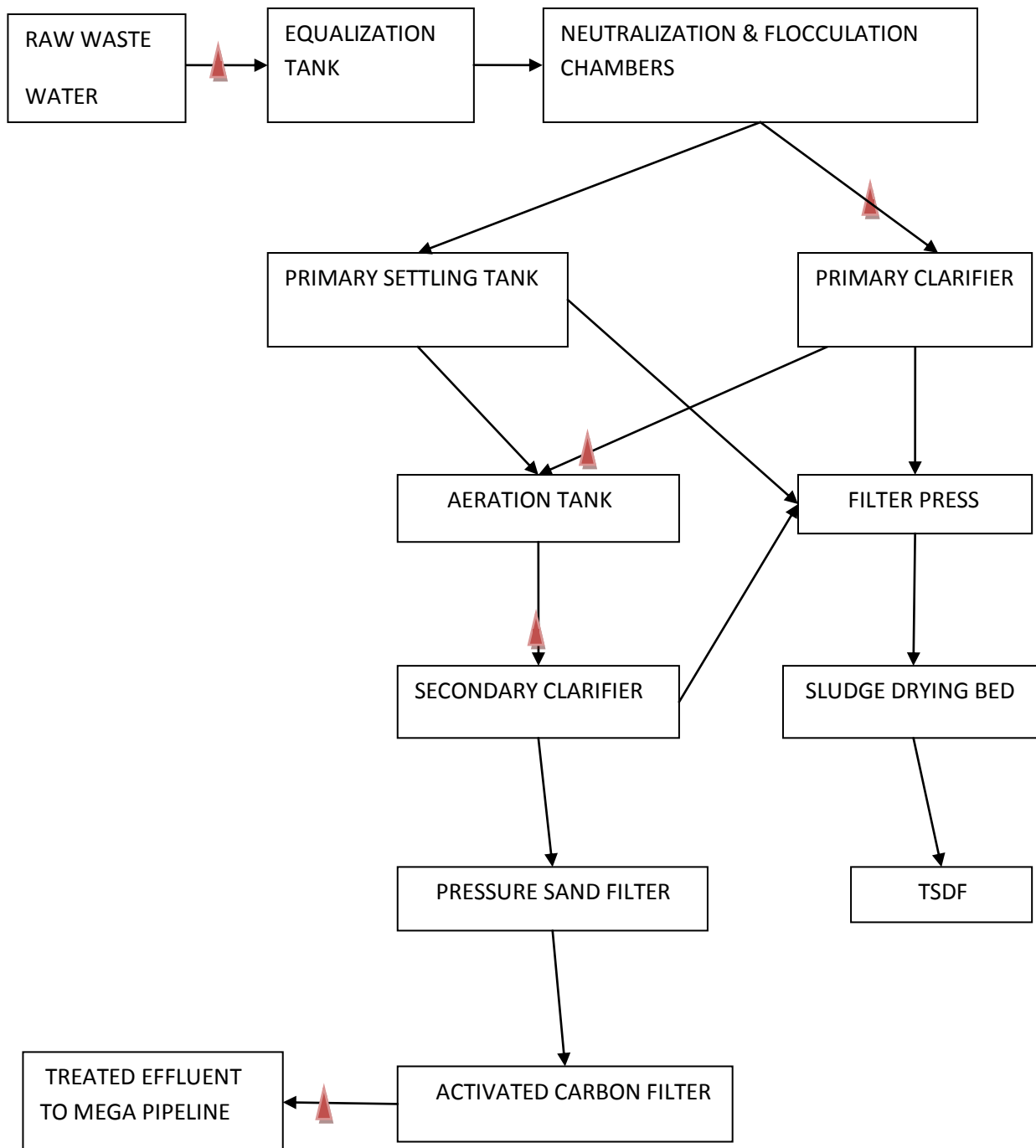


Figure 3.2: ETP flow diagram of Industry A.



Collected Samples



S1 Raw Effluent



S2 after Flocculation Chamber



S3 Inlet Aeration Tank



S4 Inlet Secondary Clarifier



S5 Final Treated Effluent

Figure 3.3: Different Units of ETP of Industry A

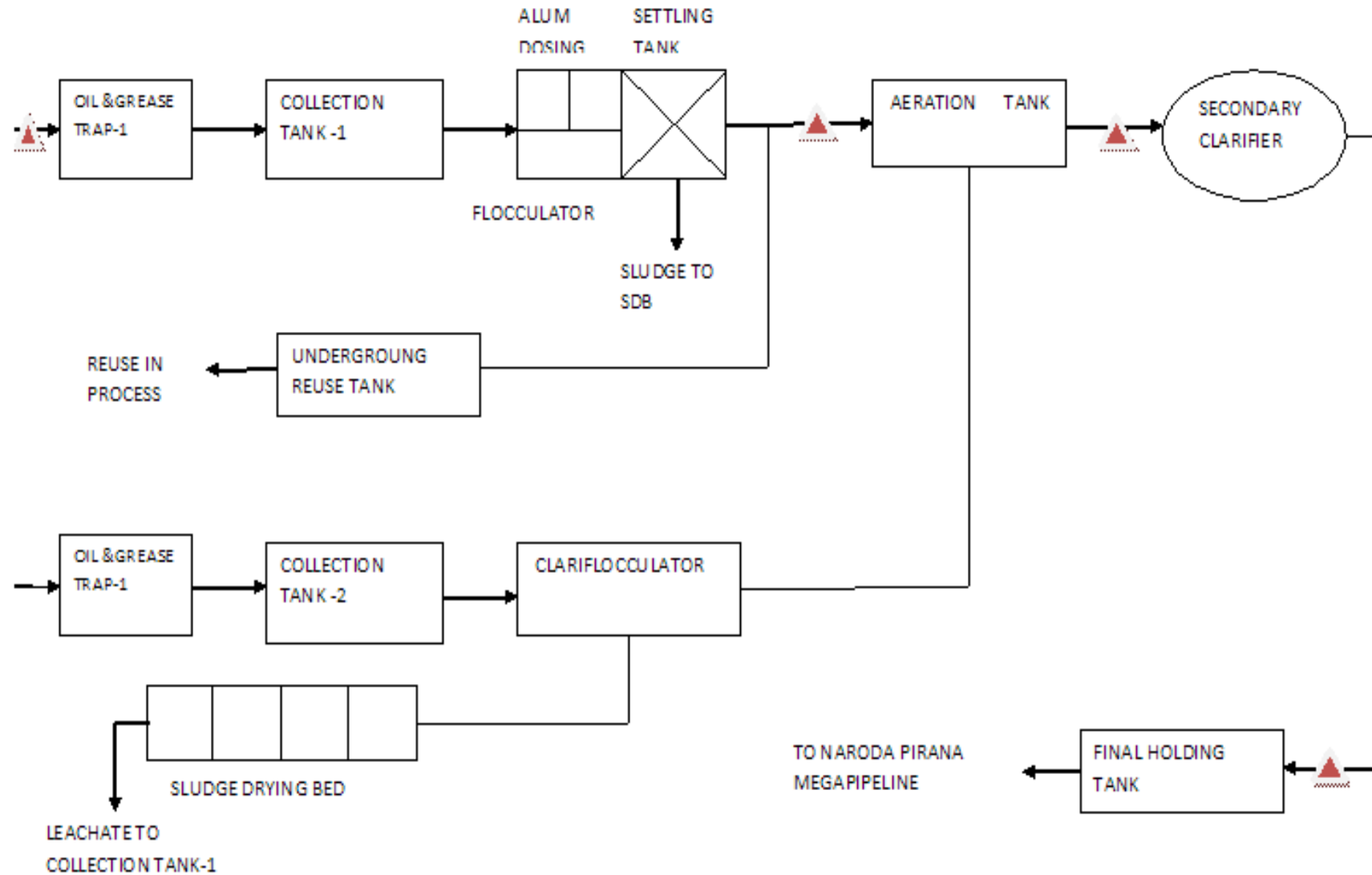
3.7.2 ETP at Industry- B

Design Capacity of ETP: 250 m³ / day. Already upgraded the primary treatment unit by installing clariflocculator .Today the plant receives 300 m³/day of wastewater. The daily effluent discharge limit to mega pipeline is 300 m³/Day. Dimensional and capacity detail of various units and facilities of the ETP are given in table 3.4. And process flow diagram of the ETP with sampling location is schematically shown in figure 3.4.

Table 3.4: Detail of Treatment Units

Sr.	Name of ETP Unit	No.	Size in Meter	Capacity ,m ³	Detention Time,hrs.
1.	Collection Cum Equalisation Tank	1	5.7 × 4.4 × 4.0	100.32	8.02
2.	Chemical Addition Tank	1	1.0 × 1.0 × 0.9	0.9	0.072
3.	Primary Settling Tank	1	6.9 × 3.7 × 2.75	70.2	5.616
4.	Aeration Tank	1	9.0 × 5.0 × 4.0	180	14.4
5.	Secondary Clarifier	1	5 Ø× 2.75	53.96	4.31
6.	Sludge drying Beds	4	1.5 × 1.5 × 1.9	4.275	-
7.	New Collection cum Equalization Tank	1	28.6 × 14.3 × 3.6	1472.32	177.7
8.	New Chemical Reaction Tank	1	3.0 × 3.0 × 3.0	27	2.16
9.	New Primary Clariflocculator	1	13.50 Ø × 4.0 SWD	572.3	45.78
10.	Sludge Drying Beds	12	4.0 × 3.0 × 1.2	172.8	-

Figure 3.4: ETP flow Diagram of Industry B





Collection cum Equalization Tank



Chemical Dosing Tank



Aeration Tank



Screening Unit



Clariflocculator



Secondary Clarifier

Figure 3.5: Different Units of ETP of Industry B

3.7.3 ETP at Industry -C

Design capacity of treatment Units is 810 m³/ day. The daily effluent discharge limit to mega pipeline is 850 m³/day. Wastewater generated is 900 m³/day. Dimensional and capacity detail of various units and facilities of the ETP are given in table 3.5. And process flow diagram of the ETP with sampling location is schematically shown in figure 3.6.

Table 3.5: Detail of Treatment Units

Sr.	Name of ETP Unit	No.	Size in Meter	Capacity ,m ³	Detention Time.hrs.
1.	Collection Tank (Old)	1	6.0 Ø × 4.8	136.0	3.6
2.	Collection Tank (New)	1	7.30 Ø × 7.3	305.0	8.13
3.	Chemical Dosing Tank	2	500 Lit each	0.5	-
4.	Reaction Channel	1	20 × 0.75 × 0.75	11.25	0.3
5.	Primary Clarifier	1	5.0 Ø × 3.70	73	1.94
6.	Primary Settling Tank	2	5.4 × 5.3 × 3.5	200	5.3
7.	Aeration Tank	1	19.0 × 9.45 × 3.6	646	17.22
8.	Secondary Clarifier	1	7.4 Ø × 3.6	155.0	4.13
9.	Pressure Sand Filter	1	2.0 Ø × 2.7	-	-
10.	Activated Carbon Filter	1	1.5 Ø × 2.2	-	-
11.	Treated Water Collection Sump	1	3.8 Ø × 2.8	32	0.85
12.	Surface Aerator	2	7.5 HP Each	-	-
13.	Sludge Drying Beds	3	3.65 × 3.65 × 0.3	12	-

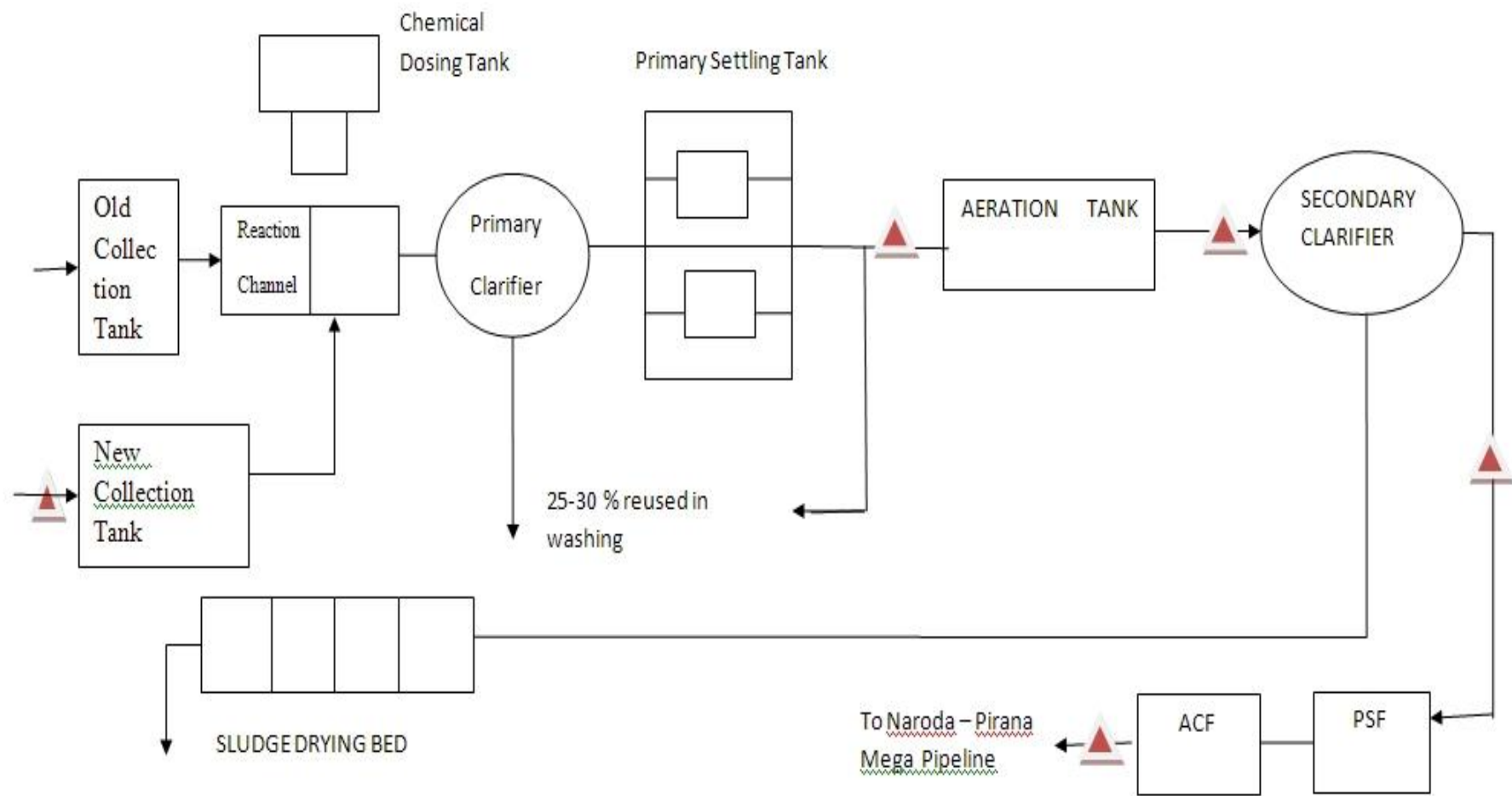


Figure 3.6: ETP flow diagram of Industry - C



Raw Wastewater



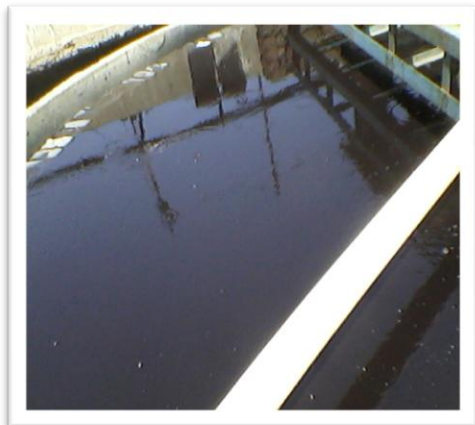
Treated Effluent



Collection Tank



Aeration Tank



Secondary Clarifier



Pressure sand Filter & Activated Carbon Filter

Figure 3.7: Different Units of ETP of Industry C

3.7.4 ETP at Industry- D

Design capacity of treatment Units is 635 m³/ Day. The daily effluent discharge limit to mega pipeline is 625 m³/Day. Dimensional and capacity detail of various units and facilities of the ETP are given in table 3.6.and process flow diagram of the ETP with sampling location is schematically shown in figure 3.8 .

Table 3.6: Detail of Treatment Units

Sr. No	Name of Unit	No.	Size(m)	Hydraulic Volume , m ³	Retention time,hrs.
1.	Collection cum neutralization tank	2	7.62 × 7.59 × 3.65	422.2	15.6
			7.62 × 7.59 × 3.65		
2.	Hopper Bottom Settling Tank	2	7.62 × 7.59 × 3.65	111.88	4.13
			4.96×3.65×3.65		
3.	Aeration tank	1	6.4×14.5×3.65	338.72	12.51
4.	Secondary Clarifier	1	5.18 Ø × 3.35	70.15	2.59
5.	Sludge drying beds	4	4.84×2.74×1.82	96.54	-
6.	Pressure sand filter	2	4.72 Ø × 1.82	-	-
			5.56 Ø × 3.81		
7.	Activated Carbon filter	1	4.87 Ø × 2 .59	-	-

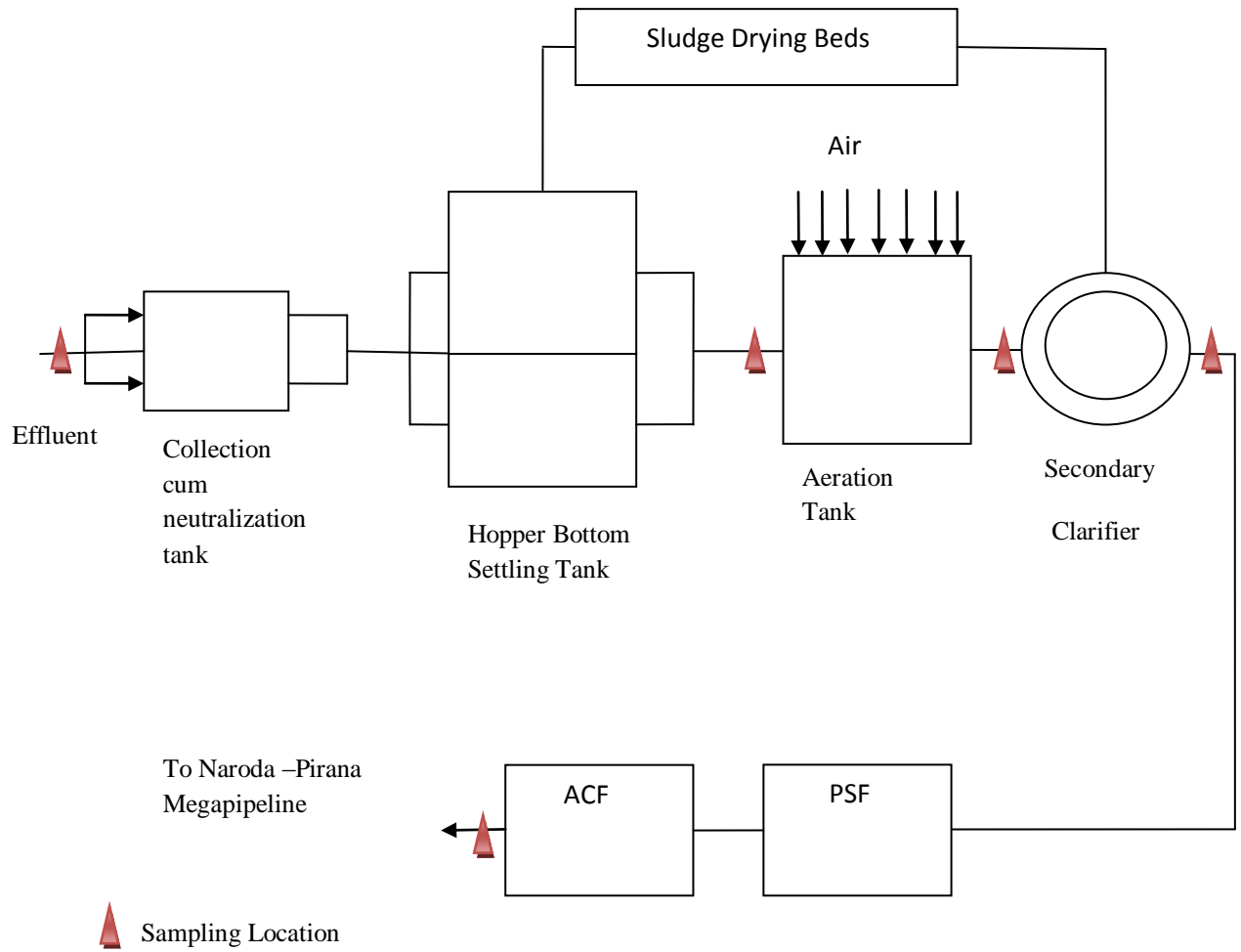


Figure 3.8: ETP flow diagram of Industry D.

3.7.5 ETP at Industry- E

Design capacity of treatment Units is 740 m³/ Day. The daily effluent discharge limit to mega pipeline is 630 m³/Day. Dimensional and capacity detail of various units and facilities of the ETP are given in table 3.7 and process flow diagram of the ETP with sampling location is schematically shown in figure 3.9.

Table 3.7: Detail of Treatment Units

Sr. No	Name of Unit	No.	Size(m)	Hydraulic Volume , m ³	Retention time,hrs.
1.	Collection tank	1	6.5 × 3.5 × 3.0	68.25	2.6
2.	Flash Mixer	1	2.5 Ø × 2.0	9.81	0.37
3.	Flocculator	1	3.0 Ø × 3.0	21.185	0.807
4.	Primary tube settler	1	4×4×(2.25+1.5 CONE)	40	0.77
5.	Aeration Tank	1	18.7 × 6.0 × 4.0	448.8	17.25
6.	Secondary Clarifier	1	8.0 Ø × 2.5 (SWD)	125.6	4.78
7.	Holding Sump	1	6.0 × 6.0 × 4.0	144	-
8.	Sludge well	1	1.7 × 3.6 × 4.0	24.48	-
9.	Sludge well	1	4.0 × 3.0 × 3.0	36	-
10.	Sludge drying beds	4	1.7 × 1.9	12.92	-
11.	Sludge drying beds	1	4 × 3	12	-
12.	Sludge drying beds	1	2.6 × 6.0	15.6	-

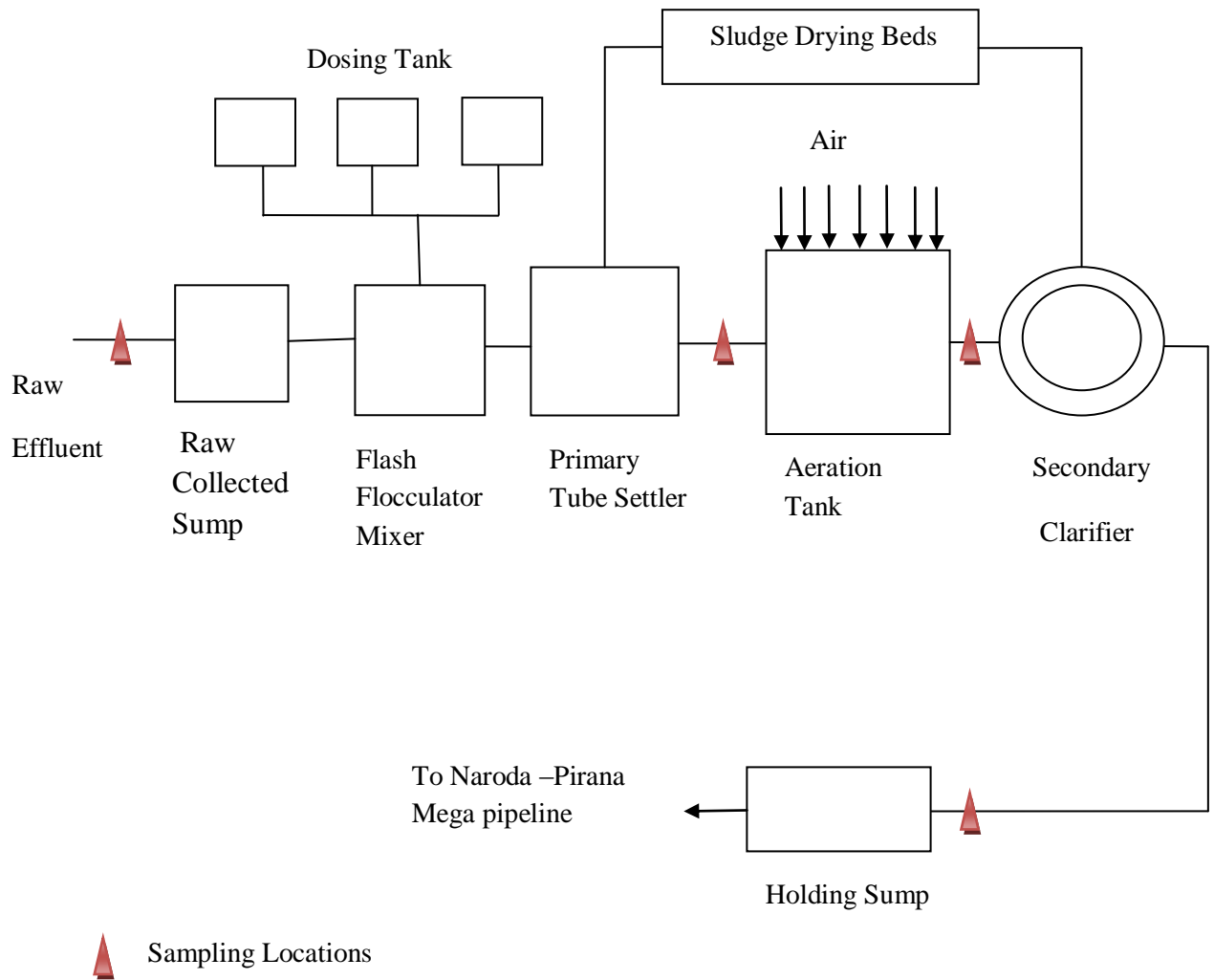


Figure 3.9: ETP flow diagram of Industry E.



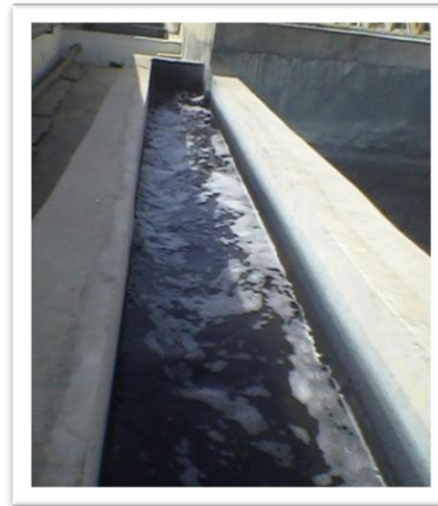
Collection Sump



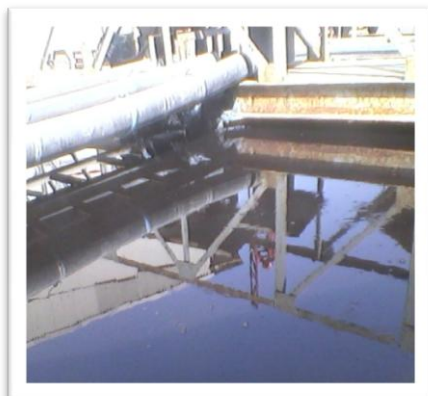
Inlet to flocculator Mixer



Primary Tube Settler



Outlet Aeration Tank



Secondary Clarifier



Final Treated Effluent sump

Figure 3.10: Different Units of ETP of Industry E

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

For evaluating the performance of ETPs the accurate idea of the composite of effluent is very important because industrial effluent contain various pollutants in different concentrations. These high concentrations of pollutants may alter the quality of effluent which creates huge contamination in the environment *Ogunlaja et.al* ,(2009).Result obtained from the monitoring of the ETPs over a study period and overall plant level performance of the ETPs of textile, wet processing industry are presented in this chapter. Based on results, Removal Efficiency of each unit is calculated. Some problems were also identified during monitoring of ETPs. The monitoring data is given in annexure 1 to 5.

4.2 Characteristics of Waste Water of different industries.

Industry –A : The characteristics of wastewater was characterized and data was represented in Annex.1.The Sample locations was selected as S1,S2,S3,S4 and S5.The pH in all locations S1 to S5 ranges between 10.16 -7.0 which is maximum 10.16 in S1 and lowest pH 7.0 in inlet of clarifier (S4) . The maximum TDS was found in S1 (raw effluent) is 3360 mg/L followed by COD 2626 mg/L,TSS 1512 mg/L, BOD 742 mg/L and NH₃-N 12.5 mg/L.Similar trends was found in COD,BOD,TSS,TDS &NH₃-N in all sampling location S2 - S5. These results indicates that degradation of all parameters are dependent upon the raw effluent, Table 1.1 (Annex.1).The removal efficiency of industry A showed in Table:1.2 (Annex.1).The removal was observed in flocculation chamber, primary clarifier, Aeration Tank, Secondary Clarifier. In flocculation chamber maximum removal observed 28.8 % in NH₃-N followed by TSS,BOD,COD,TDS which is 13.62% ,10.64 % ,5.44 % and 3.27 % respectively.

In primary clarifier the maximum reduction 30.16 % found in TSS, whereas, as minimum 3.63 % in TDS. In aeration tank also the maximum removal was found 27.39 % in NH₃-N where as in secondary clarifier the TSS removed 76.90 % . Table 1.2 (Annex.1) .These results indicates that maximum TSS was removed in primary and secondary clarifier and total removal efficiency was found 86.37 % which showed good efficiency. The total overall efficiency of removal especially BOD (25.60 %), COD (49.23%) is very less and TDS is 11.07 % which showed some failure in the system.

Industry –B : The different locations of industry B showed maximum values of TDS 3582 mg/L in raw effluent (S1) followed by COD 1632 mg/L ,TSS 604 mg/L,BOD 268 mg/L and NH₃-N 78 mg/L. These values keep on decreasing in aeration tank (S2) to Secondary clarifier (S3) and then final treated effluent (S4). All the values decreased in treated effluent (S4). These data showed that industry B having capacity to reduced the pollution in the term of COD, BOD, TDS, TSS. Table 2.1 (Annex.2).The maximum reduction 78 % was observed in NH₃-N over raw influent and minimum 44.3 % in TDS.The COD reduced to 74.7 % and BOD 71.6 % over raw effluent.

The removal efficiency of all these parameters were also observed and found that BOD removal was found 22.01 % in primary settling tank, 45.93 % in aeration tank and 32.74 % in secondary clarifier. The maximum COD removal is 64.8 % in aeration tank and minimum 4.4 % in primary settling tank. The TSS maximum removed 44.24 % in secondary clarifier whereas 29.44 % TDS in aeration tank. The NH₃-N removal was found 72.72 % in secondary clarifier and 64.10 % in primary settling tank which is more than 50 %.Table-2.2 (Annex.2)

Industry-C: In industry C the maximum TDS was found 6852 mg/L which is second highest value compared to other industry , and in the final effluent it remain 3268 mg/L which indicated that 52.3 % TDS had been removed in the final effluent. Where in case of BOD in raw effluent the BOD was 812 mg/L and in final treated effluent 145 mg/L Table 3.1(Annex.3), which showed 82 % reduction in compared to raw effluent (S1) Similar trend was observed in COD 79 % reduction,NH₃-N 73.3 % and TSS 63.6 % reduction was found compared to raw influent which showed cumulative effect in the treatment unit.

Table 3.2 (Annex.3) Showed the removal efficiency from primary clarifier, aeration tank, secondary clarifier, and filter system. The maximum removal of BOD was found 47.91 % in aeration tank followed by filter system, secondary clarifier, and then primary settling tank which was 39.58%, 31.42% and 17.24 % respectively. The maximum removal of COD was observed 46.07 % in primary settling tank ,TSS 32.92 % in filter systems, whereas 28.61 in TDS in primary settling tank .The NH₃-N 44.4 % removal was observed in secondary clarifier Table 3.2 (Annex.3) this table showed that all the units having removal efficiency. The more of less values of percent reduction may be due to efficiency of biological system which is running properly in industry C.

Industry D: - The capacity of treatment unit of industry is 635 m³/Day and their dimensions were given in Table 3.6 and the design of unit is given in figure 3.8. It was observed from the table 4.1 (Annex.4) that in raw effluent maximum COD was observed 3212 mg/L which is decreased to 223 mg/L in final effluent (S5).It indicate that 93.0 % COD was removed by this processes.BOD also reduced and left 57 mg/L which is 87.5 % compared to raw effluent (400 mg/L) .Others parameters like TSS and NH₃-N was also reduced to 89.92 % and 96 % respectively (S1-S4) Table 4.1 (Annex.4).The TDS reduced to 49 % which is even lesser than 50 % otherwise other parameters reduced more than 80-90 % compared to raw effluent.

Table- 4.2 (Annex.4) showed the removal efficiency in different units and found that most efficient unit was aeration tank and secondary clarifier as the maximum 83.52 % NH₃-N was removed and 55.53 % BOD and 55.69 % COD was removed where as in secondary clarifier the maximum removal of 68.89 % was found in case of COD followed by 45.31 TSS and 40 % NH₃-N. In hopper bottom settling tank 50.37 % removal observed in TSS, 39.28 % NH₃-N other parameters like BOD, COD and TDS was ranges 14.19 to 18 %. In filter system 52.14 % TSS was removed, other parameters were less than 50 % and ranges to 12 % to 48.18 %.

Industry E: The capacity of treatment unit 740 m³/Day and influent discharged through mega pipeline is 630 m³/Day. The dimension were given in table 3.7 and schematic sketch in Fig. 3.9.The maximum TDS was present 7020 mg/L in raw effluent (S1) followed by TSS 6000 mg /L ,COD 2840 mg/L ,BOD 478 mg/L and NH₃-N 78 mg/L . The reduction in values of all parameters were in the same trends as given in raw influent (S1) the cumulative reduction in parameters were observed in final effluent (S4).The maximum reduction 95.4 % was observed in TSS followed by NH₃-N, COD, BOD and then TDS which is 89.7 %, 86.9 %, 85.1 % and 61.2 % respectively. *Ali et,al (2005)* and *Sharif et, al (1999)* also observed maximum efficiency and found in their experiments values are enough to meet national (BD) or international (USEPA). Above reduction indicates that removal efficiency ranges between 61.2 % to 89.7 % which is quite high Table -5.1(Annex.5).

The comparison of these parameters was showed in Table 5.2(Annex.5). It was observed from the table that primary tube settler having more reduction than aeration tank except BOD and COD. In primary tube settler removal of TDS is 58.4 %, TSS 85.83 % as the removal of TDS was more than the BOD and COD reduced to 33.89 % and 38 % respectively. Whereas in case of aeration tank reduction of TDS is only 2.3 % and TSS 21.17 %, due to this reason

BOD and COD found increased which was 64.55 % and 64 % respectively. In secondary clarifier 61.09 % maximum removal was observed followed by TSS, NH₃-N, BOD and TDS which was 59 %, 42.85%, 36.6% and 4.5 respectively. The data given in this table showed that industries A, B, C, D and E showed different efficiency. The industry A having the poorest efficiency as all the parameter removal efficiency lesser than the 50 % except, TSS (86.4 %). Industry B showed improved efficiency in treatment where as other industry C & D having good improved efficiency. The industry E had maximum good removal efficiency in all parameter in all sampling locations which ranges from 61.2 % to 95 %. So, it was concluded that the parameter COD, BOD, TSS, TDS and NH₃-N reduced significantly to a greater extent to C, D, E industry due to biological treatment. *Desai and Kore (2011)* also studied the performance evaluation of textile industry and found that BOD, COD reduced significantly whereas TDS reduction was very small

Table 4.1: Removal efficiency of Primary Settling Tank

Primary Settling Tank	BOD	COD	TSS	TDS	NH ₃ -N
A	5.71	19.49	30.16	3.63	17.97
B	22.01	4.41	7.94	29.44	21.42
C	17.24	46.07	24.68	28.61	28.88
D	18	14.19	50.37	16.85	39.28
E	33.89	38	85.83	58.4	67.94

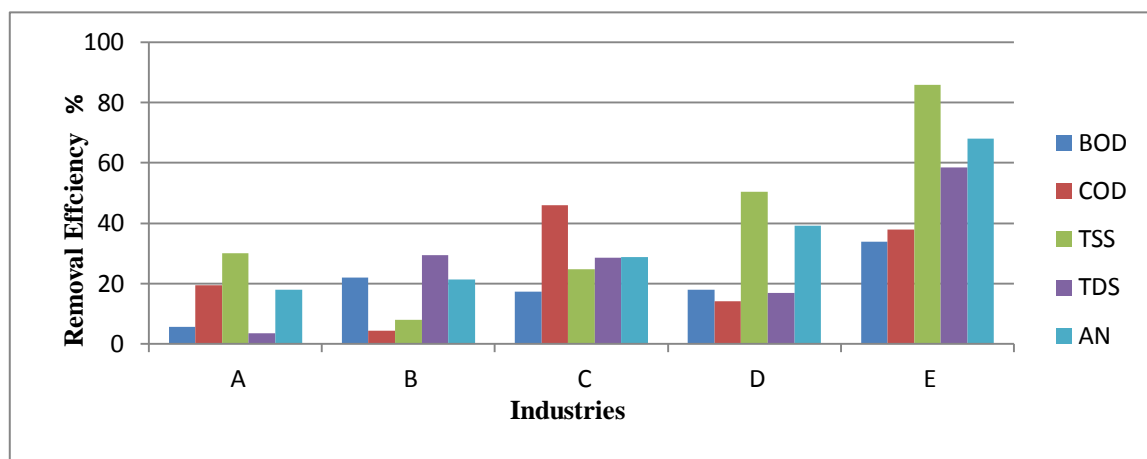


Figure 4.1: Performance of Primary Treatment in ETPs.

4.3 Characteristics of Wastewater Effluent to Primary Treatment

Table 4.1 shows the summary of results of efficiency of primary treatment unit in each industry. From the result it can be conclude that the TSS removal efficiency of tube settler is 85 percent so other industry should adopt tube settler concept for suspended solid removal. Performance of industry E and D showing positive performance which has high removal rate as compared to the result of industry A and B. Overall, All the values (BOD, COD, TDS, TSS, and NH₃-N) are decreasing but not shown removal as expected. It can be concluded that the tube settle have high suspended solid removal efficiency as compared to Normal primary settling Tank

Table4.2: Removal efficiency of Aeration Tank

Aeration Tank	BOD	COD	TSS	TDS	NH ₃ -N
A	5.44	4.9	2.19	3.67	27.39
B	45.93	64.8	18.7	29.44	21.42
C	47.91	30.48	13.9	4.7	15.6
D	58.53	55.69	22.42	25.34	85.52
E	64.55	46	21.47	2.3	44

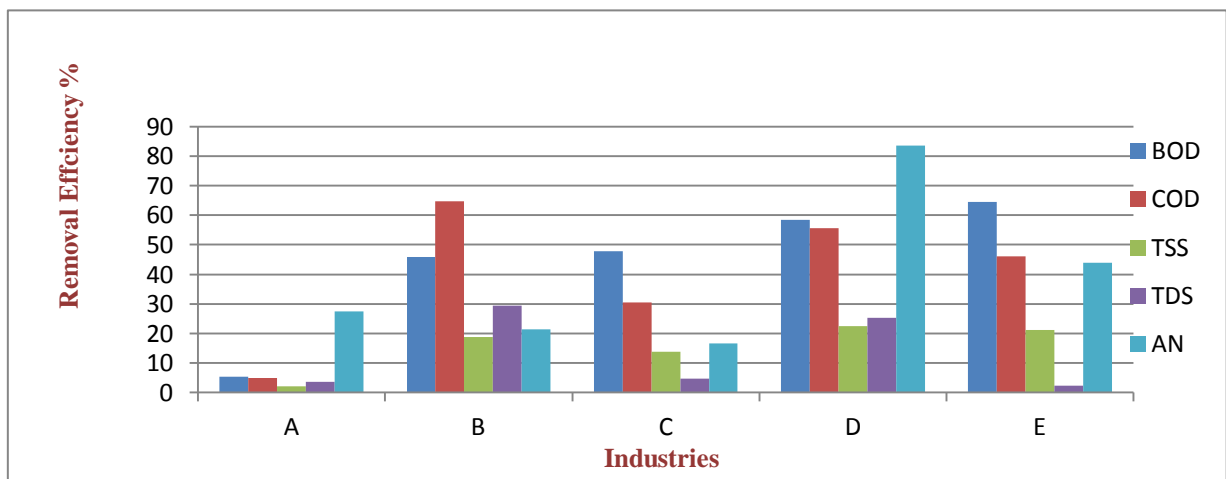


Figure 4.2: Performance of Aeration Tank in ETPs.

4.4 Characteristics of Wastewater Effluent to Aeration Tank

The aeration tank in all the effluent treatment plants is considered a most important step in activated sludge process and the priority was intended to increase the dissolved oxygen level of effluent for efficient aerobic decomposition of organic matter. Efficiency of the aeration tank was calculated by considering percentage reduction of BOD, COD, TDS, TSS and NH₃-N. The percentage removal of BOD in aeration tank of treatment plants A to E is 5.44%, 45.93%, 47.91%, 58.53%, 64.55 % respectively against the expected value of 70-85%, illustrating that BOD reduction is lower than the expected. This slight decrease is attributed to the recycling of old sludge that contained fewer microorganisms, besides insufficiency of MLSS for the aerobic digestion of the organic matter. It is also concluded that recirculation of activated sludge is not provided in certain industry. Similarly The percentage removal of COD in treatment plants of A,B,C,D,E is 4.9 %, 64.8 %, 30.48 %, 55.69%,46 % respectively is less than the expected. Likewise, The percentage removal of TSS in treatment plants of A, B, C,D,E is 2.19 %, 18.7 % , 13.9% 22.42% 21.47%.From the results it can be concluded that performance of aeration tank is not proper as much expected. So by proper monitoring biological parameter, maintaining F/M ratio and by addition of fresh nutrients can be helpful to achieve the desired performance of aeration tank.

Table-4.3: Removal efficiency of Secondary Clarifier

Secondary Clarifier	BOD	COD	TSS	TDS	NH ₃ -N
A	6.59	29.87	76.90	0.96	7.54
B	32.74	24.81	44.24	2.63	72.72
C	31.42	29.42	16.15	11.10	44.4
D	19.11	68.69	45.31	7.4	40
E	36.6	61.09	59	4.5	42.85

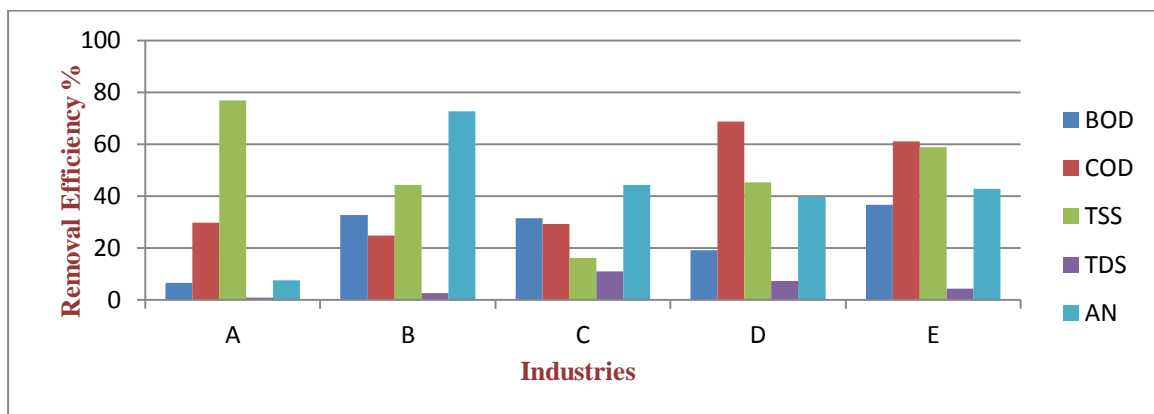


Figure 4.3: Performance of Secondary Clarifier in ETPs.

4.5 Characteristic of wastewater effluent to secondary clarifier

Table 4.3 shows the performance of the Secondary Clarifier in ETP of Different Industry. The efficiency of BOD, COD, TSS, TDS, and NH₃-N removal for the Secondary Clarifier were observed t he suspended solid removal for the secondary clarifier are 76.90 %, 44.24 %, 16.15%, 45.31%, 59% for Industry A,B, C, D, E respectively. The BOD removal for the Secondary clarifier are 6.59 %,32.74 %,31.42%,19.11%,36.6% for Industry A, B, C, D, E respectively. The COD removal for the Secondary clarifier is 29.87 %, 24.81 %, 29.42%, 68.69%, 61.09 %. The TDS removal for the Secondary clarifier are 0.96 %,2.63%, 11.10 %, 7.4%, 4.5% It can be concluded from these results that the suspended solids removal decreased due to the organic shock loads and not providing sufficient settling time. *Choudhary and ojha (2012)* found 50 % reduction in BOD in aeration tank in first 1 hr and rest with in 6 to 8 hr. Other parameters also found better in the name of removal of pollution.

4.6 Removal efficiency of Wastewater Parameters to Different Units.

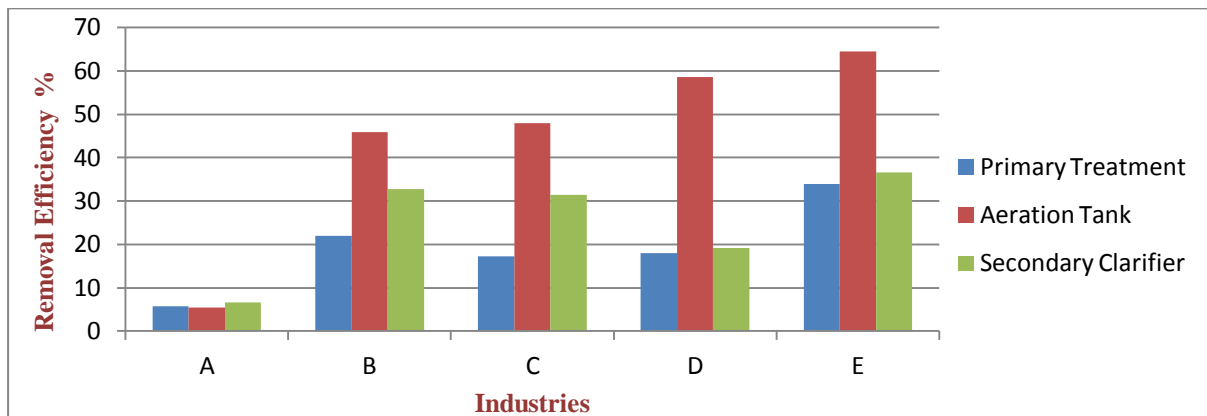


Figure 4.4: BOD removal at different Units

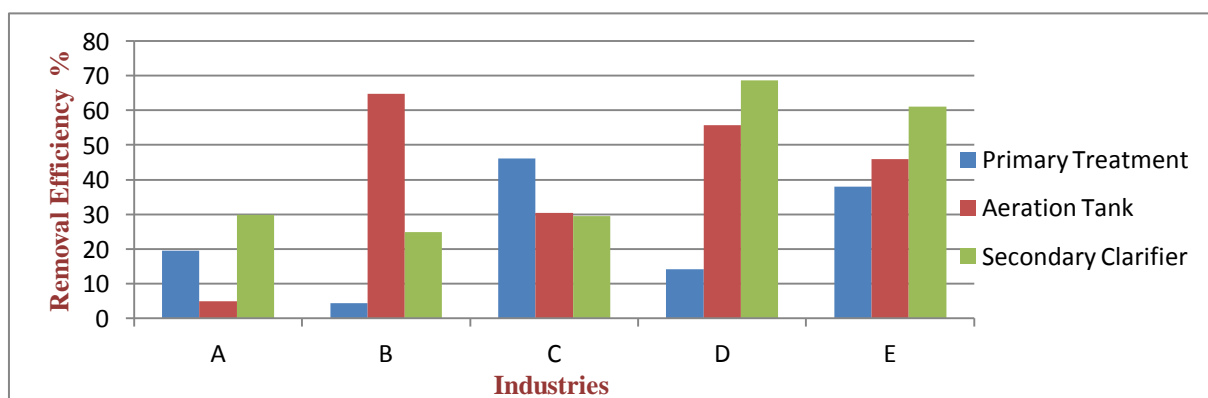


Figure 4.5: COD removal at different Units

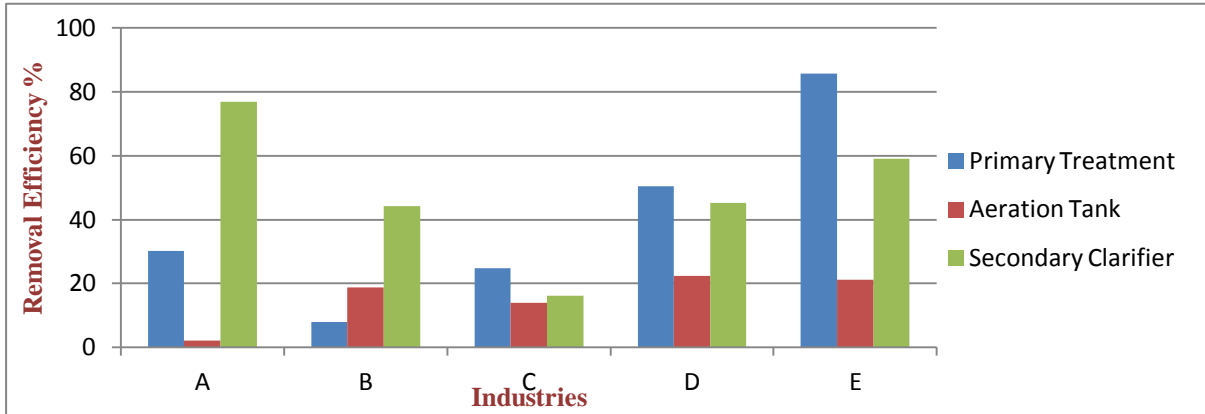


Figure 4.6: TSS removal at different Units

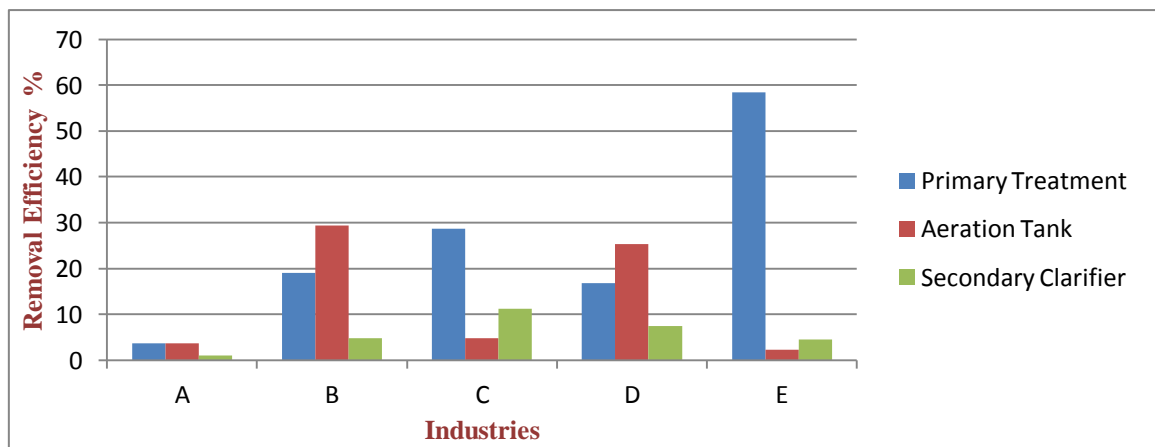


Figure 4.7: TDS removal at different Units

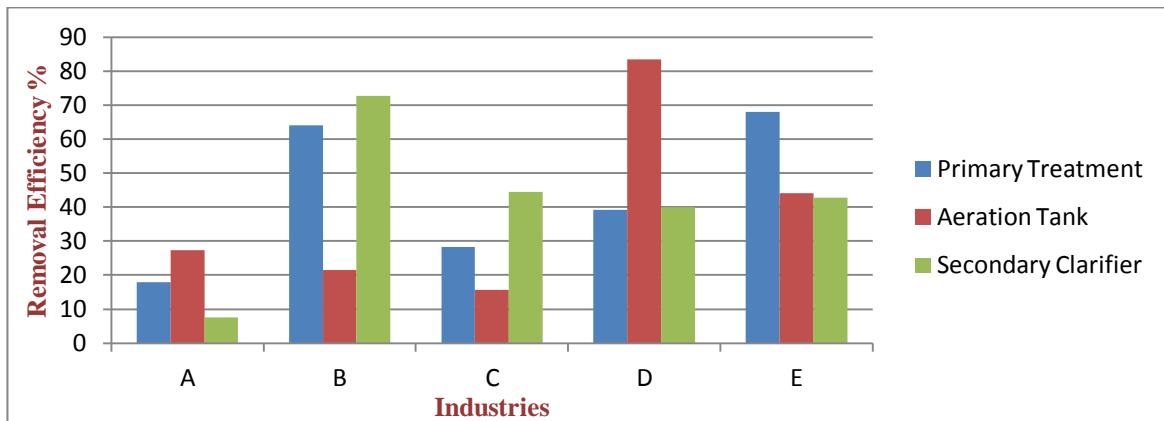


Figure 4.8: NH₃-N removal at different Units

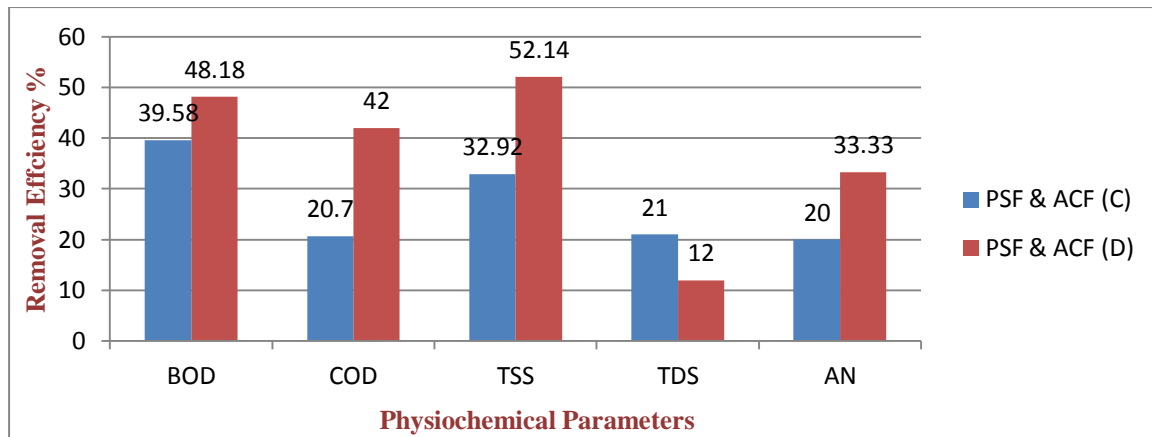


Figure 4.9: Performance of filtration Unit for industry C&D

The organic compounds in the effluent can be removed by primary and secondary treatment but complete removal is not possible in these processes, hence the effluent passed to tertiary treatment processes. The pressure sand filter is filled with sand and water, which is allowed to pass through under pressure. The application of pressure over the sand facilitates the settlement of solids and organic matter in the sand and after that effluent is passed through the adsorbing medium like activated carbon filter. Activated carbon has the ability to reduce the level of organic matter as well as levels of specific trace organics, colour and odour. Hence, considerable amount of organic matter is removed from the effluent, when it is passed through the activated carbon filter. Here in this study, industry C & D are using pressure sand filter and activated carbon as a tertiary treatment for the effluent treatment plant. Percentages of reduction in tertiary treatment (Industry C & D) for BOD, COD, TSS, TDS, NH₃-N are shown in a figure 4.9.

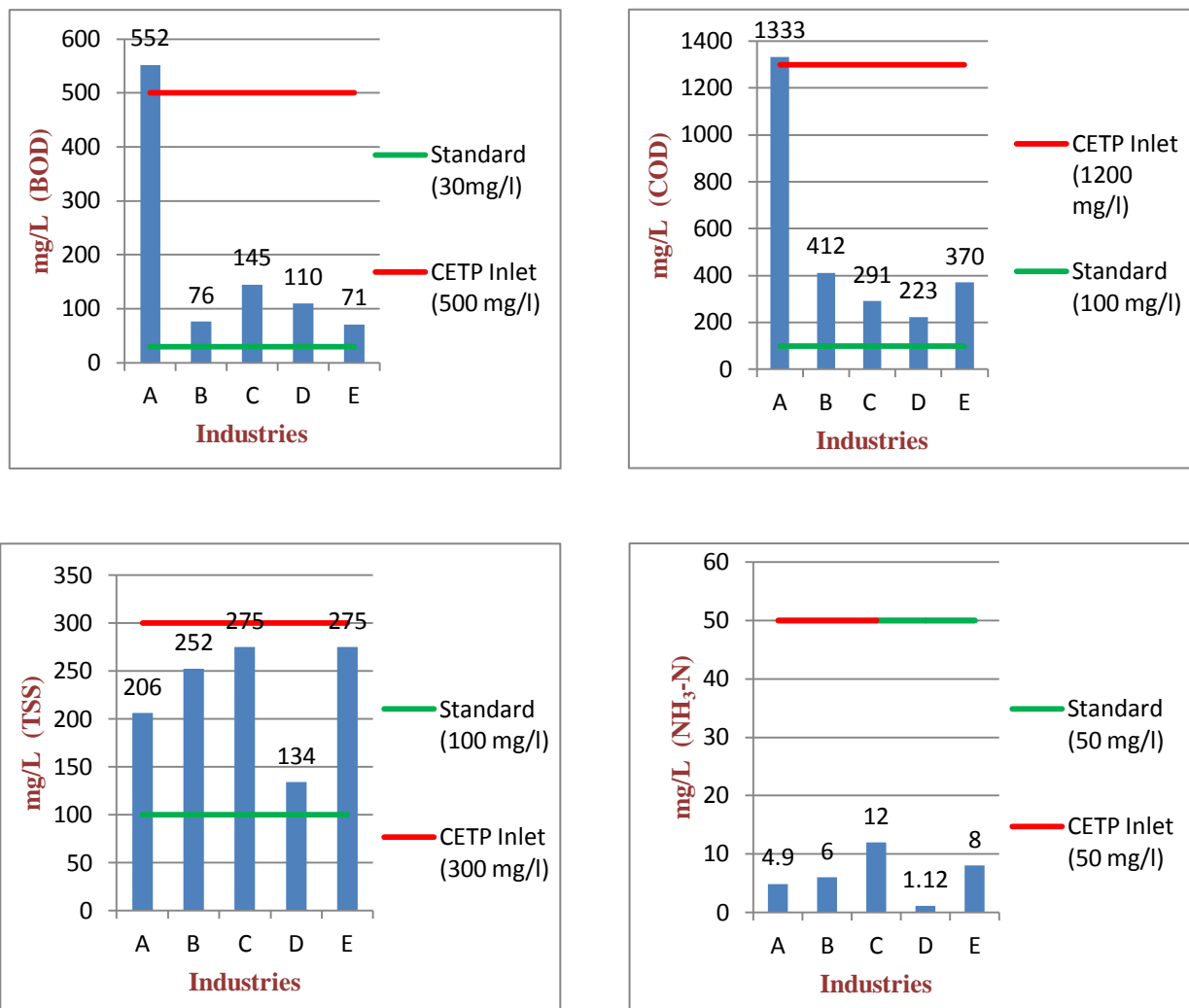
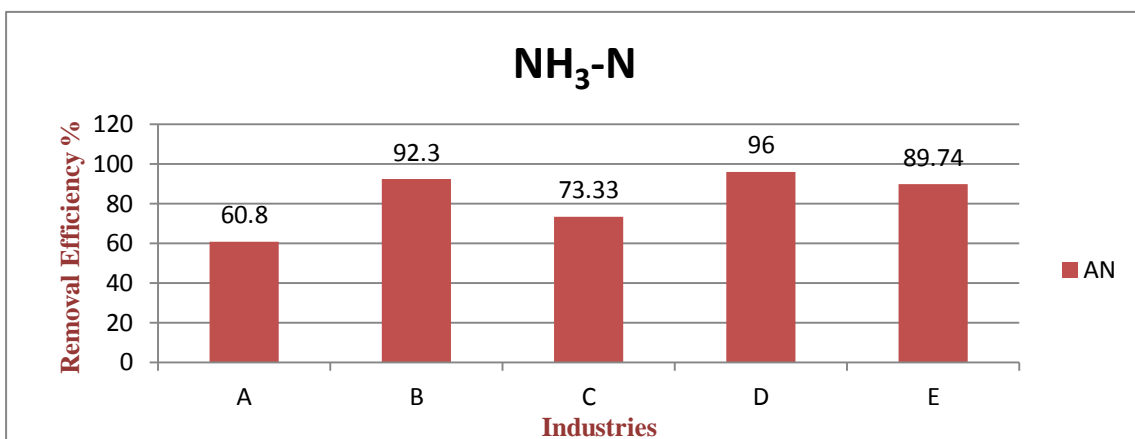
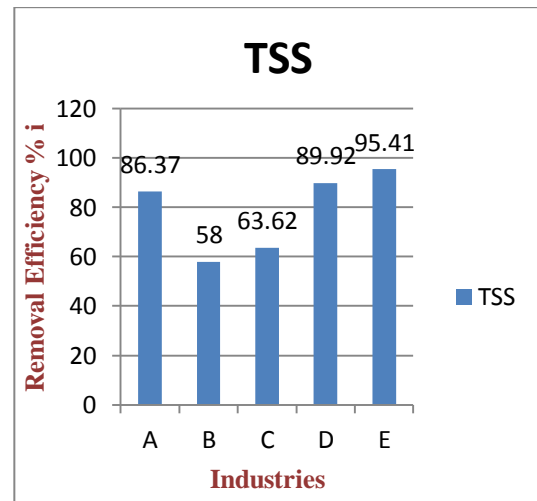
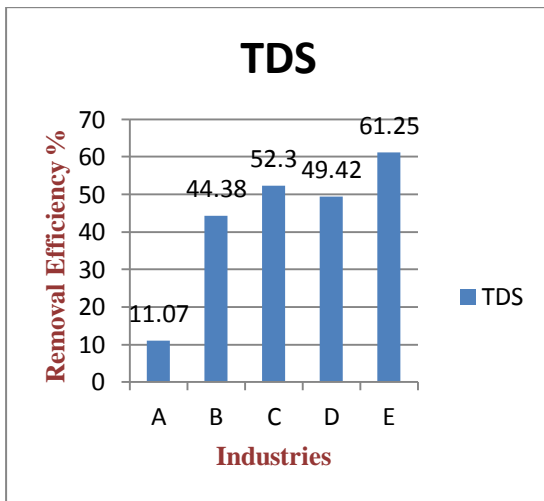
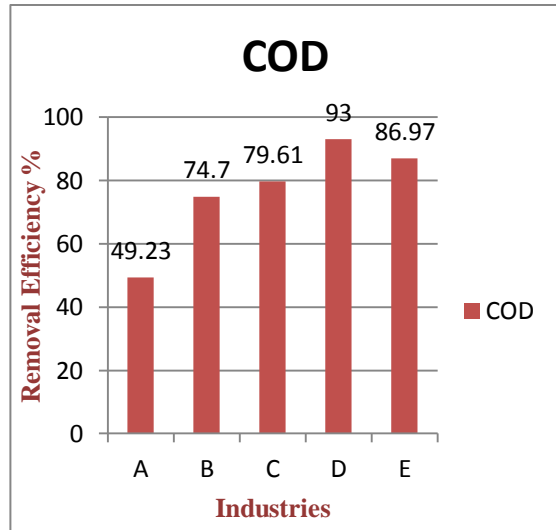
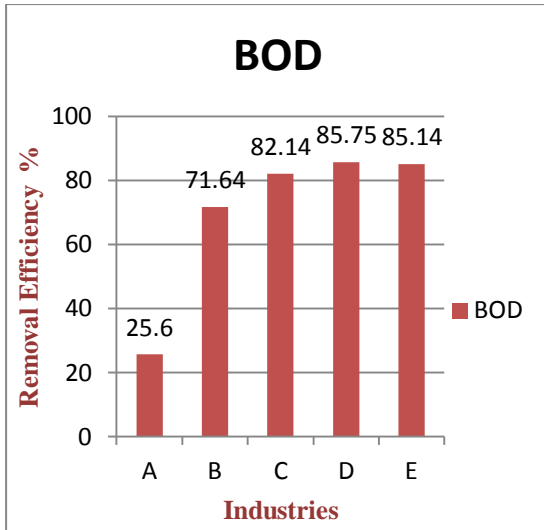


Figure 4.10: Comparison of mega pipeline inlet standard with CETP inlet Norms

4.7 Comparison of treated effluent with the discharge limits of GPCB & Proposed CETP Inlet Norms

From the above graph it is observed that all the industries which treat the wastewater not complying with the Gujarat Pollution Control Board norms for the inlet to Mega pipeline but the treated physiochemical parameters of effluent are under the inlet norms for the proposed CETP. So, the proposed CETP at narol is one of the best option available as it is technical feasible and financially viable with the financial support from the central and state government .But , prior to construction of CETP, proper planning of CETP is required in terms of technical solutions ,appropriate business and management models.



4.8 Overall Treatment Efficiency of the Five Effluent Treatment Plant

Overall efficiency of effluent treatment plant (Figure 4.8) calculated by knowing the inlet and outlet parameter of wastewater at ETP of Industry and result showed that BOD₅ and COD reduced through the system the concentrations were still above the GPCB effluent discharge standards in the final effluent. TDS, TSS also show removal throughout plants but concentrations were still above the GPCB effluent discharge standards in the final effluent. Efficiency of Industry D for BOD and COD removal is high among but the values are above the GPCB standards and there is a lowest efficiency found in the industry A for COD and BOD removal. This means that there is scope for improvement through better operation of the plant.

4.9 Analysis of Physiochemical parameter at outlet of mega pipeline

Table 4.4: Analysis of pollutants at mega pipeline outlet

	pH	DO	BOD	COD	TDS	F.Coliform	T.Coliform
Hansol bridge	8.32	6.5	1	4	162	43	120
Vasna barrage	7.5	1	Error	182	990	700	1100
Mega pipeline	8.1	0	150	690	3180	1700	5000
Gyaspur	7.6	0	8	272	1260	3000	9000
CPCB discharge limit(Inland Surface Water)	5.5-5.9	-	30	250	-	-	-

Source: The times of India, Ahmedabad, and Friday, April 5 2013

F: Fecal T: Total

The above data are from the times of India dated 5th April, 2013. It is being observed that majority of discharge of effluent is being done without satisfying the norms formed by central pollution control board.

The average pH ranges between 7.7 - 8.32 and DO found nil in all the places. i.e Vasna barrage, Mega pipeline, Gyaspur whereas Hansol bridge is 6.5, this was the reason that BOD and COD is 1 mg/L and 4 mg/L respectively. In Vasna barrage the DO is 1, it indicated that oxygen is not sufficient to degrade the organic waste and some error observed in BOD and

COD is higher than Hansol Bridge. Lesser no. of F.Coliform and T.Coliform is unexplainable. Some trend was observed in mega pipeline and Gyaspur the DO is nil and BOD, F.Coliform and T.Coliform are abundant in all 3 places.

The main problems experienced by Industries with ETPs are inadequate treatment due to incorrect dosing of chemicals required in the treatment process or inactivity and even death of necessary micro-organisms, insufficient oxygen or lack of nutrients. It may be necessary to ensure that the biological treatment unit are adequately aerated and that the correct nutrient composition is being added to “feed” the bacteria, as textile effluent contains very little of the nutrients, including nitrogen and phosphorus, required for a healthy and active bacterial population. Maintaining the purity of the chemical nutrients used is also very important in order to avoid an increase in TDS. Effluent treatment plants could potentially be modified to receive urine from the toilets (or the liquid portion of septic tanks), which would provide the nutrients without the needs for chemical dosing.

The design of biological treatment systems based on bio kinetic parameters will have a better control over the biological community in the system and process so as to achieve better treatment efficiency. All of these can be addressed through better management; usually chemical dosing. By regularly monitoring and understanding their wastewater properly ETP managers or Operator can make effective decisions to achieve optimal ETP functioning.

When the effluent values and discharge standards by GPCB are compared except TDS in industry B & D and ammonical nitrogen in all industry are complying with the discharged standard. Rest of the effluent values not complying with the discharged standards. It is possible that advanced treatment technologies might be used to treat the wastewater from these industries to a quality that could allow reuse of wastewater. It is a priority to consider the advanced treatment technologies along with the source reduction of waste rather than limiting the treatment to single-stage. Like in the European countries, many firms in textile industry are concentrated on the use of environmentally friendly chemicals and processes that use less water. It is imperative for us to carry out similar studies and to keep up with the technological developments. In addition, it is necessary to have educated and skill operators to run the treatment facilities. Moreover, the industries that need to pay the maximum attention to prevent pollution should be encouraged by the local and central authorities.

4.10 Problems identified at ETPs

Based on Site visit and discussion with plant operators the following points are noted and some problems were also identified.

- Spent Acid is used to maintain pH.
- ETPs are overloaded with incoming wastewater. Shock load is identified at each unit so buffer collection tank to be provide.
- Not provided sufficient residence time in primary as well as secondary treatment in ETP.
- Tertiary treatment (Pressure sand filter and activated carbon filter) are provided but due to maintenance unavailability they are not in working condition.
- Optimum dosing of chemical or coagulants is not provided.
- Nutrients are not added in the aeration tank for efficient biological treatment.
- Some plants are deficient with the screening unit, oil and grease trapping unit as well as equalisation tank.
- No sludge recirculation system provided in aeration tank to maintain the desired F/M ratio
- Provision of reaction tank or chemical dosing tank is not available for better mixing.
- There is no well established ETP laboratory so lack of proper monitoring of the treatment process

Problems:



(Problem in industry C)

A



(Problems in industry B)

B

A. Dry leaves of Trees nearby ETP which falls into the treated sump (After Secondary Clarifier) which may be act as barriers for further tertiary treatment.

Solution: a small mesh size of 2 mm to be provided on secondary treated sump so falling of leaves can be prevented.

B. Plastic bags, Bottles and waste clothes are collected in collection tank ,also floats in collection tank. And from the collection tank the wastewater is pumped into the flocculation tank via reaction channel. Pump Failure is observed during the monitoring and sampling period. Plastic bottles and waste matter sometime clog the pipe is also the reason of pump failure.

Solution: Percolated screen should be placed in the final manhole chamber in the effluent line entering the ETP before collection tank. At the Inlet point of all ETPs a screening chamber will be Require. This chamber removes large size floatable and Suspended Solids Such as Polythene, cloth, wooden Parts, and other garbage.

C. Foaming Problem in Aeration Tank



(Problems in industry A)



(Problems in industry E)

Foaming in aeration tank caused by the accumulation of slowly, biodegradable, hydrophobic materials that cannot be discharged to the final sedimentation tanks. Hydrophobic materials that cannot be discharged to the final sedimentation tanks. Hydrophobic materials in wastewater are attracted to the lipids on the bacteria surfaces. The slowly biodegradable hydrophobic materials accumulate with time and produce a scum on the surface of the aeration tank unless the tank has been designed for continuous removal of surface scum. Air bubbles become trapped in the scum, making it difficult for the scum to be mixed with the activated sludge moving around the aeration tank. The air bubbles also create an aerobic environment of poorly degradable, hydrophobic materials, stimulating the growth of *Nocardia*. The net effect is that *Nocardia* grow as a result of foam rather than being the cause of the foam. *Nocardia* is an organism that finds the foam a perfect environment for growth.

Probable cause of Foaming

- Low F/M ratio in the aeration tank
- Old sludge
- High MLSS due to insufficient sludge wasting
- low dissolved oxygen in the aeration tank
- Insufficient nutrients: Especially quantity of nitrogen and phosphorus important, also absence of trace element cause bulking.

Solution:

Addition of Coagulants: Polyaluminium chloride or cationic polymer addition at doses in the 3.5 to 4.5 g kg⁻¹ MLSS resulted in a 75-100 % reduction of the sludge foaming potential. PAC addition caused no inhibition on autotrophic and heterotrophic bacteria that perform nitrification and organic carbon removal, respectively *Mamais et al., (2011)*

D. Operation and maintenance of ETPs is most important thing for efficient operation of ETPs. During observation at industries it is found that the ETP operator are not skill person neither have any qualification. They are just metric pass or below metric level of education. So, a qualified and educated ETP operator would be able to optimize the treatment process and potentially save money by reducing the chemicals and energy needed to run the system.

CHAPTER 5

Conclusion and Recommendation

5.1 Conclusion

Based on the results obtained from this study, the following points are concluded:

1. At present, most effluent treatment plant of textile industry in narol textile cluster have low performances.

The main reasons for plant failure are:

- Overloading to the existing treatment plant's capacity.
- Lack of skill for operation and maintenance for ETPs.
- The operating conditions are different from designed values.

2. Lack of adequate equalization leads to fluctuations in quantities and quality of effluent in various treatment units of ETP, due to which the treatment unit may not perform as desired.

3. Poor performance of primary and secondary settling units often leads to overall poor performance of ETPs.

4. some of the problems are identified during study can be easily solved by applying necessary solution mention in this report.

5. Installation of Tertiary treatment Unit is just for eye watch but not in operational condition.

6. Result shows that There is a strong requirement of managing wastewater generated from the small scale industries and CETP is one of the best option available as it is technical feasible and financially viable with financial support from both central and state government. But, prior to construction of CETP, proper planning of CETP is required in terms of technical solutions, appropriate business and management models.

5.2 Recommendation

Based on the plant monitoring and analysis of major physiochemical parameter of the ETPs the following common suggestions are required to improve the performance and maintenance of ETPs. Mostly suggestions are cost effective and easily implementable with the present condition of the effluent treatment plant.

Screening

Inadequate screening can limit plant performance and capacity, and greatly increase O&M requirements. Although some ETPs it is found that wire mesh size at the inlet of effluent but it is not proper in working condition and clogging of screening unit also observed. So Screen cleaning should be done at regular interval and scum/solid materials collected at the screens of the open channel has to be regularly removed to avoid the chocking of effluent flow. And where there is lacking of screening unit it is recommend that to install screening unit for efficient operation of ETP.

Flow Segregation

Most wastewater leaving a textile industry needs treatment before it can be reused in any way. However, there are waste streams that can still be reused without treatment, but this requires segregation of the streams from the different wet processing area. It was observed during the time spent at the industries that the wastewater from industries was not segregated and this poses a problem in reusing any of the streams without treatment.

On the other hand, the rinsing operation produce wastewaters with lower solids content and it might be of a good practice to segregate the wastewater from different operations entailed in industries in order to reuse the rinsing wastewaters. This will have savings on the company's wastewater production as well as treatment costs because specific rinsing water can be reused as process water for a preceding operation; that is, rinsing water. In the textile wet processing industry there are several different distinct stages, for example, scouring, neutralization, dyeing, acid wash, softening and rinsing. Wastewater discharged from different stages has different characteristics. Some streams are alkaline in nature, some are acidic and some are almost neutral. According to the characteristics of different waste - stream the textile effluent can be classified into two types: highly polluted streams and less polluted streams. If wastewater from different stages can be segregated in terms of highly polluted and less polluted, then these two streams can be treated according to their characteristics, and that can

lower the running cost of the ETP. For example, wastewaters with lower COD and BOD can be treated only biologically; on the other hand highly polluted waste streams are to be treated both physico-chemically and biologically. As example, effluents with high colour and suspended solids need physico - chemical treatment and those with low concentrations of soluble pollutants may only need biological treatment. The research on flow segregation was undertaken with two textile - dyeing industries, one with dye fabrics with manually operated machines and other dyes with semi - automated machines. Samples were collected from the dyeing machine outfall at each stage and analysed. On basis of the test results the effluent was classified as highly polluted and less polluted.

After analysis of the sampling results several steps of textile dyeing sequence several steps in the process were identified as highly polluting: scouring, hot wash with soaping agent, neutralization or acid wash, enzyme wash, dyeing. These steps are recommended to be treated both physio- chemically and biologically. The rest of the steps are less polluting with relatively low BOD, COD, suspended solids, colour, and a low COD/BOD ratio (suggesting they are relatively degradable) and it should be possible to treat these solely by biological methods at controlled pH .

Optimize the Chemical Dosing

For effective treatment the chemical dosing should be optimum. To optimize the chemical dosing and set the dosing rate it is important the industry undertakes a jar test, which assesses the correct dosage of coagulants in daily practice and helps maintain the optimum dosage in the daily operations of the ETP. It was found that ETP operators often use more chemicals for highly coloured effluent and comparatively less chemicals for less coloured effluent. But visually clear effluents sometimes show more pollutant than the coloured effluents.

Using the Better Coagulant

The key advantage of PAC using the chemical coagulation is the cost effectiveness and produces larger and more readily settle able flocs than alum Using the PAC as a coagulants it is much effective for the removal of COD and BOD. Optimum dose for the PAC is 45 mg/l and which accounts for the 83.34 % BOD Removal and 64.04 % COD Removal. The sludge volume generated by PAC is less than that generated by alum. This coagulant has the

advantage of being more effective at lower temperatures and a boarder pH range than alum. *Solanki et al., (2013).*

Use of Combined Silt and Oil Trapping Tank:

Oil in textile based effluent causing treatment problems such as bulking of sludge, Death of aerobic bacteria, formation of flocs. It is also reported at ETP of Industry 1 and 3. Upstream to Downstream effluent flow of this tank settles the Maximum Silt and Suspended Solids. With this tank an extra attachment is Oil and Grease Trapping Machine can also be operated. Oil skimmer removes floating oil and Grease from incoming effluent, aerobic bacteria in aeration tank mostly affect by Oil, and so it is very important to remove that. (*Choudhary et. al, 2012*).

Enhanced settling by Preaeration

Pre aeration of raw wastewater before settling promoted flocculation of finely divided solids into more readily settle able flocs, thereby increasing suspended solids and 5-Day BOD removal efficiency. Pre aeration also improves scum floatation and removal. Other benefits include scrubbing volatile organic chemicals from raw wastewater, adding of dissolved oxygen, and preventing septicity during primary settling. A grit chamber with pre aeration before each settling tank also promoted uniform distribution of flow to settling tanks. Detention time of 20-30 minutes is necessary for floc formation and improved suspended solids and BOD₅ removals. This range is more than the 10 to 15 minutes suggested for odor control. The exact quantity of air required is a function of wastewater characteristics and tank geometry. The minimum air rate provided is $0.99 \text{ m}^3/\text{m}^2$.

Installation of Tube Settler

Inclined surfaces in a settlement tank increase the effective surface area available for settlement and also increase efficiency by more closely approximating to ideal settlement theory. The increased surface area is provided by a series of inclined plates (lamellae) or tubes (which may be circular, square, hexagonal or other) occupying up to 70% of the tank depth and lying less than 30cm beneath the water surface. Typical tube size or diameter is 25-50 mm. They are set at an angle between 40° to 60° so that settled sludge falls to the base of the tank from where it may be removed by conventional methods of de sludging. Providing an increased available surface area can result in:

- The use of a smaller tank thereby saving capital costs; and
- An increased capacity in an overloaded tank by retrofitting.

Tube and lamella settlement tanks should be frequently drained down and the plates or tubes cleaned to remove any accumulated material. Tube and lamella settlers are commonly used with package plants on a small scale in order to economise on space and costs. Due to a lack of storage capacity they may require more frequent desludging than other systems. They may be installed in circular settlement tanks but are more frequently used in new rectangular units. Tube settler offer an inexpensive method of upgrading existing wastewater treatment plant clarifies and sedimentation basin to improve performance. They can also reduce the tankage footprint required in new installation or improve the performance of existing settling basins by reducing the solids loading on downstream filters. Made of lightweight PVC, tube settlers can be easily supported with minimal structures that often incorporate the effluent through supports.

Nutrient addition

The biological activity of sludge flocs and their settling characteristics are affected by the composition of the untreated effluent and particularly by the presence of nutrients such as ammonical nitrogen and phosphorus. Maintain a BOD:N:P ratio of approximately 100:5:1 to provide the optimum nutrient balance for microbial growth. Exact nutrient ratios are site-specific and may differ in practice. Monitor nitrogen and phosphorus levels in the effluent entering and leaving the activated sludge plant to ensure that sufficient nutrients are present. Ensure an excess of at least 1 mg/litre of ammonical nitrogen and phosphorus in the effluent leaving the plant. Review nutrient addition levels regularly and adjust dose rates to optimise the use of chemicals.

Treatment of textile wastewater in activated sludge system with low food-to-micro organism's ratio (F/M)

Textile wastewater is a mixture of many different chemical compounds. These can broadly be classified into easily biodegradable, hardly biodegradable (recalcitrant), and non-biodegradable. The recalcitrant materials require a low F/M ratio (<0.15 kg BOD₅/kg MLSS. D. Almost complete nitrification is also achieved with low F/M ratio. *EPA, (2008).*

Treatment of textile wastewater using biological activated sludge method combined with coagulation

The wastewater treatment plant (WWTP) in the pilot scale and the reality (1000 m³/day capacity) of Xuan Huong Textile Co. was investigated and built by a combination between the activated sludge treatment and the coagulation-flocculation method. The analyzed wastewater results showed the effective performance in the COD and TSS removal. With $\geq 80\%$ removal efficiency for all factors, our chosen technology was proved as a right choice in textile wastewater treatment. The effluent meets Vietnamese standard TCVN 5945:2005, C level. (Source: www.congnghexanh.com.vn).

Water Conservation Measures

Fresh water is used for preparing lime slurry, and ferrous sulphate and other chemical solutions. In place of the fresh water, treated effluent can be used for the preparation of these chemical solutions. This can conserve water and reduce the expenses associated with the purchase of water.

Advance Oxidation Process (AOP)

High TDS effluents interfere with the oxygen transfer necessary for biological metabolism and there by affecting the efficiency of the activated sludge process High TDS effluents are more sensitive to hydraulic shock loads and prone to process upsets. Another method of removing colour and COD of textile mill effluents is electrochemical oxidation. *Miled et al.*, (2010)

Sludge Thickening and Dewatering

In the sludge drying bed dosing cationic Polyelectrolyte in sludge cause compact formation of sludge and controlling the leaching of Heavy metal and other toxic matter into ground water.

Table- 4.5: Adoption of cleaner production options in textile mills

Recommended measures	Environmental benefits
Caustic recovery from mercerising	50% savings in caustic consumption
Direct reuse of waste caustic from mercerising in scouring	Savings in caustic consumption
Counter current washing and replacement of nozzles at printer table blankets	50 -70% reduction in water use in washing
Pigging of dye paste from printing equipment (lance, tubes)	Reduction of dye paste emissions to water
Installation of a tray at the printers to avoid spilling	Reduction of dye paste emissions to water
Installation of shorter tubes between paste drums and printer	Reduction of dye paste emissions to water
Addition of displacement bio-dies in dye/finish equipment	Reduction of water and chemicals consumption
Introduction of pad batch dyeing system	Saving of chemicals and water Prevention of chemicals emission
Application of reactive dyes with higher fixation degrees	Prevention of dyestuff emission
Reduction of dye paste losses by in-line dye paste dosing	Reduction of dye paste losses and emissions to water
On-line conductivity measurement in washing process	Reduction of wash water Better utilization of equipment
Installation of automatic water shut down valves	5-10 % savings in water consumption and discharge
Reuse of Boiler off-gas	Savings in energy consumption
Reuse of off-gas in the drying sections of the rotary printers	Savings in energy consumption
Reuse of energy from blow down with flash tanks	Energy conservation
Counter current regeneration of ion exchangers	Energy conservation Reduction in the use of regeneration salt
Treatment of boiler feed water by R O	Energy conservation Reduction in blow

	down
Heat recovery from wastewater by heat exchange	Savings in energy
Excess water removal after washing with the help of vacuum suction boxes	Reduction of water and chemical use and chemicals discharge water, chemicals
Anti-corrosion measures	Reduction of water and chemical consumption Prevention of related safety problems

Source: IISD (2003)

ANNEXURE -1

Performance monitoring data for the ETP at Industry -A

Table - 1.1 Parameter to be characterised at different sampling location of ETP

Parameters	Sampling Location				
	Raw Effluent (S1)	Inlet Primary Clarifier (S2)	Inlet Aeration Tank(S3)	Inlet Secondary Clarifier(S4)	Final Treated Effluent(S5)
P^H	10.16	8.5	7.11	7	7.16
COD(mg/L)	2626	2483	1999	1901	1333
BOD(mg/L)	742	663	625	591	552
TSS(mg/L)	1512	1306	912	892	206
TDS (mg/L)	3360	3250	3132	3017	2988
NH₃-N(mg/L)	12.5	8.9	7.3	5.3	4.9

Table - 1.2 Removal Efficiency of Industry A

	BOD	COD	TSS	TDS	NH₃-N
Flocculation Chamber (S1- S2)	10.64 %	5.44 %	13.62 %	3.27 %	28.8 %
Primary Clarifier (S2-S3)	5.71 %	19.49 %	30.16 %	3.63 %	17.97%
Aeration tank (S3-S4)	5.44 %	4.90 %	2.19 %	3.67 %	27.39 %
Secondary Clarifier (S4-S5)	6.59 %	29.87 %	76.90%	0.96 %	7.54%
Total Removal (S1-S5)	25.60 %	49.23 %	86.37 %	11.07 %	60.8 %

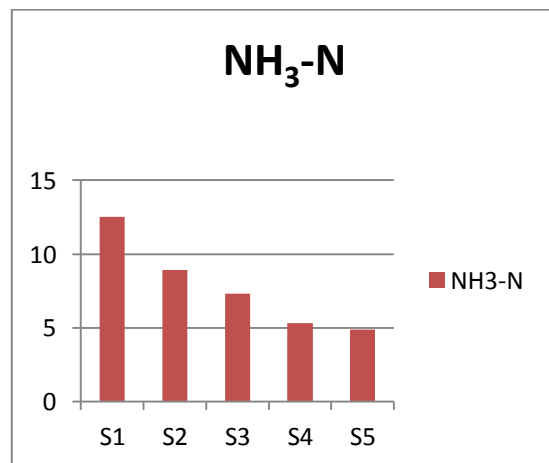
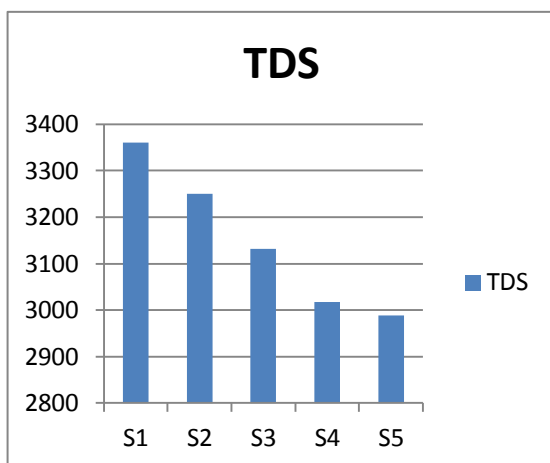
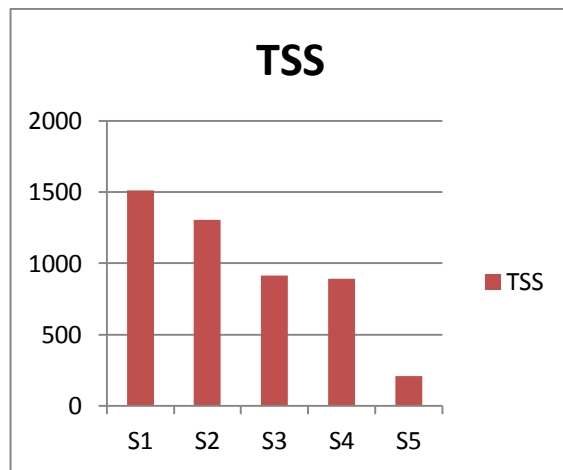
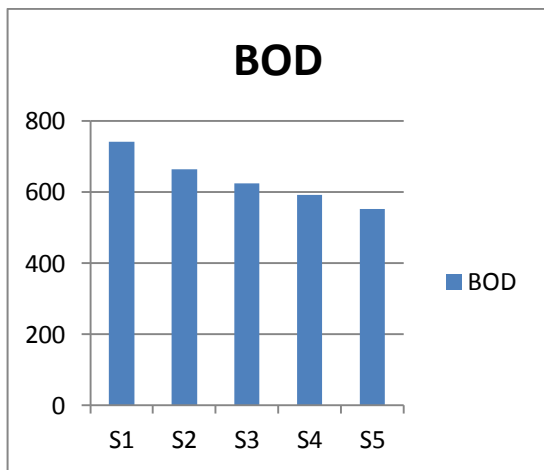
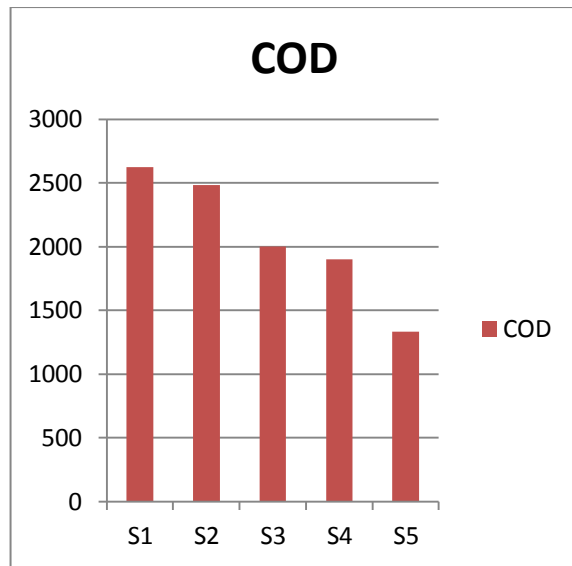
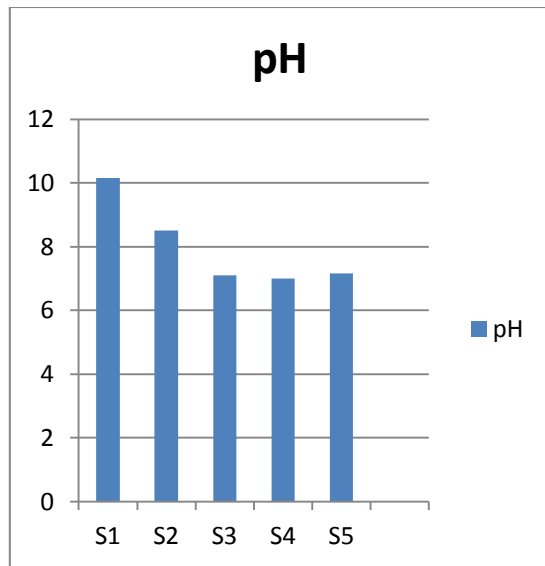


Figure -1.1: Characteristics pattern of BOD, COD, NH₃-N, TDS, TSS, pH at different unit of ETP

ANNEXURE -2

Performance monitoring data for the ETP at Industry -B

Table - 2.1 Parameter to be characterised at different sampling location of ETP

Parameters	Sampling Location			
	Raw Influent (S1)	Inlet Aeration Tank(S2)	Inlet Secondary Clarifier(S3)	Final Treated Effluent(S4)
pH	9.3	8.3	7	7
COD (mg/L)	1632	1560	548	412
BOD(mg/L)	268	209	113	76
TSS(mg/L)	604	556	452	252
TDS (mg/L)	3582	2900	2046	1992
NH₃-N(mg/L)	78	28	22	06

Table - 2.2 Removal Efficiency of Industry B

	BOD	COD	TSS	TDS	NH₃-N
Primary Settling Tank (S1- S2)	22.01 %	4.41 %	7.94 %	19.03%	64 .10 %
Aeration tank (S2-S3)	45.93 %	64.8 %	18.70 %	29.44 %	21.42 %
Secondary Clarifier (S3-S4)	32.74 %	24.81 %	44.24 %	2.63%	72.72 %
Total Removal (S1-S4)	71.64 %	74.7 %	58 %	44.38 %	92.30 %

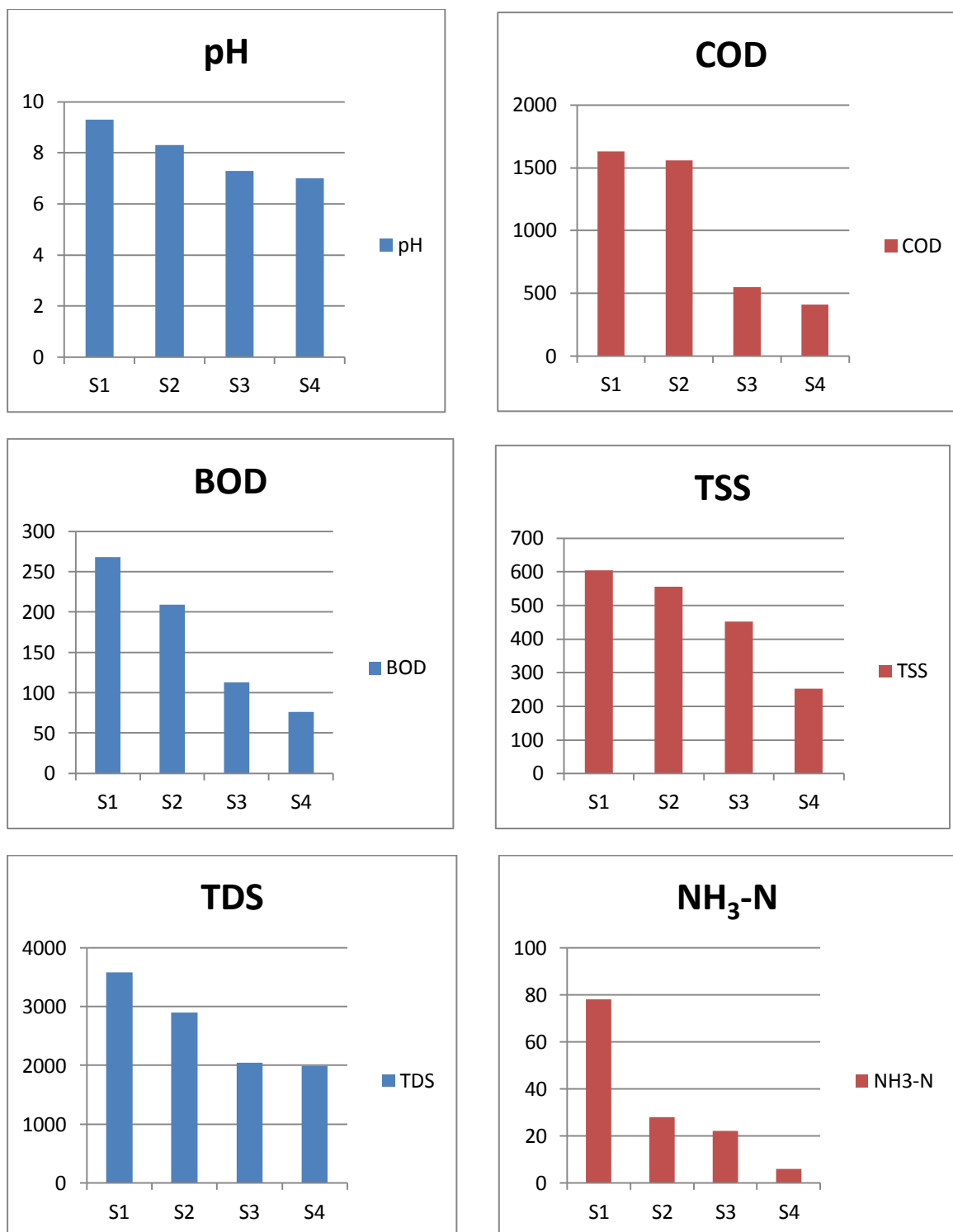


Figure - 2 .1: Characteristics pattern of BOD, COD, NH₃-N, TDS, TSS, pH at different unit of ETP

ANNEXURE -3

Performance monitoring data for the ETP at Industry -C

Table - 3.1 Parameter to be characterised at different sampling location of ETP

Parameters	Sampling Location				
	Raw Influent(S1)	Inlet Aeration Tank(S2)	Inlet Secondary Clarifier(S3)	Outlet Secondary Clarifier(S4)	Final Treated Effluent (After PSF & ACF)(S5)
pH	11	8	7.5	7	7
COD(mg/L)	1387	748	520	367	291
BOD(mg/L)	812	672	350	240	145
TSS(mg/L)	756	568	489	410	275
TDS (mg/L)	6852	4891	4659	4137	3268
NH₃-N(mg/L)	45	32	27	15	12

Table -3.2 Removal Efficiency of Industry C

	BOD	COD	TSS	TDS	NH₃-N
Primary Settling Tank (S1- S2)	17.24 %	46.07 %	24.68 %	28.61 %	28.88%
Aeration tank (S2 - S3)	47.91%	30.48 %	13.90%	4.74 %	15.6 %
Secondary Clarifier (S3- S4)	31.42 %	29.42 %	16.15 %	11.20 %	44.4%
Filter System (S4-S5)	39.58 %	20.70 %	32.92 %	21.00 %	20.0 %
Total Removal (S1-S5)	82.14 %	79.01%	63.62 %	52.30 %	73.33%

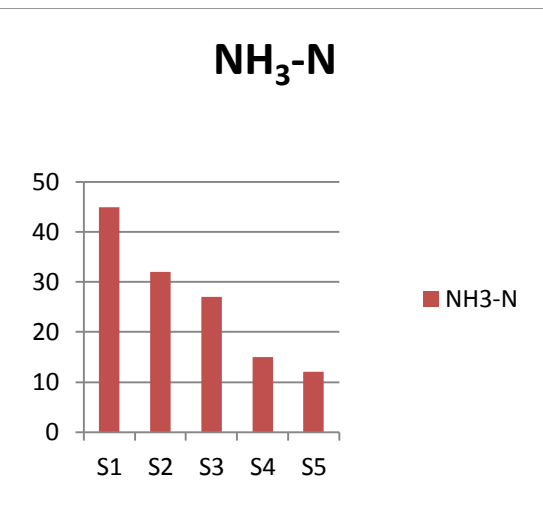
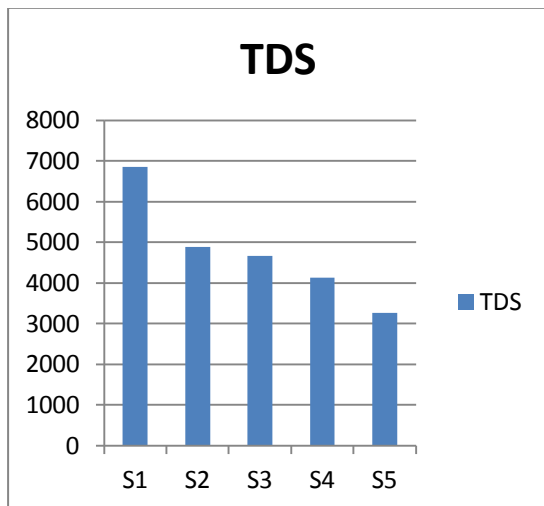
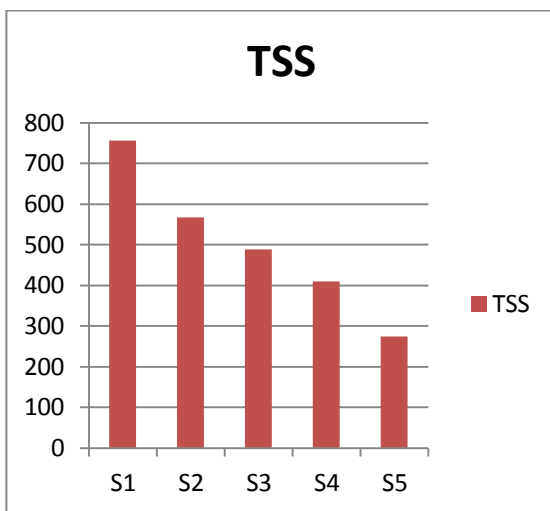
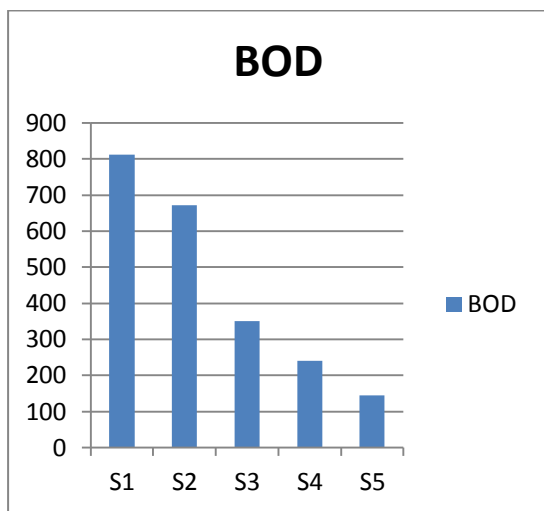
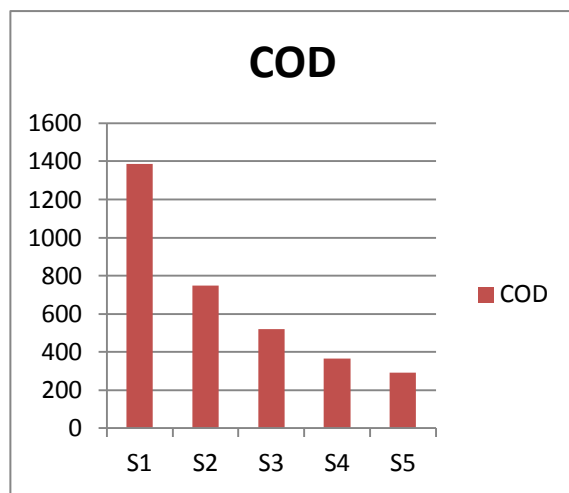
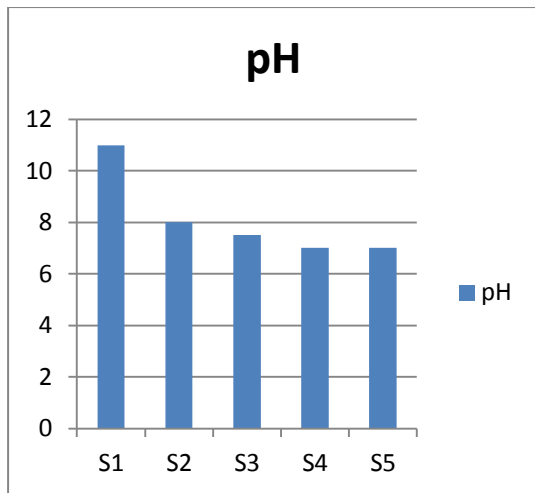


Figure -3.1: Characteristics pattern of BOD, COD, NH₃-N, TDS, TSS, pH at different unit of ETP

ANNEXURE -4

Performance monitoring data for the ETP at Industry -D

Table - 4.1 Parameter to be characterised at different sampling location of ETP

Parameters	Sampling Location				
	Raw Influent((S1)	Inlet Aeration Tank(S2)	Inlet Secondary Clarifier(S3)	Outlet Secondary Clarifier(S4)	Final Treated Effluent (After PSF & ACF)(S5)
pH	11	9.8	8	7.3	7
COD(mg/L)	3212	2756	1230	385	223
BOD(mg/L)	400	328	136	110	57
TSS(mg/L)	1330	660	512	280	134
TDS (mg/L)	2610	2170	1620	1500	1320
NH₃-N(mg/L)	28	17	2.8	1.68	1.12

Table -4.2 Removal Efficiency of Industry D

	BOD	COD	TSS	TDS	NH₃-N
Hopper Bottom Settling Tank (S1- S2)	18 %	14.19 %	50.37 %	16.85 %	39.28 %
Aeration tank (S2-S3)	58.53 %	55.69 %	22.42 %	25.34 %	83.52 %
Secondary Clarifier (S3-S4)	19.11 %	68.69 %	45.31 %	7.40 %	40.0 %
Filter System (S4-S5)	48 .18 %	42.0 %	52.14 %	12.0 %	33.33%
Total Removal (S1-S5)	85.75 %	93.0 %	89.92 %	49.42 %	96.0 %

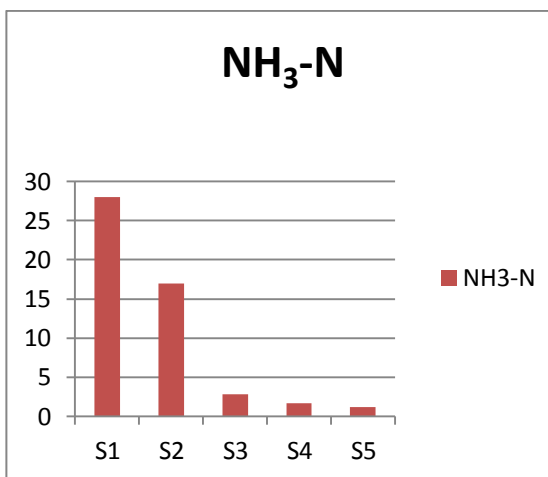
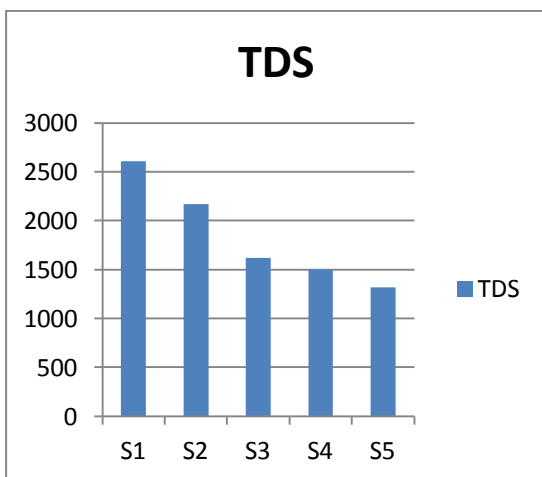
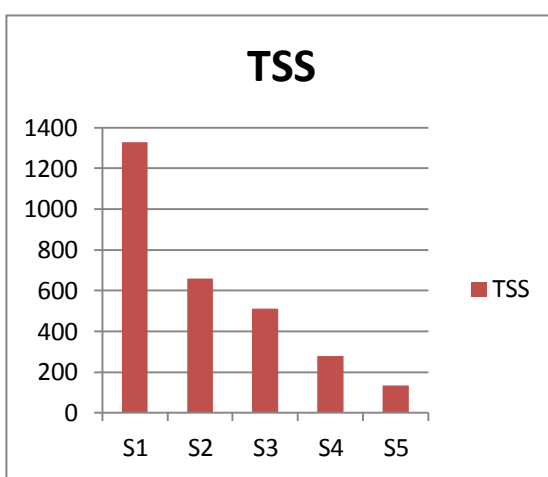
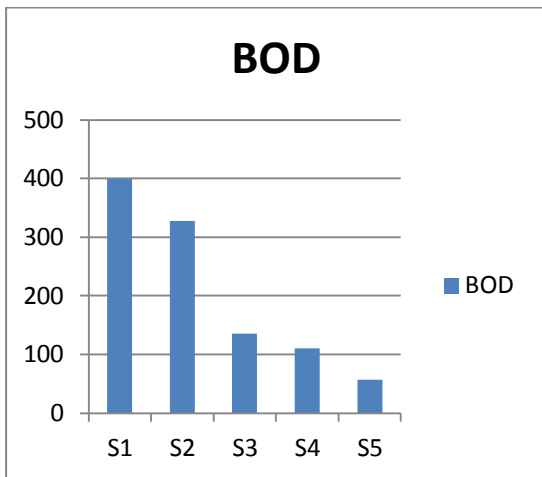
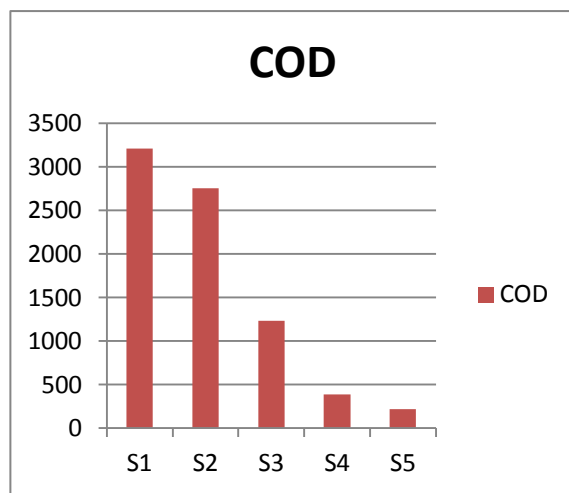
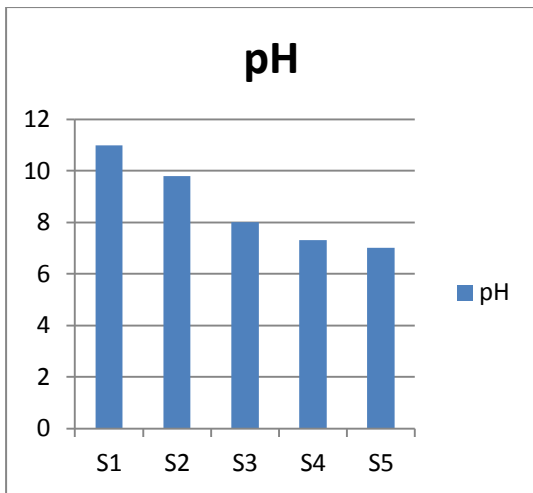


Figure - 4.1: Characteristics pattern of BOD, COD, NH₃-N, TDS, TSS, pH at different unit of ETP

ANNEXURE -5

Performance monitoring data for the ETP at Industry -E

Table - 5.1 Parameter to be characterised at different sampling location of ETP

Parameters	Sampling Location			
	Raw Influent (S1)	Inlet Aeration Tank(S2)	Inlet Secondary Clarifier (S3)	Final Treated Effluent (S4)
pH	9	7.7	7.5	6.5
COD(mg/L)	2840	1760	951	370
BOD(mg/L)	478	316	112	71
TSS(mg/L)	6000	850	670	275
TDS (mg/L)	7020	2920	2850	2720
NH₃-N(mg/L)	78	25	14	8

Table -5.2 Removal Efficiency of Industry E

	BOD	COD	TSS	TDS	NH₃-N
Primary Tube Settler (S1- S2)	33.89 %	38.0%	85.83 %	58.4 %	67.94 %
Aeration tank (S2-S3)	64.55 %	46.0 %	21.17 %	2.3 %	44.00 %
Secondary Clarifier (S3-S4)	36.60 %	61.09 %	59.00%	4.5 %	42.85 %
Total Removal (S1-S4)	85.14 %	86.97 %	95.41 %	61.25%	89.74 %

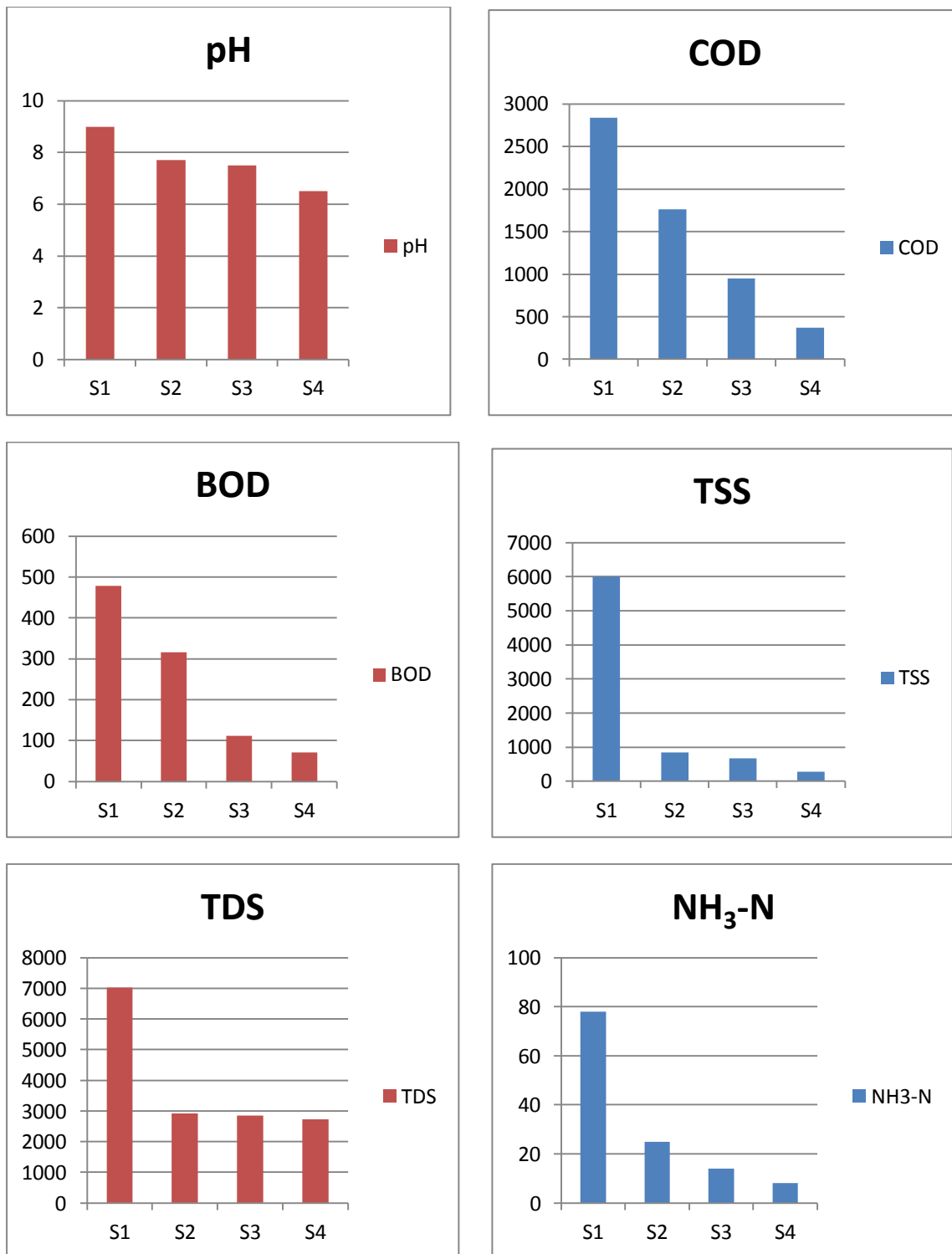


Figure - 5.1: Characteristics pattern of BOD, COD, NH₃-N, TDS, TSS, pH at different unit of ETP

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