A THESIS ON SLUDGE MANAGEMENT OF TEXTILE ETP (EFFLUENT TREATMENT PLANT) IN BANGLADESH

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A thesis submitted to the Department of Civil Engineering in partial fulfillment for the degree of Bachelor of Science in Civil Engineering



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Section: 13A
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Section: 13A
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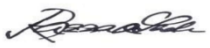
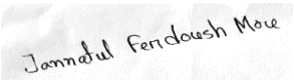
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It is hereby declared that this thesis/project or any part of it has not been submitted elsewhere for the award of any degree or diploma.

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Dedicated

To

"This thesis is dedicated to our parents and honorable teachers"

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ABSTRACT

Textile being the largest industrial sector in Bangladesh, face the problem of Effluent Treatment Plant (ETP) sludge and disposal. In this study our attempt to see the generation of textile sludge of the textile ETP. Removal and disposal of the sludge ensures that it will not adversely impact the environment. In this motivation, at first we listed most of the textile industries that have ETP around Dhaka, Bangladesh. The locations of the industries led us to obtain a list of 12 industries near Dhaka. Then we visited four textile industry ETP's which are Padma polycotton limited, Echotex limited, Galaxy sweaters & yarn dyeing Ltd. Under Annotex Group and Fakir Knitwear Ltd. We observed different treatment phases of ETP sludge and identified the source of sludge production. We collected sludge generation and characterization. We prepare a questionnaire and open-ended discussions with concerned authority of those textile factories. We come to know about sludge management from their interview/ oral discussion and also on the basis of accumulate data. Our team identified different ways to manage the sludge produced of the textile industry.

TABLE OF CONTENT

	Content	page no.
	Acknowledgement	5
	Abstract	6
	List of Figures	8
	List of Tables	9
	List of Graph	8
	CHAPTER-1	11
	INTRODUCTION	11
1.1	Background & Motivations	11
1.2	Research Objectives & Overview	11
1.3	Organization of the thesis	12
	CHAPTER-2	13
	Literature Review	13
2.1	Introduction	13
2.2	Literature Review Overview	13
2.3	General Considerations for Sludge Management	14
2.4	Phases of wet processing textile industry ETP	15
2.5	Sludge treatment method & Disposal	17
2.6	Summary	18
	CHAPTER-3	19
	Methodology	19
3.0	Introduction	19
3.1	Methodology Overview	20
3.2	The treatment phases of Padma Polycotton ETP	23
3.3	The treatment phases of Ecotex Ltd. ETP	24
3.4	The treatment phases of Annontex Ltd. ETP	26
3.5	The treatment phases of Fakir knitwear Ltd. ETP	27
3.6	The treatment phases of Knit concerned group ETP	29
3.7	The treatment phases of SDF ETP	30
3.8	Sources of Sludge	31
3.9	Sludge Management	31
3.10	Sludge treatment method according to Metcalf & Eddy	33
3.11	Disposal method of Sludge of industrial sector in Bangladesh	34
3.12	Summary	34
	CHAPTER-4	35
	Result and Discussion	35
4.1	Introduction	35
4.2	Observed different treatment phases on ETP	35
4.3	Identify source of sludge production process	36
4.4	Quantify the sludge production depending on ETP capacity	36
4.5	Graphical representation of sludge generation depending on production capacity	37
4.6	Characterization of Sludge	37
4.7	Characterization of Sludge liquor	38
4.8	Management of dried sludge from ETP	38
4.9	Summary	39

	CHAPTER-5	40
5.1	Conclusion	40
5.2	Limitations and Recommendations for future works	40
	References	41
	APPENDIX-A	43
	APPENDIX-B	43
	APPENDIX-C	44
	APPENDIX-D	45

LIST OF FIGURES

Fig.-1	Schematic diagram of a Conventional Activated Sludge Treatment	15
Fig.-2	Google map of Padma polycotton Knit Fabrics Limited	20
Fig.-3	Google map of Ecotex Ltd.	20
Fig.-4	Google map of Annotex Group	21
Fig.-5	Google map of Fakir Knitwear	21
Fig.-6	Google map of Knit concern group	21
Fig.-7	Google map of SDF (SavarDyeing & Finishing Ltd.)	22
	Some Pictures of Industry Visit	22
Fig.-8	Phases Padma Polycotton Knit Fabrics Limited	23
Fig.-9	Sludge treatment process	24
Fig.-10	Phases of Ecotex Ltd.	24
Fig.-11	Sludge treatment process	25
Fig.-12	Phases of Annotex Group	26
Fig.-13	Phases of Fakir Knitwear	27
Fig.-14	Phases of Knit concern group	29
Fig.-15	Phases of SDF	30

LIST OF GRAPH

Graph-1	Graphical representation of sludge generation depending on production capacity	37

LIST OF TABLES

Table-1	Summary of Inventory of Hazardous Waste in Bangladesh 2008	13
Table-2	Treatment and disposal options for wastewater sludge	17
Table-3	List of Textile Industry around Dhaka	19
Table-4	Sources of Sludge	31
Table-5	Possible Treatment type	32
Table-6	Sludge management options as per water class	32
Table-7	Sludge treatment method according to Metcalf & Eddy	33
Table-8	Observed different treatment phases on ETP	35
Table-9	Identify source of sludge production process	36
Table-10	Quantify the sludge production depending on ETP capacity	36
Table-11	Characterization of Sludge	37
Table-12	Characterization of Sludge liquor	38
Table-13	Dried Sludge Management & Disposal process	38

CHAPTER -1

INTRODUCTION

1.1 Background and Motivations

Textile sludge is an unwanted residual solid generated in the textile wastewater treatment plant and its management is a critical environmental issue. This sludge is consists of a cluster of organic and inorganic complex with high concentrations of heavy metals such as Fe, As, Cu, Cd, Zn, Cr etc. because a variety of dyes & chemicals are used in different wet processing steps. As per the Bangladesh Environment Conservation Act, 1995 (Amendment 2010) proper management of sludge is mandatory [1]. A World Bank study has predicted a 70% global increase in municipal solid waste by 2025, which means that the estimated waste volume will rise from today's 1.3 billion ton per year to 2.2 billion ton per year by 2025 [2]. According to ADB's (Asian Development Bank) Technical Assistance Consultant's Report in Dec'2010 the number of manufacturing establishments in Bangladesh is approaching 30,000 factories and other facilities and that these use more than 40 different types of chemicals. The factories are mostly located in the large industrialized conurbations of Dhaka, Chittagong, Khulna, Rajshahi, Barisal and Sylhet.

Our goal is to see wet processing textile ETP phases, identify the source of sludge, collect the concerned industries self-test data of textile ETP sludge, see the characteristics, quantify the sludge production and point out dried up sludge management options.

1.2 Research Objectives and overview:

ETP of a wet processing textile industry is being used for extract pollutants, remove toxicants, neutralize coarse particles, kill pathogens so that quality of discharged water is improved to reach the permissible level of water to be discharged into water bodies or for agricultural land [According Environmental Conservation Rules (ECR),1997][3]. Sludge is being produced in wet processing textile industry. Management of sludge of a wet processing textile industry is a problem which should be resolved. However, to achieve the target, we tried to attain following objectives:

Objectives of the study:
The main objectives of our study are:

- Observe different treatment process of wet processing textile effluents treatment plants (ETP).
- Identify the source of sludge production process.
- Quantify the sludge production depending on ETP capacity (m^3/day).
- Collect characterization of the sludge.
- Finally find out the management options of dried up sludge from wet processing textile ETP.

1.3 Organization of the thesis:

This thesis report has been organized as bellows:

Chapter 1 – In this chapter we introduce our topic of research along with its background and motivation of this work in the aspects of our country. We also state our goal and objectives of this research.

Chapter 2 – In this chapter we provide the importance and reasons for the study. In the literature overview we described in short the ETP steps and also described a sludge treatment process that involves four steps.

Chapter 3 – In this chapter we describes our way of collecting data i.e. select the industries, we surveyed along with plant layout, prepare a questionnaire to find out discharging amount and source of sludge, obtain average discharging and sludge production, characterization of the data tested by concerned industry.

Chapter 4 – In this chapter we quantified the tested data performed by concerned industry, sludge treatment phases, sources of sludge, sludge characteristics, sludge production quantity etc.

Chapter 5-Concludes the study by providing the findings along with some recommendations for the future work and challenges for sludge management in Bangladesh. This chapter also provides the limitations of the study and the references used.

CHAPTER 2
Literature Review

2.1 Introduction

Textile sector is the backbone of economy of Bangladesh. There are 1461 mill members in Bangladesh where, yarn manufacturing mills are 425, fabric manufacturing mills are 796 and 240 dyeing-printing-finishing mills (BTMA, 2018). The export incomes were US $ 17.9 billion in the year 2010-11, US $ 19.0 billion in the year 2011-12 and US $ 21.5 billion in the year 2012-13 [4]. Textile sector of Bangladesh has been discharging 2 million m3 effluent/day and 2.81 million metric ton sludge is produced every year in Bangladesh from this sector [5]. Heavy metals frequently found in sludge include Cd, Zn, Cu, Cr, Co, Pb, Mn, Ni, Hg, etc. These metals are very harmful, because of their no biodegradable nature, long biological half-lives and their potential to accumulate in different body parts (Manahan, 2005) [12].

2.2 Literature Review Overview

In wet processing textile ETP's, sludge treatment is the most effective and technically advanced treatment system. There are several wastewater treatment methods are used for wet processing textile effluent treatment. These are physicochemical, biological and biochemical [6]. In all methods sludge is generated after effluent treatment. The most versatile biological oxidation method which is also called activated process has been employed for the treatment of wastewater containing dissolved solids and colloids. In this process, the wastewater is aerated and agitated in a reaction tank in which some microbial floc is suspended. The aerobic bacteria flora bring about biological degradation of the waste into carbon dioxide, water and heat while consuming some organic matter for bacteria. The bacteria grows and remains suspended in the form of a floc, which is called "Activated Sludge". The effluent from the reaction is separated from the sludge by settling and discharged. A part of the sludge is recycled to the oxidation tank to provide an effective microbial population to utilize alive bacteria present in the sludge. The surplus sludge is digested in a sludge digester along with the primary sludge obtained primary sedimentation. After that sludge is dried in filter press and then a burning question arises how this sludge will be managed? There are several options available in Textile sludge management. It can be used to prepare brick, the sludge can be mixed with cement, it can be incinerated to produce electricity, sludge can be utilized for sanitary land filling, it can be used for biogas generation [7], it can be used for composting [8], it can be used for fertilizer or used as fuel of brickfield or any cement factory or else.

Table-1: Summary of Inventory of Hazardous Waste in Bangladesh 2008 [9]:

Waste Sector	Solid Waste (m^3/year)
Textile	322019.17
Hospitals	34747.6
Tannery	74331.7
Fertilisers	784.3
Pesticides	1010.9
Oil Refining	11.3

Source: National Consultant's inventory report

Some policy and legislation established for environment protection related issues, such as [10]:

Policies: National Environmental Policy, 1992 (NEP) (MOEF, 1994),
National Environmental Management Plan, 1995,

Laws: Environmental Conservation Act (ECA), 1995
Environmental Conservation Rules (ECR), 1997
The Environmental Court Act 2000

Guidelines: The EIA Guidelines for Industry,

Other related legislations:

- The Dhaka Municipal Corporation Ordinance, 1983
- Pesticide Ordinance, 1983
- Pourashava Ordinance, 1977
- Factory Act, 1965
- The Explosive Substance Act, 1908
- The Explosive Act, 1884
- Lead Acid Battery Recycling and Management Rules, 2006
- Draft National Solid Waste Management Handling Rules, 2005
- Environment Policy, 1992.
- Finally Supreme Court instructed DOE to frame rules for hazardous waste management.

Finally Supreme Court instructed DOE to frame rules for hazardous waste management.

2.3 General Considerations for Sludge Management:

The major priority of these standards and guidelines for sludge management in Bangladesh are to ensure that human health and the environment are strictly protected from any negative impacts of sludge management. According to the "National 3R Strategy" and the recommendations by the "Textile Sludge Study in Bangladesh" as well as the DWA mission report of phase 1 this guidance will follow the required principles in waste management. An important principle for guidance is the waste hierarchy of reducing, reusing and recycling (3R strategy) followed by disposal. This means that these measures shall be executed according to the state of technology and ecological feasibility before the waste has to be disposed in an end-of-pipe facility. Another central concept in this waste management guideline is to separate and segregate generated waste streams at source and, if possible, treat them directly on site which is also established in the European and German law and executed accordingly.

Challenges for sludge management in Bangladesh:

- Waste streams are not separated. Complex mixtures are difficult to classify and in consequence, it can be a problem to define an appropriate treatment/disposal route.
- An analysis for all potential pollutants, especially in complex mixtures of wastewater from industry, presents a huge challenge. Besides, the high cost of analysis can result in difficulties guaranteeing the compliance with limit values for certain disposal routes.
- Reusing and recycling technologies may not be available, or may be uneconomic or not having sufficient capacities for the rising amount of waste, specifically sludge being produced.

- Some types of disposal facilities, e.g. incineration or land fill sites do not exist or do not have the necessary capacities or standards for some types of waste (e.g. hazardous) in Bangladesh; suitable disposal facilities are a prerequisite for sustainable sludge management and before a guideline for sludge management can be implemented such facilities or other disposal routes guaranteeing a safe and final disposal need to be planned and built.

According to the Bangladesh standards and guideline sludge management, 2016, the wastewater treatment contains the following stations [1]:

- Equalization/neutralization,
- Activated sludge treatment with added lignite coke powder for bio-degradation,
- Absorption stage with added lignite coke powder to remove dyestuffs and other hardly or Non-biodegradable compounds,
- Flocculation/precipitation and removal of the sludge by flotation (aluminum sulphate and an anionic polyelectrolyte are added as flocculants),
- Filtration to remove suspended solids,
- Reverse osmosis plant (option)

There are three types of ETP Process:

i. Physical Treatment Process;
ii. Bio-Chemical Treatment Process;
iii. Chemical Treatment Process;

2.4 Phases of wet processing textile industry ETP:

Phase 1: Screening and Equalization.
Phase 2: Primary Settling.
Phase 3: Aeration / Activated Sludge.
Phase 4: Secondary Settling.
Phase 5: Filtration.
Phase 6: Disinfection.
Phase 7: Oxygen Uptake.
Phase 8: Sludge Treatment

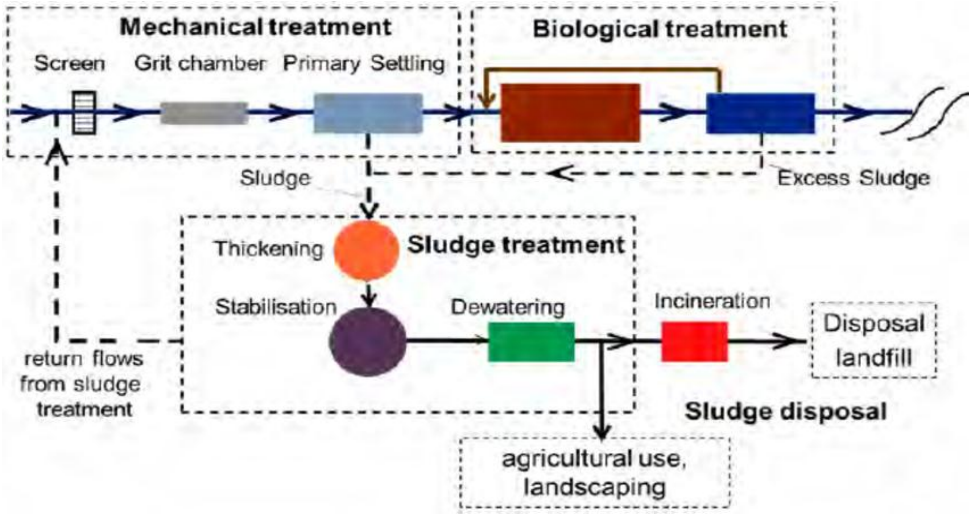


Fig-1: Schematic diagram of a Conventional Activated Sludge Treatment

Step 1: Screening and Equalization:
The incoming wastewater passes through screening equipment where objects such as rags, wood fragments, plastics, and grease are removed. The material removed is washed and pressed and disposed of in a landfill.

Step 2: Primary Settling / Clarification:
The material, which will settle, but at a slower rate than step two, is taken out using large circular tanks called clarifiers. The settled material, called primary sludge, is pumped off the bottom and the wastewater exits the tank from the top.

Step 3: Aeration / Activated Sludge Treatment:
In this step, the wastewater receives most of its treatment. Through biological degradation, the pollutants are consumed by microorganisms and transformed into cell tissue, water, and nitrogen. The biological activity occurring in this step is very similar to what occurs at the bottom of lakes and rivers, but in these areas the degradation takes years to accomplish. In this step sludge is generated.

Step 4: Secondary Settling:
Large circular tanks called secondary clarifiers allow the treated wastewater to separate from the biology (activated sludge) from the aeration tanks at this step, yielding an effluent, which is now over 90% treated.

Step 5: Filtration:
The material captured on the surface of the disc filters is periodically backwashed and returned to the head of the plant for treatment. Sludge is generated in this step too.

Step 6: Disinfection:
To assure the treated wastewater is virtually free of bacteria, ultraviolet disinfection is used after the filtration step. The ultraviolet treatment process kills remaining bacteria to levels within our discharge permit.

Step 7: Oxygen Uptake:
The treated water, now in a much stabilized high quality state, is aerated if necessary to bring the dissolved oxygen up to permit level. After this step, the treated water passes through the effluent outfall where it joins the River.

Step 8: Sludge Treatment:
The sludge treatment process involves four steps as described here-

1. Concentration (Thickening)
2. Treatment (Anaerobic Digestion)
3. Dewatering and drying
4. Disposal

2.5 Sludge Treatment Method and Disposal:

The treatment and disposal of these sludge should be considered as an integral part of the treatment process. The treatment processes should be regarded therefore as a low-solids stream (effluent or drinking water) and a high-solids stream (sludge).

It should be appreciated that the sludge consist mainly of water and that dewatering is the first and most important requirement in sludge processing. The cost of treating the sledges, particularly for wastewaters, is a major component of the total cost of treatment, and the effects of the final disposal methods and return flows from sludge treatment can have significant implications for the preceding processes.

Sludge treatment and disposal at any particular location may comprise any or all of the steps as outlined below.

a. Concentration - reduction in the volume of sludge to be treated by encouraging the sludge to compact to a higher solids content.

b. Treatment - to stabilize organic matter, destroy pathogens and/or yield by-products.

c. Dewatering and drying - removal of water, thus reducing sludge volume. Sludge with less than 80 per cent moisture content are usually spade able.

d. Disposal - the only places where sludge can be disposed of are into the air, onto land or water. Whether or not the impact on the receiving environment is legally, aesthetically and ecologically acceptable depends on both the degree of treatment provided and the method of dispersing the sludge into the environment.

In comparing the various alternative methods of sludge treatment and disposal, it is important to consider all steps necessary for the *final* disposal of the treated sludge.

A scheme which includes the majority of available processes for wastewater and mainly applicable to water treatment sludge is given in Table 2. Not all these methods would be practiced at any one site and not all of the methods are necessarily compatible. For each site, the range of options requires consideration.

Thickening	**Stabilization**	**Dewatering**	**Partial disposal**	**Ultimate disposal**
Gravity	Anaerobic digestion	Drying beds	Incineration	Sanitary landfill
Flotation	Aerobic digestion	Filter press	Pyrolysis	Crop land
Centrifuge	Lagooning	Centrifuge	Wet air oxidation	Ocean
Elutriation	Heat treatment	Vacuum filter Belt press Lagooning	Composting	

Table -2 Treatment and disposal options for wastewater sludge

Mechanical dewatering reduces sludge volumes and is a necessity for incineration. Ultimate disposal of any residue or sludge is to land or sea. If non-digested sludge are being handled, particular attention has to be paid to odor, insect and rodent infestation and hygiene. Subsequent sections deal in greater detail with particular processes.

2.6 Summary:

Along with installation of Effluent Treatment Plant (ETP) the sludge treatment is also mandatory. So after treating textile waste water we should also maintain the legal and authentic procedure to dispose of textile sludge which we discuss above as sludge treatment. If sludge is being processed as per the rules and regulations of Bangladesh standards and guideline sludge management, 2016[1] and proper supervision of DoE [11] it is critical not to fall into the trap of simply re-directing the pollution that ultimately affects water, soil and air. Appropriate treatments/disposal of sludge needs to be ascertained.

Chapter – 3
Methodology

3.0 Introduction:

To achieve our goal we collected concerned industries self-test data through field visit, collect ETP production capacity, discharging, sludge generation quantity, sludge disposal information by questionnaires (Appendix-A,B,C,D), open-ended discussion with concerned authorities. We also collected as secondary data from two industries by the help of some government publications, research papers. At first we listed (Table-3) 12 industry that has an ETP plant around Dhaka. We select four industries for successive visits. We see each phases of ETP.

Table-3: List of Textile Industry around Dhaka

Sl No.	Textile Factory Name	Address	ETP Type
1.	Anon Tex Group (Galaxy sweters & Yarn Dyeing Ltd.)	Tongi, Gazipur	Biological ETP
2.	MS dyeing, printing & finishing Ltd	Fatullah, Narayanganj	Conventional ETP
3.	Cotton Club (BD) Ltd.	Kashimpur, Gazipur	Biological ETP
4.	Esquire Knit Composite Limited	Narayanganj	Biological ETP
5.	JK Group (Knit fabrics & garments)	Savar	Biological ETP
6.	Keya Knit Composite Ltd	Konabari, Gazipur	Biological ETP
7.	Abanti Color Textile Ltd	Narayanganj	Biological ETP
8.	Padma Polycotton Knit Fabrics Ltd.	Tejgaon Industrial area, Dhaka	Biological ETP
9.	Echotex Limited	Shafipur, Gazipur	Biochemical ETP
10.	Square Knit Fashion Ltd	Joydebpur,Gazipur	Conventional ETP
11	Zaara Textile Composite Ltd	Kashimpur	Conventional ETP
12	Fakir knitwear Ltd	Narayanganj	Biochemical ETP

3.1 Methodology Overview:

Accordingly, we visited four textile industries in Dhaka and secondary data of another two industries had been considered for this thesis. Are as follows:

1. Padma Polycotton Knit Fabrics Limited:



Fig.-2: Google map location of Padma Polycotton

2. Echotex Limited Bangladesh:

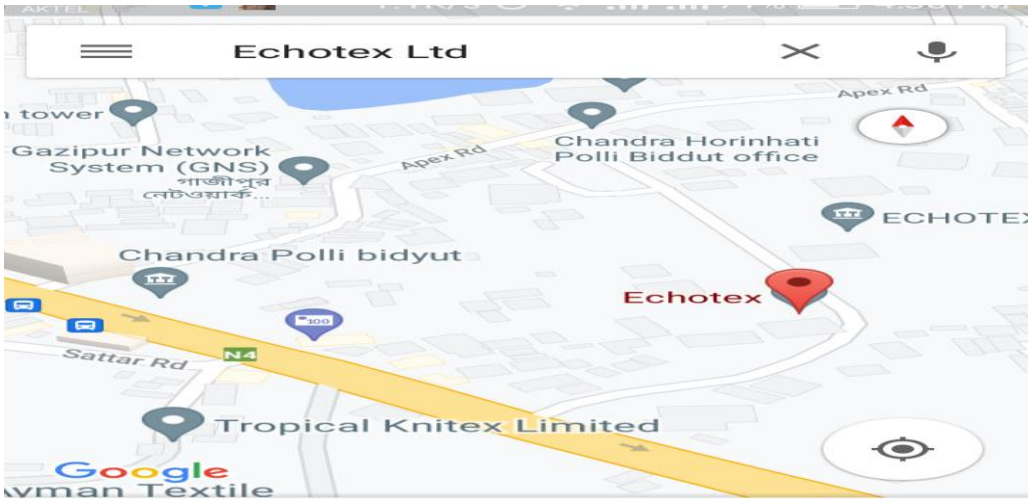


Fig.-3: Google map location of Echotex Limited

3. Annon Tex Group:

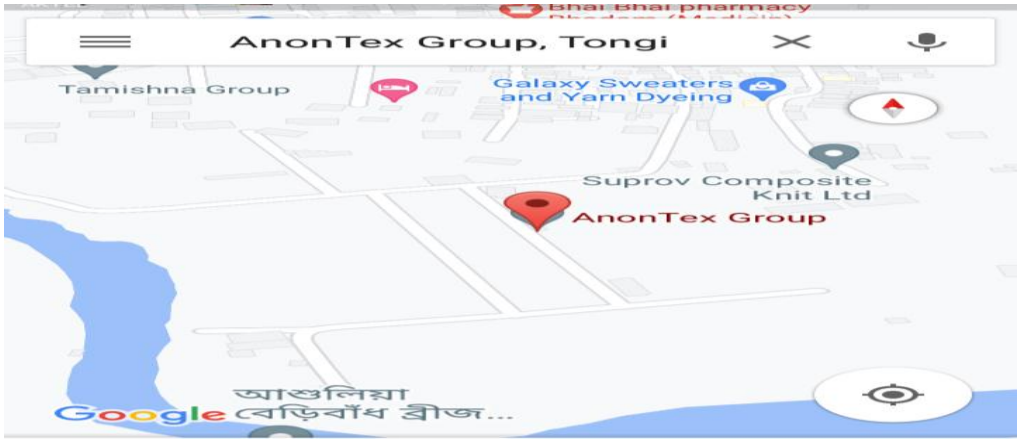


Fig.-4: Google map location of Annon Tex

4. Fakir knitwear Ltd:



Fig.-5: Google map location of Fakir Knitwear

5. Knit concern group:

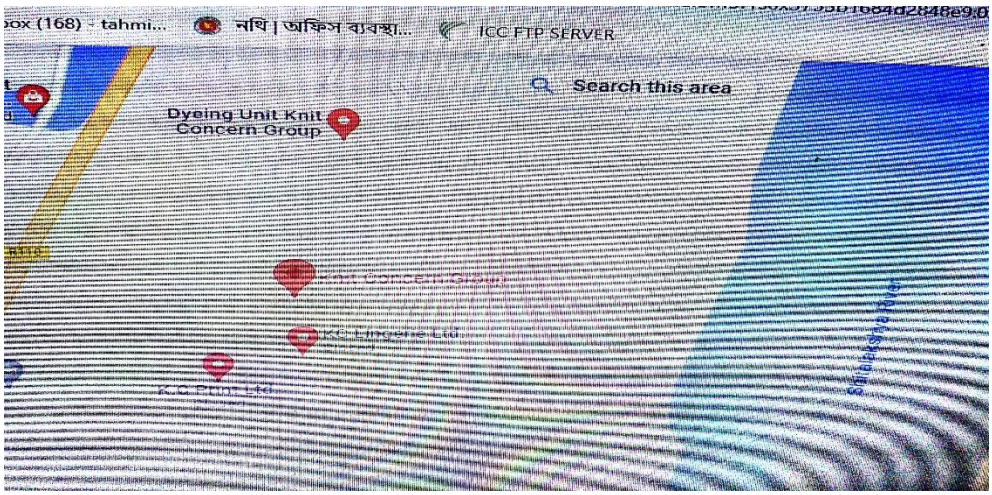


Fig.-6: Google map location of Knit concern group

6. Savar Dyeing & Finishing Ltd:



Fig.-7: Google map location of Savar dyeing & Finishing

Some field visit pictures of us:

Padma Polycotton Knit Fabrics Ltd.	
	
Ecotex Ltd.	
	 
Fakir Knitwear	



3.2 The treatment phases of Padma Polycotton Knit Fabrics Ltd. ETP:

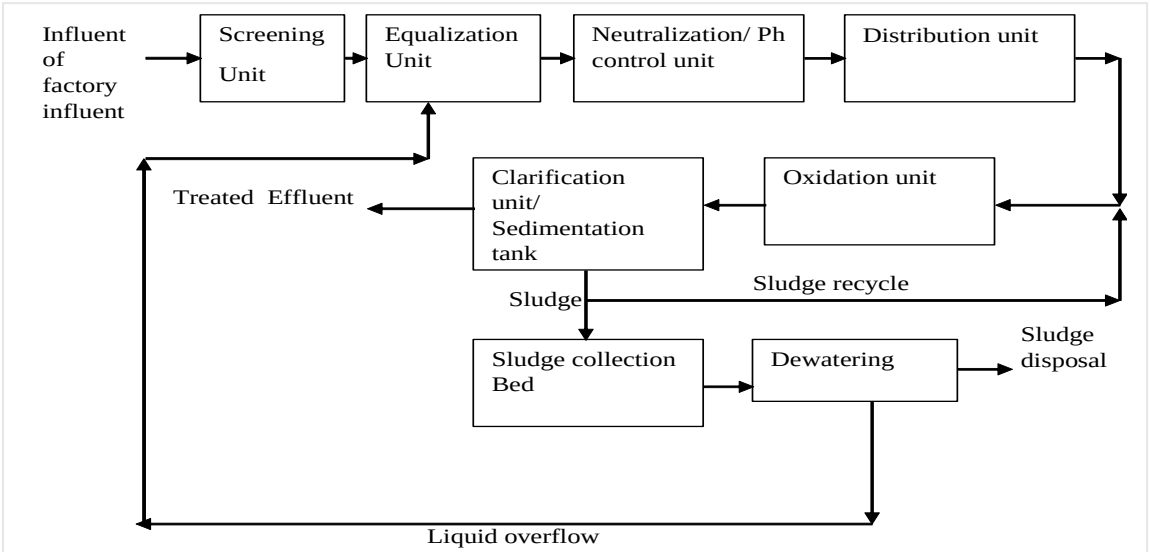
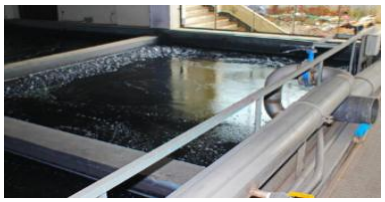


Fig.-8: ETP phases of Padma Polycotton Knit Fabrics Limited ETP

Phase-1	Phase-2	Phase-3
		
Screening	Equalization	Neutralization

Phase-4  Distribution	Phase-5  Oxidation	Phase-6  Clarification
Phase-7  Sludge Collection	Phase-8  Waiting for final disposal	

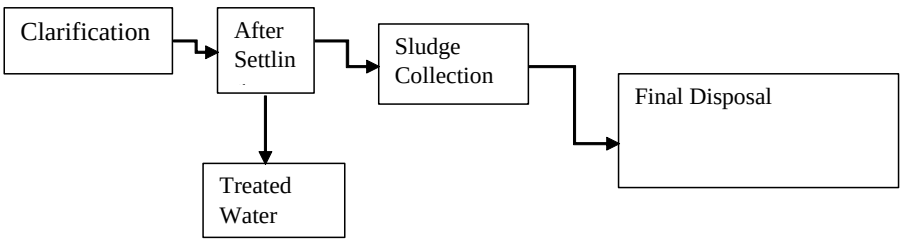


Fig.-9: Sludge treatment process

3.3 The treatment phases of Ecotex Ltd. ETP:

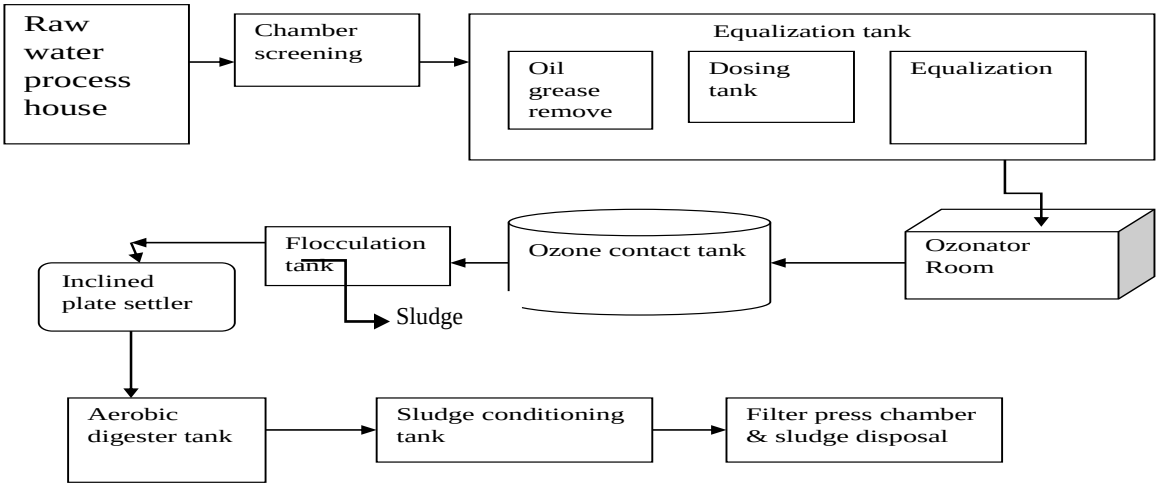


Fig.-10: ETP phases of Ecotex Ltd. ETP

Phase-1  Raw water process house:	Phase-2  Chamber screening	Phase-3  Equalization tank
Phase-4  Ozonator room	Phase-5  Ozone contact tank	Phase-6  Flocculation tank
Phase-7  Inclined plate settler	Phase-8  Aerobic digester tank	Phase-9  Sludge conditioning tank
Phase-10  Filter press chamber & sludge disposal:	 Sludge concentration	

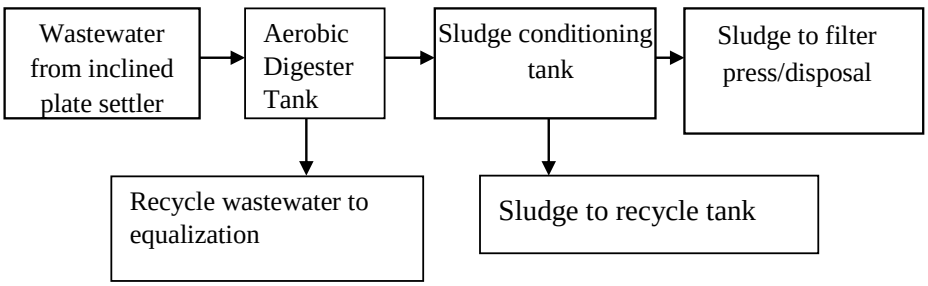


Fig.-11: Sludge treatment process

3.4 The treatment phases of Annon Tex Group ETP:

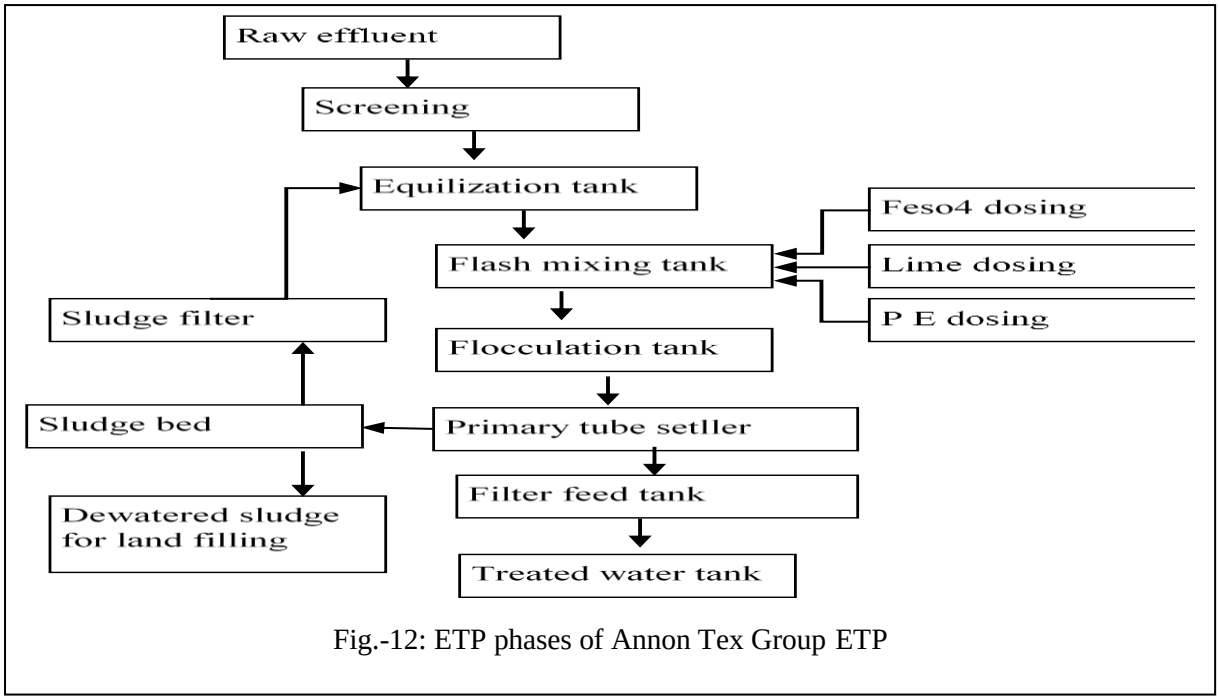


Fig.-12: ETP phases of Annon Tex Group ETP

1. Raw effluent



2.Screening — Coarse suspended matters such as rags, pieces of fabric, fibre, yarns and lint are removed. Bar screens and mechanically cleaned fine screens remove most of the fiber. The suspended fibre have to be removed prior to secondary biological treatment; otherwise they may affect the secondary treatment system. They are reported to clog trickling filters, seals or carbon beads.

3.Equalization — Effluent streams are collected into sump pit. Sometimes mixed effluents are stirred by rotating agitators or by blowing compressed air from below. The pit has a conical bottom for enhancing the settling of solid particles.

4.Flash mixing Tank — Flash Mixing where the treatment process begins. Rapid mixers to violently agitate the water with the chemicals for a short period of time before being released into the Primary tube settler for flocculation. The duration of the flash mix chamber is carefully controlled and typically lasts from 10-90 seconds.

5.Primary tube settler — Tube settlers capture the settle able fine floc that escapes the

	clarification zone beneath the tube settlers and allows the larger floc to travel to the tank bottom in a more settle able form.
6.Filter feed tank	In this chamber, the suspended solids accumulate at the bottom of the tank which is then eliminated into the sludge holding tank with the help of sludge transfer pump. Then clarified water overflows from settling tank to clear water (Filter Feed) tank.
7.Treated water tank	Last step for discharging to river/ canal
8.Sludge filter	Filtering sludge
9.Sludge Bed	Sludge bed comprises natural ways of drying to mechanical ways of removing water content.
10.Dewatering sludge for land filling:	Belt filter used for Dewatering sludge

3.5 The treatment phases of Fakir Knitwear ETP:

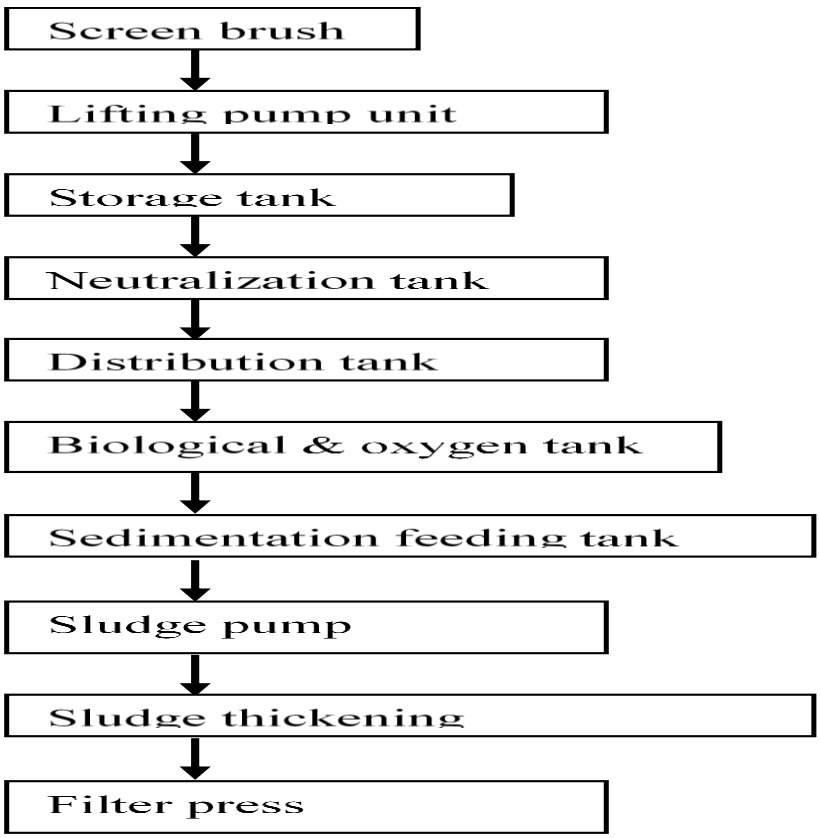


Fig.-13: ETP phases of Fakir Knitwear ETP

1.Screen brush	Big particle & materials remover
2.Lifting pump unit	Automatic flow lifter with level-censored pump
3. Storage tank	-mixing by air circulation -reduce temp -convert dissolved particles -Storing for 24 hrs. -Ph. 11-12
4. Neutralization tank	-To neutralize the alkalinity by dozing sulpheuric acid (98%) -ph. 7-9
5. Distribution tank	-Passes & store neutralized effluent water -sludge return
6. Biological & oxygen tank	-different types of micro-organisms are cultured -separate organic, inorganic & synthesized particles -dye particles are eaten by micro organisms -ph. 7-8.5
7. Sedimentation feeding tank	DE coloration of existing color particles feed to sludge pump -seperator -clarifier -scrapping bridge
8. Sludge return to pump slump	Sludge is thickened & residue passed into distributor tank
9. Sludge thickener	Sludge condensed & made cake.



3.6 The treatment phases of Knit Concern ETP:

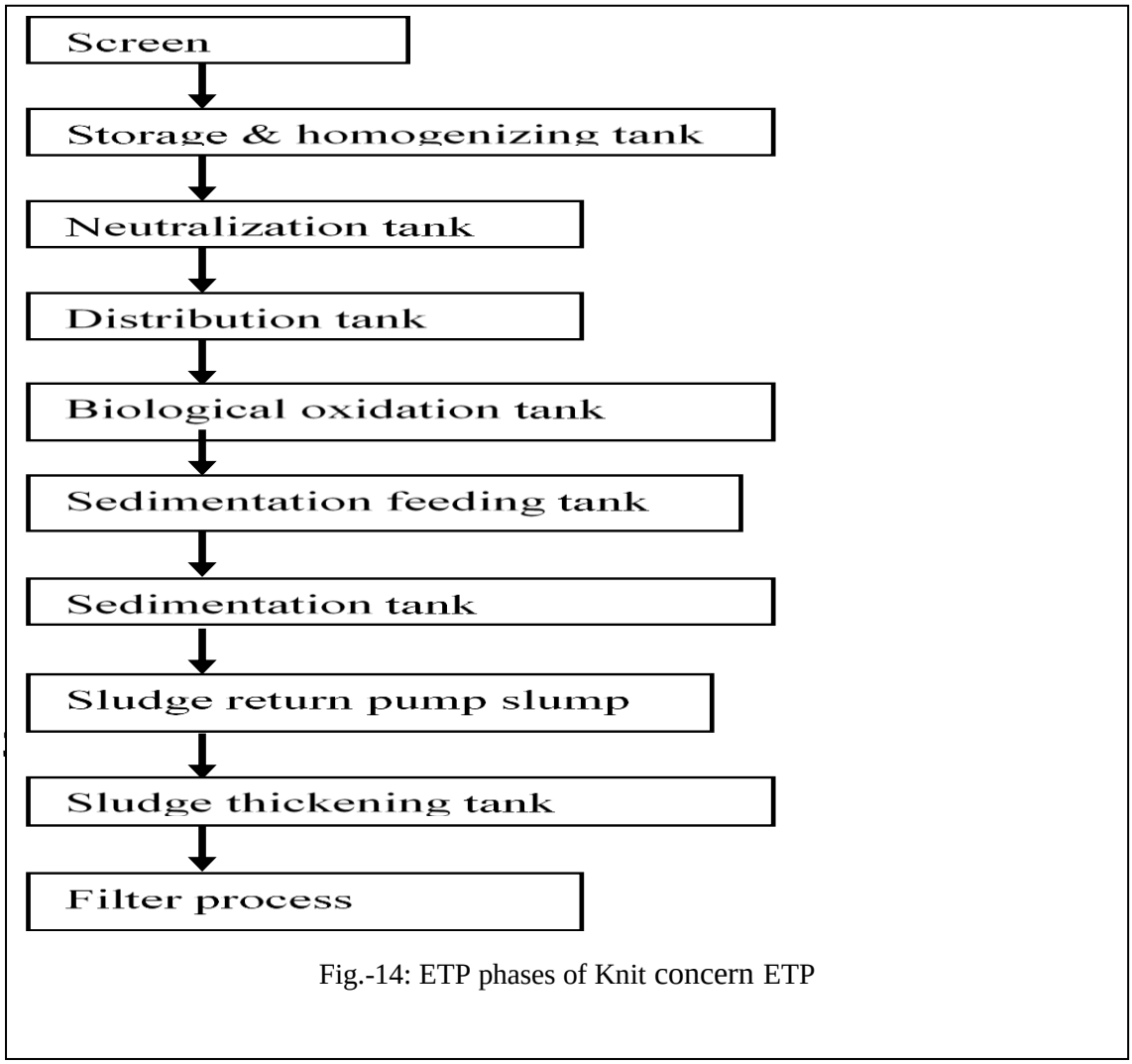


Fig.-14: ETP phases of Knit concern ETP

1.Screen	Big particles remover
2. Storage & homogenizing tank	Mixing by air circulation & convert dissolved particles
3. Neutralization tank	Neutralize the alkalinity by dozing
4. Distribution tank	Passes & store neutralized effluent water,sludge return
5. Biological oxidation tank	Different types of micro-organisms are cultured, separate organic, inorganic & synthesized particles
6. Sedimentation feeding tank	Coloration of existing color particles feed to sludge pmp -ph 7-8.5
7. Sedimentation feeding tank	DE coloration of existing color particles feed to sludge pmp

8. Sedimentation tank	Separator, clarifier, scrapping bridge
9. Sludge return pump slump	Sludge is thickened & residue passed into distributor tank
10. Sludge thickening tank	Sludge condensed & made cake
11. Filter process	

3.7 The treatment phases of Savar Dyeing & Finishing ETP:

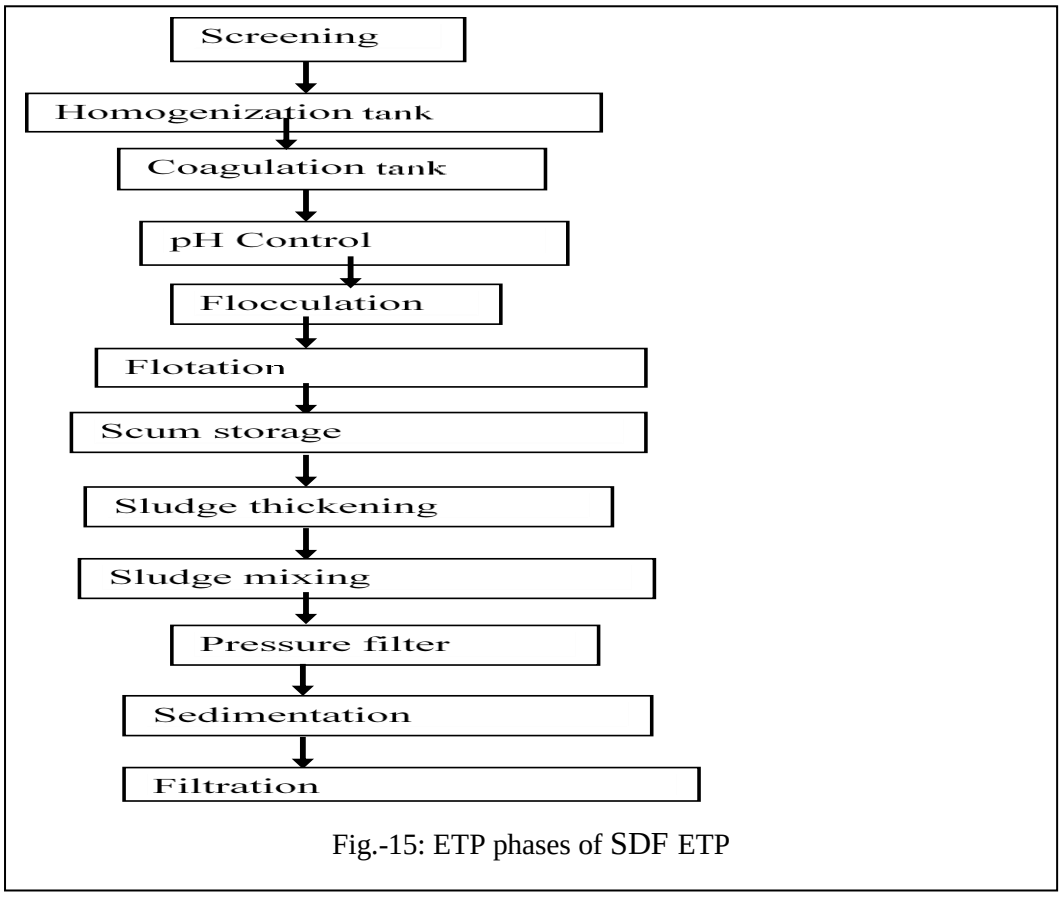


Fig.-15: ETP phases of SDF ETP

1. Screening	Big particles remover
2. Homogenization	Mixing the processed material, is provided by, a gearbox with an electric motor.
3. Coagulation	This process introduces small, highly charged molecules into water to destabilize the charges on particles, colloids, or oily materials in suspension.
4. pH Control	Adding an alkaline or acidic substance to a liquid in order to bring the measured pH within a desired range.

5. Flocculation	Creating larger aggregates which are easier to separate.
6. Flotation	Clarifies wastewaters (or other waters) by the removal of suspended matter such as oil or solids
7. Scum storage	Scum stored
8. Sludge thickening	Sludge condensed



9. Sludge mixing	Sludge is thickened & residue passed into distributor tank
10. Pressure filter	Sludge condensed & made cake
11. Aeration	
12. Sedimentation	
13. Filtration	

3.8 Sources of Sludge [13]:

The sources of sludge in a treatment plant vary according to the type of the plant and its method of operation. In textile industrial sector the principal sources of sludge from ETP plants are as follows:

Table-4 Sources of Sludge

Industries	Unit Operation or process
Padma Pollycotton knit Fabrics Ltd	Clarification
Ecotex Ltd	Inclined plate settler
Annontex group	Primary tube settler, Filter feed tank
Fakir Knitwear Ltd	Distribution & Sedimentation feeding tank
Knit concern	Distribution & Sedimentation tank
SDF Ltd	Flocculation

3.9 Sludge Management [9]:

Before the sludge is disposed of, it is required to apply pre-treatment in order to implement the "3R-principle" (reduce, reuse and recycle) which is a central component of the National 3R Strategy for Bangladesh (DoE). The main goal of pre-treatment is to minimize the volume and the organic matter of the sludge in order to reduce waste volume that must be disposed of and to enable a safer disposal. If the waste has to be transported e.g. to a central disposal facility, a pre-treatment would ensure better characteristics. Possible treatment types for industrial wastewater and sludge from industrial wastewater are the following:

Table-5 Possible treatment types

Possible treatment types	Description
Mechanical treatment	Sedimentation, thickening
Physio/chemical treatment	Use of ferrous sulphate, lime and polyelectrolyte in coagulation, flocculation.
Ozonation, chemical oxidation (wet oxidation or wet peroxidation)	Adsorption of non- biodegradables on activated carbon
Biological treatment	Activated sludge treatment (aerobic), anaerobic digestion
Further sludge treatment	Dewatering and drying by use of several aggregates (Filter presses and centrifuges).

Depending on the origin of the wastewater as per department of environment Bangladesh, [1] sludge can be classified as:

Category A: Municipal sludge including comparable sludge.
Category B: Sludge from industry including sludge from CETP.
Category C: Sludge from industry including sludge from CETP belonging to the category of hazardous waste.

Depending on the waste class, as per department of environment Bangladesh, sludge can be managed by different alternatives [1]:

Table-6 Sludge Management Options as per Waste Class

Sludge Management Options as per Waste Class			
Management option	Class-A	Class-B	Class-C
Anaerobic digestion (co-fermentation)	X1	X1	**
Aerobic digestion (composting)	X		
Agricultural use	X		
Controlled landfill	* X	X	X
Thermal incineration	X1	X1	X1
Land application (filling material e.g. for flood prevention)	X	X2	**
Recycling in brick, cement or asphalt making	X	X3	**

Where,

X1= Residues will remain that have to be disposed of, fulfilling the requirements applicable to the category, on an alternative route. E.g. By landfill.

X2= Inert material (low organic matter required)

X3= Availability and capacity limited by local conditions. Accepted sludge volume limited due to a loss of compressibility of the product

*X= Requirements for the landfill class vary depending on category of the sludge

**= If the producer provide evidence that sludge categorized as category C sludge and it does not possess any hazardous characteristics; in this case it may be categorized as category B sludge and the management options of anaerobic digestion (co-fermentation), land application (filling material e.g. for flood prevention), recycling in brick, cement or asphalt making are permissible.

3.10 Sludge Treatment Method according to Metcalf and Eddy [13]: Table-7

Unit operation, unit process or Treatment Method		Function
Pumping		Transport of sludge and liquid biosolids
Preliminary operation	Grinding	Particle size reduction
	Screening	Removal of fibrous material
	Degritting	Grit removal
	Blending	Homogenization of solids streams
	Storage	Flow equilization
Thickening	Gravity thickening	Volume reduction
	Flotation thickening	
	Centrifugation	
	Gravity-belt thickening	
	Rotary drum thickening	
Stabilization	Alkaline stabilization	Stabilization
	Anaerobic digestion	Stabilization, mass reduction
	Aerobic digestion	Stabilization, mass reduction
	Autothermal aerobic digestion(ATAD)	Stabilization, mass reduction
	Composting	Stabilization, product recovery
Conditioning	Chemical Conditioning	Improve dewateribility
	Other Conditioning method	
Dewatering	Centrifuge	Volume reduction
	Belt-filter press	Volume reduction
	Filter press	Volume reduction
	Sludge drying beds	Volume reduction
	Reed beds	Storage, Volume reduction
	Lagoons	Storage, Volume reduction
Heat Drying	Direct dryers	Weight & Volume reduction
	Indirect dryers	Weight & Volume reduction
Incineration	Multiple hearth Incineration	Volume reduction, resource recovery
	Fluidized bed Incineration	Volume reduction
	Co Incineration with solid waste	Volume reduction
Application of bio solids to land	Land Application	Beneficial use, Disposal
	Dedicated land disposal	Disposal, land reclamation
	Landfilling	Disposal
Conveyance & Storage		Solids transport & storage

3.11 Disposal method of Sludge in Industrial sectors of Bangladesh:

As a mandatory rule set by the government of Bangladesh, every industry must treat the waste effluent before discharging to the environment. But these treatment systems produce huge volume of sludge that is residual or semi-solid material in nature. This bulk waste by-product is considered as a nuisance for the industrial units and environment due to its management [18]. In Bangladesh, all types of sludge are disposed in landfill site haphazardly or openly which leads to soil, surface water and groundwater contamination. The wet processing textile we visited, awareness regarding sludge management and disposal is nearly ignored. Industries simply have the ETP that gradually generate sludge. Sludge management and disposal from the side of management is take no notice of.

3.12 Summary:

These summary were drawn based on wet processing industrial sectors textile ETP processing, source of sludge, sludge management and disposal. Land disposal of textile sludge appears to be an acceptable method for the utilization and disposal of sludge. However, serious health risks may impart from this approach, especially with land application. The principal hazards are disease transmittal through the survival of pathogens, toxicity from heavy metals and trace elements entering the ground water.

CHAPTER-4

Results and Discussion

4.1 Introduction:

The results obtained from this study will be discussed in this chapter. This chapter presents laboratory reports collected from relevant industries to determine the characteristics of sludge, sludge treatment phases, identified the sources of sludge production, quantified sludge production depending on ETP capacity. We have used secondary source of data together with collected data from industry.

4.2 Observed different treatment phases of ETP's:

Table-8

Padma polycotton	Ecotex Ltd	Annon Tex Ltd	Fakir Knitwear	Knit Concern	SDF Ltd
1. Screening 2. Equalization 3. Neutralization 4. Distribution 5. Oxidation 6. Sedimentation tank/ clarification 7. Sludge collection bed 8. Dewatering 9. Sludge disposal	➢ Raw water process ➢ Chamber Screening ➢ Equalization ➢ Ozonator room ➢ Ozone tank contact ➢ Flocculation tank ➢ Inclined plate settler ➢ Aerobic digester tank ➢ Sludge conditioning tank ➢ Filter press chamber ➢ Sludge disposal	• Raw effluent • Screening • Equalization • Flash mixing tank • Flocculation tank • Primary settler • Filter feed tank • Treated water tank • Sludge filter • Sludge bed • Dewatered Sludge	▪ Screen brush ▪ Lifting pump unit ▪ Storage tank ▪ Neutralization tank ▪ Distribution tank ▪ Biological oxygen tank ▪ Sedimentation feeding tank ▪ Sludge pump ▪ Sludge thickening ▪ Filter press	○ Screen ○ Storage & homogeneous tank ○ Neutralization ○ Distribution ○ Biological oxidation tank ○ Sedimentation feeding tank ○ Sedimentation tank ○ Sludge return pump slump ○ Sludge thickening ○ Filter process	✓ Screening ✓ Homogenization ✓ Coagulation ✓ pH Control ✓ Flocculation ✓ Flotation ✓ Scum storage ✓ Sludge thickening ✓ Sludge mixing ✓ Pressure filter ✓ Aeration ✓ Sedimentation ✓ Filtration

4.3 Identify the source of sludge production process:

Table-9

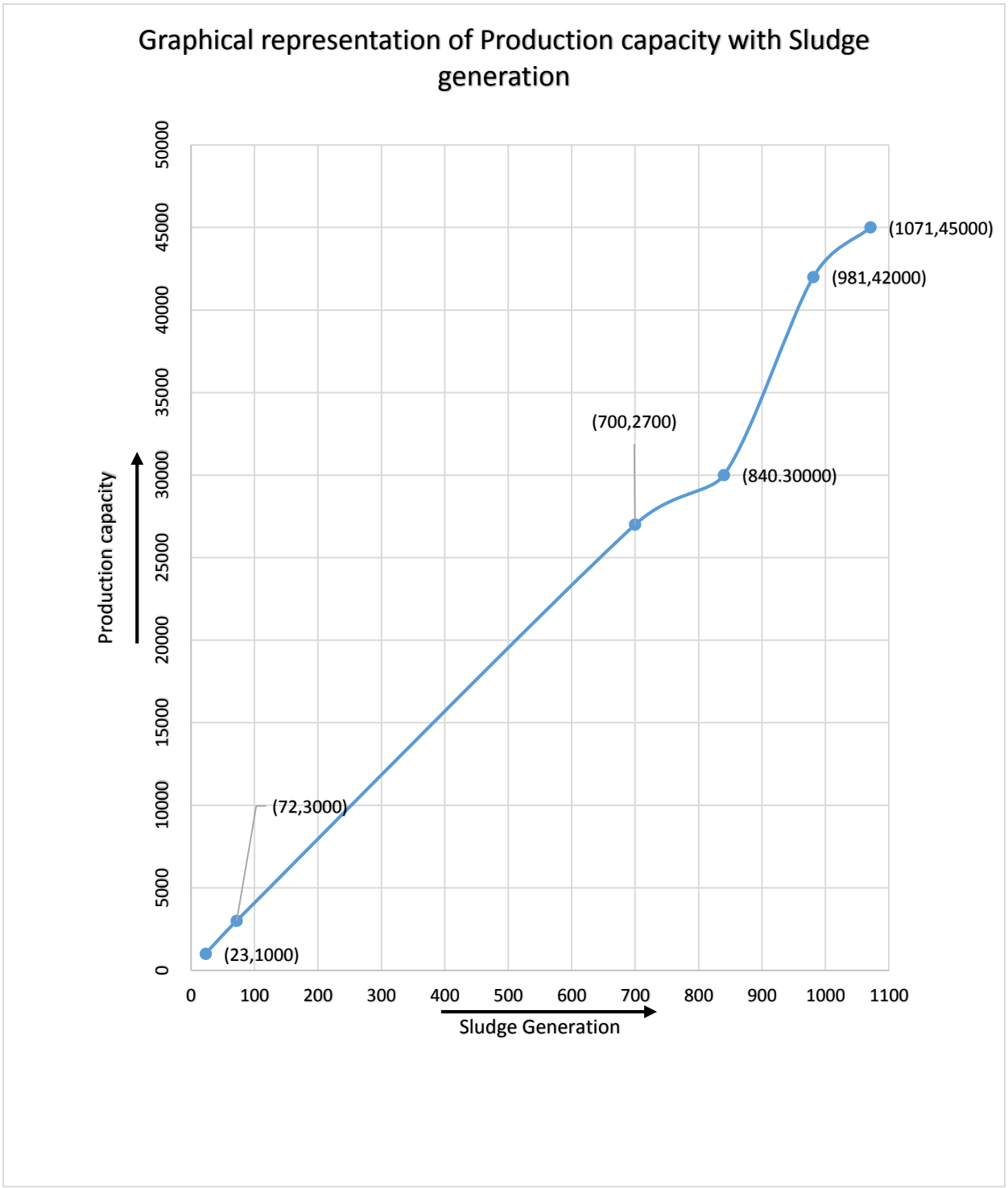
Industries	Unit Operation or process
Padma Pollycotton knit Fabrics Ltd	Clarification
Ecotex Ltd	Inclined plate settler
Annontex group	Primary tube settler, Filter feed tank
Fakir Knitwear Ltd	Distribution & Sedimentation feeding tank
Knit concern	Distribution & Sedimentation tank
SDF Ltd	Flocculation

4.4 Quantify the sludge production depending on ETP capacity (m^3/day):

Table-10

Sl. No.	Capacity (m^3/day)	Discharging amount (m^3/day)	Sludge Generation (kg/day)
Industry -1 (SDF) [19]	1000	829	23
Industry -2 (Knit) [20]	3000	2550	72
Industry -3 (Eco)	27000	2200	700
Industry -4 (Padma)	30000	2640	840
Industry -5 (Fakir)	42000	3696	981
Industry -6 (Annontex)	45000	4038	1071

4.5 Graphical represent of Sludge Generation depending on Production capacity:



4.6 Characterization of the Sludge:

Table-11

Regulatory their limits compared to industries report	Heavy Metal Concentration (mg/kg)						
	Cd	Cu	Cr	Zn	Pb	Hg	Ni
BDS for Land application[16]	10	800	900	2500	900	8	200
USEPA Limit[17]	85	4300	3000	7500	840	57	420
Industry -1 [19]	5.51	134.2	485.8	707.4	80.93	0.2	87.5
Industry -2 [20]	8.27	186.7	393.6	811.6	125.3	0.16	64.6
Industry -3	6.21	158.3	511.0	851.2	73.61	1.01	98.3
Industry -4	4.38	123.7	352.7	772.5	82.27	0.25	81.3
Industry -5	6.51	112.5	493.7	791.0	79.15	1.07	79.7
Industry -6	7.11	151.8	356.8	842.4	85.20	0.31	84.2

4.7 Characterization of the Sludge liquor:

Table-12

	unit	Industry-1[19]	Industry-2 [20]	Industry -3		Industry-4	Industry -5	Industry -6
Ph	-	6.45	8.14	7.8		6.9	7.65	7.8
Temperature	°C	31	28.5	28.3		34	37	28
Conductivity	scm-1	155.8	224.8	159		150	391.2	159
Specific Gravity	-	1.02	0.99	0.99		1.01	-	1
Turbidity	NTU	2485	2520	2501		2407	-	2465
D0	mg/1	3.8	2.9	3.1		2.85	4.8	2.9
BOD5	mg/1	556	550	354		560	273	204
COD	mg/1	1776	1790	1699		1790	1700	1695
Total Alkalinity	mg/1	980	997	986		980	1045	990
Hydrogen carbonate alkalinity	mg/1	70.2	74.1	70		73	72.2	72
Ammonia nitrogen	mg/1	31.5	32.2	33.1		31	30.4	31
Nitrate nitrogen	mg/1	27.6	28.3	28.1		27.7	28.3	28.3
Organic nitrogen	mg/1	19.7	20	19.9		19.6	20	20

Chloride	mg/1	121	122	121		124	121	122
Sulphate	mg/1	124	124	125		124	126	124
ABS	mg/1	105	109	107		105	105	106
Total Bacterial count	100 /ml	$39x10^6$	$48x10^6$	$30x10^6$		$89x10^6$	$66x10^6$	$33x10^6$

4.8 Management of Dried Sludge from ETP:

As we stated in section-3.11 that, sludge management and disposal from the side of concerning industries take no notice of. So we proposed some dried sludge management and disposal method below.

In selecting the appropriate method of sludge processing, reuse and disposal, consideration must be given to the appropriate regulations in DOE. The regulations were designed protect public health and the environment from any reasonably anticipated adverse effects of pollutants contained in the bio solids. To achieve compliance, appropriate treatment requirements or methods are stipulated by the regulations.

Table-13 Dried sludge management and Disposal Process

Land Application[21]:	Land application of biosolids has proven a cost-effective method of waste disposal by beneficially recycling organic matter and nutrients and improving soil quality; however, it may also pose potential threat to the environment and human health.
Surface Disposal[21]:	Surface disposal refers to the stockpiling of sludge, fecal, bio solids (e.g. humanure or compost) or other materials that cannot be used elsewhere.
Pathogen and Vector attraction Reduction [21]	Pathogens are disease-causing organisms such as certain bacteria, fungi, viruses, protozoans and their cysts, and intestinal parasites and their ova. Vector attraction is the characteristic of sewage sludge that attracts rodents, flies, mosquitoes, or other organisms capable of transporting infectious agents. Process to significantly reduce pathogens: - Composting - Heat drying - Heat treatment - Thermophilic aerobic digestion - Beta ray irradiation - Gamma ray irradiation - Pasteurization
Incineration[21]	Bio-solids like municipal sludge, industrial sludge and fine solids can be incinerated with the advantage of eliminating the sludge. Energy from the incineration process can be recovered as green energy source. Depending on their calorific value of the sludge being incinerated, pre-drying of the sludge and pre-heating of the combustion air may be necessary.
Concrete [14]	Feasibility of using sludge textile mill sludge as fine aggregates in M:20 grade of concrete. The replacement of

	fine aggregate with sludge in conventional concrete mix affects workability and density of concrete. The compressive strength gradually reduces with replacement and later it falls below desired value when fine aggregate replaced by textile mill sludge is beyond 32%. The fly ash is added to replace cement along with 32% sludge. It shows slight decrease in compressive strength.
Co Processing of ETP sludge in Cements Industry [15]	Co processing of ETP sludge along with the cement raw material has negligible impact on Clinker composition and the overall impact of the Hazardous waste co processing is beneficial to environment in terms of disposal, air impacts and conservation of raw material. Hence Co-processing is an Eco Friendly Technology for disposing the hazardous Waste Technology.

4.9 Summary:

Though we have used secondary source of data together with collected data from industry visit, in future, doing all tests the further decision could be made.

CHAPTER-5

CONCLUTIONS & FUTURE WORKS

5.1 Conclusion:

The sludge in the effluent treatment plants is currently stored in the treatment unit premises. It creates leach ate with toxic metals and organic impurities and cause pollution of ground water and land. It is very essential to manage the sludge generated from the treatment. The sheer volume of the sludge generated by the Textile industries based dyeing and bleaching units, which was estimated a large amount per day and their disposal will prove a knotty issue for the local dyers, especially when there is no viable technology available for recovery or reusing the salty sediments found in the treated effluents discharged from the units. After producing solid waste / sludge the major fact is reuse of it. We should find more way to reuse of solid waste.

5.2 Limitations and Recommendations For Future Works:

Limitations:

- In this study only six textile sludge phases, characteristics, source and management information was collected where there are a lot of industries around. Sludge from different industries may have a wide range of constituents (including toxic metals).

- This study comprises concerned industries own testing report, data of dried sludge samples. So, in future, implementing all tests the further decision could be made.

- Visiting concerning industries we faces a lot of barrier regarding taking photos or delivering data and report to us. That might be cause of the outer appearance of each ETP phases was not beautifully maintained by them. Dust was every out of the phases.

Future Works:

- Different researchers showed that sludge generated from sewage, ternary can be successfully utilized through concrete, pavement blocks and ceramics. So, similar studies can be carried out for dyeing sludge.

- Though we have used secondary source of data together with collected data from industry visit, in future, doing all tests the further decision could be made

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APPENDIX

Appendix-A : Padma Polycotton Knit Fabrics Limited		
1. What is ETP establishment year?	2008	
2. ETP type?	Biological	
3. What is total production capacity?	30,000 m3/day	
4. Total discharge amount per day?	2640 m3/day	
5. What amount of sludge is generated per day?	840 /day (approx.)	
6. Sludge disposal method used?	• AFT (Air floatation thickening) • Digestion • Dewatering • Disposal	
7. Uses of treated sludge?	○ Agricultural • **Landscaping** • **Cement Factory** ○ Brickfield as fuel	
8. Do they follow the Directorate of Environment guidelines?	•Yes	○ No

Appendix-B: Echotex Limited:	
1. What is the ETP establishment year?	2008
2. ETP Type?	Bio-chemical
3. What is total production capacity?	27000 m3/day
4. Total discharge amount per day?	2200 m3/day

5. What amount of sludge is generated per day?	700 kg/day (approx.)	
6. Sludge disposal method used?	• AFT (Air floatation thickening) • Digestion • Dewatering • Disposal	
7. Uses of treated sludge?	○ Agricultural (sell to fertilizer company) • **Landscaping** ○ Cement Factory ○ Brickfield as fuel	
8. Does this industry follow the Directorate of Environment guidelines?	• Yes	○ No

Appendix-C: Annon Tex Group:		
1. What is the ETP establishment year?	2004	
2. ETP Type?	Biological	
3. What is total production capacity?	45,000 m3/day	
4. Total discharge amount per day?	4038 m3/day	
5. What amount of sludge is generated per day?	1071 kg/day (approx.)	
6. Sludge disposal method used?	• AFT (Air floatation thickening) • Digestion • Dewatering • Disposal	
7. Uses of treated sludge?	○ Agricultural (sell to fertilizer company) • **Landscaping** ○ Cement Factory ○ Brickfield as fuel	
8. Does this industry follow the Directorate of Environment guidelines?	• Yes	○ No

Appendix-D: Fakir knitwear Ltd:		
1. What is ETP establishment year?	N/A , (Factory establish in 1988)	
2. ETP Type?	Biochemical	
3. What is total production capacity?	42,000 m3/day	
4. Total discharge amount per day?	3696 m3/day	
5. What amount of sludge is generated per day?	981 kg/day	
6. Sludge disposal method used?	• AFT (Air floatation thickening) • Digestion • Dewatering • Disposal	
7. Uses of treated sludge?	○ Agricultural (sell to fertilizer company) ○ **Landscaping** ○ Cement Factory ○ Brickfield as fuel	
8. Does this industry follow the Directorate of Environment guidelines?	• Yes	○ No