Choosing an Effluent Treatment Plant

Choosing an Effluent Treatment Plant

M. Akhtaruzzaman
Alexandra Clemett
Jerry Knapp
Mahbubul A. Mahmood
Samiya Ahmed

STOCKHOLM ENVIRONMENT INSTITUTE

BCAS

UNIVERSITY OF LEEDS

DFID Department for International Development

This booklet forms part of a series written by the "Managing Industrial Pollution from Small- and Medium-Scale Industries in Bangladesh" Project. The Project is funded by the Department for International Development, UK under its Knowledge and Research Programme, and is undertaken in collaboration with the pollution component of the Investment Support to MACH, (MACH refers to the Managing Aquatic Ecosystems through Community Husbandry project) which is funded by the Government of Bangladesh.

The work has been undertaken by the Stockholm Environment Institute, the Bangladesh Centre for Advanced Studies and the University of Leeds.

More information about the project, including downloads of project documents, can be found at http://www.sei.se.

Stockholm Environment Institute

Lilla Nygatan, 1
Box 2142,
S-103 14 Stockholm, Sweden
Tel:+46 8 412 1400
Fax:+46 8 723 0348
Web: www.sei.se

Bangladesh Centre for Advanced Studies

House # 10, Road # 16A, Gulshan-1
Dhaka, Bangladesh
Tel: +8802 8851237
Fax: +8802 8851237
Email: info@bcas.net

ISBN: 984 - 8121 - 07 - 2

Printed by Genesis (Pvt.) Ltd.
Dhaka, Bangladesh

Contents

1

National Standards for Wastewater

1.1 What do these Standards Mean?

National Standards for Wastewater

Textile industries produce wastewater, otherwise known as effluent, as a bi-product of their production. The effluent contains several pollutants, which can be removed with the help of an effluent treatment plant (ETP). The “clean” water can then be safely discharged into the environment.

Effluent from textile dyeing industries must meet the national effluent discharge quality standards set by the Government of Bangladesh, including the “Quality Standards for Classified Industries” (Tables 1 and 2), and may also need to meet additional standards set by international textile buyers. Consequently any ETP must be designed and operated in such a way that it treats the wastewater to these standards.

The regulations state that these quality standards must be ensured from the moment of going into trial production for industrial units. They also state that the Department of Environment can undertake spot checks at any time and the pollution levels must not exceed these quality standards. Furthermore, the quality standards may be enforced in a more stringent manner if considered necessary in view of the environmental conditions of a particular situation[1].

The waste discharge quality standards differ according to the point of disposal. So, the standards are different for inland surface water (ponds, tanks, water bodies, water holes, canals, river, springs or estuaries); public sewers (any sewer connected with fully combined processing plant including primary and secondary treatment); and irrigated land defined as an appropriately irrigated plantation area of specified crops based on quantity and quality of wastewater[1].

Table 1: National Standards - Waste Discharge Quality Standards for Industrial Units and Projects (quality standard at discharge point)[1]

Parameter	Unit	Inland Surface water	Public Sewer secondary treatment plant	Irrigated Land
Ammoniacal Nitrogen (N molecule)	mg/l	50	75	75
Ammonia (free ammonia)	mg/l	5	5	15
Arsenic	mg/l	0.2	0.5	0.2
BOD_5 200C	mg/l	50	250	100
Boron (B)	mg/l	2	2	2
Cadmium (Cd)	mg/l	0.05	0.5	0.5
Chloride (Cl—)	mg/l	600	600	600
Chromium (total Cr)	mg/l	0.5	1.0	1.0
COD	mg/l	200	400	400
Chromium (hexavalent Cr)	mg/l	0.1	1.0	1.0
Copper (Cu)	mg/l	0.5	3.0	3.0
Dissolved Oxygen (DO)	mg/l	4.5-8	4.5-8	4.5-8
Electrical Conductivity	micro mho/cm	1200	1200	1200
Total Dissolved Solids (TDS)	mg/l	2100	2100	2100
Fluoride (F)	mg/l	7	15	10
Sulfide (S)	mg/l	1	2	2
Iron (Fe)	mg/l	2	2	2
Total Kjeldahl Nitrogen (N)	mg/l	100	100	100
Lead (Pb)	mg/l	0.1	0.1	0.1
Manganese (Mn)	mg/l	5	5	5
Mercury (Hg)	mg/l	0.01	0.01	0.01
Nickel (Ni)	mg/l	1.0	1.0	1.0
Nitrate (N molecule)	mg/l	10.0	Undetermined	10.0
Oil & grease	mg/l	10	20	10
Phenol compounds (C_6H_5OH)	mg/l	1.0	5	1
Dissolved Phosphorus (P)	mg/l	8	8	10
Radioactive materials:	As determined by Bangladesh Atomic Energy Commission			
pH		6-9	6-9	6-9
Selenium (Se)	mg/l	0.05	0.05	0.05
Zn (Zn)	mg/l	5.0	10.0	10.0
Temperature	Centigrade			
Summer	^0C	40	40	40
Winter	^0C	45	45	45
Total Suspended Solid (TSS)	mg/l	150	500	200
Cyanide (CN)	mg/l	0.1	2.0	0.2

Under the Environmental Conservation Rules 1997, industrial units and projects are classified into four categories (Green, Orange A, Orange B, and Red) based on their environmental impact and location. Fabric dyeing and chemical treatment industries fall under the Red category. This means that when they are applying for site clearance they must submit an ETP plan to the Department of Environment, including the layout and location. When the design has been approved by the Department of Environment and the ETP has been constructed, then Red category industries can apply for an environmental clearance certificate.

Table 2: Discharge Quality Standard for Classified Industries - Composite Textile Plant and Large Processing Units (investment over Tk 30,000,000)[1]

Parameter	**Limit (mg/l)**
Total Suspended Solid (TSS)	100
BOD_5 20°C	150*
Oil and Grease	10
Total Dissolved Solid (TDS)	2100
Waste Water Flow	100 l/kg of fabric processing
pH	6.5-9
Special parameters based on classification of dyes used	
Total Chromium (as Cr molecule)	2
Sulfide (as S molecule)	2
Phenolic compounds as C_6H_5OH	5

** BOD limit of 150 mg/l will be applicable only for physico-chemical processing method.*

1.1 What do these Standards Mean?

Some of the main parameters listed in the water quality discharge standards are briefly discussed here to give a working knowledge of what they are and why they are important.

Colour

Although colour is not included in the Environment Conservation Rules (1997), it is an issue in dye house effluent because unlike other pollutants it is so visible. Reducing colour is therefore important for the public perception of a factory. Consequently, international textile buyers are increasingly setting discharge standards for colour. However, as a health and environmental issue colour is less of a concern than many of the other parameters.

BOD and COD

Measurement of the oxidisable organic matter in wastewater is usually achieved through determining the 5-day biological oxygen demand (BOD_5), the chemical oxygen demand (COD) and total organic carbon (TOC).

BOD_5 is a measure of the quantity of dissolved oxygen used by microoganisms in the biochemical oxidation of the organic matter in the wastewater over a 5-day period at 20°C. The test has its limitations but it still used extensively and is useful for determining approximately how much oxygen will be removed from water by an effluent or how much may be required for treatment and is therefore important when estimating the size of the ETP needed.

COD is often used as a substitute for BOD as it only takes a few hours not five days to determine. COD is a measure of the oxygen equivalent of the organic material chemically oxidised in the reaction and is determined by adding dichromate in an acid solution of the wastewater.

TDS and TSS

Wastewater can be analysed for total suspended solids (TSS) and total dissolved solids (TDS) after removal of coarse solids such as rags and grit. A sample of wastewater is filtered through a standard filter and the mass of the residue is used to calculate TSS. Total solids (TS) is found by evaporating the water at a specified temperature. TDS is then calculated by subtracting TSS from TS.

Metals

A number of metals are listed in the national environmental quality standards for industrial wastewater, including cadmium, chromium, copper, iron, lead, mercury, nickel and zinc. Many metals, which are usually only available naturally in trace quantities in the environment, can be toxic to humans, plants, fish and other aquatic life.

Phosphorus, Total Nitrogen, Nitrate and Ammonia

These parameters are all used as a measure of the nutrients present in the wastewater, as a high nutrient content can result in excessive plant growth in receiving water bodies, subsequent oxygen removal and the death of aquatic life.

pH

pH is a measure of the concentration of hydrogen ions in the wastewater and gives an indication of how acid or alkaline the wastewater is. This parameter is important because aquatic life such as most fish can only survive in a narrow pH range between roughly pH 6-9.

Sulphur and Sulphide

Textile dyeing uses large quantities of sodium sulphate and some other sulphur containing chemicals. Textile wastewaters will therefore contain various sulphur compounds and once in the environment sulphate is easily converted to sulphide when oxygen has been removed by the BOD of the effluents. This is a problem because hydrogen sulphide can be formed which is a very poisonous gas, it also has an unpleasant smell of rotten eggs. The presence of sulphides in effluents can interfere with biological treatment processes.

Oil and Grease

This includes all oils, fats and waxes, such as kerosene and lubricating oils. Oil and grease cause unpleasant films on open water bodies and negatively affect aquatic life. They can also interfere with biological treatment processes and cause maintenance problems as they coat the surfaces of components of ETPs.

2

Planning an Effluent Treatment Plant

Planning an Effluent Treatment Plant

Certain factories are required by law to install an ETP but deciding what type of ETP to install, what components it should contain and how it is best managed can be quite complicated. This chapter aims to present some simple ideas about treatment plants and offers practical advice on how to choose the most suitable one for a particular factory.

2.1 Factors to Consider

Any factory needing to install an ETP has to consider several factors. For example, information about the wastewater from the factory is required, including quantity and quality. To get this information the factory will have to take samples and have them analysed at a reputable laboratory.

Some of the factors to be considered are presented in Figure 1.

Figure 1: Considerations when Planning an Effluent Treatment Plant

What national or international standards must you comply with?

↓

What volume of effluent do you have?
What chemicals does it contain?
At what concentrations?
e.g. 30m^3/hour with COD of 500ppm, and pH of 11.5
Do you plan to increase production?
Will this increase the amount of effluent to be treated?

↓

How much can you afford to spend on constructing an ETP?

↓

How much can you afford to spend on running an ETP?

↓

How much land do you have available, or can you buy, on which to build the ETP?

↓

Which ETP expert or designer should be used?

↓

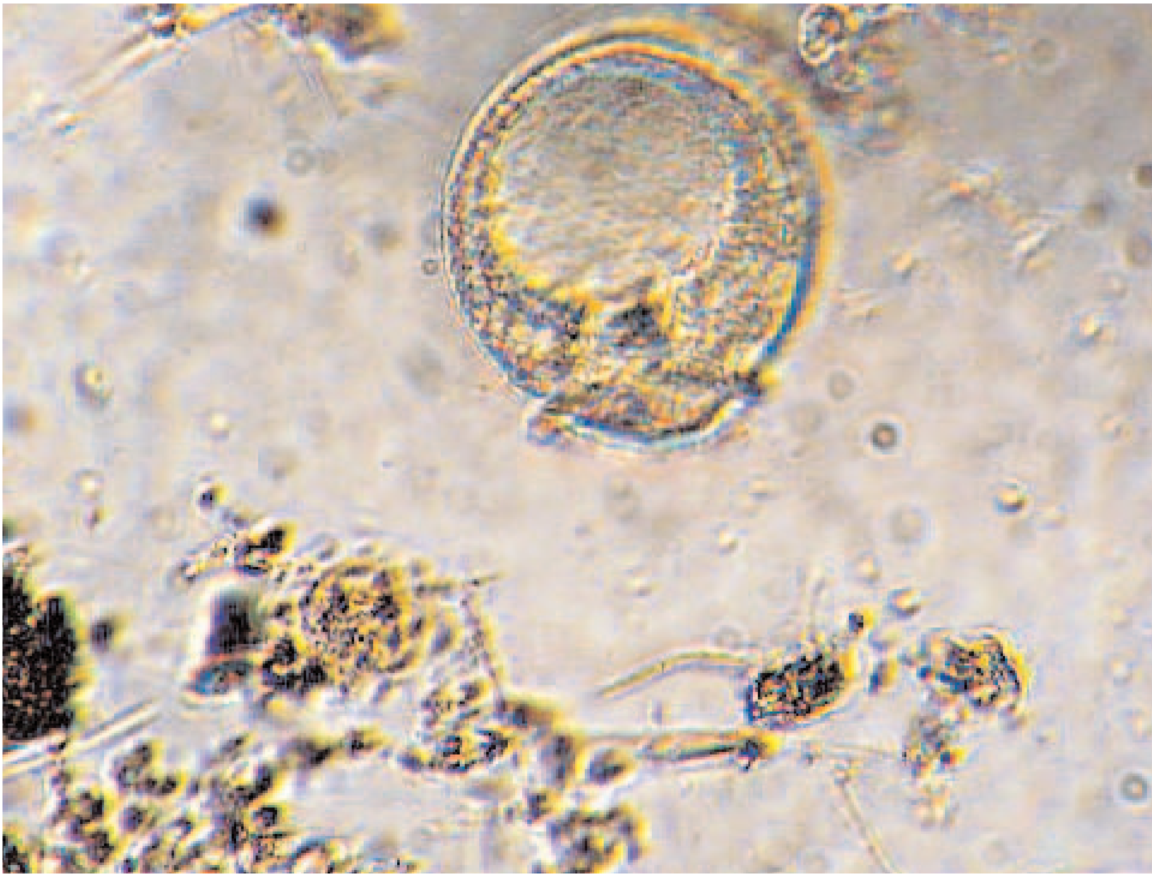
What type of plant will best suit your requirements?
(the answers that you give to the above questions will help you and the designers to decide this).

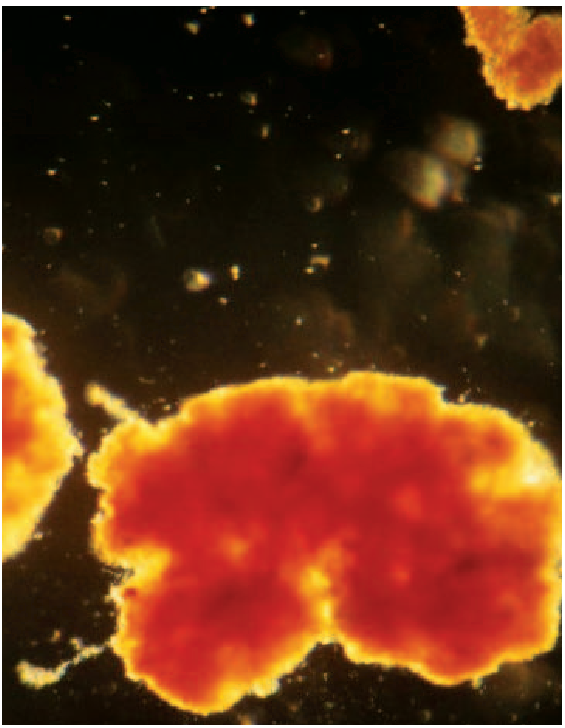
↓

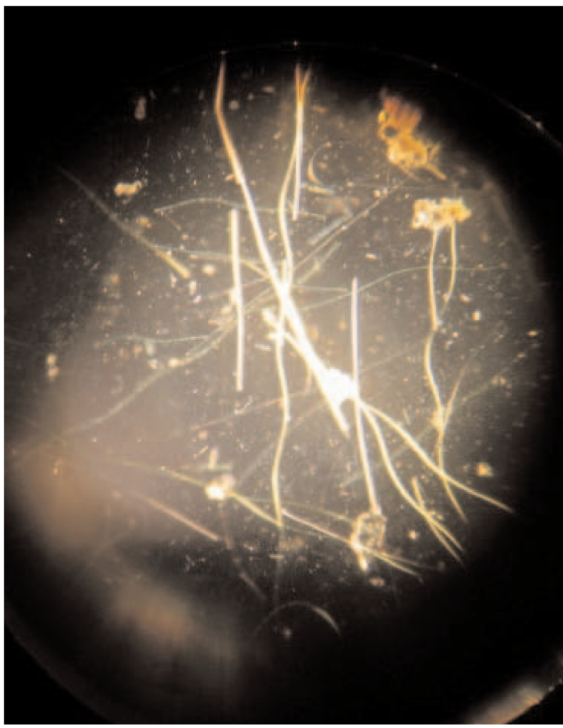
What capacity do you have in your factory to manage the ETP?
Do you need to hire more staff or train existing staff?

3

Treatment Methods







Treatment Methods

Effluent can be treated in a number of different ways depending on the level of treatment required. These levels are known as preliminary, primary, secondary and tertiary (or advanced). The mechanisms for treatment can be divided into three broad categories: physical, chemical and biological, which all include a number of different processes (Table 3). Many of these processes will be used together in a single treatment plant. Descriptions of the most commonly used processes are given in this chapter.

Table 3: Wastewater Treatment Levels and Processes[2]

Treatment Level	Description	Process
Preliminary	Removal of large solids such as rags, sticks, grit and grease that may damage equipment or result in operational problems	Physical
Primary	Removal of floating and settleable materials such as suspended solids and organic matter	Physical and chemical
Secondary	Removal of biodegradable organic matter and suspended solids	Biological and chemical
Tertiary/advanced	Removal of residual suspended solids / dissolved solids	Physical, chemical and biological

3.1 Physical Unit Operations

Common physical unit operations include among other processes screening, flow equalisation, sedimentation, clarification and aeration.

Screening

A screen with openings of uniform size is used to remove large solids such as cloth, which may damage process equipment, reduce the effectiveness of the ETP or contaminate waterways.

Flow Equalisation

There are several different steps in the textile dyeing process and therefore wastewater quality and quantity varies over time. ETPs are usually designed to treat wastewater that has a more or less constant flow and a quality that only fluctuates within a narrow range. The equalization tank overcomes this by collecting and storing the waste, allowing it to mix and become a regular quality before it is pumped to the treatment units at a constant rate. To determine the required volume of an equalization tank the hourly variation of flow needs to be determined.

Sedimentation and Filtration

The flocs formed in flocculation (see chemical unit processes for a description of flocculation) are large enough to be removed by gravitational settling, also known as sedimentation. This is achieved in a tank referred to as the sedimentation tank, settling tank or clarifier. Sedimentation is also used to remove grit and suspended solids, to produce clarified effluent, and to thicken the sludge produced in biological treatment.

Flocculation and sedimentation should remove most of the suspended solids and a portion of the BOD.

Aeration

Aeration is required in biological treatment processes to provide oxygen to the microorganisms that breakdown the organic waste (this is described in more detail in the biological treatment section). Two main methods are used for this, either mechanical agitation of the water so that air from the atmosphere enters the water, or by introducing air into the tank through diffusers.

3.2 Chemical Unit Processes

Chemical unit processes are always used with physical operations and may also be used with biological treatment processes, although it is possible to have a purely physico-chemical plant with no biological treatment. Chemical processes use the addition of chemicals to the wastewater to bring about changes in its quality. They include pH control, coagulation, chemical precipitation and oxidation.

pH Control

Waste from textile industries is rarely pH neutral. Certain processes such as reactive dyeing require large quantities of alkali but pre-treatments and some washes can be acidic. It is therefore necessary to adjust the pH in the treatment process to make the wastewater pH neutral. This is particularly important if biological treatment is being used, as the microorganisms used in biological treatment require a pH in the range of 6-8 and will be killed by highly acidic or alkali wastewater. Various chemicals are used for pH control. For acidic wastes (low pH) sodium hydroxide, sodium carbonate, calcium carbonate or calcium hydroxide, may be added among other things. For alkali wastes (high pH) sulphuric acid or hydrochloric acid may be added. Acids can cause corrosion of equipment and care must be taken in choosing which acid to use. Hydrocholoric acid is probably better from an environmental view point but can corrode stainless steel therefore plastic or appropriately coated pumps and pipes must be used.

Chemical Coagulation and Flocculation

Coagulation is a complex process but generally refers to collecting into a larger mass the minute solid particles dispersed in a liquid. Chemical coagulants such as aluminium sulphate (alum) or ferric sulphate may be added to wastewater to improve the attraction of fine particles so that they come together and form larger particles called flocs. A chemical flocculent, usually a polyelectrolyte, enhances the flocculation process by bringing together particles to form larger flocs, which settle out more quickly. Flocculation is aided by gentle mixing which causes the particles to collide.

3.3 Biological Unit Processes

The objective of biological treatment of industrial wastewater is to remove, or reduce the concentration of, organic and inorganic compounds. Biological treatment process can take many forms (Table 4) but all are based around microorganisms, mainly bacteria. These microorganisms use components of the effluent as their "food" and in doing so break them down to less complex and less hazardous compounds. In the process the microorganisms increase in number.

There are two main types of processes, these involve suspended microbial growth (e.g. activated sludge) and attached microbial growth (e.g. fixed film). With both approaches large populations of microorganisms are brought into contact with effluent in the presence of an excess of oxygen. In both systems the microbial population has to be retained in a tank referred to as the reactor.

With suspended growth systems microbes grow in small aggregates or "flocs" (this is known as activated sludge). Activated sludge (AS) leaves the reactor with the treated effluent but is settled out in a clarifier and returned to the aeration unit to recycle the bacteria. If the amount of AS is excessive some may be disposed of rather than being recycled.

In fixed film systems the microbial population grows as a thin layer (a "bio-film") on the surface of an inert support medium. The classical fixed film system is known as a percolating or biological filter and uses small stones as a medium to support microbial growth. In the more modern system microbes grow on plastic supports. In the traditional percolating filters effluent is sprayed over the medium and trickles through a packed bed with oxygen entering from the air. In more recent reactor designs, the medium (usually plastic) is submerged in effluent and air is blown into the base of the reactor. Traditional percolating filters require large areas of land and are unlikely to be of use in Bangladesh due to land costs. Submerged fixed film reactors using plastic media require much less land.

Fixed film systems require a final clarifier to remove particles of biofilm that become detached from the medium. However, this material is not recycled to the reactor.

While most of the activated sludge is recycled some may be surplus to requirements and needs to be disposed of, as does detached biofilm from fixed film reactors. This material must be disposed of appropriately so that the pollutants now present in this sludge do not enter the water cycle. The treated liquid is discharged to the environment or taken for further treatment depending on the desired standard of effluent quality or the required use of the wastewater.

Biological treatment plants must be carefully managed as they use live microorganisms to digest the pollutants. For example some of the compounds in the wastewater may be toxic to the bacteria used, and pre-treatment with physical operations or chemical processes may be necessary. It is also important to monitor and control pH as adverse pH may result in death of the microorganisms. The ETP must be properly aerated and must be operated 24 hours a day, 365 days a year to ensure that the bacteria are provided with sufficient “food” (i.e. wastewater) and oxygen to keep them alive.

Like humans, microorganisms need a “balanced diet” with sources of carbon, nitrogen, phosphorus and sulphur. While textile wastes have enough carbon and sulphur (sulphate) they are generally lacking in nitrogen and phosphorous containing compounds. If the microorganisms are to grow and work effectively they are likely to need addition of nutrients. Normally materials such as urea and ammonium phosphate are added. It is possible to replace these nutrients by substituting the liquid portion of effluent from toilets, which is rich in nitrogen and phosphorus containing chemicals (the solid portion may cause problems).

Both activated sludge and fixed film systems can produce high quality effluent but both have advantages and disadvantages. In the AS process, the settling and recycling of AS to the aerobic reactor is vital, and the settling process can be difficult to accomplish. Fixed film systems do not require recycling of biomass and so do not have this problem.

Table 4: Biological Treatment Processes

Treatment Processes	Definition
Suspended-growth processes e.g. activated sludge	The microoganisms are maintained in suspension in the liquid
Attached-growth processes or fixed-film processes	The microoganisms are attached to some inert medium such as rock or inert plastics
Combined processes	A combination of suspended-growth and fixed-film

4

Choosing an Effluent Treatment Plant


M/C NO 2

Choosing an Effluent Treatment Plant

So far this booklet has presented some of the possible components of an ETP for treating industrial waste, especially from the textile industry. Every factory that is having an ETP designed and constructed must decide which components are needed to treat the waste from that particular factory. This decision must be based on the answers to the questions presented in Chapter 2, such as the quality and quantity of the wastewater to be treated.

This chapter provides suggestions of how such an ETP may be designed and discusses the advantages and disadvantages. Three models are used for this, a purely biological ETP, a physico-chemical ETP and an ETP that combines all three. This chapter does not prescribe one particular design and there are many other ways of combining the operations and processes described in Chapter 3 that would also be highly effective.

4.1 Biological Treatment

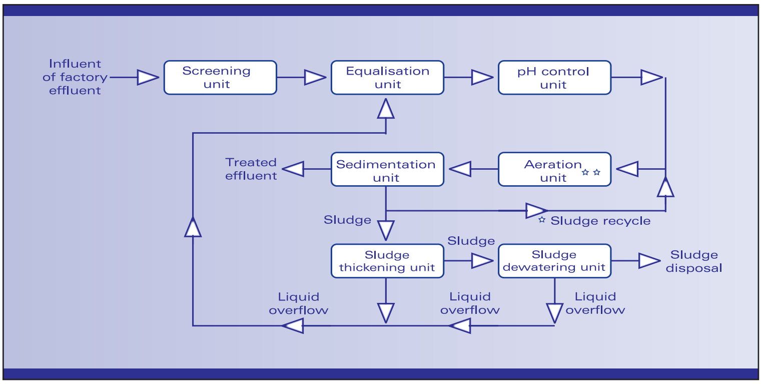
The basic units needed for biological treatment are: screening; an equalization unit; a pH control unit; an aeration unit; and a settling unit (Figure 2). A sludge dewatering unit may also be included.

Biological treatment plants require the presence of microorganisms that are adapted to degrade the components of the effluent to be treated. Textile industry waste will not contain suitable microorganisms so these must be added to the ETP when it is set up. Traditionally in South Asia cow dung is used as a source of microorganisms. While it may be useful to use cow dung it is unlikely to be the best source of microbes for treatment of textile waste. If possible new reactors (either activated sludge or fixed film systems) should be set up using activated sludge from an existing ETP, preferably one treating a similar waste. If this is not possible polluted river water is likely to be a good source of suitable microorganisms and can be used together with cow dung or activated sludge. It is likely to take several months for the microbial population to establish itself and successful treatment to result.

Output quality

Evidence shows that output quality from biological treatment can satisfy the national standards for most of the required parameters except colour. According to Metcalf & Eddy (2003) a properly designed biological ETP can efficiently satisfy BOD, pH, TSS, oil and grease requirements. However, as already mentioned, the compounds in industrial wastewater may be toxic to the microorganisms so pre-treatment may be necessary. Similarly most dyes are complex chemicals and are difficult for microbes to degrade so there is usually very little colour removal.

Figure 2: Typical Flow Diagram of a Biological Treatment Plant in Bangladesh



* *A sludge recycle line is essential for activated sludge systems but is not needed for fixed film systems.*

** *The aeration unit can be either activated sludge or a fixed film reactor.*

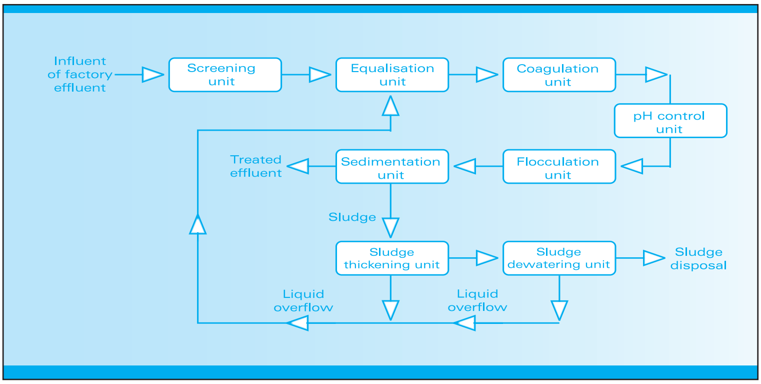
4.2 Physico-chemical Treatment

The basic units needed for a stand-alone physico-chemical treatment plant are screening, an equalization unit, a pH control unit, chemical storage tanks, a mixing unit, a flocculation unit, a settling unit and a sludge dewatering unit (Figure 3).

Output quality

With physico-chemical treatments generally used in Bangladesh (coagulation and flocculation) it is possible to remove much, possibly all of the colour depending on the process used. It is however difficult to reduce BOD and COD to the value needed to meet the national effluent discharge standard, and impossible to remove TDS. The removal rate is dependent on the influent wastewater quality. The removal efficiency of this type of treatment has been found to be 50% and 70% for BOD_5 and COD respectively[3].

Figure 3: Typical Flow Diagram of a Physico-chemical Treatment Plant in Bangladesh



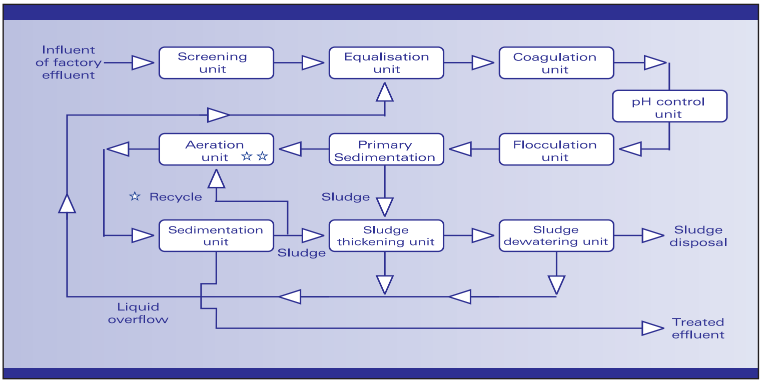
4.3 Physico-chemical and Biological Treatment

In this type of treatment a combination of physical operations, and physico-chemical and biological processes are used. The basic units needed for a physico-chemical and biological treatment plant are screening, an equalization unit, a pH control unit, chemical storage tanks, mixing units, flocculation units, a primary settling unit, an aeration unit, and a secondary settling unit (Figure 4). The physico-chemical unit always comes before the biological unit.

Output quality

These are the most common form of ETP used in Bangladesh for the treatment of textile waste and are the most likely to meet the water quality standards set by the Government of Bangladesh, as they provide the benefit of physical, chemical and biological treatment and can therefore raise the efficiency of BOD and COD removal to 90 %.

Figure 4: Typical Flow Diagram of a Physico-chemical and Biological Treatment Plant in Bangladesh



** A sludge recycle line is essential for activated sludge systems but is not needed for fixed film systems.*

*** The aeration unit can be either activated sludge or a fixed film reactor.*

4.4 Area Requirement Comparison

The area needed for an ETP depends mostly on the quality of wastewater to be treated, flow rate, the type of biological treatment to be used and the orientation of different treatment units. In general physico-chemical treatment plants require the least area and biological treatment plants require the largest area (Table 5), but good civil engineering can greatly reduce the land area required and some factories in Bangladesh have had ETPs designed on several levels to minimise the land area used. This will require extra pumps and piping, and stronger tank walls, so construction costs may be higher for tall structures.

Table 5: Common Area Requirements of Different Types of ETPs*

	Physico-chemical	Biological	Combined physico-chemical and biological
Area required (for 30 cubic metre/hour flow)	80 sq metres	170 sq metres	140 sq metres

* *The area requirement values given in this table are not absolute and depend on the exact design of the ETP but they provide a broad comparison of the possible area requirements.*

4.5 Cost Comparison

The installation costs of ETPs can vary greatly depending on such factors as the materials used, including the quality and source of the equipment (e.g. pumps and air blowers), land area and dimensions for construction, the quality and quantity of wastewater to be treated, and the quality of the required output. In addition, the operating costs of ETPs can also vary greatly depending on quality and quantity of inputs such as chemicals, the efficiency and size of motors and therefore the energy required, the method of treatment and the efficiency of ETP management.

Table 6 gives an idea of the potential costs. These are based on examples of costs provided by industrialists with ETPs or those who are planning to install ETPs in Bangladesh (and therefore may not be entirely accurate.)

Table 6: Installation and Operational Costs Comparison of ETPs in Bangladesh*

	Capacity (m^3/month)	Installation cost (Tk)	** Running Cost (Tk/month)	** Running Cost (Tk/m^3)
Normal Range	20,000	4,000,000 6,000,000	400,000 800,000	20-40
Possible Range	20,000	3,000,000 12,000,000	300,000 3,000,000	15-150

* *These figures were provided by designers and industrialists and may vary considerably from plant to plant.*
** *Excluding depreciation.*

References

[1] Government of the People's Republic of Bangladesh (2000), *The Environment Conservation Rules* 1997, (unofficial translation), Ministry of Environment and Forests, Dhaka.

[2] Metcalf and Eddy (2003) *Wastewater Engineering Treatment and Reuse* McGraw - Hill, New York.

[3] Nicolaou M. and Hadjivassilis I. (1992), Treatment of wastewater from the textile industry, *Water Science and Technology*, **Vol. 25**, No. 1, pp 31-35.

This booklet has been put together to give a brief and straightforward introduction to effluent treatment plants (ETPs) for the textile industry. It provides some informtion on the effluent quality standards set by the Government of Bangladesh and briefly describes what they mean. It also outlines the basic components of ETPs and how they can be combined effectively to produce effluent that meets the national environmental quality standards. It is not a comprehensive manual but one in a series of booklets that cover various aspects of the dyeing industry including efficiency, cost reduction, pollution mitigation, effluent treatment, environmental legislation, health and safety, and corporate responsibility.

The booklet has been written by a team from, the Stockholm Environment Institute (SEI), the Bangladesh Centre for Advanced Studies (BCAS) and the University of Leeds, for the "Managing Pollution from Small- and Medium-Scale Industries in Bangladesh" project. The work was funded by the UK Department for International Development under its Knowledge and Research Programme, and the Government of Bangladesh under the pollution component of the Investment Support to MACH. However, the views and opinions expressed here are not necessarily those of the funding agencies.

SEI STOCKHOLM ENVIRONMENT INSTITUTE

BCAS

UNIVERSITY OF LEEDS

DFID Department for International Development