EFFECTIVENESS OF WASTEWATER TREATMENT METHODOLOGIES AVAILABLE FOR TEXTILE INDUSTRIES IN SRI LANKA

By

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00/AS/099

This thesis is submitted in partial fulfillment of the requirements for the degree of

Bachelor of Science
in
Natural resources

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May 2004

DECLARATION

The work described in this thesis was carried out by me at Lanka Environmental Recycler's Institute and Faculty of Applied Sciences under the supervision of Dr. (Mrs.) Ajantha Perera and Ms. Enoka. P. Kudavidanage. A report on this has not been submitted to any other university for another degree.

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Affectionately Dedicated
To
My Parents
And
Teachers

ACKNOWLEDGEMENT

First I should express my deepest gratitude to my internal supervisor Ms. Enoka Kudavidanage, lecture, Department of Natural Resources, Faculty of Applied Sciences, for her encouragement and guidance through this study.

I wish to express my sincere thanks to my external supervisor Dr. (Mrs.) Ajantha Perera Chairman, Lanka Environmental Recycler's Institute for her advice, encouragement and guidance through the study and for sparing her valuable time in bringing this study to a successful completion.

I express my sincere gratitude to all factory managers and staff members of Hirdaramani Industries- Seethawaka, Melbourne Washing Plant-Mahiyangana, Ocean Lanka Private Limited- Biyagama and Stretchline Private Limited-Buiyagama for the providing me the opportunity to carry out the study at the factory site.

A special thanks to all the staff members of Board Of Investment (BOI)- Head office, BOI – Seethawaka, BOI- Avissawella and Water Supply and Drainage Board-Seethawaka, for providing me with laboratory facilities and information.

I express my sincere gratitude to Dr. Mahinda Wickramarathne the Dean, Faculty of Applied Sciences, Sabaragamuwa University of Sri Lanka, and Prof. Mahinda Rupasinghe, Head, Department of Natural Resources, Faculty of Applied Sciences, Sabaragamuwa University of Sri Lanka, for guiding me toward a successful completion.

Finally, I express my heart-felt gratitude toward the Lecturers for their co-operation throughout my study and my colleagues for their individual help and guidance at all times.

ABSTRACT

Textile industry is one of the most income generating as well as polluting industries in Sri Lanka. The study was carried out to identify the methodologies available for waste treatment in Textile industry through analysis of the effectiveness of the available methodologies in terms of quality of the wastewater. The industries selected for the study were Hirdaramani, Melbourne Washing Plant, Ocean Lanka and Stretchline Private Limited.

Both Melbourne and Hirdaramani use Pre treatment, Physical and Chemical treatment as well as Biological treatment. Ocean Lanka and Stretchline on the other hand used Pre treatment, Physical and Chemical treatment, but no Biological treatment. Hirdaramani show an overall efficiency of 94% in decreasing BOD (Biochemical Oxygen Demand), COD (Chemical Oxygen Demand as well as TSS (Total Suspended Solid). Melbourne revealed an overall efficiency 95% in same parameters. Ocean Lanka showed an overall efficiency of 64% in decreasing BOD, COD, as well as TSS. Stretchline showed an overall efficiency of 70% in all parameters. Hirdaramani and Melbourne show higher overall efficiencies compare to Ocean Lanka and Stretchline. This is due to the efficiency BOD, COD and TSS through Biological treatment.

Sri Lanka standards set for wastewater release to the inland waters as obtained from the treatment plants are as same as standard set by India, Thailand and Nepal. One of the major current improvements in wastewater treatment in Textile industry is the availability of efficient laboratory facilities, and the reuse of wastewater.

CONTENT

LIST OF ABBREVIATIONS

BEPZ	-	Biyagama Export Processing Zone
BOD_5	-	Five Day Biochemical Oxygen Demand
BOD	-	Biochemical Oxygen Demand
BOI	-	Board Of Investment
CEA	-	Central Environmental Authority
COD	-	Chemical Oxygen Demand
DAF	-	Dissolve Oxygen Demand
DO	-	Dissolve Oxygen
EPZ	-	Export Processing Zone
IPZ	-	Industrial Processing Zone
RBC	-	Rotating Biological Contactor
TDS	-	Total Dissolved Solid
TSS	-	Total Suspended solid
TS	-	Total Solid

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CHAPTER 01

Introduction

1.0 Introduction

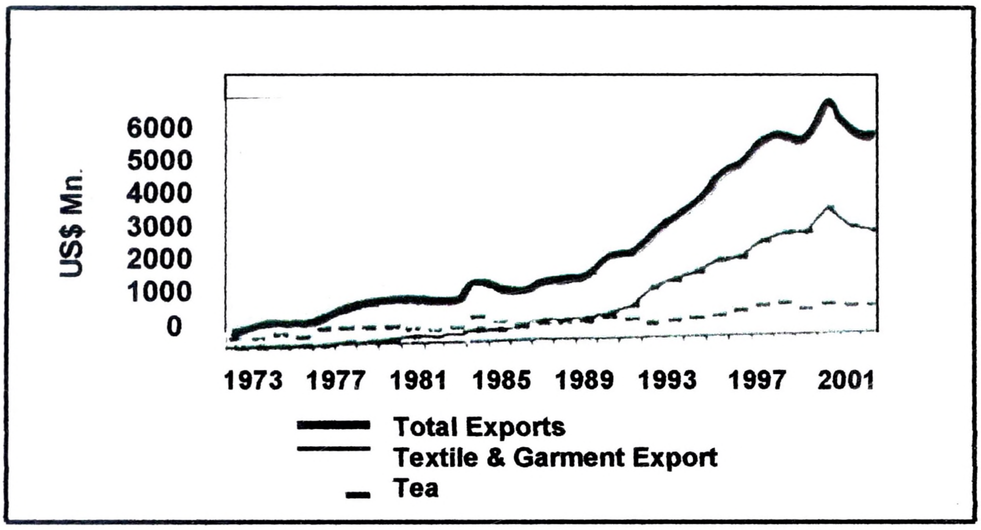
The textile and garment industries at Sri Lanka are presently some of the most important industries in Sri Lanka. There are over 1000 medium and large-scale Textile factories in Sri Lanka. They are established within Export Processing Zones under Board Of Investment (BOI) or outside Export processing Zone, some independent and some under BOI.

1.1 Economic Review

Since liberation the export structure has became diversified with industrial exports led by textile and garments, becoming the largest contributor to export earning; accounting for 77% of total export in 2002. (Economic Review, July/August-2003)

According to the Central Bank Annual Report of 2002, Textile and garment industry contribute 53% of total export value and, it contribute 55% to Gross National Product. There are over 1000 medium and large-scale factories established in Sri Lanka providing direct employment to about 330,000 people. (Central Bank, 2002)

Textile and Garment, which became the Sri Lankas largest single item of exports in 1986, continues to maintain its position and has increased its share from 28% in 1986 to 52% in 2002. (Figure 1.1)



Source: Economic Review, July/August 2003

Figure 1.1 Export earning Textile and Garment and Tea.

Although the gross earning from the textile and garment sector is high, tea remained the country' s largest net foreign exchange earner till 1991. The textile and Garment sector has became Sri Lankas largest net foreign exchange earner since 1992. (Figure 1.2)

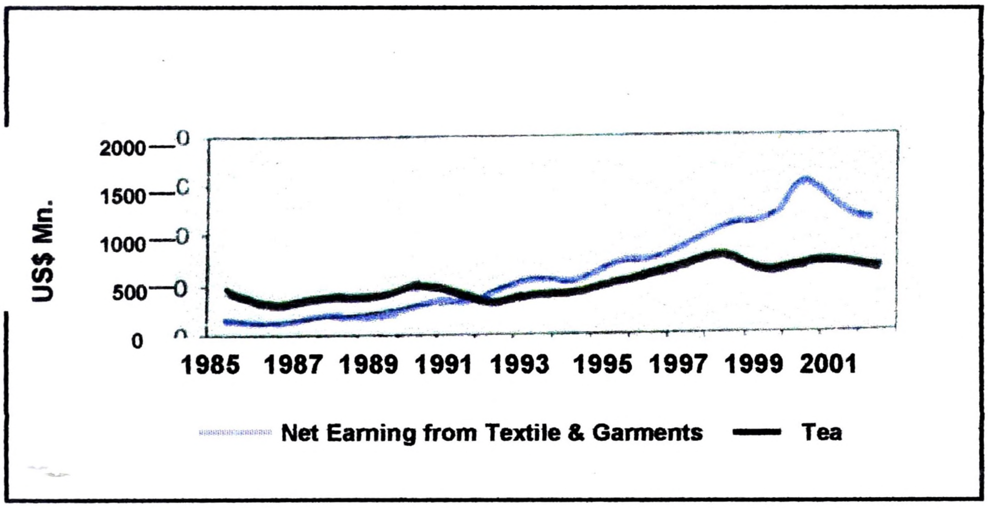


Figure 1.2 Net earning from Textile and Garments Vs Tea.

Source: Economic Review, July/August 2003

1.2 Nature of the Sri Lankan Textile Industry

Normally, Sri Lankan textile industries involve three major operations. They are Spinning, Weaving/Knitting and Finishing. Spinning and weaving operations are dry processes. They cause minor pollution problems. But Finishing operations are essentially wet processes. They release much amount of wastewater and create major problems.

1.3 Environmental point of view

The textile industry generates gaseous, Solid and liquid waste. Its main environmental issue is water pollution.

From an environmental point of view, the textile industry release wide spectrum of waste and it varies in terms of raw materials and techniques employed chemical use and the final products. Textile processing generates many waste streams, including water based effluents as well as air emission solid and hazardous wastes.

The textile processing industry is one of the most polluting industrial sectors in Sri Lanka, after the Natural Rubber industry. The textile processing generates largest liquid waste loads. (CEA, 1992 a)

The textile processing industries cause serious water pollution problem in specific areas, due to the relatively large size of the textile processing and concentration of mills in certain areas.

The environmental impact of gaseous emission and solid waste are of minor concern in comparison with the impact of wastewater discharge.

1.4 Scope of the study

The wastewater discharge quality standards, Acts introduced by the Sri Lanka. Government is discussed and some modifications for these standards and intermediate standards are proposed. In some cases, it has been observed that some plants are able to comply with the environmental regulations setup by local authorities creating some minor environmental problems.

Presently most textile processing industries discharge their wastewater into the nearest surface water. Most factories have wastewater treatment facilities, but the treatment efficiency of the existing wastewater treatment systems is generally low.

However, the nature of the waste generated depends on the type of textile facilities the processes and technologies being operated and type of raw material and chemical used. Treatment plants using several treatment methods have been established to minimize the hazardous effects of the waste released, a clear investigation has not yet been performed to study their effectiveness. Therefore this study was carried out identifying of their existing methodologies and check of effectiveness.

1.5 Objectives of the study

1. Studying the present methodologies available for wastewater treatment in Textile Industry.

2. Analysis of the effectiveness of the available methodologies in terms of the quality of the wastewater.

3. Comparison with the technologies available in three other countries and their standards.

CHAPTER 02

Wastewater Treatment in Textile Industry

2.1 A brief history of the Sri Lankan Textile industry

The textile industry of Sri Lanka rapidly developed from the 1960s. Before this period the industry was confined to the operation of scattered handlooms. Though the country with the single exception of one integrated textile mill, the Wellawatta spinning and weaving mills being around 1888.

Up until the 1960s the textile requirements of the country were largely met by imports. The local handloom industry, which grew during the Second World War and the year following faced several competitions from, unrestricted imports. Protective measures for its survival were introduced.

A significant step was the establishment of the National textile cooperation in 1958 as an instrument for the implementation of the textile development plan of the government through public sector enterprises.

From late 1977, with the change of government and the free import textile, the quantity and range of textile available to the consumer increased. However the free import of textile had serious repercussions on weaker industrial unit of the industry, many of which provide unable to withstand competition of unrestricted imported goods. Furthermore, increasing competition international markets continues to threaten the viability of old and relatively inefficient mills in Sri Lanka.

The most important event to occur on recent time is the privatization or "people-isation" of the large public sector textile mills of the four large government mills; Pugoda and Thuhiriya has been privatized. Veyangoda was converted in to a public limited company in December 1989 and the privatization of Mttegama is expected shortly. Thulhiriya was sold to Kabool of Korea and Lakshmies of India acquired a 60% equity stake in Pugoda. The Government of Sri Lanka hopes that the deeper involvement of the private sector in the industry will act as stimulus for the much needed technical and managerial moderation of the industries (CEA, 1992a).

2.2 Sri Lankan Textile processes and waste generation

The Sir Lankan textile industries involve major three operations. They are Spinning, Weaving/kitting and Finishing.

Spinning and weaving are essentially dry processes and cause therefore relatively minor pollution problems. Significantly pollution problem are, however, caused by the various finishing operations (Table 2.1), including desizing, washing, scouring, mercerizing bleaching, dyeing/printing and various types of final treatment processes.
The finishing processes consume large quantities of waste producing substantial volumes of liquid waste, which is a significant source of water polluting in Sri Lanka. The textile industry is also associated with significant occupational health hazards, such as exposure to noise, dust and obnoxious vapours.

The growing awareness of pollution and its harmful effects in recent years had much influence on changes both in equipments and methods. Among the major pollution problems presented by the textile wet processing industry those relating to water pollution and air pollution have assumed considerable significance in the present day context (Trivedi, 1987).

The wastewater discharge quality standards, as introduced by the Sri Lanka. Government is also discussed and some modifications for these standards and intermediate standards are proposed. In some cases, it has been observed that some plants are able to comply with the environmental regulations setup by local authorities creating some major environmental problems.

2.3 Water Utilization

Through numerous studies ATIRA (Ahmedabad Textile Industries Research Association) has determined the general pattern of consumption of water in mills. The daily water consumption of an average sized textile mil having cloth production of about 8,000 kg/day is about 1.6 million liters and the pattern of water consumption for the various processes/plants is given Table 2.1, which sows the water consumption in the bleaching department to be the highest. The major water consuming machine in different department of wet processing are kiers, washing machines, mercerizing machine, open-width soapre, jigger, etc (Jhala et.al, 1981).

Cost of water is thus rising steeply and as in many other industries measures to conserve water have been introduced. Textile mills which need large quantity of water for various process and also demand is increasing every year with expansion and introduction of new finishing processes

Table 2.1

Water Consumption Pattern in Textile Mills

No.	Process	Total Water Consumption, %
1.	Bleaching, Finishing	38
2.	Dyeing	16
3.	Printing	08
4.	Boilers	14
5.	Humidification in Spinning	06
6.	Humidification in Weaving	09
7.	Sanitary, Domestic, etc.	09

Source: Jahala et.al, 1981, Water and Effluent in Textile Industry.

2.4 Definition of Wastewater

Every community produces both liquid and solid wastes. The liquid portion-wastewater-is essentially the water supply of the community after it has been fouled by a variety of uses. From the standpoint of sources generation, wastewater may be defined as a combination of the liquid or water-carried waste removed from residence, institution, and commercial and industrial establishments, together with such ground water, surface water, and storm water as may be present (George and Franklin, 1999).

2.5 Common Characteristics of wastewater

Wastewater is characterized in its Physical, Chemical and Biological composition. Many of the parameters are interrelated. For example, temperature, a physical property, and affects both the biological activity in the wastewater and amounts of gases dissolved in the wastewater.

2.5.1 Physical characteristics

The most important physical characteristics of wastewater is its total solids content. Which is composed of floating matter, settle able matter, colloidal mater, and matter in solution. Other important physical characteristic includes odour, temperature, density, color and turbidity (CEA, 1992b).

2.5.2 Chemical characteristics

Chemical characteristics of wastewater are presented in three parts. They are Organic matter, Inorganic matter and Gases (CEA, 1992b).

2.5.3 Biological characteristics

This part consist the live part of wastewater. Biological characteristics are Bacteria, Fungi, Algae, Protozoa, Plant, Animal and Viruses (CEA, 1992b).

2.6 Types of Textile-works Effluents

The process used in textile works need on introduction to textile finishers, but the properties of the discharged may not be familiar from the point of view of effluent treatment. It is worthwhile surveying the processes that are responsible for the bulk of the pollution in waste and to conceder some of their properties that affects the treatment processes used. (Table 2.2)

Table 2.2

Wastewater composition of the individual textile processing operations

Operations	Effluent constituents
• Desizing	Enzymes, acids, sodium chloride ($NaCl$), starch and glucose
• Scouring	spent caustic soda ($NaOH$), sodium phosphate (Na_3PO_4), Natural Organic Substance (wax, grease, and oil)
• Bleaching (Hypochlorite)	spent hyphochlorite, sodium hydroxide, sodium carbonate, sodium sulphate, oxalic acid
• Bleaching (Peroxide)	sodium silicate, sodium hydroxide, sodium phosphate, surfactant and chelating agent
• Mercerizing	spent sodium hydroxide, suspended solid (Foreign material and Wax) This wastewater is generally concentrated and reuse.
• Dyeing and Printing	organic acids, acetic acid, kerosene, solvent, pigment and sodium carbonate
• Final treatment	detergents, starch, resins, chlorinated aromatic compounds

Source: Kelani River pollution study, 1988

2.7 Environmental Impacts

Waste arising from the textile processing industries may cause pollution of land, air and surface water. The environmental impacts of the textile processing industries are briefly described in the following.

2.7.1 Wastewater discharge

The crude waste, if discharge in to the stream, causes rapid depletion of the dissolved Oxygen (DO) of the stream. The condition. aggravates due to the settlements of the suspended substance and subsequent decomposition of the deposited sludge in anaerobic condition. The alkalinity and the toxic substances like sulphides and Chromium affect the aquatic life and also interfere with the biological treatment process: some of the dyes are also found toxic. The color often renders. The water unfits for use some industrial porpoises in the downstream side. The presences of sulphide make the waste corrosive particularly to concrete structures (Rao and Datta, 1987).

Wastewater from textile processing contains various components which are harmful for the aquatic environment and are toxic for man and animal in the cause of ingestion or physical contact Textile processing wastewaters contain oil and biodegradable organic compounds, which may cause anaerobic conditions in receiving surface waters, resulting in die off fish and other water organisms and emission of foul odors.

Presently most textile processing industries discharge their wastewater into the nearest surface water. A few factories have wastewater treatment facilities, but the treatment efficiency of the existing wastewater treatment systems is generally low.

In many cases the textile processing wastewater, after discharge, diluted to such a degree, that little or no damage to the receiving water is observed. However in a number of cases the discharges of textile processing wastewater contribute significantly to serious pollution of surface water.

The most salient example of surface water pollution, caused by discharge of industrial wastewater of which textile processing wastewaters are the most important, are the Bolagoda Lake and the Lunawa Lake in Ratmalana/Moratuwa area. Both Lake receive wastewater from the five (05) textile processing industries in Ratmalana.

The Lunawa Lake, which is tidal lagoon with brackish water, is already seriously polluted. The Lake is unsuitable for fisheries or any other purpose. The environmental nuisance, caused by this, lake is how ever some what reduce by the periodic inflow of clean water from the ocean.

The Bolagoda Lake is an inland Lake, which has an important function for fishery and recreation. Some art of the lake is seriously polluted, due to discharge of industrial and domestic wastewater and also illegal dumping of solid wastes along the embankments and in adjoining low-lying lands, if further degradation of lake continues, it will become completely unsuitable for the purposes, it is used for presently (CEA, 1992b).

2.7.2 Gaseous emissions

Air pollution from textile processing industries can be classified in to two categories being stake emission and vapours containing organic solvent from the dyeing and printing processes.

Gaseous emissions from textile processing industries generally cause little air pollution or nuisance for the environment. However, complaints regarding nuisance caused by emissions of obnoxious vapors from textile processing industries have been made however by Ratmalana Civilians living in the vicinity of these industries.

2.7.3 Solid waste disposal

The textile mills produce relatively little quantities of solid waste. Solid wastes arising from textile processing industries include pieces of yarn, pieces of cloth and Packing materials such as polythene. In some of the textile processing industries these waste are burnt in the open air within then premises of the industry-causing nuisance to the surroundings.

In some other cases the solid wastes are dumped along the roadsides or in drains or watercourses, causing deterioration of the water quality and clogging drains and watercourses (CEA, 1992b).

2.8 Wastewater Treatment in Textile Industry

2.8.1 Selection of Treatment system

The selection of wastewater treatment system depend on the local conditions and on a number of selection criteria, such as,

- Investment cost
- Operation and maintenance cost
- System efficiency and reliability
- Availability of land
- Skilled personal
- Local effluent discharged quality standards

2.8.2 Wastewater Treatment Methodologies

2.8.2.1 Pretreatment methods

Textile processing wastewaters have to be pretreated before they can be treated by biological or physical/chemical methods. The type of pretreatment system, to be applied, depends on the type of treatment system that is selected for further treatment. Most commonly applied pretreatment methods are Screening, Equalization and Neutralization

2.8.2.1.1 Screening

Screens are applied for the removal of coarse materials, such as pieces of cloth and yarn, from the wastewater. The screen should be installed in the wastewater outlets from the separate production processes. Series of with gradually narrow mesh widths should be installed (CEA, 1992b).

2.8.2.1.2 Equalization

Wastewaters from textile processing are often characterized by an irregular flow pattern. By storing the wastewater in an equalization tank it is possible to create a uniform flow rate to the following treatment step. Shock loads are prevented by equalization. Equalization is not required if the following treatment step has a long retention time (more than 24 hours) (CEA, 1992b).

2.5.2.1.3 Neutralization

Some textile processing wastewaters (e.g. from scouring and bleaching) have a high pH (>10), and the combined wastewater generally also has a high pH (>9.5). Before the wastewater can be treated by a biological or a physical/chemical method, the pH of the wastewater should be reduced to a specific level (CEA, 1992b).

2.8.2.2 Physical/ Chemical treatment methods

Wastewater from dyeing, printing and processes (textile finishing wastewaters) contain pigments, (chlorinated) organic compounds, heavy metals and a great variety of other compound, added in the production processes. Physical/chemical treatment processes, are usually applied, when these wastewaters are treated in a separate system.

Most commonly applied physical/chemical methods are Coagulation/flocculation, Activated carbon adsorption, Membrane filtration and Ozone oxidation

2.8.2.2.1 Coagulation/flocculation

In the coagulation process destabilization of the colloid particles in the wastewater takes place by means of addition of specific chemicals. As a result these particles grow into flocs (flocculation). By adsorption of more colloidal and suspended substances the mass of flocs increase. The flocs can be separated from the wastewater by sedimentation, flotation or filtration. Sedimentation is the most applied separation method. Coagulation/flocculation is an effective method for removal of phosphors, microorganisms, heavy metals and various other impurities. Coagulation agents most frequently used in wastewater treatment are iron

(Fe^{3+}) and aluminium (Al^{+3}) salts and lime. The flocculation process efficiency is improved by addition of poly-electrolytes. A coagulation/flocculation system generally consist consists of a coagulation tank (with vigorous mixing of wastewater coagulating chemicals, retention time of about 3 minutes); a flocculation tank (with slow mixing, retention time of about 20 minutes); and sedimentation tank.

For treatment of textile finishing waste by coagulation/flocculation approximately 300 mg/l Al-salt and 5mg/l poly-electrolyte have to be added to the wastewater. According to literature data the COD removal efficiency of this process is approximately 40% and the colour removal efficiency 50-70% (CEA, 1992b).

2.8.2.2.2 Activated carbon adsorption

In the activated carbon adsorption treatment process the wastewater is led through a filter of activated carbon granular, which are characterized by a high a very high specific surface. Impurities, especially organic molecules are removed from the wastewater by adsorption to the surface of the activated carbon. This is an effective for treatment of textile finishing wastewater with a colour removal efficiency of approximately 90%.

Prior to activated carbon adsorption the wastewater has to be pretreated to remove suspended solid and oil. Disadvantages of activated carbon adsorption are the complicated operation and the high costs. For these reason this system is presently not considered as a feasible system for treatment of textile processing wastewater (CEA, 1992b).

2.8.2.2.3 Membrane filtration

Various membrane filtration systems are available for treatment of industrial wastewaters.

Best-known membrane filtration systems are:

Micro filtration, to remove particles with a diameter between 0.1 and 30 µm

Ultra filtration, to remove particles with a diameter between 0.002 and 1 µm

Hyper filtration (or reverse osmosis) to remove dissolved particles

In membrane filtration the wastewater is pressed through the membrane, resulting in a diluted stream and a concentrated stream, which contains the impurities. Membrane filtration is an effective method for removal of heavy metals and organic pollutants. Prior to membrane filtration the wastewater often has to be pretreated for removal of suspended solid, pH adjustment or precipitation of dissolved particles. Due to the high costs of this system it is presently not considered feasible for treatment of textile finishing wastewaters (CEA, 1992b).

2.8.2.2.4 Ozone oxidation

Ozone is a strong oxidizing agent. It degrades organics, which are non-biodegradadable. As a result ozone oxidation is an effective method for removal of the colour from the textile finishing wastewaters.

However due to the high costs of this process it is presently not considered feasible for treatment of textile finishing wastewaters (CEA, 1992b).

2.8.2.3 Biological treatment methods

The following biological treatment methods are applied for treatment of textile processing wastewaters. They are Activated sludge, Aerated ponds and Rotating Biological Contactors (RBC).

2.8.2.3.1 Activated sludge

In the activated sludge process wastewater is I\led in to a tank, where it is mixed with flocs of aerobic micro-organisms (activated sludge). The mixture of wastewater and activated sludge is kept in suspension and aerated by mechanical aerator or by supply of diffused air. Organic matter and suspended solids in the wastewater are absorbed by the activated micro-organisms, which biodegrade the organic matter aerobically, utilizing it as a substrate for the growth of the new cell and as a source of energy. As a result the quantity of sludge in the aeration tank increases. Part of the micro-organisms in the aeration tank is oxidized (endogenous respiration) into inert solids (mineralization).

The mixture is led from the aeration tank in to a sedimentation tank, where the flocs settled into sludge. Part of the settled is returned to the aeration tank in order to maintain a constant activated sludge concentration in the aeration tank. The remainder of (surplus sludge) is removed and disposed of

Some different types of activated sludge wastewater treatment system exist. The different between the systems has been on the organic loading rate of the system (kg BOD/kg) dry sludge per day). High load, low load and ultra-low load system are in use. Low and ultra-low load system are generally preferred for treatment of textile processing wastewater, because of the better effluent quality and the higher reliability of these systems (CEA, 1992b).

2.8.2.3.2 Aerated ponds

Various types of ponds system for treatment of wastewater exist: anaerobic ponds, facultative ponds, aerated ponds and maturation ponds.

In anaerobic ponds organic matter is biodegraded by anaerobic bacteria.

In facultative ponds aerobic biodegradation takes place in the upper layers of the ponds and anaerobic biodegradation at the bottom. Oxygen is mainly, supplied by algae.

In aerated ponds organic matter is biodegraded aerobically,
Oxygen is supplied artificially, usually by means of mechanical surface aerators.

Maturation ponds are used to improve the quality of the effluents from other types of ponds.

Aerated ponds are the only type of ponds, which can be used for treatment of textile processing wastewaters, due to ponds high concentration of colour and of organics, which are hard to biodegrade.

Two different types of aerated pond systems are applied in wastewater treatment. They are Completely mixed aerated ponds and Facultative aerated ponds (CEA, 1992b).

2.8.2.3.3 Rotating Biological Contactors (RBC)

A rotating biological contactor unit (RBC) consists of a porous filter medium mounted to an horizontal shaft. The filter medium provides a surface for the growth of film of active microorganisms. The RBC slowly rotates through a tank to which the wastewater is fed. During its rotation the RBC lift ups quantity of wastewater, resulting of incentive contact between the wastewater, the biomass on the filter surface and oxygen from the air. The film of microorganisms absorbs organic matter from wastewater, which is biodegraded aerobically in the process of substrates utilization by the microorganisms for growth and formation of new cells. The effluent of the RBC tank is led into a sedimentation tank in which excess sludge, washed off from the contact surface, settles (CEA, 1992b).

2.9 Environmental Legislation related Textile Industry

Wastewater generation was increased due to the establishment of industries with industrialization. To prevent the environmental pollution from wastewater, many countries introduced regulations and wastewater quality standards.

As all the other countries, Sri Lanka is subjected to rapid industrialization in the competitive world. The government if Sri Lanka promotes the industrial activities in order to increase the income level of people while giving much profits of the country. Industrialization contributes to the deterioration of the environment to a sign extent. (CEA, 1992 b)

The government has, therefore, introduced environmental legislation to enhance environmental protection and pollution controlled. The National Environmental Act No.47 of 1980, amended by Act No. 56 of 1988 is the main piece of legislation in this regard. The Central Environmental Authority (CEA), which was setup under the National Environmental Act, is the leading agency in the implementation and enforcement of the environmental legislation. The industrial pollution control guidelines prepared by CEA describe the wastewater discharge quality standards which should be satisfied by Textile processing industries. (Table 2.3)

Now, CEA delegate their authorities to BOI and they have another tolerance limits for common wastewater treatment plant in the BOI processing zone (Table 2.4).

Table 2.3
General standards for industrial wastewater (Effluent) discharge in to Inland Surface Waters (After Treatment)

Parameters	Maximum Tolerance Limit
pH	6.5-8.5
Suspended Solid (mg/l)	50
Temperature (C^0)	40
BOD (5 day at 20^0 C) (mg/l)	30
COD (mg/l)	250
Phenolic compound (as C_6H_5OH)(mg/l)	1.0
Cyanides (mg/l)	0.2
Sulphides (mg/l)	2.0
Fluorides (mg/l)	2.0
Total residual Chlorine (mg/l)	1.0
Total residual Chlorine	50
Ammonical Nitrogen (as N) (mg/l)	0.2
Arsenic (as As) (mg/l)	0.1
Cadmium (as Cd) (mg/l)	0.1
Chromium (as Cr) (mg/l)	3.0
Copper (as Cu) (mg/l)	0.1
Lead (as Pb) (mg/l)	0.0005
Mercury (as Hg) (mg/l)	3.0
Nickel (as Ni) (mg/l)	0.05
Selenium (as Se)((mg/l)	5
Zinc (as Zn) (mg/l)	Nil
Pesticide	10.0
Oil and grease (mg/l)	-
Radioactive Materials	
Alpha emitters (µc/ml)	10^{-7}
Beta emitters (µc/ml)	10^{-8}

mg/l = milligram/liter
µc/ml = microcuries/milliliter
BOD = Biochemical Oxygen Demand
COD = Chemical Oxygen Demand

Note: -
These values are based on a dilution of the effluents by at least 8 volume of clean receiving water. If the dilution is bellow 8 times, the maximum tolerance limits shall be worked out on a proportionate basis taking in to consideration the dilution factor. However on increase in the limits will be allowed as a result of increased dilution beyond 1:8.

*All efforts should be made to remove colour and unpleasant odour from the effluent

Source: Environmental Norms, 2001

Table 2.4
Tolerance Limits for Industrial Wastewater (Effluents) discharge in to Common Wastewater Treatment Plant

Parameters	Maximum Tolerance Limit
BOD (5 day at 20^0 C) (mg/l)	200
COD (mg/l)	600
pH	6.5-8.5
Suspended Solid (mg/l)	500
Total dissolved solids (inorganic) (mg/l)	2100
Temperature (C^0)	40
Phenolic compound (as C_6H_5OH)(mg/l)	5
Oil and grease (mg/l)	30
Total Chromium (mg/l)	2(Chromium VI 0.5)
Copper (as Cu) (mg/l)	3
Lead (as Pb) (mg/l)	1
Mercury (as Hg) (mg/l)	0.001
Nickel (as Ni) (mg/l)	3
Zinc (as Zn) (mg/l)	10
Arsenic (as As) (mg/l)	0.2
Boron (as B) (mg/l)	2
Ammonical Nitrogen (as N0 (mg/l)	50
Sulphides (as S) (mg/l)	2
Sulphaes (as SO_4) (mg/l)	1000
Chlorides (as Cl) (mg/l)	900
Cyanides (as CN) (mg/l)	0.2
Free Residual Chlorine (as Chlorine) (mg/l)	Nil

Colour-Wave Lenth Range	**Maximum Spectral Absorption Coefficient**
400-499 nm (Yellow range)	$7m^{-1}$
500-599 nm (Red range)	$5\ m^{-1}$
600-750 nm (Blue range)	$3\ m^{-1}$
Radioactive Materials	
Alpha emitters (µc/ml)	10^{-7}
Beta emitters (µc/ml)	10^{-6}

mg/l = milligram/liter
µc/ml = microcuries/milliliter
BOD = Biochemical Oxygen Demand
COD = Chemical Oxygen Demand
Nm = nano meter

Note: -

The quality of wastewater discharge in to common sewer or collection system should be such as to ensure that the wastewater.

1. Does not damage the sever by physical or chemical action;
2. Does not endanger the health of the workers cleaning the sewer;
3. Does not upset the processes that are normally used in sewage treatment;
4. Does not overload the common treatment plant;
5. Does not damage the crops or affect the soil in case the effluent after treatment is used for irrigation and,
6. Does not create fire and explosion hazards due to certain constituent's presents in the effluents.

The industrial effluents not conforming to the to the specified tolerance limits or containing solids such as ash, sand, feathers, large floatable, straw, plastics, wood, lime slurry, residue, beer or distillery slops, chemical or paint residue, gross solids, from cannery wastes, cinder, sand, tar, hair, rags, metal shavings, garbage and broken glass shall not be permitted to be discharged directly in to the common sewer line leading to the wastewater treatment plant. Such effluents have to be subjected to an in-house treatment to bring them to be within the suggested tolerance limits and or free those from the undesirable material mentioned above prior to discharge into the sewer line.

Source: Environmental Norms, 2001

2.10 Previous Studies

Studies carried out with the aim on waste treatment and pollution control in textile industry are limited. Some of these important studies are discuss bellow.

One study was carried out by Central Environmental Authority (CEA) with bkh Consulting Engineers in 1992. The title was feasibility study on pollution control for priority industries in Sri Lankan; the textile processing industry (CEA, 1992b).

Another study was carried out in one of Sri Lanka largest textile industries. Ocean Lanka (Pvt) Ltd in Biyagama textile manufacturing plant to formulate green productivity (GP) option in view of promoting GP in textile industry. All the data related to water consumption, energy consumption and waste generation of the plant were collected. Proper GP and options were generated through numerous discussion and brain storming session. Although twenty seven green productivity options were generated, out of which nine options were waste reduction (Perera, 2000).

Novotex is a dyeing factory which has been situated in Denmark. Industry had several problematic occasions to face. They introduced the life cycle approach to the textile production. This effort has succeeded in many water and energy saving actives and in the necessary. Development of a mechanical. Chemical and biological waste water treatment facilities. Chlorine is not used for bleaching, no formaldehyde is used for post treatment, and no component of organic solvent is used in the detergents. To compile with the environmental standards set by the local authority. Use Company decided to eliminate the use heavy metals in the dyeing machines. The company's water and energy saving activities reduced the use of water and energy with 30% although, the cost of the dyeing process in the industry remains same as before the sludge could be disposed to a farmland other than putting it as hazardous waste to a controlled land fill. At present the Novotex produces fabrics heavy metal waste by 80% (Chandak, 1994).

Another green productivity study was carried out at textile located in north Carolina USA .In this factory, dye bath reuse in jet dyeing was implemented in order to extent the use of raw materials .Replenishing dyes were added to the used liquor at the of a cycle to prepare the dye both for next cycle . Dye bath reuse conserves dye and other specially chemicals a conserves energy by avoiding the cost of re heating. Economic benefits were resulted form the savings in water, chemicals and energy (Chandrk, 1994).

Dinex Dyeche Ltd,is an dye and dye –intermediate manufacturing industry situated in India . Annual sales turnover of Dintex Dyechem Ltd is US$ 6.6 million. It had amain problem, such as highly acidic waste water from sulfonetion process, waste water with highly lead of salt from condensation process and dust emission from condensation process. Because of these problems the company ordered to be cut down by the high country in India. There are economics, and environmental benefits gaining by the implementation of green productivity programmer in this industry. Their saving was over US $450,000. The pay back period was 3-13 months. The company met with regulatory discharge limit after green process productivity implementation. As environment at benefits, 70% reduction in sulfanation water, 50% reduction in condensation water were achieved .Further, these were some reduction of sludge from waste water treatment plant, reduction of hydrochloric acid, elimination of dust emission etc (Shah and Saxene, 1996).

CHAPTER 03

Materials and Methodology

The study was based on main five phases. Those phases are shown by figure 3.1.These five phases are gone integrated.

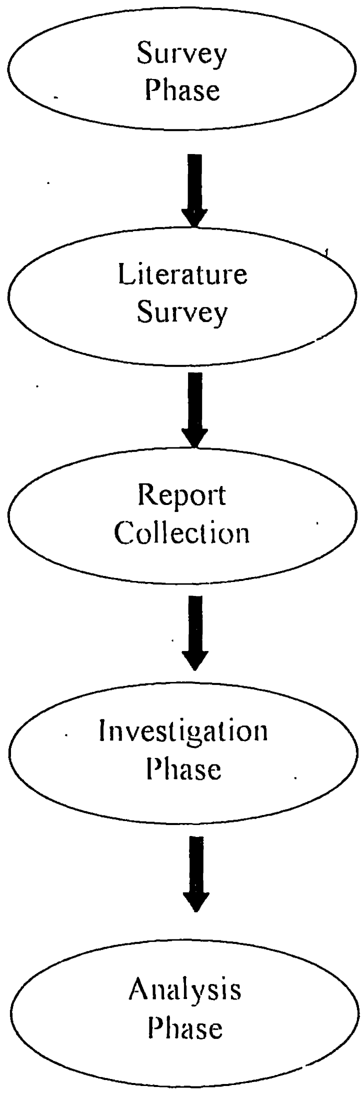


Figure 3.1: Flow diagram for the methodology of the study.

3.1 Survey Phase

Four Textile Industries were selected and studied their existing treatment plants in this phase. BOI instructions and guidelines were used to select two textile industries. They were Ocean Lanka (Pvt) Ltd and Stretchline (Pvt) Ltd. While private contact were used to select other two textiles industry anomaly Hirdaramani Industries (Pvt) Ltd and Melbourne Washing Plant (pvt) Ltd. The scale of the production processes production for the export market, generation of considerable amount of wastewater and availability of treatment methodology were considered in selected of the industry.These factories were established in an Export Processing Zone or out of an Export Processing Zone. But all of them got BOI approval. Some of factories are involving Dyeing, Knitting, Spinning and Finishing process and some factories carry out Dyeing and Knitting process while some factories are involving dyeing and Finishing process.

3.1.1 Introduction of selected textile manufacturing industries

Ocean Lanka Private Ltd.

Ocean Lanka private Limited is a well famous textile industry situated at Biyagama Export Processing Zone (BEPZ). It was started in 1996. This is a large BOI approved textile mill, which provides export quality fabrics to export market. It produces knit wears for most of export oriented garment industries in Sri Lanka. It has a work force of about 900 employees. It is working during 24 hours within to two shifts. Production process of Ocean Lanka mainly comprise with three sections. They are Knitting, Dyeing and Finishing.

Stretchline Private Ltd.

Stretchline Privet Limited is one of largest Elastic production industry situated at Biyagama Export Processing Zone. This is also BOI approved textile industry. It was started at about 1996. It is working during 24 hours In to three shifts. 850 to 1100 workers are employing at presently. Their production processes are weaving, Knitting and Dyeing.

Hirdaramani Industries (Limited

Hirdaramani Industries Limited was stated at August 1999 in the Seethawaka C.V. Gunerathne Industrial Park, Avissawella. It is a, one of largest factory of the Hirdaramani Group. This is a BOI approved textile industry. It has working force of about 299 employees working pending is minimum 6 hours to maximum 24 hours in to two shifts per day. Hirdaramani Industries is mainly involves Dyeing, Spraying, Sand Blasting and Washing (Finishing) Production processes. Products are entirely for export markets.

Melbourne Textile Washing Plant Private Limited

Melbourne Textile Washing Plant is a one of largest factory of the Eam Maliban group. This is situated in Mahiyanganaya. It is factory also BOI approved. But it is established at without industrial park / Export Processing Zone. About 150 of employs are working at now. Their main production processes are Dyeing and Washing (Finishing). All of production for exports market.

3.2 Literature Survey

A relevant literature was collected from following institution and their libraries. Literature sources are Sabaragamuwa University, University of Moratuwa, Open University, and Central Environment Authority, Board Of Investment, Public library of Colombo were used to find local wastewater discharge standards in to surface inland waters, wastewater treatment plants and their treatment methodologies and nature of Sri Lankan Textile Industry.

Nature of foreign other country Textile Industry and standard of certain country were found from using Internet.

3.3 Reports Collection

Wastewater analysis repots and other relevant reports and information were collected. Normally, wastewater analysis reports are maintained by these textile industries daily or weekly or monthly or quarterly. Wastewater samples are analysis by their own laboratory or outside laboratory.

Two methods were followed for collection of analytical reports.

For Hirdaramani Industries and Melbourne Textile Washing Plant wastewater analytical reports were collected from industry it self.

The other method was collecting reports from Biyagama BOI Environmental Monitoring Laboratory. This method was used for Ocean Lanka and Stretchline where wastewater analytical reports were collected.

Data records of the past few years on wastewater treatment were obtained from the reports. Parameters were pH, Temperature, Biochemical Oxygen Demand, Chemical Oxygen Demand, Total Suspended Solid, Conductivity and Total Dissolved Solid. All of above parameters or few of above parameter were collected, depending on the availability of data.

3.4 Investigation Phase

During the investigation phase wastewater samples were collected as grab samples from inlet of the wastewater treatment plant and outlet of the wastewater treatment plant of selected textile industries.

Collected wastewater samples were analysis in the out side laboratories. Wastewater samples of Hirdaramani Industries were analysis in the Water Board Laboratory, Seethawaka Industrial Park. Ocean Lanka and Stretchline wastewater samples were analysis in the BOI Environmental Laboratory, Biyagama Export Processing Zone.

Existing methods in the laboratory standards solutions and equipments were used in the analyzing of wastewater samples.

Analysis of samples and preparation of Test Reports were done under best examination of chemists of selecting laboratories.

3.6 Analysis Phase

Collected data reports were stored and tabulated parameter wise. Five day BOD, COD, pH, Temperature, TSS and TDS were considered as parameters for analysis part. Finding the effectiveness's of the collected reports data possible used only for Hirdaramani Industries wastewater treatment plant and Melbourne Washing Plant. Finding treatment effectiveness's of other two-treatment plant were done using Test Reports data, Because of the non-availability of data's from influent wastewater collected by the factories, to compare surface inland water quality standards with those from the Reports.

CHAPTER 4

Results and Discussion

4.1 Wastewater Treatment Methodologies

4.1.1 Wastewater Treatment Plant- Hirdaramani Industries

Hirdaranami Industries runs Wastewater Treatment Plant monitoring under BOI. Designer and constructor were H plus R Company in Singapore. It is modern technological plant and it can operate automatically also manually. Its wastewater flow rate was 40 m^3/hrs designing capacity was 750 m^3. Some days it is operates over 1000 m^3 in capacity. Daily wastewater generated averagely 200m^3. Running time is this plant depends on 6 hours to 24 hours per day. Small changes of treatment plant variations for possibility of operations. It does mainly contain 11 units. According to the Figure.4.1 they numbed TK.01 to TK.11. Figure 4.2 gives a detailed design of the plant.

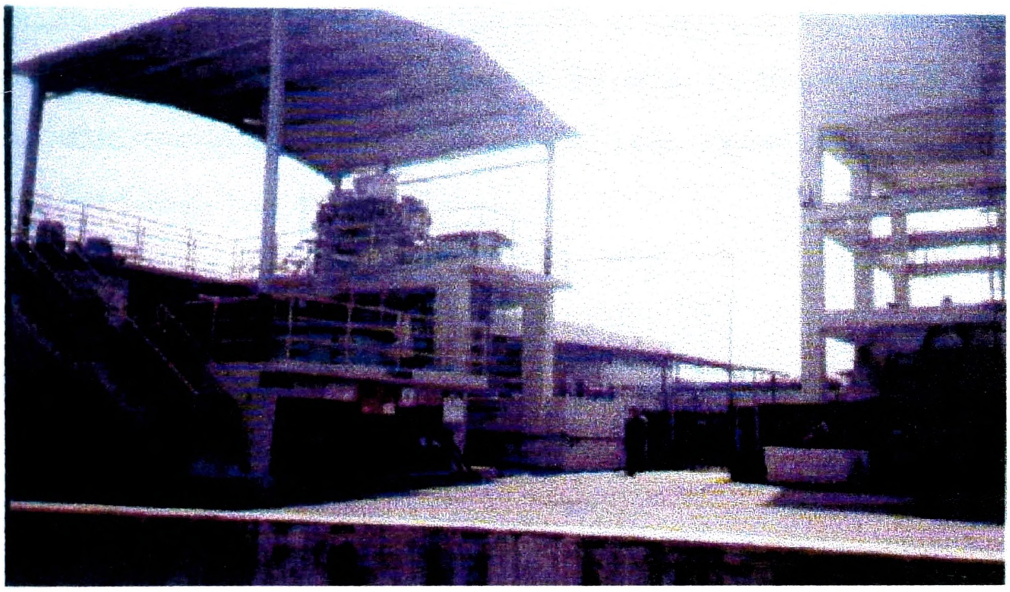


Figure 4.1 Hirdaramani Wastewater Treatment Plant

TK.01-Primary Sedimentation Tank

The influent wastewater is collected by channel, pass through bar screen and run down screen to come to temporary storage tank. Then wastewater is pumped to primary sedimentation tank by submersible pump. In the primary sedimentation tank, fine partials are deposited by gravity. The bottom of the tanks is V shaped. This shape facilitates deposition only heavy particles. Sediments are sucked by air and passed to the TK.09. Remaining wastewater is collected to sewer and then goes to TK.02.

TK.02-Equalization Tank

It provides aerobic condition and used as storage tank. Here wastewater is mixed well with Oxygen and is not allow to deposit. Using compressor air inject/bubbled from bottom of the Equalization tank. It capacity is about 200 m^3. Temperature is decreased specially to $40C^0$, odor and color treated little in this tank. Then wastewater is pumped to TK.03 by using lifting pump.

TK.03- pH adjust ion Tank

In this tank, main purpose is adjustment of pH. pH adjust by using NaOH (Sodium Hydroxide) and H_2SO_4 (Sulfuric acid). Maintained pH range is 7-8 in here create condition for growth of bacteria in next tank. Urea and Phosphorus like nutrients are also add to this tank. From this point wastewater is passed through gravity.

TK.04- Oxidation Tank

Biological treatment is take place .pH adjacent and nutrient full wastewater comes to the Oxidation tank. This ditch is a flash flow ditch. It's a bacteria cultured and well-aerated tank. Aerated by using compressor air comes from bottom of the tank. Bacteria digest wastewater. This process can be varying with characteristic of wastewater. In this process pH, BOD, COD and DO factors have to maintain. Flow rate of this tank is $80m^3$/hrs because of mixing. SV_{30} (Sludge volume of 30 minutes) is measured. Portion of sludge is added from TK.09 acts as Activated Sludge. Then wastewater is passed to Tk.05.

TK.05-Sedimentation Tank/Clarifier

In sedimentation tank, which contain died microorganisms are floated upwards and particles which contain live microorganisms, deposited at the bottom. Died particles are removed with scum Scum is (sludge scraper) frequently rotating. The removed sludge is passed to TK.06. Then water is passed to TK.07.

TK.06- Sludge Well

This is the temporary sludge storage from the sedimentation tank. From this excess sludge is passed to TK.09.

TK.07-Flash Mixing Tank

Chemical treatment is taking place here. Flocculent and Decolorent is added. Decolorent is added for color treatment and Flocculent added to make flocks. Sodium hydroxide is added for increase pH level up to 8. A motor mixes wastewater.

TK.08-DAF (Dissolved Air Flotation)

Treated water from flash mixing tank is fed in DAF. It reacts as separation unit for sludge and clear water. Flocculation is taken place here. Floated sludge is removed mechanically then passed to TK.09. Water, without solid flocks is passed to TK.10.

TK.09- Sludge Holding Tank

Sludge from the DAF and Sedimentation tank is fed to this. Sludge is stored before passing to TK.11

TK.10- Treated Water Storage Tank

Treated water comes from DAF is temporally stored before send to BOI common wastewater treatment plant.

TK.11- Sludge Conditioning Tank

Sludge is mixed with water, which came from TK.06 and TK.09.Polymer, is added to this tank for polymerization. Then ticked sludge pass to the belt press machine.

Sludge Thickener/ Belt Pressure

Sludge is flows into dewatering equipment through belt pressing; the concentration of sludge is higher than 15% for volume reduction easy to handling. The dewatered sludge cake is stored in sludge hopper for dispose.

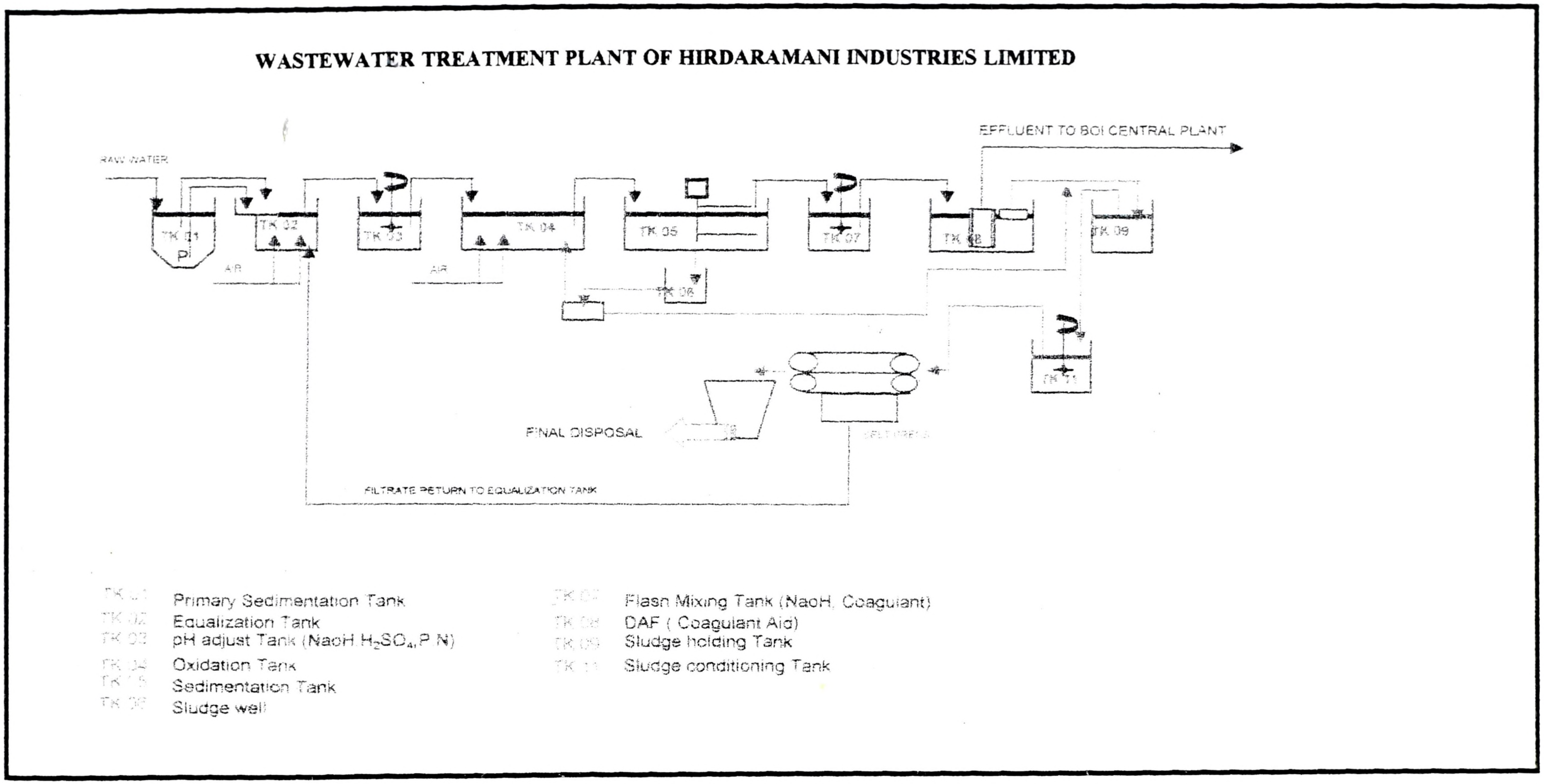


Figure 4.2 Wastewater Treatment Plant flow diagram of Hirdaramani Industries Limited

4.1.2 Waster water Treatment Plant - Melbourne Washing Plant

Melbourne Washing Plant also BOI approved Treatment Plant, establish outside Industrial Processing Zone. They have to achieve strict wastewater quality standards than others, which are, established in to IPZ. It released their treated water direct in to Mahaweli River. Its flow rate is $40m^3/hrs$ and capacity about 600 m^3. It generates 300 m^3-700 m^3 wastewater volumes per day. Its can run automatically and also manually. The main sectors of the plant are as follows (Figure.4.3)

TK.01- Primary Treatment Unit

Row wastewater from production area is subjected to primary treatment. Initially primary treatment of Grit removal and Oil trapping are performed. For this, three sections are installed. They are Grit chamber, Oil trapper and Screen chamber. Then water is passed to TK.02.

TK.02-Equalization Tank

Using compressor air, wastewater is equalized. Air blowers are installed at the bottom of the equalization tank. Then water is passed to TK.03

TK.03-First Settling Tank

It consists of three parts. They are Flash mixer, Flocculator and settling tank. Lime, Alum, Polymer and $FeSO_4$ are added to the flash mixer. Chemicals and wastewater are mixed well and pass to the Flocculator. In the here flocks are formed and then passed to settling tank. In the settling tank sediments are settled. Chemical treatment is taken place here. V shape settling tank collects sludge at the bottom and pass to TK.10.

TK.04- Second settling Tank

As same as TK.02. Normally adding acid occurs pH control. If TK.02 is not working properly or wastewater contain higher COD value. Lime, Alum, Polymer and $FeSO_4$ are added to TK.03. Then water is passed to TK.05.

TK.05- RBC (Rotating Biological Contactor)

Biological treatment is taken place. Its made up of coir string, that coir strings are provided to surface for microorganisms. RBC reduce BOD from 400mg/l to 200mg/l. Wastewater is treated by microorganisms. Sediments are formed because of biological digestion. Treated water is passed to TK.06.

TK.06

Chlorine is added to this tank. Here disinfections process is taken pace. Then water is passed to TK.07

Tk.07- Filter

It is a FCC/AT model filter. The filter fills up with two type of filter medias. Top layer contain sand and bottom layer is contain activated carbon. Water pass through filter and then go to TK.08 or TK.09.

TK.08 –Disposal Tank / TK.09- Production Tank

If treated water is not reused, fill to TK.08 and then disposal to river. If treated water is reused, after the filtering water is filled to TK.09

TK.10- Sludge Tank

It's a sludge-collected tank. Sludge is collected from first settling tank, second settling tank and RBC. Then sludge passed to the filter fresh machine.

TK.11-Filter press Machine

Sludge is subjected to filter press sludge cake as made. Sludge cakes are disposed to dumping yard while dewatered water is passed to equalization tank.

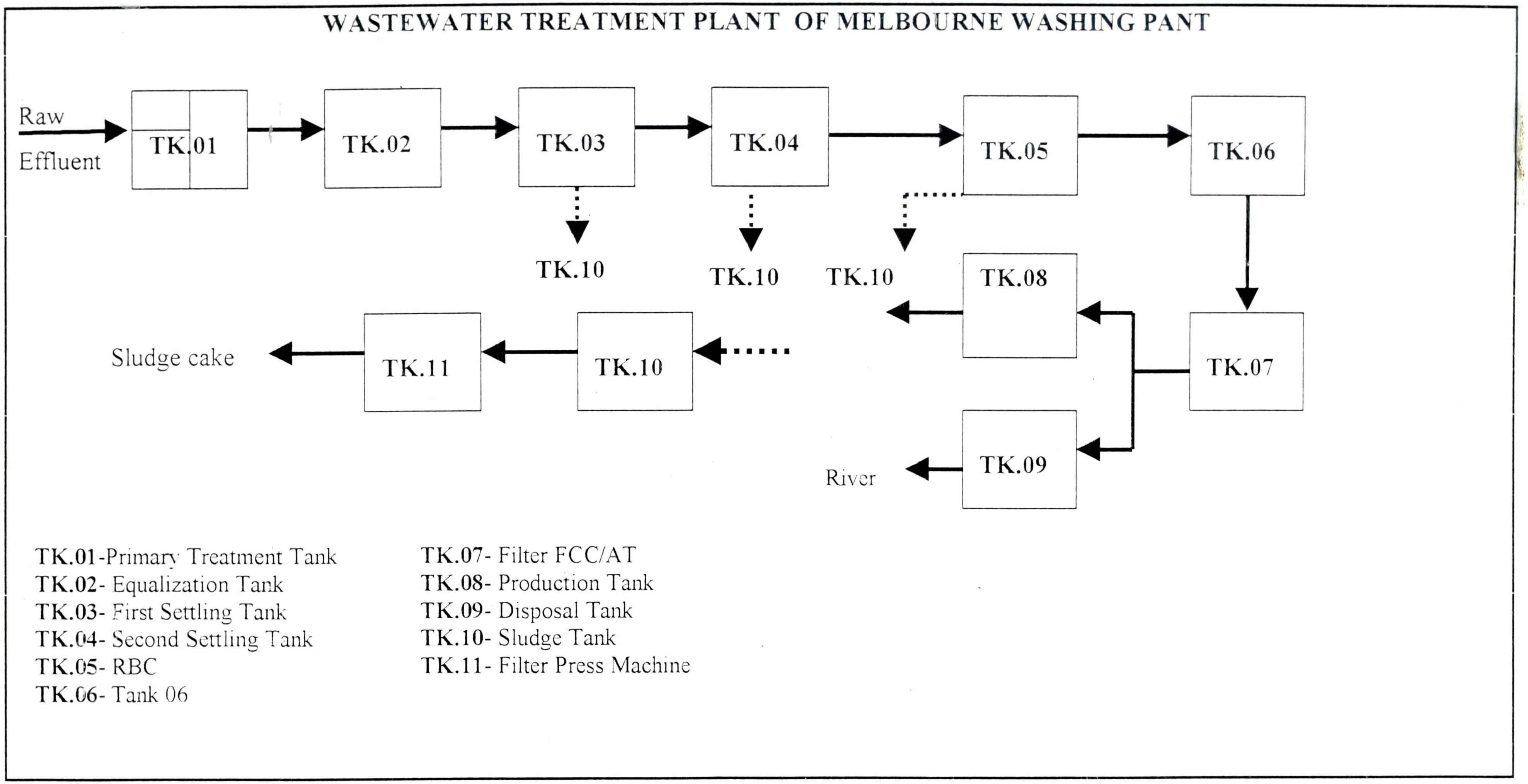


Figure 4.3 Wastewater Treatment Plant flow diagram of Melbourne Washing Plant

4.1.3 Wastewater Treatment Plant-Ocean Lanka

This also BOI approved wastewater treatment plant. They had got ISO 14001 certificate in 2003. It is a one of the largest treatment plant, in the Biyagama EPZ. It contributes 40% for common wastewater treatment plant of BEPZ. Its maximum runtime is 24 hours per day. Its treats wastewater with high amount of dye. It is designed in Thaiwan. Flow rate is $400m^3$/hours. This can operate manually and also automatically. The diagram is given in (Figure.4.4)

TK.01-Equalization Tank

Mainly comprises of two inlets and two outlets. Two types of effluents enter through these two inlets.

Effluent below 40^0C Temperature (cool water)

This effluent is passed to the equalization tank through bar screen, which is installed at the first inlet. All the larger solid particles are removed by the bar screen.

Effluent more than 40^0C temperature (Hot water)

The dye bath effluents, which has a higher temperature is passed through a heat exchanger and the hot effluent outlet of the heat exchanger acts as the second inlet to the equalization tank.

The function of the equalization tank, equalization the different types of waste streams in order to treat them evenly. Air blowers have been installed in the bottom of the equalization tank. It will reduce the temperature and the BOD level f the wastewater to a certain extent.

TK.02-Cooling Tower

The hot water of the equalization tank is passed through a cooling tower where the temperature of hot water is further lowered in order to meet the required BOI regulations. The water passed through the cooling tower is again flowed in to the equalization tank.

TK.03-Flash Mixture

The wastewater from equalization tank is passed to chemical reaction tank where the wastewater is treated with chemicals such as $FeCl_3$ (Ferric Chloride), De-colourant, NaHO/ H_2SO_4. $FeCl_3$ is added as a coagulant (instead of $FeCl_3$, Fe_2SO_4, $Al_2 (SO_4)_3$, Poly Aluminum Chloride can be added. But, this is a continuous process, the Biological Oxygen Demand (BOD). Chemical Oxygen Demand (COD) values should be lowered using a high strength coagulant as $FeCl_3$. As further improvements $FeSO_4$ is also used as a coagulant at present.

Color is removed by adding De-colourtants. pH is adjusted by adding NaOH or H_2SO_4 short chain polymer is added for the flocculation process prior to sending of wastewater to Dissolved Air Flotation (DAF) unit as it not advisable to settle down the particles in DAF.

TK.4- Dissolved Air Flotation (DAF)

Raw wastewater from the flash mixing tank is fed into this Air Flotation unit. This unit acts as a separation unit for sludge and clean water. The treated wastewater is passed to a pH adjustment tank, while the sludge is passed in to the sludge tank. This process use compressed air and some time surface where it is removed by a mechanically driven skimmer.

TK.05- pH Adjustment Tank

Treated wastewater is passed to a tank where the pH is adjusted to comply with the BOI regulations. After the pH is adjusted, clear water discharged to the BOI outlet. The sludge, which is separated from the Dissolved Air Flotation unit, is passed to a mechanical De-watering unit through sludge pump.

TK.06- Mechanical De-watering Unit (Filter Press)

The sludge is passed in to the filter press where approximately 25% of water is removed out. A long chain polymer is added at this storage to increase the particle size in order to increase the fastness of setting down.

The sludge is ultimately disposed to the BI dumping yard while the belt wash water used in the filter press is passed to a clarifier. Rest of the solid particle are settled down sludge is again passed in to the mechanical De-watering unit while squeezed water is sent to the Equalization tank.

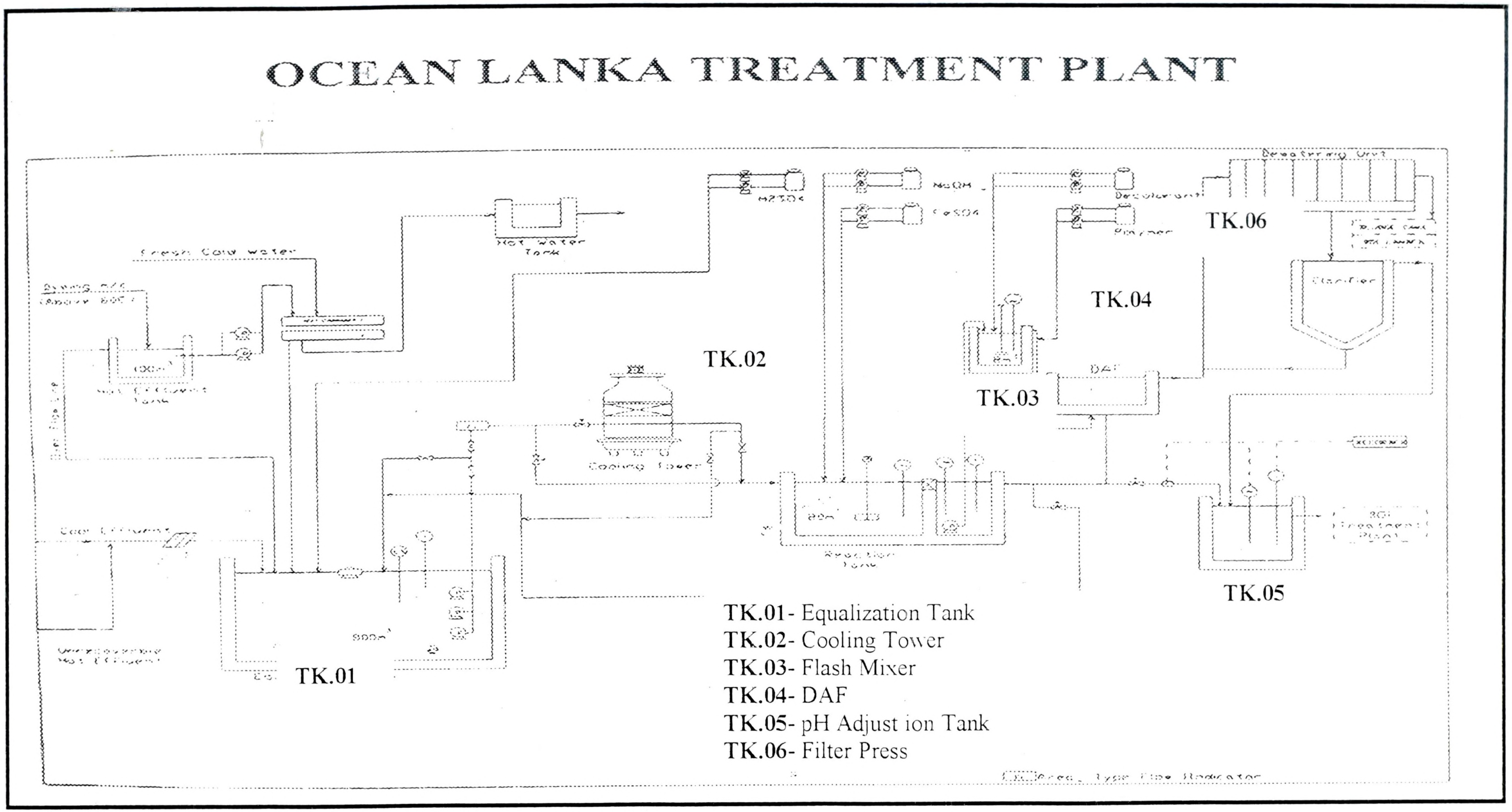


Figure 4.4 Wastewater Treatment pant Flow diagram of Ocean Lanka

4.1.4 Wastewater treatment plant -Stretchline

It is also BOI approved Treatment plant. It runs under well examination of BOI. Later it has been installed in with two more similar plants. But capacities of them are difference. Flow rates of three plants are $7.5m^3$/hrs, $9m^3$/hrs and $12m^3$/hrs. It designer and contractor was Industrial Technological Institute. The factory consumed $700m^3$ –$800m^3$ raw water for all purposes. The plant is run 24hrs. It can run manually and also automatically. It contains main eight sections (Figure 4.7).

TK.01- Equalization Tank

Influent raw wastewater is collected by channel and through bar screen, comes to here. Due to dye wastewater got color. The function of equalization is equalization of wastewater and mix with oxygen well. For aeration air blowers were installed in the bottom of the tank. It is reduces temperature of wastewater.

TK.02- Chemical Mixing Tank

To wastewater from equalization tank, NaOH, $FeSO_4$ and Polymer are added and mixed well by motor. Then water is passed to TK.03

TK.03- Flocculator

Chemical mixed wastewater produce flocks in the flocculation tank. Flocks production is increased by polymer (mostly used anionic polymer) Flocks rich water is passed to TK.04.

TK.04- Clarifier

It acts as sedimentation tank. Sediments are settled on the bottom. It called slurry. Slurry is removed to slurry collection tank. Clear water comes to up ward an off low the TK.05

TK.05-Acid Mixing Tank

In acid mixing tank add sulfuric acid and pH adjusts up to 6-8. It is requirement for BOI common treatment plant.

TK.06- Sludge Thickener

Bottom of the sludge-thickening tank is V shaped. Sludge is installed in to the bottom and thickened. Thickened sludge is passed to sludge collection tank while treated water is sent to BOI common treatment plant.

TK.07-Sludge collection Tank

Sludge from clarifier and thickener temporary storage in this tank. Then sludge is passed to filter press machine or drying beds.

Filter Press Machine

Sludge is subjected to filter press and make sludge cake. Filtered water is passed to TK.01. (Figure 4.5)

Figure 4.5 Filter Press Machine of Stretchline Wastewater Treatment Plant.

Drying Beds

Drying beds fill up with sludge from TK.07. In the drying beds water is evaporated by sunlight and sludge cake is made. (Figure 4.6)

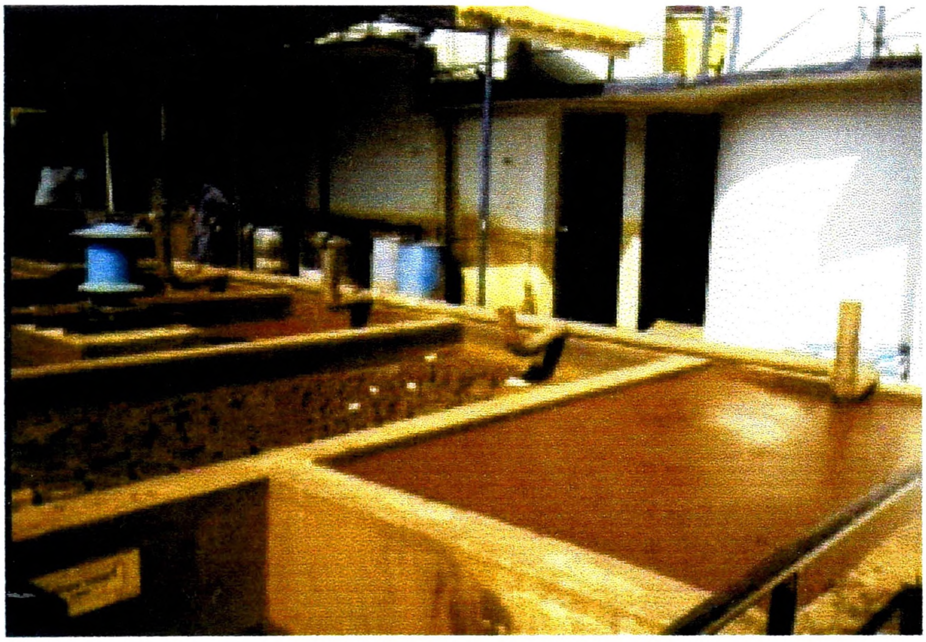


Figure 4.6 Drying Beds of Stretchline Wastewater Treatment Plant.

WASTWATER TREATMENT PLANT OF STRETCHLINE (PVT) LIMITED

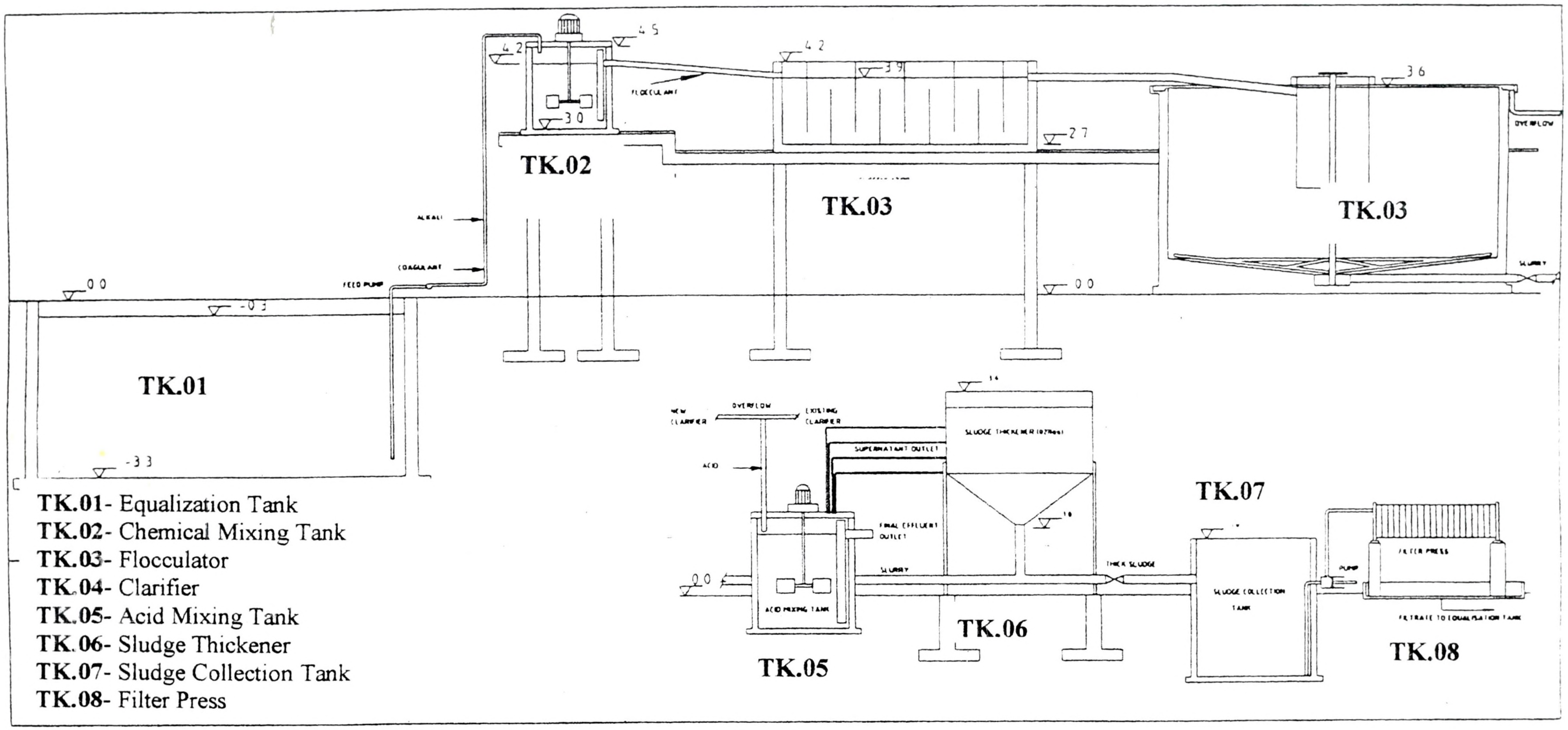


Figure 4.7 Wastewater Treatment Plant flow diagram of Stretchline (Pvt) Limited

4.2 Water Quality Parameters Variation With Time

4.2.1 Hirdaramai Industries Limited (HI)

4.2.1.1 HI - Biochemical Oxygen Demand (BOD)

From 8th of January 2001 to 29th of October 2003, Influent BOD_5 value varied from maximum 405 mg/l to minimum 30mg/l and Effluent BOD_5 value had varied maximum 52mg/l to minimum 8.7mg/l. Its BOD removal efficiency varied from 96% to 33% (Figure 4.8).

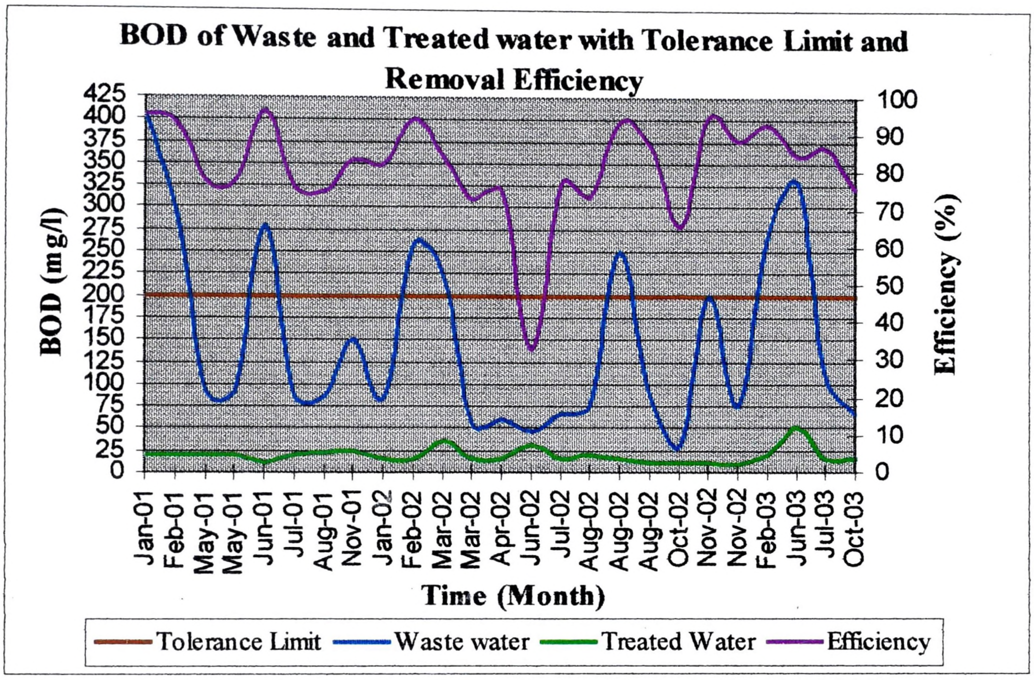


Figure 4.8 HI-BOD of influent and Effluent with Tolerance limit and Removal Efficiency.

Considering BOD tolerance limit is 200mg/l. Graph of Influent shows fluctuation peaks. Reason for that was, variation of production processes. Washing and dyeing of different styles of garments normally vary production processes. They maintain their influent wastewater level below the tolerance limit. However they maintain their influent BOD level below 50mg/l and also tolerance limit which is required for BOI common wastewater treatment plant. The efficiency of BOD removal is maintained better except at one point. This is due to default of the plant.

4.2.1.2 HI - Chemical Oxygen Demand (COD)

From 8th of January 2001 to 29th of October 2003, Influent COD value varied from maximum 1385mg/l to minimum 240mg/l and Effluent COD value had varied maximum 230mg/l to minimum 15mg/l. Its COD removal efficiency varied from 96% to 74% (Figure 4.9).

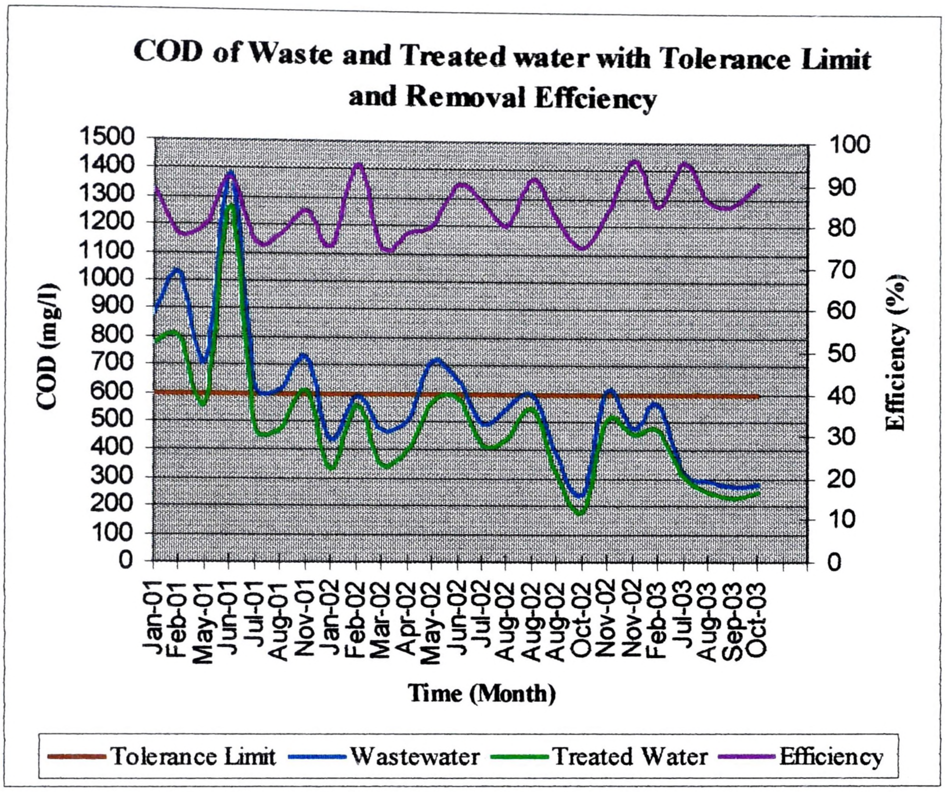


Figure 4.9 HI-COD of Influent and Effluent With Tolerance Limit and Removal Efficiency

Considering tolerance limit is 600 mg/l From January to July of 2001, COD values of Influent and effluent were gone higher because of highly dyeing production. After that, they had been tried to control the COD value below the tolerance limit of the influent also. COD removal efficiency has been in good condition during this period.

4.2.1.3 HI - pH Value

From 8th of January 2001 to 29th of October 2003, Influent pH value varied from maximum 9.3 to minimum 4.5 and Effluent pH value varied from maximum 7.7 to minimum 5.7.

Tolerance limits are 6.5 to 8.5. Even there were small changes, always they maintained pH of effluent within the tolerance limits.

4.2.1.4 HI -Total Suspended Solids (TSS)

From 8th of January 2001 to 29th of October 2003, Influent TSS value varied from maximum 275 mg/l to minimum 17 mg/l and Effluent pH value had varied maximum 50 mg/l to minimum 6 mg/l. Its TSS Reduction efficiency varied from 91% to 43% (Figure 4.10).

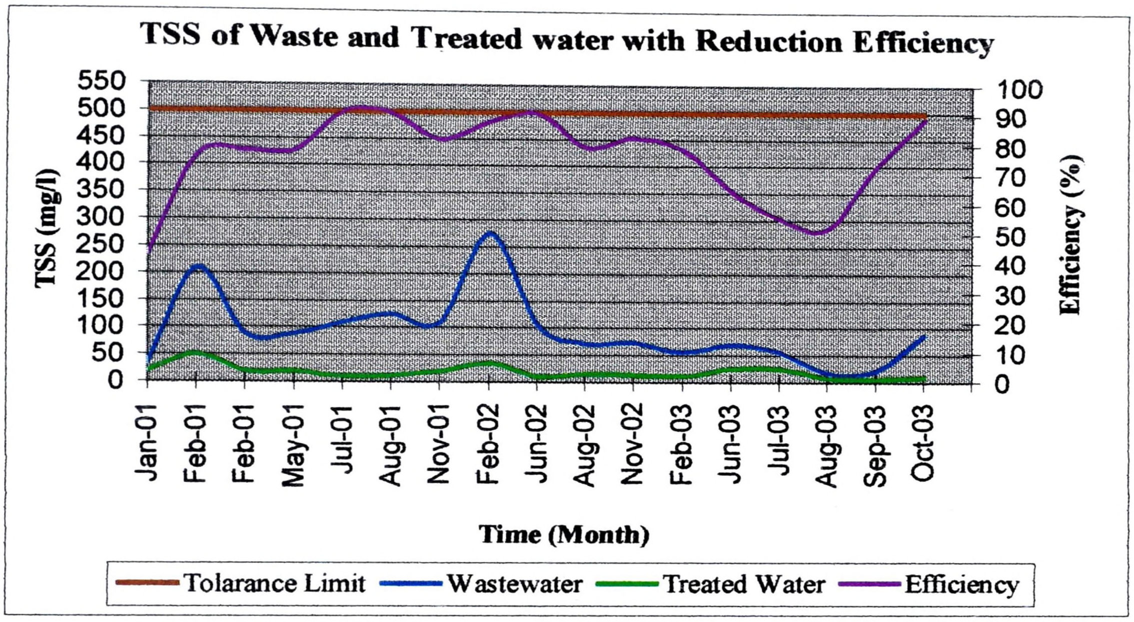


Figure 4.10 HI-TSS of Influent and Effluent with Tolerance limit and Reduction Efficiency

They have always maintained their total suspended solid of Influent and Effluent below the tolerance limit of 500mg/l.

4.2.1.5 HI-Total Dissolved Solids (TDS)

From 6th of February 2001 to 29th of October 2003, Influent TDS value varied from maximum 1093 mg/l to minimum 20 mg/l and Effluent TDS value varied from maximum 1495 mg/l to minimum 12 mg/l.

Accepted tolerance limit is 2100 mg/l or bellow it. The total dissolve solid of influent was maintained below the this value. Total dissolved solid also vary with production process.

4.2.2 Melbourne Washing Plant (MW)

4.2.2.1 MW-Biochemical Oxygen Demand (BOD)

From 16th of July 2001 to 3rd of November 2003, Influent BOD value varied from maximum 500 mg/l to minimum 150 mg/l and Effluent BOD value varied from maximum 20 mg/l to minimum 10 mg/l. Its BOD Removal efficiency varied from 96% to 90% (Figure 4.11).

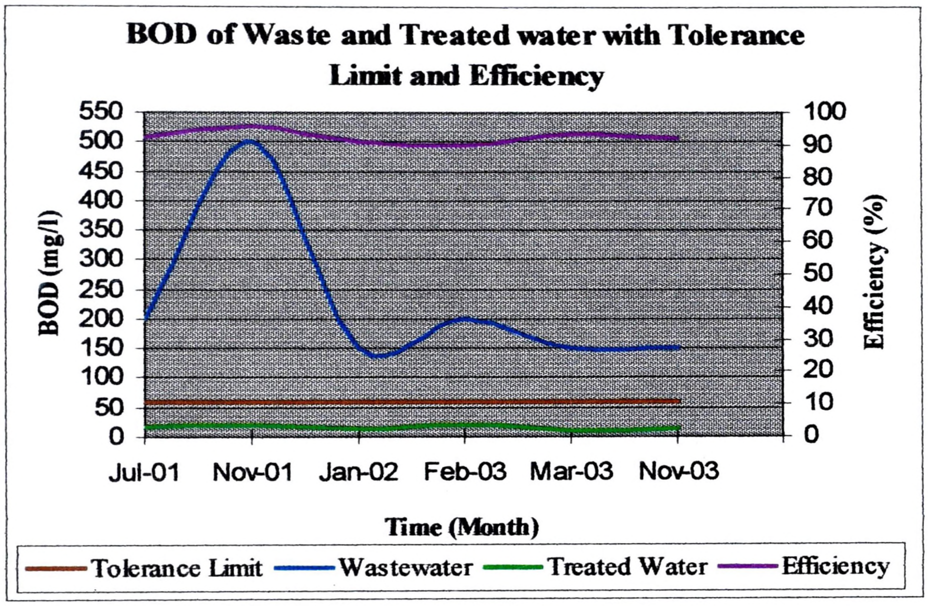


Figure 4.11 MW-BOD of Influent and Effluent with Tolerance Limit and Removal Efficiency

Melbourne Washing Plant is established out side of an Industrial processing zone. Therefore treated water is released into Mahaweli River directly. Not like other plants, they have to maintain a tolerance limit of 60 mg/l. In November of 2001 BOD value has gone up. But they have maintained their effluent bellow the tolerance limit. And also the removal efficiency was good.

4.2.2.2 MW-Chemical Oxygen Demand (COD)

From 16th of July 2001 to 3rd of November 2003, Influent COD value varied from maximum 1700 mg/l to minimum 600 mg/l and Effluent COD value varied from maximum 274 mg/l to minimum 43 mg/l. Its COD Removal efficiency varied from 95% to 80% (Figure 4.12).

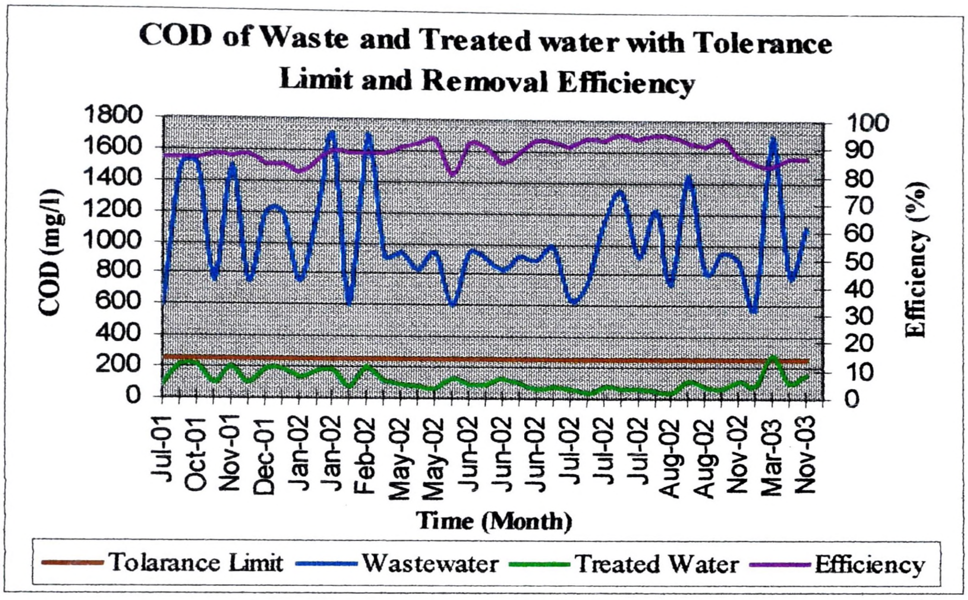


Figure 4.12 MW-COD of Influent and Effluent with Tolerance Limit and Removal Efficiency.

Tolerance limit is 250mg/l. This limit is also strict than tolerance limit that is required for common treatment plant of IPZ. COD curve of influent always fluctuated due to higher usage of chemicals, especially dyes. But their COD values of effluent and COD removal efficiency took better values.

4.2.2.3 MW-pH value

From 20th of January 2001 to 3rd of November 2003, Influent COD value varied from maximum 9.0 to minimum 6.7 and Effluent COD value varied from maximum 9.0 to minimum 6.7.

Required tolerance limit is 6.0 to 8.5. with in that period, pH was gone toward Alkalinity. But curve of effluent had lie within the tolerance limits.

4.2.2.4 MW-Temperature

From 5th of October 2001 to 24th of November 2002, Influent temperature value varied from maximum 47^{0}C to minimum 30^{0}C and Effluent temperature value varied from maximum 40^{0}C to minimum 30^{0}C.

Tolerance limit is 40^{0}C. During the period temperature was increased from about 7 degrees of Celsius. Therefore they have maintained their temperature within the tolerance limit. Actually average effluent temperature had been 30^{0}C.

4.2.2.5 MW-Total Suspended Solid (TSS)

From 16th of July 2001 to 3rd of November 2003, Influent TSS value varied from maximum 200 mg/l to minimum 100 mg/l and Effluent Temperature value varied from maximum 20 mg/l to minimum 12 mg/l. Its TSS Reduction efficiency varied from 94% to 80% (Figure 4.13).

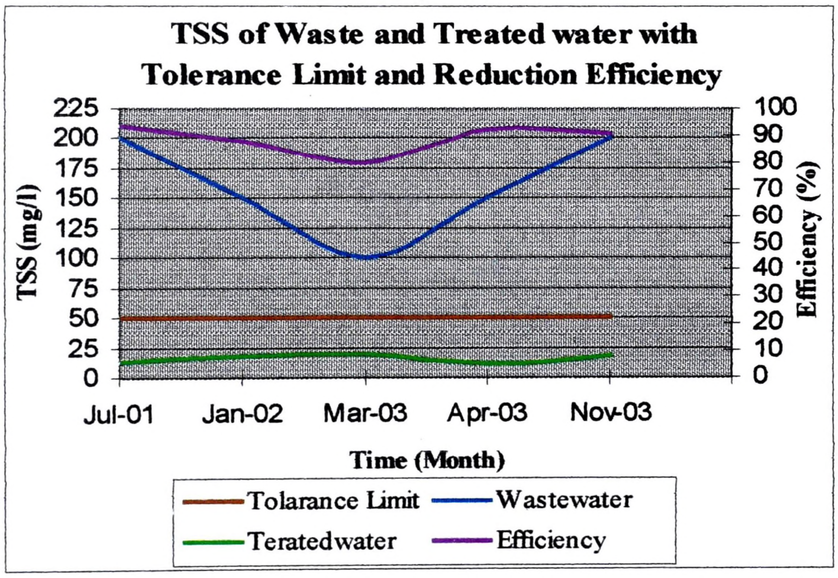


Figure 4.13 MW-TSS of Influent and Effluent and Reduction Efficiency

Tolerance Limit is 50 mg/l. This value is 1/10th from requirement of common wastewater treatment plant. Accidentally TSS values of the march of 2003 have decreased. Accordingly the efficiency was decreased. But they maintained their TSS of effluent below to tolerance limit.

4.2.2.6 MW-Total Dissolved Solid (TDS)

From 14th of September 2001 to 8th of October 2002, Influent TDS value varied from maximum 2100 mg/l to minimum 980 mg/l and Effluent TDS value varied from maximum 2000 mg/l to minimum 250 mg/l.

There is no introduced tolerance limit for Total Dissolved Limit to treated water which is disposed in to surface inland waters. But they had tried to reduce some amount from Influent. A higher TDS means inorganic ion concentration is higher.

4.2.3 Ocean Lanka (Pvt) Ltd. (OL)

4.2.3.1 OL-Biochemical Oxygen Demand (BOD)

From 18th of January 2000 to 25th of September 2003, Effluent BOD value varied from maximum 290 mg/l to minimum 200 mg/l (Figure 4.14).

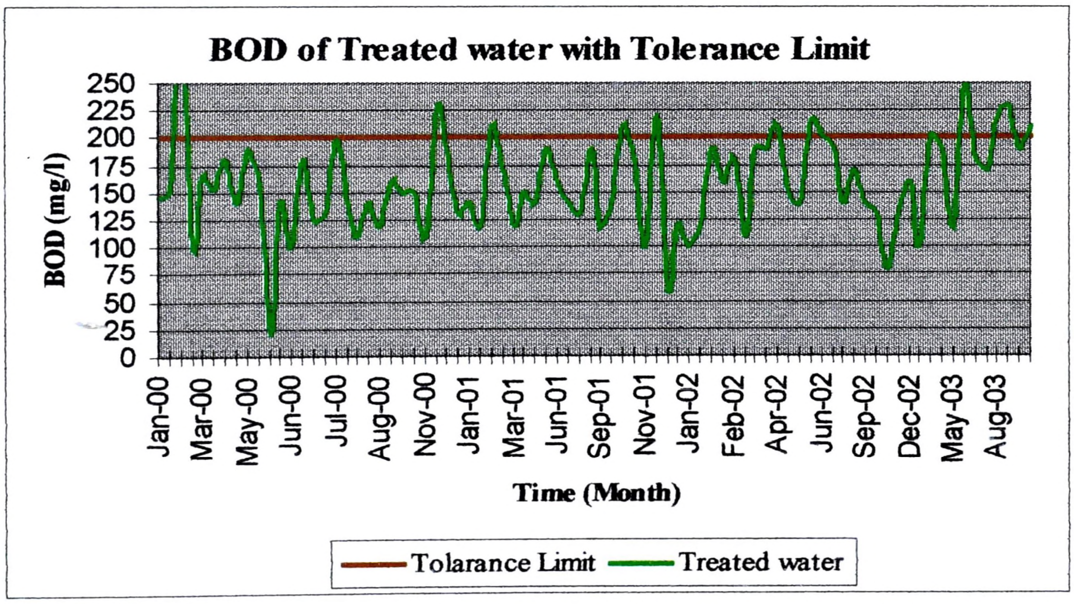


Figure 4.14 OL-BOD of Effluent with Tolerance Limit.

Tolerance limit is 200 mg/l. Because BOD of Influent was not recorded, any comment on BOD removal efficiency can not be made. But during this period, BOD of Effluent have been below the tolerance limit except in few points. However its fluctuation was very high. The reason for this fluctuation is the lack of biological treatment.

4.2.3.2 OL-Chemical Oxygen Demand (COD)

From 18th of January 2000 to 25th of September 2003, Effluent BOD value varied from maximum 643 mg/l to minimum 103 mg/l (Figure 4.15).

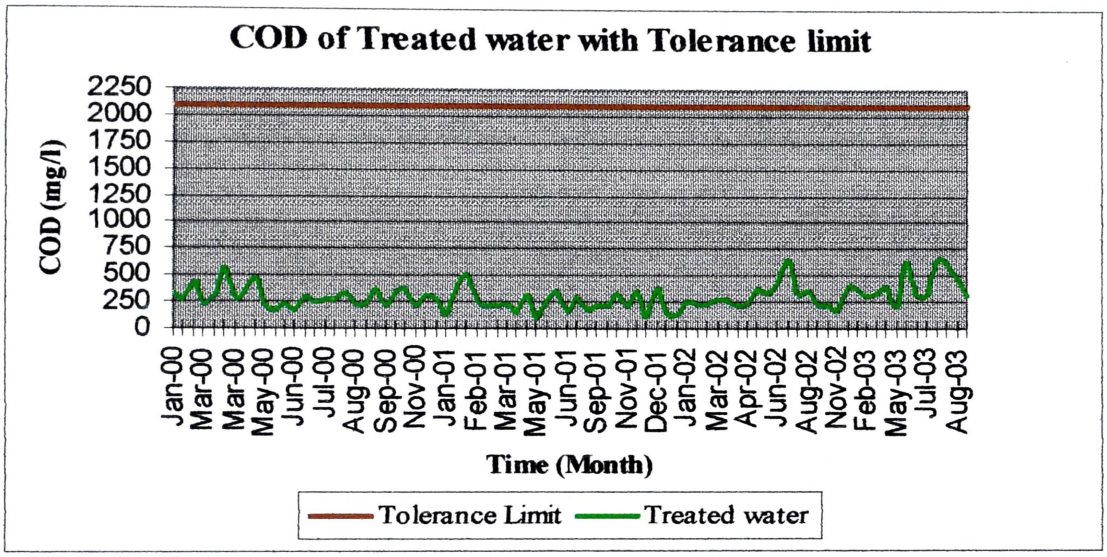


Figure 4.15 OL-COD of Effluent with Tolerance Limit.

Tolerance limit is 2001 mg/l. Influent COD values are not recorded. Therefore cannot get any idea about the efficiency. But they have had maintained their effluent with low COD values.

4.2.3.3 OL-pH Value

From 18th of January 2000 to 25th of September 2003, Effluent pH value had been varied maximum 8.1 to minimum 2.8.

Tolerance pH range is 6.0-8.5. They have maintained their influent pH value below the maximum tolerance limit only. Its pH values were closed to acidity. That is why, they did not adjust pH properly.

4.2.3.4 OL-Temperature

From 18th of January 2000 to 25th of September 2003, Effluent temperature value varied from maximum 47^{0}C to minimum 30^{0}C.

Its tolerance limit is 30^{0}C. Temperature have being maintained very close to the required limit. Therefore temperature controlling is good.

4.2.3.5 OL-Total Suspended Solid (TSS)

From 18th of January 2000 to 25th of September 2003, Effluent TSS value varied maximum from 932 mg/l to minimum 12 mg/l (Figure 4.16).

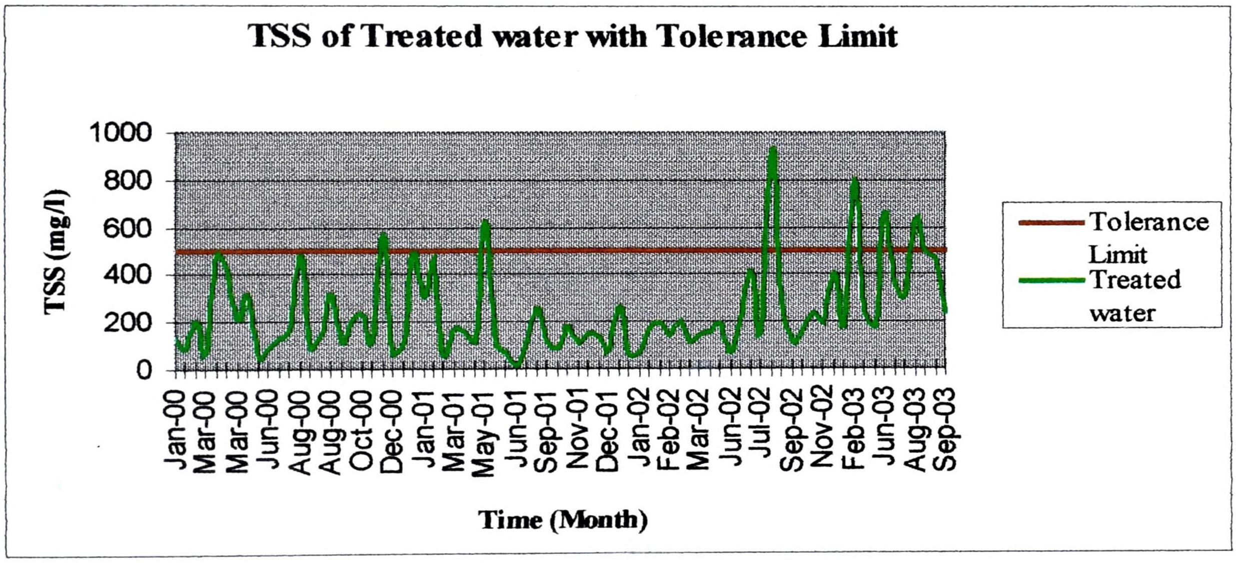


Figure 4.16 OL-TSS of Effluent with Tolerance Limit.

Tolerance limit is 500 mg/l. It was high fluctuation. Up to July of 2002, they had maintained their TSS values under tolerance limit. But after that, they could not maintain it properly.

4.2.3.6 OL-Total Dissolve Solid (TDS)

From 18th of January 2000 to 6th of Arial 2001, Effluent TDS value varied from maximum 3700 mg/l to minimum 2150mg/l.

The tolerance limit is 2100 mg/l. From January of 2000 to Arial of 2001 Total Dissolved Solid values gone beyond the tolerance limit. Reason for that was heavy usage of ionic chemicals.

4.2.4 Stretchline (Pvt) Ltd. (SL)

4.2.4.1 SL-Biochemical Oxygen Demand (BOD)

From 10th of August 2000 to 14th of November 2003, Effluent BOD value varied from maximum 220 mg/l to minimum 10 mg/l (Figure 4.17).

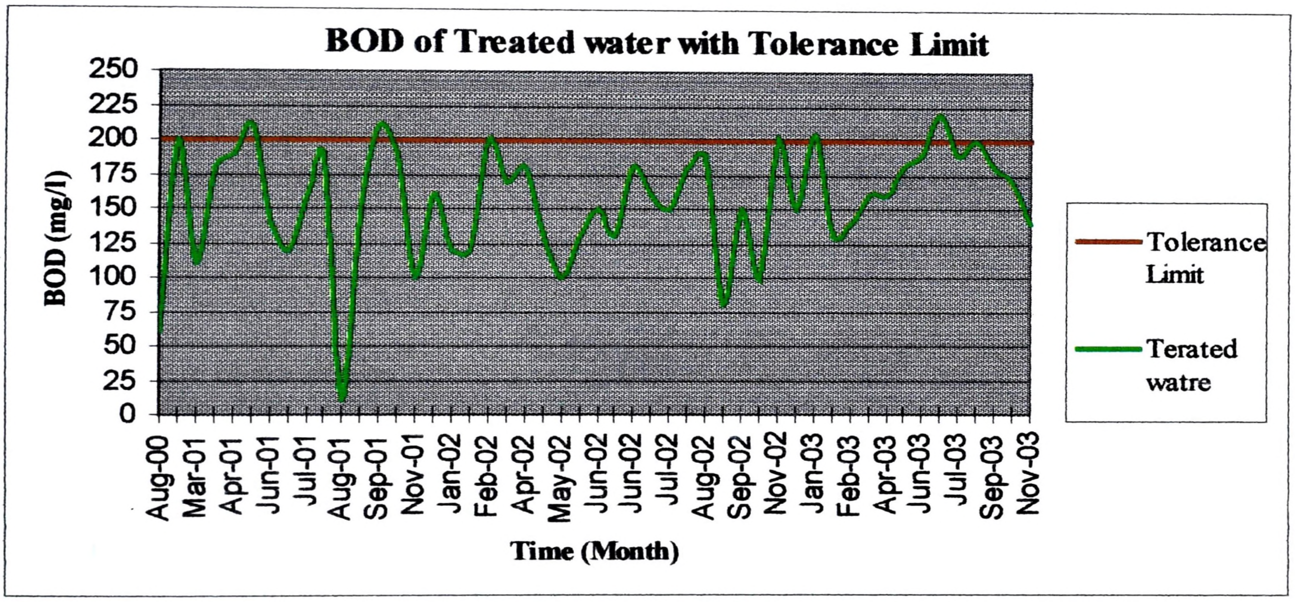


Figure 4.17 SL-BOD of Effluent with Tolerance Limit.

Tolerance limit is 200 mg/l. Few peaks are shown above the limit. Curve is not in regular. Majority of values are lay below from the limit .Cant say any thing about the efficiency. The reason for this irregularity in the BOD curve is due to the lack of biological treatment.

4.2.4.2 SL-Chemical Oxygen Demand (COD)

From 10th of August 2000 to 14th of November 2003, Effluent BOD value varied from maximum 679 mg/l to minimum 179 mg/l (Figure 4.18).

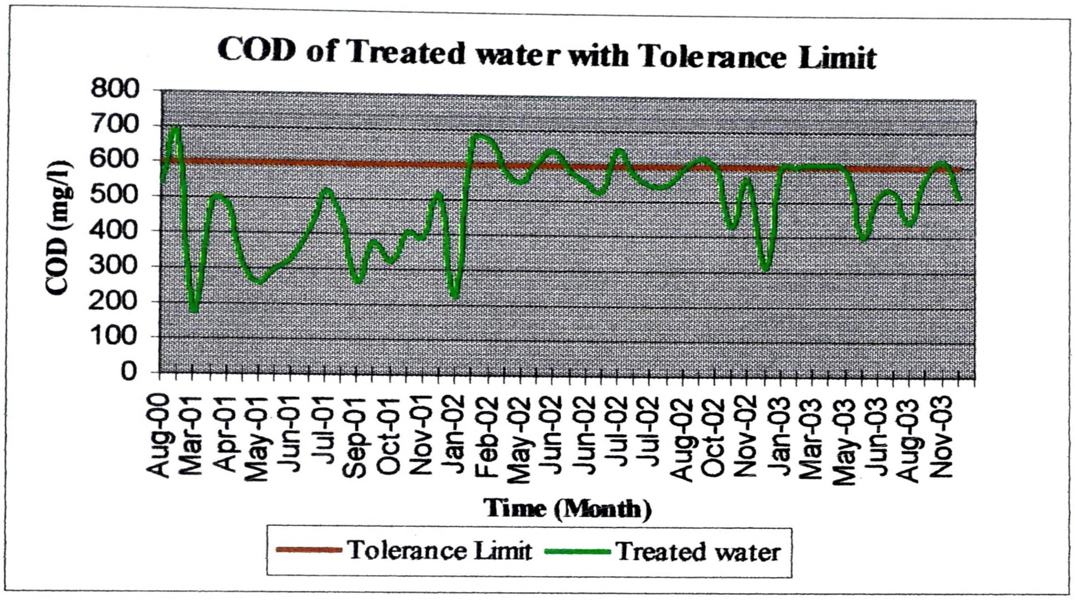


Figure 4.18 SL-COD of Effluent with Tolerance Limit.

After that November of 2001, they have not maintained the COD values properly.

4.2.4.3 SL-pH Value

From 10th of August 2000 to 14th of November 2003, Effluent p-H value varied from maximum 10.5 to minimum 5.8.

Tolerance pH range is a 6.0-8.5.pH values agree with minimum tolerance limit ,thus but do not agree with maximum tolerance limit.

4.2.4.4 SL-Temperature

From 10th of August 2000 to 14th of November 2003, Effluent average Temperature had been 30 ^{0}C .

Temperature was remained constant. Possibility reason for this can be suspect as wrong measurements or error of the thermometer.

4.2.4.5 SL-Total Suspended Solid (TSS)

From 10th of August 2000 to 14th of November 2003, Effluent average TSS value had been varied maximum 282 mg/l to minimum 16 mg/l (Figure 4.19).

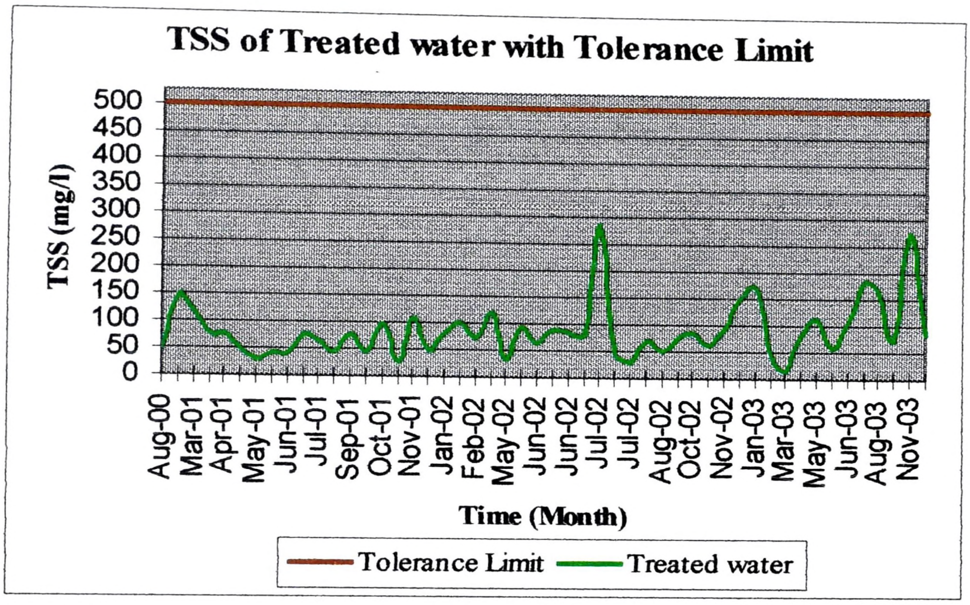


Figure 4.19 SL-TSS of Effluent with Tolerance Limit.

The tolerance limit is 500mg/l and they have maintained the TSS below this limit.

Table 4.1; summarized the methodologies used by the selected four plants.

Table 4.1 Treatment Plants and available Treatment Methodologies

Methodology / Industry	Pre Treatment	Physical/Chemical Treatment	Biological Treatment
Hirdaramani	YES	YES	YES
Melbourne	YES	YES	YES
Ocean Lanka	YES	YES	NO
Stretchline	YES	YES	NO

Table 4.2; summarized the overall effectiveness of the four plants.

Table 4.2 Overall Effectiveness of Selected Treatment plants

Industry / Efficiency (%)	Hirdaramani	Melbourne	Ocean Lanka	Stretchline
Max. BOD_5 Removal	96	96	81	60
Max.COD Removal	96	95	68	74
Max.TSS Reduction	91	94	45	76
Overall Efficiency	94	95	64	70

Table 4.3; compares the Temperature, pH, BOD, COD, TSS and TDS parameter between the plants.

Table 4.3 Results of Test Reports

Industry / Parameter	Hirdaramani		Ocean Lanka		Stretchline	
	Influent	Effluent	Influent	Effluent	Influent	Effluent
Temperature (^0C)	34.3	33.2	38	42	30	30
PH (mg/l)	9.43	7.66	9.84	5.79	4.55	8.98
BOD_5 (mg/l)	90	28	800	150	500	200
COD (mg/l)	434	64	1200	384.8	2616.6	692.6
TSS (mg/l)	134	16	108.82	60	225	53
TDS (mg/l)	1399	1871	2400	2272.72	1410	1248

4.3 Wastewater Treatment method in foreign countries

Like in the case of Sri Lanka, countries like India, Thailand and India uses one or more water treatment methods such as Pre treatment ,Physical Chemical treatment and Biological treatment in the textile industry.

4.4 Wastewater treatment standards -Sri Lanka vs. other countries

Table 4.4; Comparison of the Inland Surface Wastewater Quality standards of Sri Lanka with India, Thailand and Nepal.

Table 4.4 Sri Lankan Inland Surface Wastewater Quality Standards comparison with other countries

Parameter	Sri Lanka		India	Thailand	Nepal
	General	**Textile Industry**			
Temperature(^{0}C)	42	40	40	40	40
pH	6.0-8.5	6.5-8.5	5.5-9.0	5.5-9.0	5.5-9.0
BOD_5 (mg/l)	30	60	30	60	30-100
COD (mg/l)	250	250	250	<400	250
Suspended Solid (mg/l)	50	50	100	50	30-200

CHAPTER 05
Conclusion and Recommendation

5.1 Conclusion

Hirdaramani use as its treatment process a Pre treatment, Physical Chemical treatment as well as Biological treatment similarly Melbourne also use a Pre treatment, Physical and Chemical treatment as well as Biological treatment. Ocean Lanka and Strechline on the other hand use Pre treatment, Physical and Chemical treatment, but not Biological treatment.

Hirdaramani shows an overall efficiency of 94% in decreasing BOD (Biochemical Oxygen Demand), COD 9Chemical Oxygen Demand), as well as TSS (Total Suspended Solid). Melbourne revealed an overall efficiency 95% in decreasing BOD, COD as well as TSS. Ocean Lanka showed an overall efficiency of 64% in decreasing BOD, COD, as well as TSS. Stretchline shows an overall efficiency of 70% in decreasing BOD, COD as well as TSS.

When looked at the overall efficiency Hirdaramani and Melbourne show higher efficiency when compared with Ocean Lanka and Stretchline. This can be due to the extra efficiency of BOD, COD, and TSS gaind through Biological treatment.

Sri Lanka also has standards set for wastewater released to the inland waters. When these standards were compared with the standard set by India, Thailand, and Nepal they are approximately in the same range. One of them improvements in wastewater in textile industry is the availability of efficient laboratory facilities, and the reuse of wastewater.

5.2 Recommendation and further studies

The availability of effluent treatment processes must be studied further. An advantage for the textile industry using this study as a baseline the process should be studied into further details. An inventory of wastewater treatment plants should be provided all textile industry of Sri Lanka. Cleaner production and eco design technique should be applied for further enhancement of efficiency.

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www.pcd.go.th

htpp://www.pcd.go.th/impormation/regulation/waterquality/effluents.htm#industry.

APPENDIX I

TEST REPORT- 01

Site of Sampling	: Ocean Lanka (Pvt) Ltd, Export Processing Zone, Biyagama
Type of Sampling	: Wastewater Treatment Plant Inlet and Outlet
Date and Time of Sampling	: 15.01.2004 11.30am
Collected by	: W.G.C.Pushpakumara
Analyzed by	: W.G.C.Pushpakumara
Laboratory of Analysis	: BOI Environmental Monitoring Laboratory-Biyagama
Period of Analysis	: 15.01.2004 - 19.01.2004

Parameter	Unit	Test Methods	Standard Limits	Test Result	
				Inlet	Outlet
Appearance	-	-	-	Pink	Yellow
PH	-	Electrometric	6.0-8.5	9.84	5.79
Temperature	^0C	Electrometric	40	38	42
Conductivity at 25^0C	µs/cm	Electrometric	-	2.63	3.46
TSS	mg/l	Gravimetric	500	108.82	60
TDS	mg/l	Gravimetric	2100	2400	2272.72
BOD_5	mg/l	Winkler Method	200	800	150
COD	mg/l	Closed Reflux Method	600	1200	384.8

TSS - Total Suspended Solid
TDS - Total Dissolved Solid
BOD_5 - 5 Days Biochemical Oxygen Demand
COD - Chemical Oxygen Demand
mg/l - Milligrams pre Liter
ms/cm - Milli Semen's per Centimeter
^0C - Celsius

Note: Tolerance Limits for Industrial Wastewater (Effluents) Discharged into the common Wastewater treatment Plant

TEST REPORT- 02

Site of Sampling :Strechline(Pvt) Ltd,Export Processing Zone Biyagama

Type of Sampling : Wastewater Treatment Plant Inlet and Outlet

Date and Time of Sampling : 15.01.2004 11.00am

Collected by : W.G.C.Pushpakumara

Analyzed by : W.G.C.Pushpakumara

Laboratory of Analysis : BOI Environmental Monitoring Laboratory-Biyagama

Period of Analysis : 15.01.2004 - 19.01.2004

Parameter	Unit	Test Methods	Standard Limits	Test Result	
				Inlet	Outlet
Appearance	-	-	-	Dark Orange	Light Orange
PH	-	Electrometric	6.0-8.5	4.55	8.98
Temperature	^0C	Electrometric	40	31	30
Conductivity at 25^0C	µs/cm	Electrometric	-	433	1580
TSS	mg/l	Gravimetric	500	225	53
TDS	mg/l	Gravimetric	2100	1410	1248
BOD_5	mg/l	Winkler Method	200	500	200
COD	mg/l	Closed Reflux Method	600	2616.6	692.6

TSS - Total Suspended Solid
TDS - Total Dissolved Solid
BOD_5 - 5 Days Biochemical Oxygen Demand
COD - Chemical Oxygen Demand
mg/l - Milligrams pre Liter
µs/cm - Micro Semen's per Centimeter
^0C - Celsius

Note: Tolerance Limits for Industrial Wastewater (Effluents) Discharged into the common Wastewater treatment Plant

TEST REPORT- 03

Site of Sampling :Hirdaramani Industries, Seethawaka.Idustrial Park.

Type of Sampling : Wastewater Treatment Plant Inlet and Outlet

Date and Time of Sampling : 08.01.2004 10.45am

Collected by : W.G.C.Pushpakumara

Analyzed by : W.G.C.Pushpakumara / S.Gamini

Laboratory of Analysis : National Water Supply and Drainage Board,Avissawella.

Period of Analysis : 08.01.2004 - 14.01.2004

Parameter	Unit	Test Methods	Standard Limits	Test Result	
				Inlet	Outlet
Appearance	-	-	-	Turbid	Clear
PH	-	Electrometric	6.0-8.5	9.43	7.66
Temperature	^0C	Electrometric	40	34.3	33.2
Conductivity at 25^0C	µs/cm	Electrometric	-	915	1345
TSS	mg/l	Gravimetric	500	134	16
TDS	mg/l	Gravimetric	2100	1399	1871
BOD_5	mg/l	Winkler Method	200	90	28
'COD	mg/l	Closed Reflux Method	600	434	64

TSS - Total Suspended Solid
TDS - Total Dissolved Solid
BOD_5 - 5 Days Biochemical Oxygen Demand
COD - Chemical Oxygen Demand
mg/l - Milligrams pre Liter
µs/cm - Micro Semen's per Centimeter
^0C - Celsius

Note: Tolerance Limits for Industrial Wastewater (Effluents) Discharged into the common Wastewater treatment Plant

APPENDIX II

ISI: 4290-1974 (INDIAN STANDARDS INSTITUTE) TOLERANCE LIMITS FOR INDUSTRIAL EFFLUENTS TO BE DISCHARGED INTO INLAND SURFACE WATERS IN INDIA

INDIAN INDUSTRIAL EFFLUENT STANDARDS			
Parameter		Unit	Tolerance Limit
1.	BOD (5day 20 ^{0}C)	mg/l	30
2.	COD	mg/l	250
3.	pH	-	5.5-9.0
4.	Total suspended solids	mg/l	100
5.	Temperature	^{0}C	40
6.	Oil and Grease	mg/l	10
7.	Phenolic compounds	mg/l	1.0
8.	Cyanides (as CN)	mg/l	0.2
9.	Sulphides (as S)	mg/l	2.0
10.	Florides (as F)	mg/l	2.0
11.	Total residual chlorine	mg/l	1.0
12.	Insecticides	mg/l	Zero
13.	Ammonical nitrogen,	mg/l	50
14.	**Radioactive materials:**		
	a. Alpha emitters	c/ml	10^{-7}
	b. Beta emitters	c/ml	10^{-6}
15.	**Heavy metals:**		
	1.Arsenic (as As)	mg/l	0.2
	2.Cadmium (as, Cd)	mg/l	2.0
	3. Chromium, hexavalent (as Cr)	mg/l	0.1
	4.Copper	mg/l	3.0
	5.Lead	mg/l	0.1
	6.Mercury	mg/l	0.01
	7.Nickel (as Ni), Max	mg/l	3.0
	8.Selenium	mg/l	0.05
	9.Zinc	mg/l	5.0

Source: Rao and Datta, 1987,Waste Water Treatment

TOLERANCE LIMITS FOR INDUSTRIAL EFFLUENTS TO BE DISCHARGED INTO INLAND SURFACE WATERS IN THAILAND

THAILAND INDUSTRIAL EFFLUENT STANDARDS			
Parameter		Unit	Standards Values
1.	PH	-	5.5-9.0
2.	Total Dissolved Solids (TDS)	mg/l	not more than 3,000 mg/l depending on receiving water or type of industry under consideration of PCC but not exceed 5,000 mg/l not more than 5,000 mg/l exceed TDS of receiving water having salinity of more than 2,000 mg/l or TDS of sea if discharge to sea
3.	Suspended solids (SS)	mg/l	not more than 50 mg/l depending on receiving water or type of industry or wastewater treatment system under consideration of PCC but not exceed 150 mg/l
4.	Temperature	°C	not more than 40
5.	Color and Odor	-	not objectionable
6.	Sulphide (as H_2S)	mg/l	not more than 1.0
7.	Cyanide (as HCN)	mg/l	not more than 0.2
8.	Fat, Oil & Grease (FOG)	mg/l	not more than 5.0 mg/l depending of receiving water or type of industry under consideration of PCC but not exceed 15.0 mg/l
9.	Formaldehyde	mg/l	not more than 1.0
10.	Phenols	mg/l	not more than 1.0
11.	Free Chlorine	mg/l	not more than 1.0
12.	Pesticides	mg/l	not detectable
13.	Biochemical Oxygen Demand (BOD)	mg/l	not more than 20 mg/l depending on receiving water or type of industry under consideration of PCC but not exceed 60 mg/l
14.	Total Kjedahl Nitrogen (TKN)	mg/l	not more than 100 mg/l depending on receiving water or type of industry under consideration of PCC but not exceed 200 mg/l
15.	Chemical Oxygen Demand (COD)	mg/l	not more than 120 mg/l depending on receiving water of type of industry under consideration of PCC but not exceed 400 mg/l
16.	Barium (Ba)	mg/l	not more than 1.0
17.	**Heavy metals:**		
	1. Zinc (Zn)	mg/l	not more than 5.0
	2. Chromium (Hexavalent)	mg/l	not more than 0.25
	3. Chromium (Trivalent)	mg/l	not more than 0.75
	4. Copper (Cu)	mg/l	not more than 2.0
	5. Cadmium (Cd)	mg/l	not more than 0.03
	6. Lead (Pb)	mg/l	not more than 0.2
	7. Nickel (Ni)		not more than 1.0
	8. Manganese (Mn)	mg/l	not more than 5.0
	9. Arsenic (As)	mg/l	not more than 0.25
	10. Selenium (Se)	mg/l	not more than 0.02
	11. Mercury (Hg)	mg/l	not more than 0.005

Remark:	1) PCC	Pollution Control Committee
	2)	The standards were summerized from the Notification of the Ministry of Science, Technology and Environment, No. 3, B.E. 2539 (1996) and it specifies that pollution sources that the above standards are to be applied are factories group II and III issues under the Factory Act B.E.2535 (1992) and every kind of industrial estates.
	3)	Notification of the Pollution Control Committee, No. 3, B.E. 2539 (1996) dated August 20, B.E. 2539 (1996) has issued types of factories (category of factories issued under the Factory Act B.E.2535 (1992) that are allowed to discharge effluent having different standards from the Ministerial Notification No. 3 above as follows : 1. BOD up to 60 mg/l o animal furnishing factories (category 4 (1)) o starch factories (category 9 (2)) o food from starch factories (category 10) o textile factories (category 15) o tanning factories (category 22) o pulp and paper factories (category 29) o chemical factories (category 42) o pharmaceutical factories(category 46) o frozen food factories (category 92) 2. COD up to 400 mg/l o food furnishing factories (category 13 (2)) o animal food factories (category 15 (1)) o textile factories (category 22) o pulp and paper factories (category 38) 3. TKN o 100 mg/l - effective after 1 year from the date published in the Royal Government Gazette of the Ministerial Notification No. 4 o 200 mg/l - effective after 2 year from the date published in the Royal Government Gazette of the Ministerial Notification No. 4
		o for the following factories: o for the following factories: 1. food furnishing factories (category 13 (2)) 2. animal food factories (category 15 (1))

Source: htpp://www.pcd.go.th

TOLERANCE LIMITS FOR INDUSTRIAL EFFLUENTS TO BE DISCHARGED INTO INLAND SURFACE WATERS IN NEPAL

NEPAL INDUSTRIAL EFFLUENT STANDARDS			
Parameter		Unit	**Tolerance Limit**
1.	Total Suspended solids, Max	mg/l	30-200
2.	Particle size of total suspended particles	-	Shall pass 850-micron Sieve
3.	pH	-	5.5 to 9.0
4.	Temperature	°C	Must not exceed 40 degree C in any section of the stream within 15 meters down-stream from the effluent outlet.
5.	Biochemical oxygen demand (BOD) for 5 days at 20 degree C, Max	mg/L	30-100
6.	Chemical Oxygen Demand, Max	mg/L	250
7.	Oils and grease, Max	mg/l	10
8.	Phenolic compounds, Max	mg/l	1
9.	Cynides (as CN), Max	mg/l	0.2
10.	Sulphides (as S), Max)	mg/l	2
11.	**Radioactive materials:**		
	a. Alpha emitters, Max	c/ml	10^{-7}
	b. Beta emitters, Max	c/ml	10^{-8}
12.	Pesticides	mg/l	Absent
13.	Total residual chlorine	mg/l	1
14.	Fluorides (as F), Max	mg/l	2
15.	Ammonical nitrogen, Max)	mg/l	50
16.	**Heavy metals:**		
	1.Arsenic (as As), Max	mg/l	0.2
	2.Cadmium (as, Cd), Max	mg/l	2
	3.Hexavalent chromium (as Cr), Max	mg/l	0.1
	4.Copper (as Cu), Max	mg/l	3
	5.Lead (as Pb), Max	mg/l	0.1
	6.Mercury (as Hg), Max	mg/l	0.01
	7.Nickel (as Ni), Max	mg/l	3
	8.Selenium (as Se), Max	mg/l	0.05
	9.Zinc (as Zn), Max	mg/l	5
	10.Silver, Max	mg/l	0.1

Source: Ministry of Pollution and Environment (http://www.mope.gov.np/environment/generic.php)

APPENDIX III

COLLECTED REPORTS DATA TABLE OF -HIRDARAMANI INDUSTRIES

Date	BOD_5 (mg/l)		COD (mg/l)		pH		TSS (mg/l)		TDS (mg/l)	
	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent
8-Jan-01	405	20	880	100	4.5	6.2	35	20	-	-
9-Feb-01	269.95	-	1027.52	-	5.75	-	210	-	651	-
3-Mar-01	-	19.9	-	230	-	6.59	-	50	-	1495
2-May-01	90	20.1	715.1	142.27	5.96	6.93	90	20	423	852
12-May-01	90	20.1	715.1	142.27	5.96	6.93	90	20	423	852
25-Jun-01	280	10	1385	120	4.8	6.0	-	—	-	-
23-Jul-01	85.8	20.4	620	150	6.2	6.77	110			
23-Jul-01	85.5	20.4	620	150	6.2	6.77	110	10	415	729
7-Aug-01	85.6	21.6	610	135	6.1	6.84	-	-	125	12
25-Nov-01	150.8	25	730	120	6.43	6.74,	110	20	-	-
31-Jan-02	85.2	15.1	440	110	7.32	6.93	-	-	1093	807
1-Feb-02	260	15	590	34	8.78	6.98	275	-	-	-
18-Mar-02	55.3	15.1	470	120	6.71	6.84	-	-	400	724
24-Apr-02	60.4	15	510	110	7.19	7.42	-	-	626	479
3-Jun-02	220	35	645	65	9.31	7.18	106	10	-	-
4-Jun-02	45.8	30.7	430.08	340.88	6.38	6.9	-	-	258	438
6-Jul-02	65.5	15	490	70	5.95	6.65	-	-	402	517
6-Aug-02	75	20.1	550	110	6.28	7.00	-	-	759	843
23-Aug-02	250	15	600	53	5.17	6.6	72	15	-	-
31-Aug-02	85.4	10.9	390	70	6.77	7.01	-	-	487	742
9-Sep-02	30.6	10.5	240	60	7.71	6.77	-	-	342	650
14-Nov-02	200	15	610	101	7.84	7.62	74	13	-	-
22-Nov-02	75.8	8.7	480	20	5.82	5.95	-	-	-	-
24-Feb-03	270	20	560	85	6.3	6.98	56	12	-	-
23-Jun-03	70.5	25	328	52	6.9	7.7	20	12	330	960
11-Jul-03	110	15	322	15	7.11	6.49	56	25	-	-
11-Sep-03	-	-	268	40	9.1	6.7	22	6	300	340
29-Oct-03	66	16	276	27	7.3	6.8	88	10	450	600

COLLECTED REPORTS DATA TABLE- MELBOURNE WASHING PLANT

Date	BOD_5 (mg/l)		COD (mg/l)		pH		Temperature (C°)		TSS (mg/l)		TDS (mg/l)	
	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent
16-Jul-01	200	15	600	82	-	7.2	-	-	200	13	-	-
4-Sep-01	-	20	-	-	9.2	8.4	-	-	-	-	1000	250
5-Oct-01	-	-	-	112	9.3	8.1	30	30	-	-	1200	940
20-Oct-01	-	-	-	198	9.0	7.5	30	40	-	-	690	-
23-Oct-01	-	-	1500	210	11.0	8.5	40	30	-	-	-	-
27-Oct-01	-	-	1500	210	10.5	8.5	-	30	-	-	2000	2000
30-Oct-01	-	-	-	-	10.5	8.5	40	30	-	-	2000	1900
2-Nov-01	-	-	760	95	8.8	8.0	-	-	-	-	1200	1000
10-Nov-01	500	20	-	-	9.0	8.0	32	30	-	-	1200	1000
15-Nov-01	-	-	894	112	11.0	9.0	-	-	-	-	-	-
18-Nov-01	-	-	1500	200	11.0	8.5	40	30	-	-	-	-
20-Nov-01	-	-	-	-	11.0	9.5	-	30	-	-	-	-
23-Nov-01	-	-	760	95	11.0	8.5	37	30	-	-	2000	1900
2-Dec-01	20	-	-	-	10.8	8.5	32.	30	-	-	-	-
7-Dec-01	-	-	1200	190	11.2	8.7	-	-	-	-	1900	1800
12-Dec-01	-	-	-	-	9.0	8.0	32	30	-	-	1800	1500
15-Dec-01	-	28	570	-	-	8.0	-	-	-	-	-	-
23-Dec-01	-	28	-	-	11.0	8.5	32	30	-	-	-	1500
26-Dec-01	570	-	-	-	11.0	8.5	32	30	-	-	1500	1500
3-Jan-02	-	-	1120	-	190	11.0	8.5	32	30	-	-	-
9-Jan-02	-	-	752	142	11.0	9.0	40	30	-	-	1800	1500
15-Jan-02	-	-	1200	175	10	9.0	-	-	-	-	-	-
20-Jan-02	-	17	-	75	10	9.0	-	-	-	-	1900	400
25-Jan-02	-	-	1700	192	9.8	9.0	-	-	-	-	-	2500
31-Jan-02	150	13	600	70	-	9.5	-	-	150	18	-	-
5-Feb-02	-	30	-	-	11.3	9.0	-	-	-	-	-	3100
10-Feb-02	-	-	-	190	11.2	8.7	-	-	-	-	-	3000
14-Feb-02	-	-	-	-	11.2	9.0	-	-	-	-	-	3000
20-Feb-02	-	-	1700	200	12.0	9.0	-	-	-	-	-	3500
25-Feb-02	-	-	-	190	11.3	8.7	-	-	-	-	-	3000
4-Mar-02	-	-	-	180	12.0	8.4	-	-	-	-	-	1600
23-Mar-02	-	20	-	-	11.4	8.1	-	-	-	-	-	2400
4-Apr-02	-	-	-	190	12.2	8.4	-	-	-	-	-	1800
4-Apr-02	-	-	-	190	12.2	8.4	-	-	-	-	-	1800
27-Apr-02	-	25	-	180	11.9	8.1	41	32	-	-	-	1800
6-May-02	-	-	-	180	12.3	8.3	-	-	-	-	-	2100
9- May-02	-	21.1	920	112	11.9	7.5	41	31	-	-	-	1900
19- May-02	-	-	942	94	12.1	8.1	-	-	-	-	-	990
24- May-02	-	12	830	70	12.3	8.0	44	32	-	-	1200	500
29- May-02	-	-	944	64	12.1	7.9	45	31.5-	-	-	1340	910
4-Jun-02	-	-	610	120	11.9	8.1	-	-	-	-	1600	820
8-Jun-02	-	-	942	82	11.7	8.0	43	30.3	-	-	1730	920
12-Jun-02	-	18.1	912	90	11.3	7.7	-	-	-	-	1920	1070
17- Jun-02	-	14.3	830	130	11.8	7.9	43	30	-	-	1700	960
20- Jun-02	-	-	920	102	11.9	7.4	-	-	-	-	1640	980
24- Jun-02	-	17.1	-	-	11.6	7.5	40	31.1	-	-	1830	990
29- Jun-02	-	-	890	62	10.8	7.3	-	-	-	-	1900	1070
3-Jul-02	-	19.3	982	74	11.7	7.7	-	-	-	-	1840	1020
8-Jul-02	-	-	640	60	11.1	7.7	40	30.3	-	-	-	-
11-Jul-02	-	18.3	740	44	11.4	7.3	-	-	-	-	1240	690
15-Jul-02	-	-	1140	80	11.9	7.7	-	-	-	-	1940	990
17-Jul-02	-	15.3	1340	67	11.3	7.7	41	31	-	-	1800	740
22- Jul-02	-	-	920	60	10.8	7.6	-	-	-	-	1890	870
26- Jul-02	-	-	1223	56	11.1	8.1	33	-	-	-	1890	830
9-Aug-02	-	-	742	43	11.1	7.3	-	-	-	-	1340	630
13- Aug-02	-	19.1	1442	110	11.6	7.8	44	33	-	-	1830	870
17- Aug-02	-	-	822	73	11.3	8.1	41	31	-	-	1670	1120
20- Aug-02	-	-	943	61	10.9	7.6	40	30	-	-	1470	680
23- Aug-02	-	15.3	-	93	11.0	7.8	45	32.1	-	-	1870	1120
27- Aug-02	-	-	-	110	11.7	8.1	40	32	-	-	1650	970
31-Aug-02	-	14.3	-	53	11.1	7.2	39	30.1	-	-	980	570
6-Sep-02	-	19.1	-	63.3	7.1	11.3	40	33	-	-	-	870
10-Sep-02	-	17.3	-	130	11.3	7.0	47	35	-	-	1970	1130
14-Sep-02	-	-	-	93	11.1	7.3	40	30	-	-	-	680

25- Sep-02	-	21.3	-	112	11.4	7.1	41	33	-	-	1720	1180
28- Sep-02	-	-	-	83	10.9	7.6	43	31	-	-	-	760
2-Oct-02	-	15.7	-	71	11.7	7.3	43	33	-	-	1780	1100
5- Oct-02	-	-	-	82	11.3	7.9	47	35.2	-	-	-	69
8- Oct-02	-	21.3	-	63.1	11.7	7.8	46	32	-	-	2100	1860
16-Oct-02	-	19.3	79	-	11.3	7..00	43	30	-	-	-	840
20- Oct -02	-	20	-	67	11	6.7	44	30	-	-	-	800
27- Oct -02	-	-	-	74	11.7	7.1	45	31.3	-	-	-	840
13-Nov-02	-	17.3	-	6.3	11.1	7.0	43	30.1	-	-	-	790
24-Nov-02	-	-	-	59.2	10.9	7.2	43	30	-	-	-	810
21-Dec-02	-	-	-	61.3	10.8	7.1	-	33	-	-	-	670
25-Feb-03	200	20	600	93	-	-	-	-	-	-	-	-
24-Mar-03	150	10	1700	247	-	6.6	-	-	100	20	-	-
3-Apr-03	150	10	800	105	-	6.9	-	-	150	12	-	-
3-Nov-03	150	12	1100	150	9	6.8	-	-	200	18	-	-

COLLECTED REPORTS DATA TABLE- OCEAN LANKA (PVT) LTD.

Date	BOD_5 (mg/l)	COD (mg/l)	pH	Temperature (C^0)	TSS (mg/l)	TDS (mg/l)
	Effluent	Effluent	Effluent	Effluent	Effluent	Effluent
18-Jan-00	145	325	5.1	39	135	3120
25-Feb-00	151	272	5.9	41	86	-
28-Feb-00	290	435	6.6	40	200	3600
8-Mar-00	100	238	5.2	41	70	-
14-Mar-00	165	306	5.4	42	284	-
16-Mar-00	154	553	5.8	41	434	-
22-Mar-00	180	293	6.1	41	210	-
25-Apr-00	140	350	5.2	43	315	3700
11-May-00	190	468	6.9	47	-	-
24-May-00	160	206	5.8	40	-	-
30-May-00	20	170	6.9	-	50	3500
3-Jun-00	140	227	7.2	42	-	-
7-Jun-00	100	170	6.8	42	90	1150
14-Jun-00	180	286	7.2	42	-	-
22-Jun-00	125	256	6.0	39	-	-
13-Jul-00	130	270	5.4	42	134	-
27-Jul-00	198	270	6.5	38	164	-
3-Aug-00	110	225	6.7	38	94	-
10-Aug-00	140	225	6.1	39	146	-
17-Aug-00	120	375	6.0	40	314	-
31-Aug-00	140	322	6.3	-	480	-
7-Sep-00	150	349	5.7	42	204	-
21-Sep-00	160	118	6.6	38	118	-
5-Oct-00	150	363	6.4	38	230	-
10-Nov-00	110	207	5.1	37	118	-
22-Nov-00	230	319	7.0	38	572	-
13-Dec-00	190	270	5.5	38	74	-
4-Jan-01	130	140	5.5	39	112	-
12-Jan-01	140	403	4.8	38	494	-
24-Jan-01	120	500	8.1	38	306	-
22-Feb-01	210	284	8.1	36	460	-
2-Mar-01	170	216	6.8	38	64	-
21-Mar-01	120	204	6.2	38	268	-
29-Mar-01	150	230	4.5	39	162	2846
6-Apr-01	140	155	6.5	38	126	2324
4-May-01	190	319	2.8	38	624	-
17-May-01	-	103	6.4	38	96	-
1-Jun-01	160	273	6.0	38	74	-
15-Jun-01	140	346	5.4	38	112	-
29-Jun-01	130	164	6.2	38	118	-
20-Jul-01	190	299	6.5	39	256	-
21-Sep-01	120	174	4.5	38	112	-
28-Sep-01	240	291	5.0	38	184	-
26-Oct-01	210	222	6.7	39	172	-
15-Nov-01	180	335	5.2	38	102	-
22-Nov-01	100	220	4.5	30	146	-
28-Nov-01	220	352	6.5	38	132	-
21-Dec-01	120	376	5.5	38	262	-
21-Dec-01	60	125	5.5	39	80	-
9-Jan-02	100	160	4.5	38	58	-

16-Jan-02	120	143	5.1	39	74	-
22-Jan-02	190	257	6.4	30	166	-
7-Feb-02	160	228	6.4	38	190	-
21-Feb-02	180	224	5.3	38	140	-
8-Mar-02	110	271	6.7	38	198	-
11-Mar-02	190	271	5.6	38	114	-
22-Mar-02	190	204	5.6	38	144	-
10-Apr-02	210	232	5.2	39	154	-
8-May-02	150	370	5.6	38	192	-
5-Jun-02	140	337	5.9	38	68	-
14-Jun-02	215	429	6.7	38	214	-
20-Jun-02	200	643	6.7	38	414	-
3-Jul-02	190	324	6.8	38	158	-
7-Aug-02	140	737	4.0	38	932	-
16-Aug-02	170	340	5.4	38	296	-
13-Sep-02	140	232	3.9	38	110	-
10-Oct-02	130	219	5.4	38	154	-
14-Nov-02	80	170	6.4	38	240	-
24-Nov-02	130	393	4.5	39	204	-
13-Dec-02	160	367	4.1	39	402	-
6-Feb-03	100	301	6.8	38	188	-
14-Feb-03	200	324	4.5	38	800	-
24-Apr-03	190	383	5.7	38	248	-
28-May-03	120	220	5.1	39	184	-
27-Jun-03	250	620	6.0	38	662	-
4-Jul-03	180	308	6.1	38	354	-
17-Jul-03	170	318	4.2	39	310	-
8-Aug-03	215	641	5.2	39	634	-
15-Aug-03	230	612	5.7	39	500	-
21-Aug-03	190	474	4.5	38	454	-
25-Sep-03	210	316	5.9	38	236	-

COLLECTED REPORTS DATA TABLE- STRETCHLINE.

Date	BOD$_5$ (mg/l)	COD (mg/l)	pH	Temperature (C^0)	TSS (mg/l)
	Effluent	Effluent	Effluent	Effluent	Effluent
2-Aug-0	190	546	8.5	30	70
21-Feb-01	200	679	6.8	30	144
6-Mar-01	110	179	9.3	30	114
22-Mar-01	180	488	8.5	30	76
17-May-01	-	308	10.2	30	50
24-May-01	210	256	10.5	30	32
15-Jun-01	140	302	6.7	30	44
29-Jun-01	120	328	7.6	30	42
13-Jul-01	160	411	6.7	30	76
18-Jul-01	190	522	7.6	30	64
9-Aug-01	180	445	9.8	30	46
5-Sep-01	150	264	7.1	30	78
28-Oct-01	210	378	6.6	30	46
15-Nov-01	100	407	7.5	30	26
28-Nov-01	160	396	7.5	30	106
9-Jan-02	120	512	7.0	30	50
16-Jan-02	120	221	6.8	30	80
7-Feb-02	200	671	7.6	30	98
14-Feb-02	170	671	7.2	30	74
6-Apr-02	190	480	7.4	30	76
10-Apr-02	180	581	7.1	30	120
8-May-02	130	555	7.2	30	36
30-May-02	100	606	6.4	30	92
5-Jun-02	130	643	7.5	30	66
14-Jun-02	150	582	7.1	30	90
21-Jun-02	130	551	7.3	30	84
28-Jun-02	180	530	7.5	30	80
4-Jul-02	160	647	9.8	30	282
11-Jul-02	150	579	7.6	30	50
24-Jul-02	180	547	7.1	30	32
10-Aug-02	60	540	8.5	30	50
16-Aug-02	80	595	7.3	30	50
26-Sep-02	150	626	7.2	30	76
25-Oct-02	100	599	5.8	30	84
27-Nov-02	150	566	6.6	30	92
9-Jan-03	205	310	6.3	30	148
31-Jan-03	130	602	6.6	30	170
6-Feb-03	140	602	7.8	30	42
28-Mar-03	160	606	7.2	30	16
3-Apr-03	160	606	6.0	30	82
28-May-03	180	586	6.2	30	112
11-Jun-03	190	402	7.5	30	56
27-Jun-03	220	519	8.1	30	106
17-Jul-03	190	531	6.8	30	182
21-Aug-03	200	442	6.8	30	164
18-Sep-03	180	568	6.5	30	72
1-Nov-03	170	620	7.5	30	272
14-Nov-03	140	517	6.4	30	84
20-Nov-03	200	427	6.7	30	60

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