WASTEWATER TREATMENT

FOR

THE DESICCATED COCONUT INDUSTRY

IN

SRI LANKA

AN ENVIRONMENTAL ENGINEERING DESIGN APPROACH

A DISSERTATION SUBMITTED TO

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KARUNA SUSIL SENEVIRATNE

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Sue. I. Seneviratne

K S Seneviratne

November , 1996

ABSTRACT

This thesis is an attempt to introduce a wastewater treatment system to treat wastewater generate in the production of Desiccated coconut in Sri Lanka.

In the preparation of this method of treatment based on biological treatment, attention was focused on the generation of liquid, gaseous and solid wastes and their impacts on the environment.

Alternative methods were discussed for ene-of-pipe treatment of waste water, and in-plant measures to prevent and reduce waste generation also considered.

In conclusion, the proposed treatment system was evaluated in terms of economic and found that, it is economically viable.

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CHAPTER 1

INTRODUCTION

1.1 PRODUCTION PROCESS AND ITS CONTRIBUTION TO NATIONAL ECONOMY

Desiccated coconut is manufactured from the white inner layer of the coconut i.e the kernal. Seasoned mature coconuts are supplied to the factory in lorries after the coir fibres have been removed. The coconuts are hatcheted or cut open manually, producing coconut shells as a by products. These shells are either sold to manufactures of charcoal and activated carbon, or they are burned in the factory furnaces. The second layer of the inner shell, being the transition of the brown coconut shell to the white kernel , is also removed manually. The result is a second by product which is called copra. Copra has a very high oil content and is usually sold to oil mills for oil-extraction. Occasionally copra is used as animal food.

The remaining kernel is finally cut open into several pieces. The coconut water is released and is the major source of waste water. The white kernel pieces are subsequently washed with chlorinated water (calcium hypochlorite, 2 mg/1). Washing is also a major source of waste water. Then, the coconut pieces are sterilized. Generally sterilizing is carried out by boiling in water for 1 to 2 minutes. after sterilizing the kernel pieces are cut or grined mechanically into small particles.

In one of the modern large-scale DC mills, the process of sterilizing is carried out differently. Here, the sterilization takes place after grinding of the kernel into small particles. The particles are not boiled in water, but treated with steam for 1 or 2 minutes in a continuous process. This type of sterilizing with steam generates less waste water than sterilization in boiling water.

After sterilization the fine particles are dried at 90-95C in order to reduce the moisture content from 55% to 3 - 3.5%. Heat is generally provided by burning firewood and coconut shells.

Finally, a mechanical shifter screens the desiccated coconut into fractions of fine, medium and large size particles. The largest fraction is re-cut. fine and medium size particles are packed separately in bags containing 50 kg.

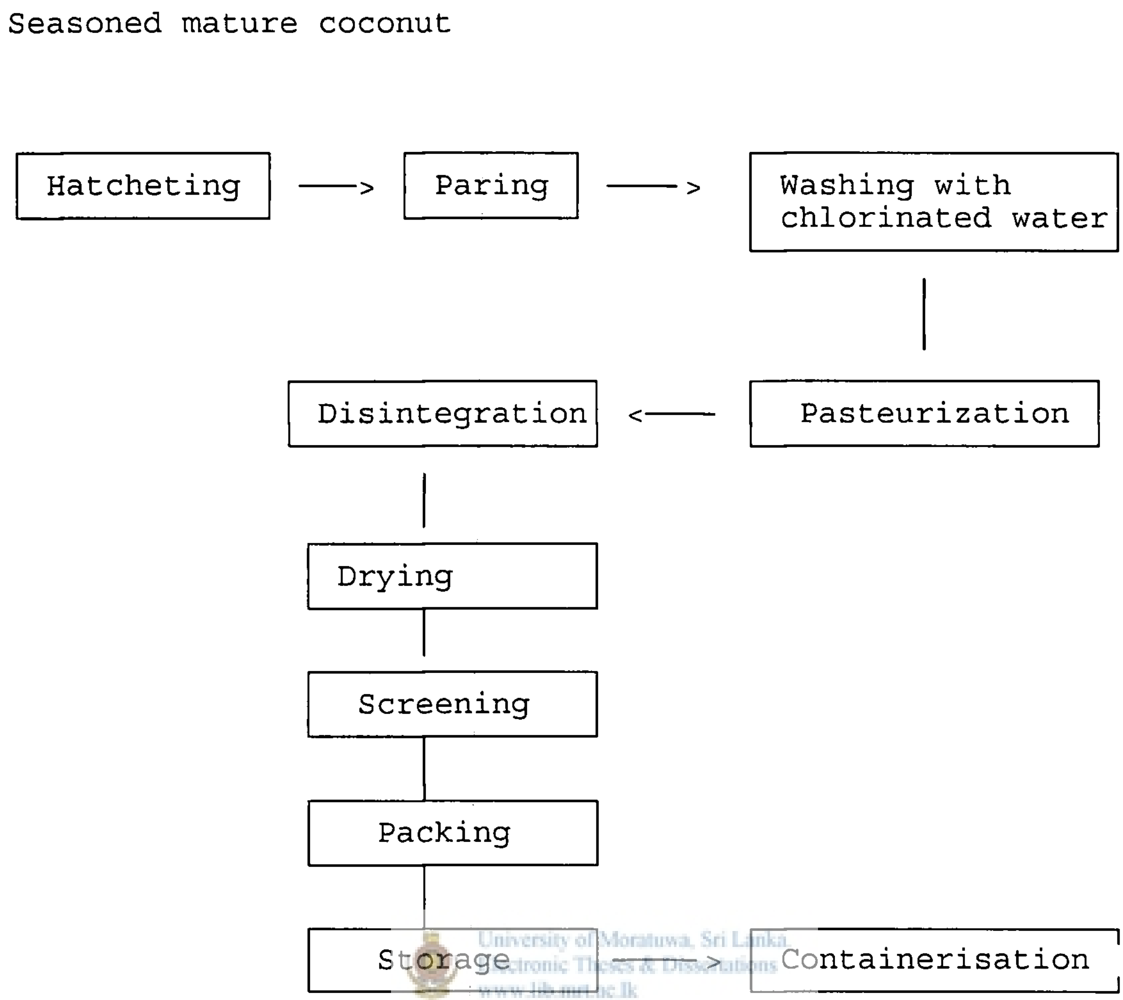

Fig 1.1 : Desiccated Coconut Manufacturing Process

Source : Coconut Development Authority 1990

The Sri Lankan coconut processing industries produce 50,000 tonnes of desiccated coconut [DC] per year,accounting for almost 40% of the worldwide production of Desiccated Coconut.The production is still increasing. Currently the installed production capacity amounts to 75,000 metric tonnes of Desiccated Coconut per annum. There is no local market for Desiccated Coconut in Sri Lanka, all of it is exported.

The manufature of Desiccated Coconut in Sri Lanka first began in 1891, when approximatrly 600 tonnes of the product were exported from the country. In the 1930s annual Desiccated Coconut exports average around 35,000 tonnes and by the 1950s exports increased to approximately 52,000 tonnes per annum with a peak of 70,000 tonnes in 1968.

In terms of foreign exchange , the Desiccated Coconut industry earns approximately US$ 50 million per annum and constitutes an important part of Sri Lanka's export earnings. The Coconut industry as a whole earns around US$ 100 million annually.

1.2 Waste generation and Environmental Impacts

1.2.1 Wastewater

There are 3 major sources of wastewater in this process and as

I Washing of white kernel pieces - 40000 litres

II Coconut water - (200ml x 50000) - 10000 lit

III Sterlization of ground kernel particles - 2700 litres

The total wastewater generation of an average size factory, processing 50000 coconuts per day amounts to about $50m^3$. The combined wastewater generally has following characteristics.

pH	4.0 - 5.5
BOD	1000 - 5000 mg/l
COD	4000 - 8000 mg/l
Oil	4000 mg/l

(CEA, 1992)

1.2.2 Solid waste

At the begining of the process, coconuts are hatcheted and as a result of this shells are produced, amounting 20000 kg/d in an average size factory processing 50000 nuts/day . However, the coconut shells are either sold to producers of activated carbon or used as a fuel in the factory, and therefore does not create a solid waste problem.

The second layer of the inner shell, being the transition of the brown coconut shell to the white kernel is also removed manually and accumulated as a by product which is called copra. In average size facotry amount of copra generated is approximately 2500 kg/d. Copra too has a ready market and does not usualy create a solid waste disposal problem.

If there is a wastewater treatment plant in operation, dewatered sludge is generated as a result of aerobic and anaerobic processes. These sludge have to be disposed of without polluting environment.

1.2.3 Air Emissions

Air emissions are caused by furnaces, which are mostly fulled by firewood and coconut shells. When wet coconut shells in particular, are burned, black smoke, flyash and volatiles are generated.

1.2.4 Environmental Impacts

The wastewater from desiccated coconut mills is generally discharged without treatment into nearby streams. pits, paddy fields, or uncultivated lands.

These discharges may result in depletion of dissolved oxygen in receiving water bodies and in emission of the bad odours caused by anaerobic degradation of organic substances.

The presence of oily substances in the discharged wastewater in combination with bad odours, makes the surface water unfit for drinking and bathing purposes. The discharge of wastewater into paddy fields may cause crop damages due to the low pH of the wastewater.

Emission of black smoke and flue gases from the boilers may cause enormous nuisance to neighbouring residents.

Depletion of ground water is also a negative impact to the environment which is caused as a result of massive abstraction of ground water in this industry. In an average size factory 63,000 lit/day of ground water is consumed for domestic activities and production processes, as no other alternative source of water is available nearby. As most factories are located in rural areas, there is a direct impact on farming activities with low yield of ground water.

1.3 Legislation and Institutional Frame Work.

1.3.1 Environmental Legislation & related Ordinances

Environmental Legislation

Sri Lanka has a number of laws dealing with various aspects of environmental protection and management. However, in the present context of development taking place in the country, most of these laws have, time and again, proved inadequate to address the environmental challenges brought down by this very same development.

The National law on Environment, titled "National Environmental Act, No 47 of 1980" came into operation in 1988. This Act created the Central Environmental Authority (CEA) as a policy making and coordinating agency for the protection, management and conservation of the environment and filled a long standing gap created by the absence of institutional framework to coordinate environmental policy making and programming in Sri Lanka.

The National Environmental Act was amended in 1988 to introduce a licensing procedure and given legislative backing to an environmental impact assessment procedure for development projects, which incorporated public participation, the amendment also introduced new water, soil air and noise pollution control standards.

The Central Environmental Authority is primarily responsible for developing National environmental and natural resources policies and pollution control by way of issuing of waste emission licences and overall administration of the EIA procedure.

Under the amendment to the NEA, the CEA has become the sole authority for assessing and developing Sri Lanka's environmental pollution control strategy. In contrast, the CEA may only recommend to the Minister with regard to natural resources, land use planning, forestry, wildlife, aquatic resources and fisheries and Soil Conservation, which are the responsibilities of the respective departments and agencies.

Sri Lanka has a number of ordinances, laws, acts regulations and by - laws together forming Sri Lanka's environmental legislation which are in one way or another, related to the environment . These cover a wide area and variety of situations and some of the important pieces of legislation and as follows.

1. Nuisances Oesinance -15/1862

- Provisions on polluting any water way, tank reservoir, well, drain

- Provision on offensive smells

2. Local Government Laws

- Municipal Council Ordinance No. 29/1497

- Urban Council Ordinance No. 61/1939

- Pradeshiya Sabhas Act No. 15/1987

In general, contains provisions on detection and abatement of nuisances, control and administration of all matters relating to public health, public utility services and abatement of industrial pollution.

3. Water Resources Board Act No. 29/1964
Provides for the prevention of pollution of rivers, streams and other water courses.

4. Urban Development Authority Law No. 41/1978
Contains provisions on water supply, drainage and sewage, also provide the provision for control of pollution, environmental quality.

1.3.2 **Environmental Protection Licencing procedure for industries**

The Central Environmental Authority is implementing a major programme for the issue of Environmental Protection Licence to industries. The EPL issued to industries sets out certain conditions to be adhered to by the industry in order to minimize pollution. The licence further stipulates the standards to be met by waste effluents generated by such industries before being discharged into the environment.

Industries are monitored as regularly as possible with the limited staff available, in order to ensure compliance with conditions set out in the licence, up to 30th September 1996 a total of 2746 industries have applied for the licence out of which 1411 licences have already been issued.

1.3.3 Development of Guidelines and standards for pollution Control.

The CEA has established standards and criteria to be met by industries in order to minimize pollution arising from their operations. Industries which discharge waste effluents into the environment are required to meet these standards before discharge in order to ensure pollution free operations. In addition the CEA has developed a series of comprehensive guidelines to be followed by different types of industries, for pollution mitigation.

For the following types of industries guidelines were prepared.

1. Natural Rubber Industry
2. Concentrated Latex Industry
3. Desiccated Coconut Industry
4. Leather Industry
5. Dairy Industry
6. Textile Processing Industry
7. Pesticide Formulating Industry
8. Metal Finishing Industry

1.4 Objective and Scope of the Project

Before achieving to the main objective of the project, finding the most suitalbe treatment system, following steps have to be considered carefully.

1. Characterisation of wastewater (Estimating the Organic Content). This should consider the form of the pollutant whether it is in
   a. Suspended form
   b. Colloidal form
   c. Dissolved form, and Biodegradability and toxicity.
2. The required effluent quality.
3. The costs and availability of land for the treatment plant. One or more treatment combinations can produce the desired effluent.
4. A detailed cost analysis should be made before final process design selection.

Scope of the project

1. Evaluating the removal efficiecy of organic matter of treatment units.
2. Evaluating Hydraulic Retention time for Anaerobic treatment unit and Aerobic treatment as well.
3. Evaluating a proper organic loading rate for Anaerobic treatment and proper F / M ratio for Aerobic treatment.

CHAPTER 2

LITREATURE REVIEW AND THEORTICAL CONSIDERATIONS

2.1 General

The industrial revolution in developed countries has concentrated urban areas with a high density of industries and factories which are discharging large amount of wastes into the environment, already stressed to the limit by pollution created by human habitation. If development takes place properly planned and programmed with scientifically developed strategies to compromise with nature for environmental protection and conservation and sustainable development, the Sri Lanka situation could be brought under control for the betterment of the present generation and generations to come. However to achieve such a goal, a strong policy and statuatory control should be in place together with necessary institutional support and proper linkage between relevant authorities.

Environmental degradation caused by industries discharging effluents in untreated form has been the object of increasing concern among the authorities and as a result the Sri Lankan government introduced environmental legislation (National Environmental Act) to enhance environmental protection and control.

Central Environmental Authority is the lead agency in the implementation and enforcement of the environmental legislation, under which the environmental protection licensing scheme was introduced. According to the National Environmental Act (appendix 1)

Obtaining an Environmental Protection Licence for industries is a legal requirement since July 1990 and therefore wastewater generated has to be treated to a such limit that it meets standards (appendix 1) stipulated by the Central Environmental Authority.

Therefore it is absolutely essential that all DC Mills have to install waste water treatment plants and treated effluents be properly discharged into the environment in an environmentally acceptable manner.

The production of desiccated coconut generates waste water with high concentrations of bio degradable organic compounds, including carbohydrates, oil and greases. With comparison of other industries, most descidated coconut industries are located in rural areas and discharge their waste water into nearby streams or pits with little or no treatment to reduce the pollutional load on the environment.

Unfortunately, there is no treatment method available in Sri Lanka as yet, that could cover the entire spectrum of wastewater generated from this industry. However, Biological treatment has been recommended in industrial pollution control guidelines for desiccted coconut-industry prepared by the Central Environmental Authority in 1992 with technical assistance from the Government of the Netherlands. As coconut water contains high concentrations of biodegradable organic compounds, including Carbohydrates, Oil and Greases, a biological treatment process can be employed.

Approximate composition of coconut water from tender nuts

Water, percent	95.5
Carbohydrates, percent	4.0
Protein, percent	0.1
Fat, percent	<0.1
Mineral, percent	0.4

Source : Indian coconut Journal 1980

Biological treatment may be aerobic (Oxygen required) or anaerobic (Oxygen absent), process and there are instances where both systems are adopted in such way that one system followed by the other depending on the strength of the wastewater, achieves maximum removal efficiency of BOD or COD.

Presently 63 desicated coconut industries are in operation of which 5 mills are large scale factories, processing over 100,000 nuts per day. The remaining 48 mills are small and medium scale processing less than 50,000 nuts per day. Virtually no waste water treatment facilities exist at the DC mills in Sri Lanka.

However institutional frame work and legislation covering effluent disposl into the environment are as such, a little or no attention has been paid by Dessicated coconut millers in this regard, mainly due to lacking of

1. proper financial resources
2. waste water treatment technology available to them and
3. significant increase in cost of production with waste treatment

Considering above facts it was the main objective to make this attempt carrying out this study with a view to approach a feasible solution with econmically viable and environmentally sound.

2.2 Pollution Control Measures

Process modification and in - plant pollution control The wastewater generation from sterilizing and washing operations could be reduced by good house keeping methods and by process integrated measures.

Coconut water has an oil content of around 2% and most of the oil can be separated significantly by recovering the oil from coconut water through gravity settling followed by mechanical or manual skimming, depending on the size of the factory.

Process modification also enhances to minimize wastewater generation of this industry. In one of the large scale desiccated coconut mills in Sri Lanka, (Industrial Pollution Control Vol. 3, CEA) the process of sterilizing is carried out in such a way that, the ground particles are not boiled in water but treated with steam for 1 or 2 minutes in a continuous process, generating less amount of wastewater comparing with conventional Desiccated Coconut production process.

2.2.1 Pre - treatment of coconut water

Oil content of coconut water is relatively high and can be recovered passing through a properly designed oil trap, with a retention time of approximately 3 hours. Oil is skimmed off at the surface of the tank by means of a number of baffles in the tank.

Suspended solids settled at the bottom of the tank are removed regularly by means of an outlet.

Table 2.1

Characteristics of coconut water before and after oil trap/ sedimentation tank (CEA 1992)

Parameters	Before Oil trap	After Oil trap
pH (mg/L)	4.8	4.8
COD (mg/L)	40000	28000
BOD (mg/L)	10000	6000
Oil (mg/L)	2000	100
Suspend solids (mg/L)	750	
Total Nitrogen (mg/L)	225	200

2.2.2 Anaerobic processes.

a. Upflow anaerobic sludge Blanket (UASB)

In the UASB reactor the wastewater flows upwards through a blanket of anaerobic bacteria, which bio degrade part of the Organic material into gases such as methane, carbon dioxide, ammonia and hydrogen sulphide. The gases are collected in the upper section of the reactor by a gas collector. The optimum temperature for the anaerobic process is 35°c. The advantage of this system is that no energy input is needed under tropical conditions.

b. Anaerobic Ponds

If sufficient land is available an anaerobic pond system can be applied instead of an anaerobic reactor. In this system the Organic matter in the wastewater is biodegraded by anaerobic bacteria into gases, such as methane, hydrogen sulphide, ammonia and Carbon dioxide. Solids settle into a sludge layer at the bottom of the pond which has to be removed periodically.

c. **Fixed bed upflow/ down flow anaerobic filter**

In the attached growth upflow and down flow anaerobic filters or in other words anaerobic trickling filter, the liquid passes through static media of rock or synthetic material over which a biomass of facultative and obligate anaerobic organisms are formed. These organisms break down the incoming organic matters to intermediate products and finally to carbon dioxide and methane.

2.2.3 Aerobic processes

Under the aerobic process a biological reactor is (aeration tank) is always supplied with air (Oxygen), either mechanically or under natural conditions, including the productions and supply of oxygen by algae in an oxidation pond. Most important aerobic processes which can be applied in coconut water treatment systems are as follows.

a. **Activated sludge process**

In the activated sludge system the wastewater is led into an aeration tank where it is mixed with flocs of aerobic microorganisms (activated sludge). The mixture of activated sludge and wastewater is aerated vigorously.

Organic substances in the wastewater are absorbed by the active microorganisms, which bio degrade the organic matter, utilizing the breakdown products as a substrate for growth and formation of new cells. As a result the sludge quantity in the aeration tank is increased. Microorganisms die off in the aeration tank, the dead cells being oxidized into inert materials (mineralization). The mixture is led from the aeration tank into a sedimentation tank where the flocs settle into a sludge. A part of this sludge is returned to the aeration tank, in order to maintain a constant concentration of activated sludge in it. The remainder of the sludge (surplus sludge) has to be removed. The surplus sludge is often dewatered in a sludge drying bed to decrease its volume.

High load activated sludge system with a high loading rate of organic matter per quantity activated sludge (kg BOD per kg sludge solids per day) and low load activated sludge systems are used in wastewater treatment.

BOD removal efficiency of this system is 95 - 98%
(Pollution Control Volume 3 ,CEA)

b. **Rotating Biological contactors System (RBC)**

The rotating biological contacters system consist of a series of biorotors, a biorotor being a central horizontal shaft to which a contact surface has been attached. the biorator is fitted into the tank, into which the combined wastewater, after pretreatment (including equalization) is led. The submersion depth of the biorotor in the tank is 40% of the biorotor diameter. The biorotor rotates slowly, about 1-2 rotations per minute, and a film of sludge containing aerobic microorganisms develop on the contact surface of the biorator. While rotating in the tank the biorator lifts up a quantity of wastewater, causing intensive contact between wastewater, microorganisms and oxygen from the air.

The sludge film absorbs organic matter, which is biodegraded aerobically in the process of substrate utilization by the microorganisms for growth and formation of new cells. The excess sludge is washed off from the contact surface.

The effluent of the biorator tanks is led into a sedimentation tank in which the excess sludge settles. BOD removal efficiency of this system is 90-95%

c. **Facultative Ponds**

The combined wastewater can be led into a facultative pond. Organic matter is biodegraded aerobically in the upper layers of the pond. Oxygen for this process is mainly supplied by algae. Some anaerobic biodegradation of settled Organic material takes place at the bottom of the facultative pond. BOD removal efficiency is 80 - 90% (Pollution Control Volume 3, CEA)

Facultative ponds are usually applied in series of 2 or more ponds. The last pond functions as a polishing or maturation pond, in which micro organisms die off and settle to the bottom.

d. **Mechanically aerated ponds**

An alternative for the facultative pond is a mechanically aerated pond where oxygen for aerobic bio degradation is supplied by mechanical aerators. There are two types of aerated ponds,

(I) Completely mixed aerated pond

(II) Facultative aerated pond

Completely Mixed Aerated Pond System

In the completely mixed aerated pond the contents are completely mixed, and the whole system is aerobic. The effluent from this pond is led into a sedimentation tank or pond in which solids settle into a sludge.

A mechanically aerated pond is usually followed by a maturation pond in which microorganisms die off and settle.

BOD removal efficiency is 80-90% (Pollution Control Volume 3, CEA)

Facultative Aerated Pond System

In a facultative aerated pond only the top layers are kept aerobic by the mechanical aerators. Suspended solids settle to the bottom of the pond, where anaerobic biodegradation takes place.

BOD removal efficiency is 80 -90% (Pollution Control Volume 3, CEA)

Facultative aerated ponds are usually followed by a maturation pond.

2.3 Process theory Involved

2.3.1 Terminology and Definitions

Biochemical Oxygen Demand (BOD)

BOD is usually defined as the amount of oxygen required by bacteria while stablizing decomposable organic matter under aerobic conditions.

Chemical Oxugen Demand (COD)

COD test is widely used, as a means of measuring the pollutional strength of domestic and industrial wastes. During the determination of COD, organic matter is converted to carbon dioxide and water regardless of the biological assimilability of the substances. As a result COD values are greater than BOD. Values and may be much greater when significant amounts of biologically resistant organic matter is present.

The major advantage of the COD test is the short time required for evaluation. the determination can be made in about 3 hour rather than 5 days required for the measurement of BOD.

COD data can often be interpreted in terms of BOD values after sufficient experience has been accumulated to establush reliable correlation factors.

Reactors

Reactor is a vessel in which chemical or biological reactions are taking place. Aeration tanks and anaerobic filters are reactors used in environmental engineering practices.

Oxidation

Oxidation involves the transfer of an electron from a reduced substance termed the electron donor to an oxidizing material termed the electron acceptor.

Generally we think of the electron donor as being the food for the organisms. Organic matter is generally used as food by bacteria and fungi as well as for animals.

However, with some bacteria, reduced inorganic materials such as ammonia, sulphide, molecular hydrogen and ferrous iron may also serve as electron donors, and thus an energy source.

Substrate

substrate is defined as the source of energy. It can be organic or inorganic (eg.ammonia) or even light.

Anaerobic docomposition

Anaerobic docomposition involves the break down of organic wastes to methane and Carbon dioxide in the absense of oxygen.

In the absense of oxugen, other materials such as sulphates and carbon dioxide may bocome electron acceptors.

Sulphate, $S^{+6} + 6e^{-}$ ---- S

Sulphite, $S^{+4} + 4e^{-}$ ---- S

The use of sulphates and carbon dioxide requires strictly anaerobic conditions. In this process oxygen plays a role of nutrient.

Aerobic decomposition (Oxic)

Aerobic decomposition involves the break down of organic substances to carbon dioxide and water, in the presence of molecular oxygen.

In aerobic systems, oxygen is the terminal electron acceptor and is reduced while organic or inorganic electron donors are being oxidized.

Anoxic Condition

Nitrite and Nitrate are used as electron acceptors by facultative organisms living under intermediate conditions referred to as anoxic, which are characterized by end products of Carbon dioxide, water and nitrogen gas.

Nitrate $N^{+5} + 5e^{-}$ ---- N_2

Nitrite $N^{+3} + 3e^{-}$ ---- N_2

Oxygen plays a role of nutrient under anoxic conditions.

Nitrification

Nitrification is a two stage microbiological process by which ammonia is converted first to nitrite and then to nitrate.

Denitrification

Denitrification is the microbiological process by which nitrate is converted to nitrogen and other gaseous end products.

2.3.2 Mathematical Relationships of Decompositon Under Aerobic Conditions

When Organic matter is removed from solution by microorganisms the two basic phenomena occur.

Organics + $(a^1)O_2$ **+ N + P** **cells (a)** **new cells +** Co_2 **+** H_2O

(K)

+ non bio degradable Soluble residue

Cells + $(b^1)O_2$ (b) Co_2 + H_2O + N + **P + Non biodegradable celluar residue**

(K) ----- Rate coefficient (Function of the biodegradability of the organic in the waste water)

(a^1) --- Fraction of the organics removed that is oxidized to end products for energy

(a) ---- Fraction of the organics removed that is synthesized to cell mass

(b) ---- Fraction per day of degradable bio mass oxidized

(b^1) --- Oxygen required

Mathematical Relationship of BOD removal according to Eckenfelder, 1989

Monod relationship

$$-\frac{1}{X}\frac{s}{dt} = \frac{M}{a}\frac{S}{K_s+S}$$

S ---- Substrate Concentration

M_m --- Maximum Specific growth rate of organisms

X_v --- Volatile suspended solids

K_s --- Monod's constant (substrate concentration when rate = 1/2 maximum rate)

a ---- biamass yield coefficient

the kinetics of the oxidation can therefore be expressed as (ref. 7)

$$\frac{S_o - S}{X_v t} \quad \frac{K\ S}{S_o}$$

S_o - Initial subatrate concentration

Oxygen utilization and sludge yield W. Wesley Eckenfelder 1989

As aeration proceeds the degradable portion of the biomass is oxidized, resulting in a decrease in the degradable fraction. Through kinetic and mass balances the degradable fraction can be related to endogenous rate coefficient and the sludge age.

$$X_d = \frac{X^1 d}{1 + b x^1_n \ \theta_c}$$

X_d --- Degradable fraction of the VSS

$X^1 d$ --- Degradable fraction of the VSS at generation

X^1_n --- Nondegradable fraction of the VSS generation

b ----- endogenous rate coefficient (d^{-1})

θ_c ---- sludge age (d)

In a recycle system such as an activated sludge plant, the sludge age is defined as (W. Wesly Eckenfelder, 1989)

$$\theta_c = \frac{X_v t}{\Delta X_v}$$

ΔX_v --- sludge wasted per day (mg/L)

Process performances can also be related to the organic loading to the process as defined by the Food / Microorganism ratio

$$F/M = S_o/X_v t$$

The F/M is related to the sludge age as (W. Wesly Eckenfelder, 1989)

$$1/\theta_c = (aF - bx_d)/M$$

Sludge generation from the biological oxidation can be expressed as (7)

$$\Delta X_v = a\ S_r - bX_d X_v t$$

S_r ---- Soluble substrate removed

In a system with sludge recyle and wastage of excess sludge, sludge age can be defined as W. Wesley Eckenfelder, 1989

$$\theta_c = X_v t\ /\ (\ aS_r - bX_d X_v t)$$

When volatile suspended solids are present in the wastewater, they will contribute to the sludge yield and get,

$$X_v = aS_r + a_x(1-f)x_i - bX_dX_vt + fX_i$$

X_i ---- Influent volatile suspended solids

f ---- fraction not degraded

a_x ---- g VSS produced / f VSS removed

Total oxygen requirements in a system are related to the oxygen consumed to supply energy for synthesis and the oxygen consumed for endogenous respiration.

$$r_r = a^1s_r + b^1X_dX_vt$$

r_r ---- Oxygen uptake rate (mg/L) per hour

Several mineral elements are essential for the metabolism of organic matter by microorganisms, as W Wesley Eckendfelder 1989.

$$N = 0.123\ X_d\ \ X_v/0.8 + 0.07\ \ (0.8 - X_d)\ \ X_v/0.8$$

$$P = 0.026\ X_d\ \ X_v/0.8 + 0.01\ \ (0.8 - X_d)\ \ X_v/0.8$$

N ..... Nitrogen   P .... Phosphorous

Effect of temperature as W. Wesley Eckenfelder(1989)

Variations in temperature affect all biological processes. there are 3 temperature regimes.

Table 2.2 **Temperature effect on bacterial activity**

Type	Range (°C)
Mesophilic	4 - 39
Thermophilic	55
Psychrophilic	Below 4

Over a temperature range of 4°C - 31°C, the K rate is corrected as

$$K_T = K_{20}\ \Theta^{(T-20)}$$

Effect of pH

For most biological processes this covers a range of 5 to 9 with optimum rates occuring over the range 6.5 to 8.5

Toxicity

Toxicity in biological oxidation systems may be due to one of several causes.

1. An organic substances such as phenol which is toxic in high concentrations but biodegradable in low concentrations.

2. Substances such as heavy metals, which have a toxic threshold depending on the operating conditions.

3. Inorganic salts and ammonia which exhibit a retardation at high concentrations.

Sludge Volume Index (SVI) As W. Wesley Eckenfelder 1989

The volume of settled sludge after 30 minutes Sedimentation is a base for calculating a sludge Volume Index (ml/g)

$$SVI = 1000\ V_{30}/X$$

Where X is Mixed Liquer Suspended Solids

Sludge Age as Eckenfelder Wesley (1989)

Sludge Age = XD/S_o

Where D is detention time in days

S_o is concentration of solids entering into aeration system

Role of microorganisms in aeration system as Eckenfelder Wesley 1989

Bacteria in the aeration system use organic matter (Heterotrophs) for food and reproduction. In turn new bacterial growth is consumed by protozoa (Uni cellular) and Rotifers (Multi Cellular).

The increased bacterial growth results accelerated extraction of wastes from solution, improved flocculation characteristic in the activated sludge system and a biological floc with improved settling characteristic as shown in figure 2.1 and figure 2.2.

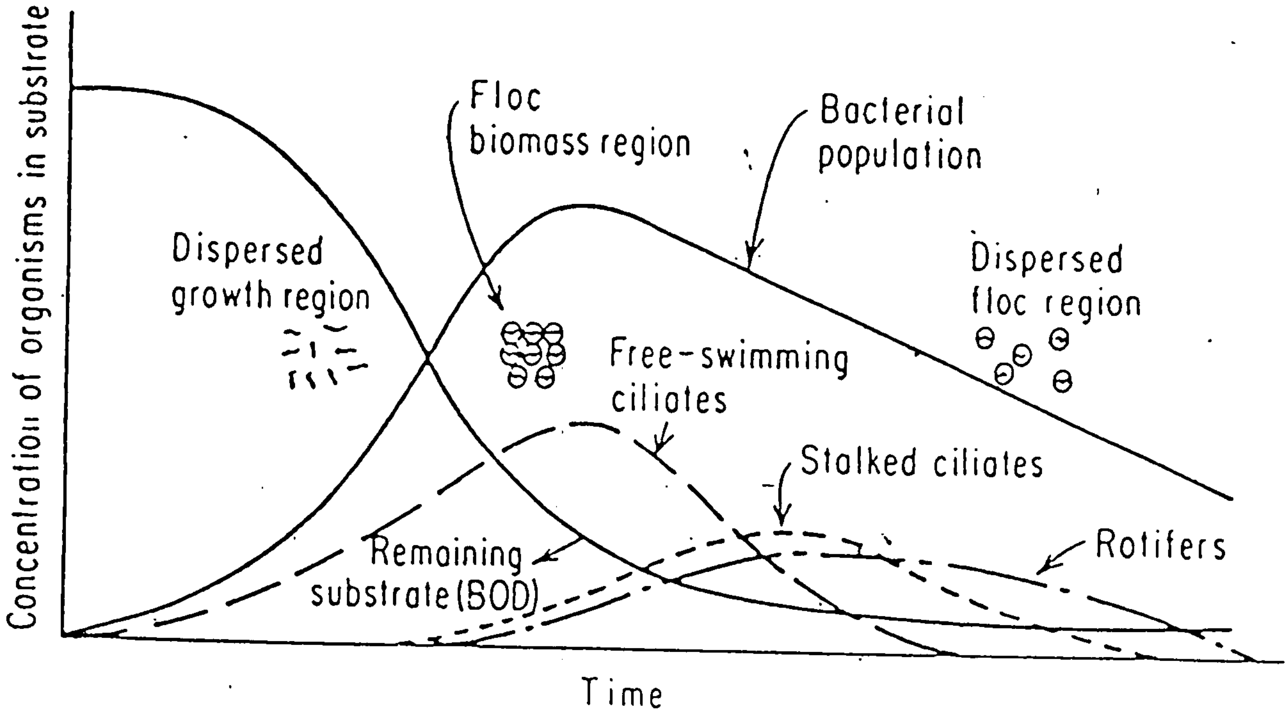

Figure 2.1 Phases of microorganism development.

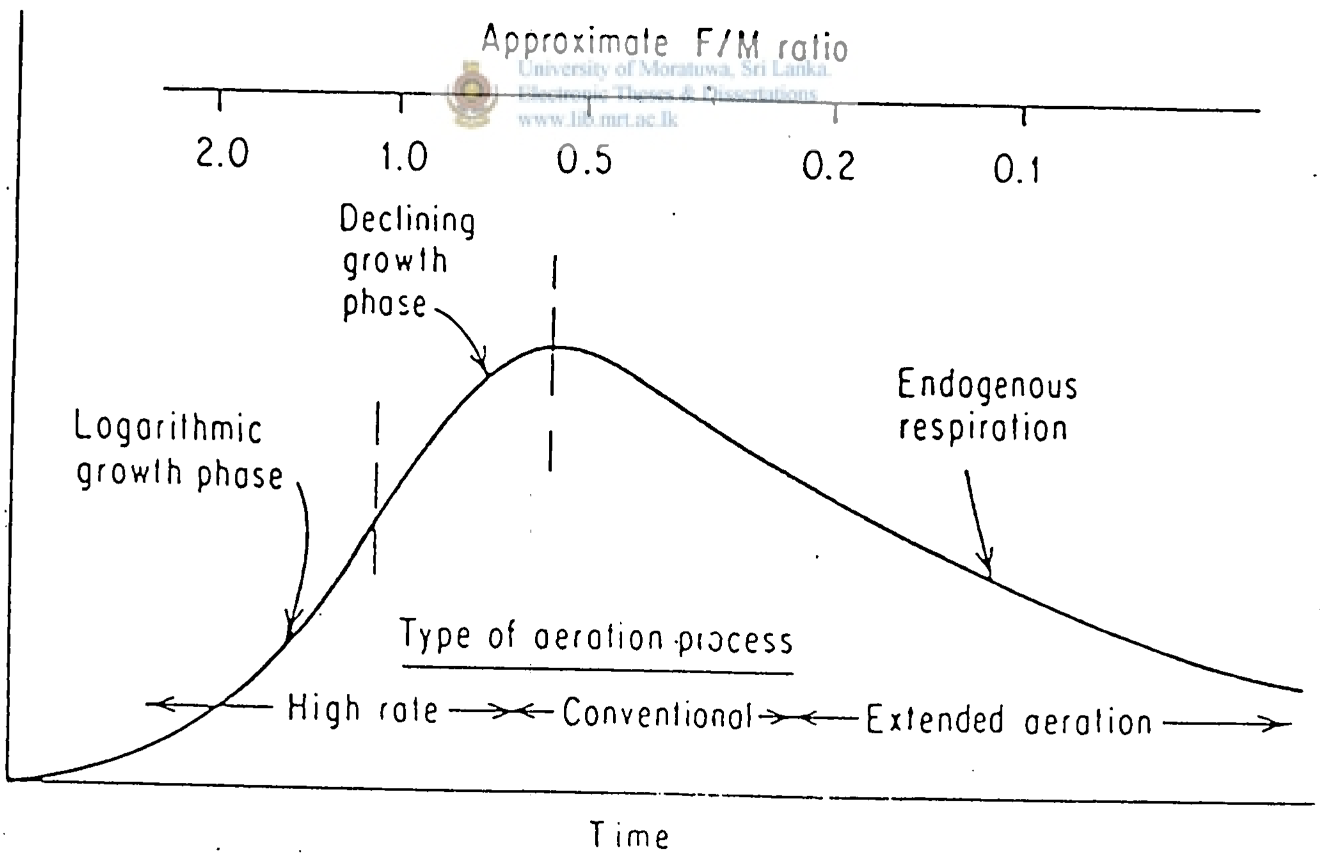

Figure 2.2 Relationship of bacterial growth phase to food supply in an aerated system.

An examination of the characteristics of the specific waste water to be treated can provide valuable information for screening the suitability of anaerobic treatment technology, the type of anaerobic process to be selected and perhaps the need for pretreatment of the waste water.

Anaerobic process is widely used as Andrew John (1971) for the treatment of industrial wastes which contain high concentrations of organic materials. The process has several significant advantages such as low production of sludge, low power requirements, formation of a useful product, methane gas which is a form a energy that is easily stored and transported.

Since the concentration of coconut water is approximately 40000 mg/l, It has to be treated anaerobically followed by aerobic treatment and the configuration of anaerobic reactor is selected based on economic and other related factors.

For the treatment of coconut water, a fixed bed type pilot plant was selected since no pumping is required and media is Freely available.

Advantages and Disadvantages of Fixed Bed Anaerobic Processes

ADVANTAGES

- High biomass concentrations and long SRTs achievable
- Smaller reactor volumes due to high organic loading rates
- relatively stable operation under variable feed conditions or toxic shocks
- Suitable for wastes with low suspended solids concentrations
- No mechanical mixing required
- Biogas evolution and effluent recycle insure relatively uniform temperature, pH, and substrate concentrations in reactor
- Land area required is relatively small

DISADVANTAGES

- Suspended solids accumulation may negatively impact reactor hydraulics and internal mass transfer characteristics
- Not suitable for high suspended solids wastewaters
- Provision may be required for periodic biomass removal
- Limited access to reactor HRT results in reduced equalization capacity for shock inputs
- Relatively short anaerobic reactor HRT results in reduced equalization capacity for shock inputs
- Costs of packing material and support systems are high

CHAPTER 3

EXPERIMENTAL PROCEDURE

3.1 General

In working with wastewater containing organic matter of an undefined nature, bench testing followed by pilot palnt testing is absolutely essential for obtaining data needed to design the biological treatment system.

Before this work can commence, the waste water flow must be studied over a sufficient period of time to indicate the variations that can be expected in composition and temperature so that provisions can be made for equalization, which is usually required.

A sampling system should then be installed to withdraw a sample of the wastewater flow at regular intervals, deliver it to a miniature equalization basin, and produce a composite sample of wastewater that is representative of the total flow and can be drawn as at any time for the bench studies.

A water analysis must then be run on the composite sample to determine the mineral analysis and also organic material as determined by BOD, COD and TOC. The Mineral analysis must include the determination of total Nitrogen and Phosphorous to determine whether there is a need for nutrient addition. Once this has been done a miniature biological digestion system is set up to operate on a batch basis.

Since Anaerobic systems are usually confined to strong organic wastes (with very high BOD Values), for the treatment of Coconut Water, a suitable Anaerobic treatment process is recommended followed by Aerobic treatment process in order to achieve designated water quality standards.

The following assumptions were ensured before begining of any experimental works.

1. There is no toxic elements in the waste
2. There is no big floating particle or coarse particle in the waste eg. wood, stone etc.
3. Oil trap is working properly upto its standards
4. Domestic waste water/sewage is not mixed with coconut waste water.
5. Nitrogen and Phosphorus are present in sufficient amount with other nutrients to assist biological growth.
6. There is no much more significant flow variations in influent. (50000 nuts/day)

Also and

I. All chemical analysis to be carried out as specified in standard methods for the examination of water and waste water (16th Edition)

II. Coconut water were collected from the Bandarawatta Desiccated Coconut Mill, Gampaha.

III. Variables pertaiching to Aerobic and Anaerobic treatment processes were evaluated, under pilot plant study

IV. Equalization followed by biological treatment, processes the purpose of equalization are

1. To provide adequate pH control

2. To provide adequate dampening of arganic fluctuations in order to prevent shock loading of biological system.

3. To provide continuous feed to biological system over periods when the desiccated coconut mill is not operating. (10 hrs production per day)

4. To prevent high concentrations of toxic materials from entering the biological treatment plant.

3.2 Laboratory and pilot plant procedure for the development of process design criteria.

Laboratory and pilot plant procedure involves process evaluation and to produce engineering design data for a project of wastewater treatment process, including solids handling, and disposal processes.

Effluent Criteria

Designing of waste water treatment plant is to meet effluent standards set up by the state regulatory agencies from time to time.

CHAPTER 04

RESULTS

4.1 Coconut Water Characteristics

Table 4.1 Average characteristics of Coconut water before oil is removed at oil trap.

Parameter	Average concentration
pH	4.8
Chemical oxygen Demand (mg/L)	40000
Chemical oxygen Demand (oil removed) (mg/L)	28000
Suspended solids (mg/L)	760
Total Nitrogen (mg/L)	230
Total Phosphorous (mg/L)	36
Oil (mg/L)	2000
Temperature (^0C)	29.6
COD : N : P	780 : 6 : 1

Table 4.2 Pilot Plant performances and effluent Quality during fixed bed Anaerobic Treatment of Coconut Water

Mixed Liquer suspended solids (mg/L)	COD (mg/L)	Sampling Time (d)	Removals %
450	28000	Start up	-
	21300	0.5	24
980	14000	1.0	50
	11200	1.5	60
1300	9600	2.0	66
	8200	2.5	70
1330	7600	3.0	73
	7300	3.5	74
1400	7000	4.0	75

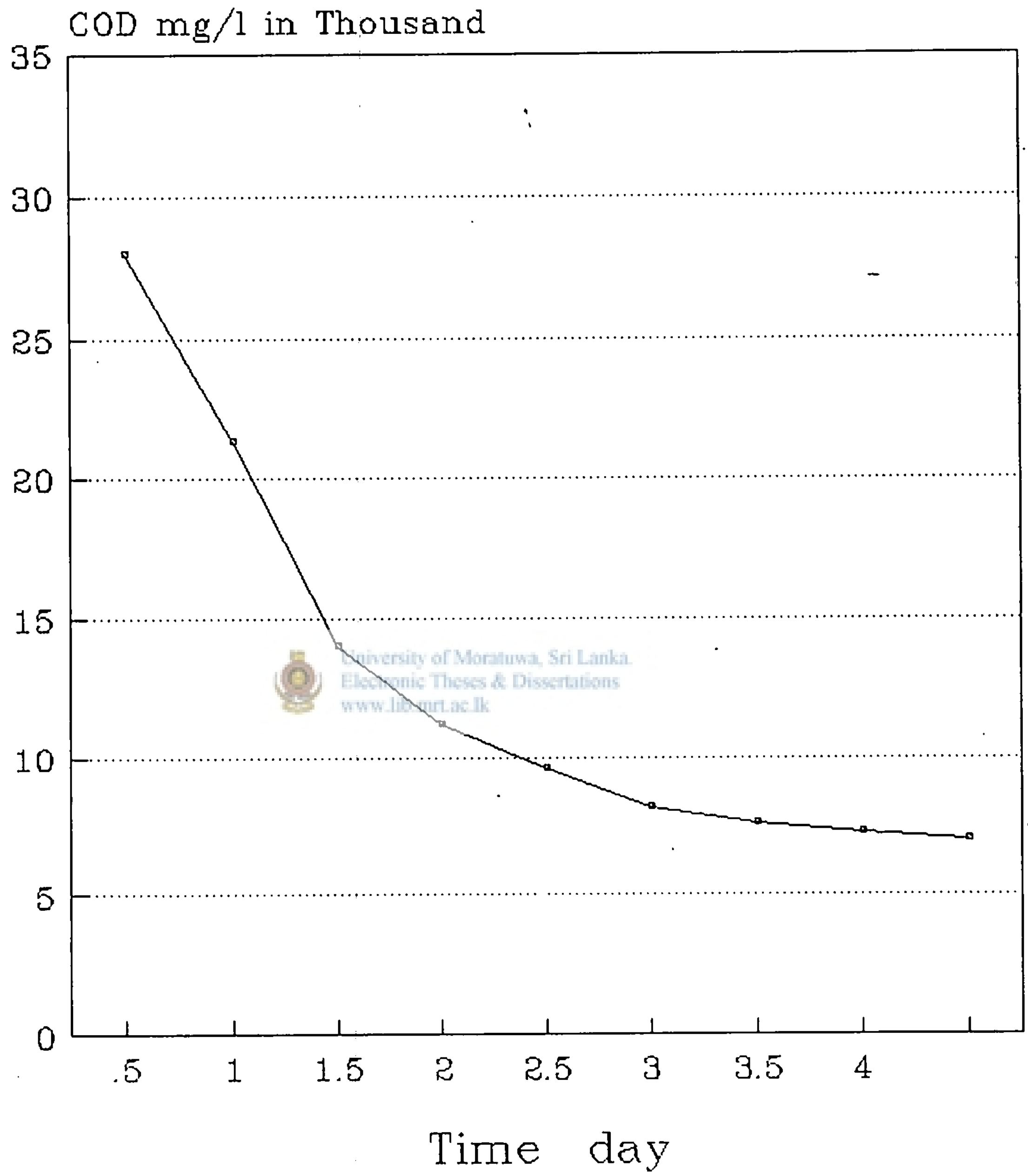

Fig 4.1 COD Variation with time

Reactor was fed with coconut water just after oil is removed and COD was determind as 28,000 mg/L

COD loading (kg COD/m^3d)	14	9.3	7
Hydraulic Retention time (d)	2	3	4
COD Removal (%)	65	72	75
Effluent COD (mg/L)	9600	7600	7000
Effluent MLSS(mg/L)	1300	1330	1400

Table 4.3 : Results at different loading rates.

Following Paramenters were maintained as such during the study.

Temperature 29 ^{0}C
pH 7.2
Alkalinity (Bicarbonate) (mg/L) 2600

Alkalinity was maintained at above level by adding of Sodium Bicarbonate to waste water.

A graph was plotted (figure 4.1) and in keepipng with above results, Hudraulic Retention Time (HRT) was selected as 3 days.

Table 4.4 Average Characteristic of Partially treated (Anaerobic Process) Coconut Water after 1:6 dilution

Parameter	Average Concentration
pH	7.2
Temperature (^oC)	28.
COD (mg/L)	1200.
Suspended Solids (mg/L)	220.
Total Nitrogen (mg/L)	34.
Total Phosphorous (mg/L)	11.

Partially treated (Anaerobically) waste water was mixed with other waste waters as such to obtain 1:6 dilution ratio.

After mixing of partially treated waste water with other water, it was treated under Aerobic Process and performances were recorded.

Bench Scale study for Aerobic treatment process

Table 4.5 variation of COD with time

Time (hrs)	COD (mg/L)
08	330
10	315
15	310
20	270
24	240

Following parameters were maintained during above study

Miled Liquor volatile Suspended Solids	(MLSS)	- 1500 mg/L
Dissolved Oxygen	(DO)	- 1.5 mg/L
COD : N : P		- 98 : 3 : 1

Table 4.6 Data developed from bench scale study

F/M, (d^{-1})	MLVSS, mg/l X_v	COD in (mg/l) so	COD out (mg/l) se
0.75	1600	1200	240
0.9	1450	1200	270
1.2	1550	1200	310
1.9	1460	1200	315
2.4	1500	1200	330

Average temperature 29 °C

4.2 Anaerobic treatment Pilot Plant Study

The reactor was a plastic cylindrical bucket and coconut water was fed to the reactor from the top and removed by a valve at the bottom.

The reactor was packed with 600 rubber bushes that were installed so as to create a void area. Each rubber bush of having dimensions of 4cm x 3cm (diameter).

Approximate surface area provided by bushes = 0.45 m^2
The total empty bed reactor volume = 0.027 m^3 (27 lit)
Initial surface to volume ratio = 17 m^2/m^3
Prior to start up, the initial void volume
with the packing in place was = 4 Litres

The fixed film reactor was put into operation in April 1996 by seeding with cowdang and coconut water. Start up period was one week and observed emission of gases at the top of the reactor. Coconut water which has undergone oil removal process in the oil trap was fed into the reactor. This procedure was repeated for 4 times.

Following parametere were evaluated and controlled to required level taking necessary steps throughout the anaerabic process being operated to ensure a high rate of methane production.

pH

Alkalinity (Bicarbonate)

Temperature

Coconut water was analyzed for COD before being fed to the reactor and then was subjected to anaerobic decomposition and samplings were carried out at various time intervals and results were recorded to select levels of the following parameters.

- Hydrautic Retention Time (HRT)

- Volumetric organic loading rate (B_v)

The variation of COD removal was studied with varying organic loading rate, in order to select suitable design criteria

For Anaerobic process design purposes, it is best to determine the potential anaerobic treatment efficiency by direct biodegradability testing in batch or continuous flow reactors.

However, for the initial screening of treatment process alternatives for wastewater that are primarily soluble, it is reasonable to assume the following hypothetical anaerobic treatment performances as Malina Joseph F (1992) .

Treatment parameter	Typical Value
BOD removal %	80 90%
COD removal (mg/L)	1.5xBOD removed
Biogas production	0.5m^3/kg COD removed
Methane production	0.35m^3/kg COD removed
Sludge production	0.05-0.10kg VSS/Kg COD removed

Table 4.7

Coconut water characteristic after oil trap and equalisation followed by neutralisation as industrial pollution control volume 3, CEA.

- Wastewater flow rate to the reactor (Assuming 50000/nuts are processed per day) - $10m^3/d$

- Biodegradable COD Concentration of wastewater (assuming 80% is biodegrable) - 22400 mg/L

- pH 6.7 - 7.3

- Oil 100 mg/L

- Total Nitrogen 200 mg/L

4.3 Aerobic Treatment Bench Scale Study

A Bench scale Aeration chamber consisting of a five gallon container with an aeration device, such as an aquarium aerator obtained from a pet supply store was used, as recommended in Nalco Handbook 1989.

Feeding waste to the aeration vessel was on a batch basis since non availability of a laboratory pump. Aeration Volume was 15 litres of wastewater consisting of 10 liters of partially treated waste water with 5 litres of sludge obtained from outside.
Feed Portion volume was 800 ml

Sludge Acclimatization as Nalco Handbook 1989

The sludge was acclimatised to the anarobicaly treated Coconut water followed by 1:6 dilution. Acclimatisation were carried out when a sample of 1000 ml withdrew from the aeration vessel and settled for 30 minutes in a 1000 ml Cylinder to recored settled sludge, followed by dacanting and discarding of 800 ml of wastewater and refill cylinder to 1000 ml with fresh waste and returning to aeration vessel.

Sludge build up was accomplished by increasing the feed rate after the period of sludge acclimatization.

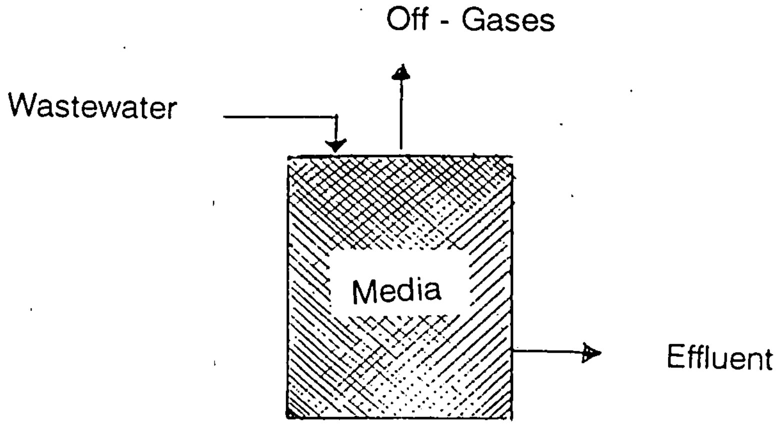

Fig 4.2 Fixed Bed Type anaerobic Pilot Plant

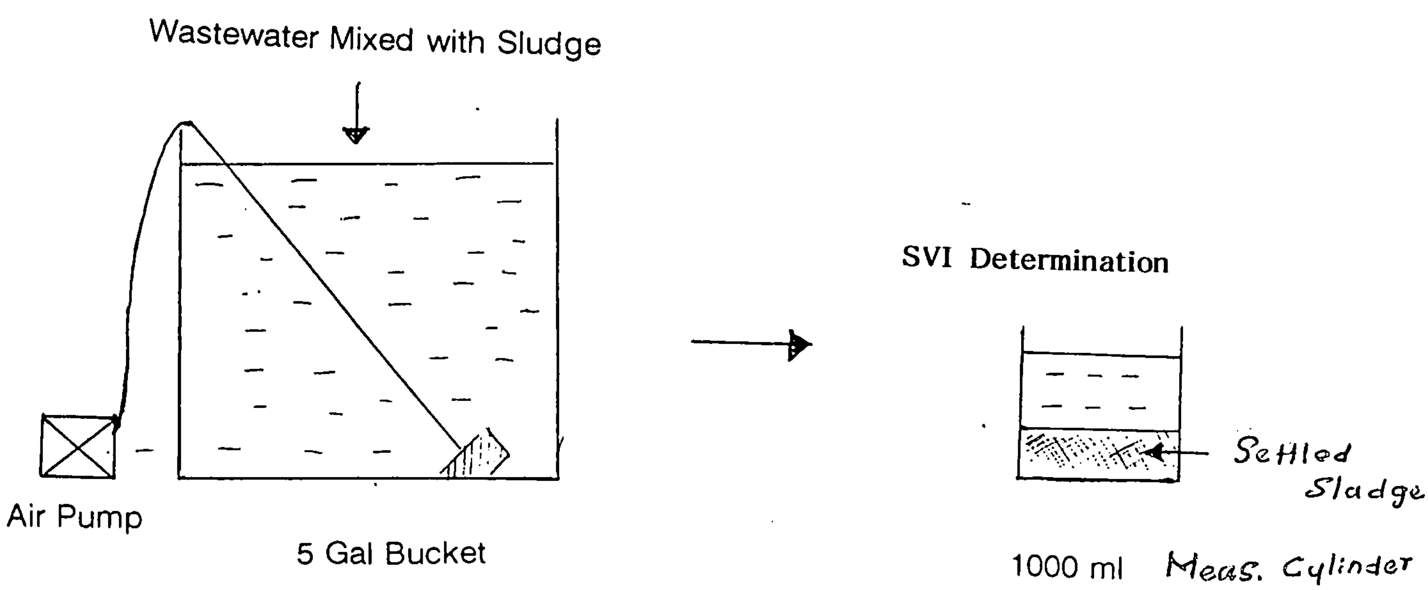

Fig 4.3 Equipment for Aerobic Bench scale Study

This procedure was repeated until the sludge volume index (SVI) is reached 100 ml/g and performances were recorded in terms of

- Food to Microorganisms ratio (F/M) (D^{-1})
- Mixed liquor volatile suspended solids (MLVSS) (ms/L)
- Chemical Oxygen Demand (COD) (ms/L)
- Removal Efficiency of COD
- Hydralic Retention Time (d)
- COD : N : P
- Temperature

Monitoring the aerator performances

Following parameters were evaluated and maintained to required level taking appropriate steps to ensure a high degree of agglomeration.

pH

Dissolved Oxygen

Microscopic examination

This bench scale study was repeated for several times with a view to obtain more reliable performances.

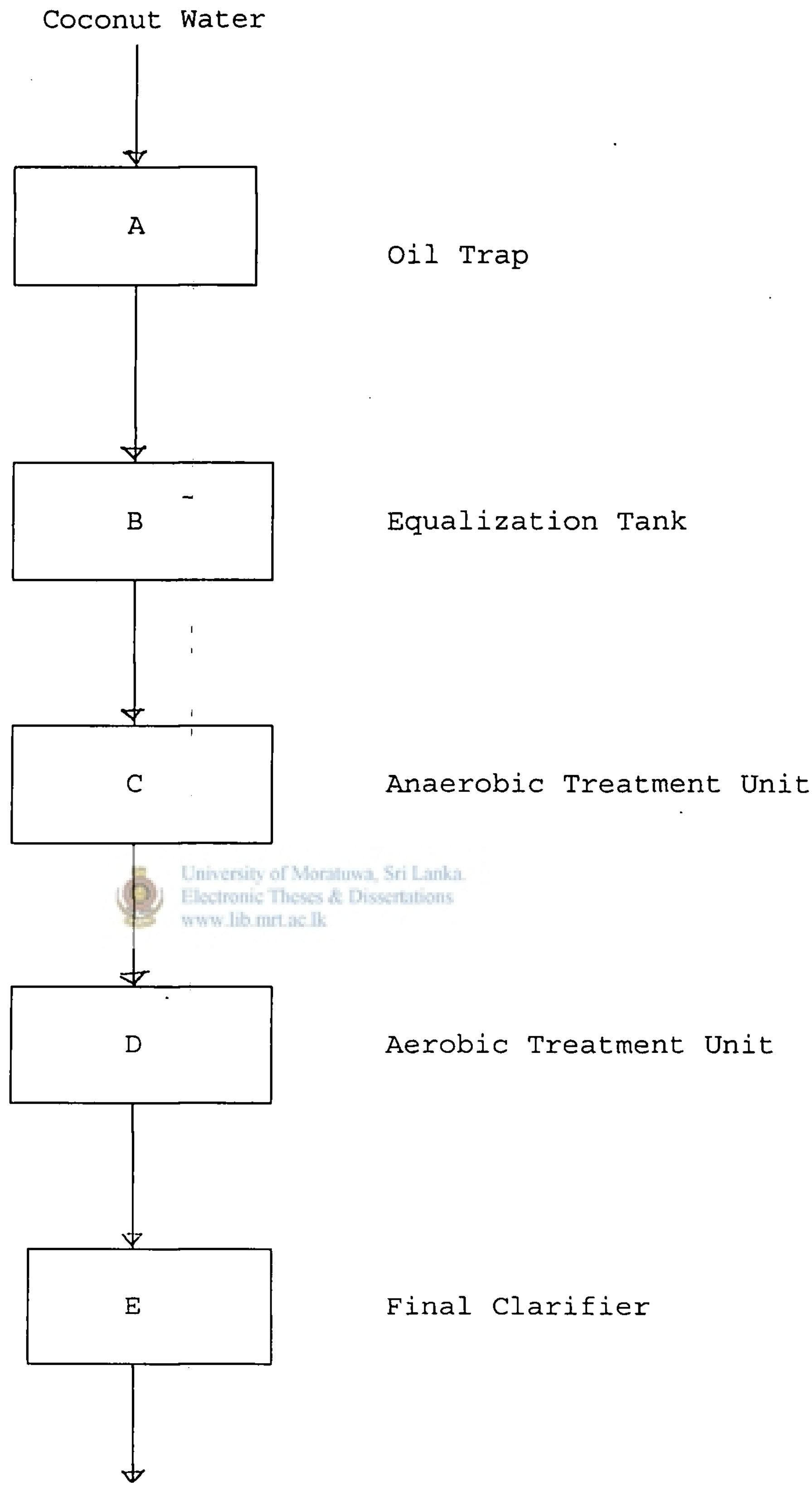

Figure 4.4 Proposed Waste Water Treatment Process Flow Diagram

4.4 Anaerobic treatment Unit

When it has been decided to apply anaerobic treatment process sizing the system so that reliable performances can be delivered at minimal capital and operating cost will be the major task in designing part.

Selecting a design volumetric organic loading rate (B_v) can be done using results obtained from the pilot plant studies for anaerobic reactor.

Computation for Anaerobic reactor Volume

Volumetric organic loading rate is (B_v) is calculated as Joseph F Malina (1992)

$$B_v = C_i . Q / V \quad \text{- Equation 1}$$

B_v is the volumetric organic loading rate (kg COD/m^3d)

C_i is the untreated wastewater biodegradable COD concentration (kg COD/m^3)

Q is the wastewater flow rate (m^3/D)

V is the bioreactor Volume (m^3)

From the results of Anaerobic treatment process, hydarlic retention time to achieve 72% removal of COD is 3 days.

Hence, Volumetric Organic loading rate (B_v) for the pilot plant is

$$\frac{28000 \times 1000}{1000 \times 1000 \times 4} = 9.3 \text{ kg COD/m}^3\text{d}$$

for the full scale unit,

Wastewater flow rate (Q) = 10 m^3/d

Biodegradable COD concentration (C_i) = 22.4 kg/m^3 (Assuming 80%Biodegradable)

Substituting above values in the equation 1, we get

Volume of the Reactor (V) = 24 m^3

Using a factor of safety of 1.5,

Volume of reactor = 1.5x24 = 36 m^3

4.5 Aerobic Treatment Unit

Evaluation of Reaction Rate Coefficient under Aerobic Treatment Process as Eckenfelder Wesley (1989)

The data obtained can be correlated as shown in Fig. 4.4 and the rate coefficient determined from this plot. Notations as defined in chapter 2.3.2

Se	$So\ (So - Se)/x_v t$
240	720
270	962
310	1148
315	1818
330	2320

Table 4.4

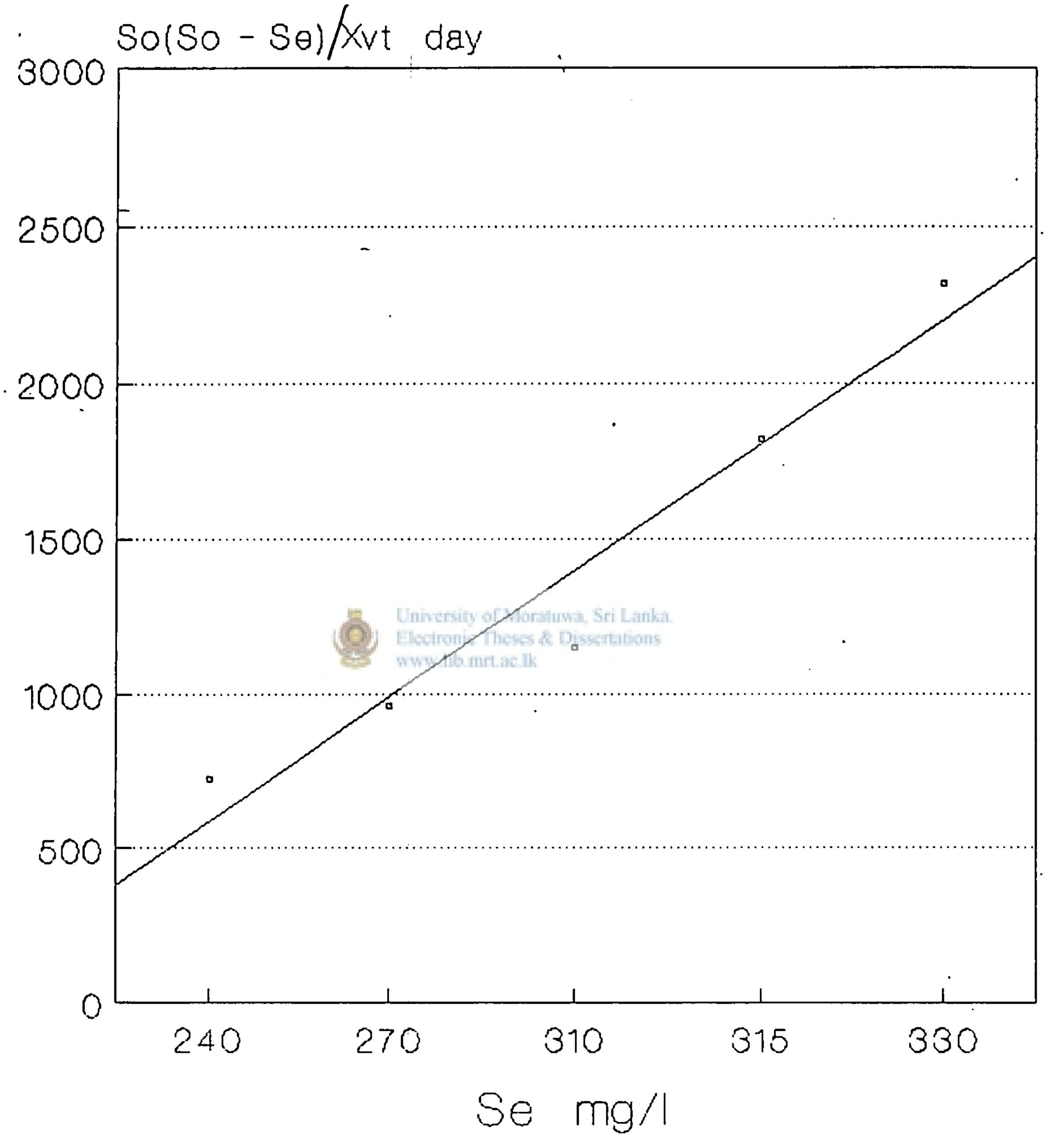

Fig 4.5 Tanθ = So(So-Se)/XvtSe K = Tan θ = 12d^{-1}

Aeration Tank (Reactor) Design

Based on Bench Scale study following parameters used to size aeration tank.

Average flow rate	=	70000 l/d
Chemical Oxygen Demand COD (Inlet)	=	1200 mg/L
Chemical Oxygen Demand COD (Outlet)	=	330 mg/L
Hydarulic Retention Time (HRT)	=	8 Hrs
Hence required aeration volume	=	24 m^3

Considering factor of safety and, Return flow from the clarifier, aeration volume is proposed to 30 m^3

Factors such as Solid Retention Time, Sludge wasted, Return Sludge Rate, Sludge Age are to be considered when evaluation Aeration tank volume.

However, such factors, can be well determined and set for operation after commissioning the plant.

CHAPTER 5
DISCUSSION

5.1 Discussion of Results

5.1.1 Results of Anaerobic Teatment Process Pilot Plant Study

During the pilot plant study the performances of Anaerobic reactor (Fixed bed) was determined as 3 days considering following factors.

1. Least time taken to reach its peak level of COD removal %

2. Minimum Anaerobic reactor volume

During the study, it was possibe to maintain pH and Alkalinity (Bicarbonate) to desirable standards. Caution was taken to apply Sodium bicarbonate for raise pH during the study since excess application of lime will result in precipitation of calcium carbonate.

However, temperature was at 29^0C and anaerobic (Mesophilic) processes will effectively funciton at the temperature range of 29^0 to 38^0C.

Gas production was not taken into account since non availability of a gas flow measuring device.

Nutrients ratio i.e. COD : N : P was computed at the beginning of the trial and was found that it is keeping with the required level.

sludge Retention time (SRT) was not determined due to time constraints. However, it should essentially be greater than HRT so as to prevent suspended biomass wash out.

With long running of trial, sludge has to be returned to the reactor and therefore, obtaining a more realistic value for the Hydraulic Retention Time (HRT) is possible.

5.1.2 **Results of Aerobic Process**

During aerobic bench scale study, following parameters were determined with respect to time, in order to obtain a suitable Hydraulic Retention time in the Aerobic treatment process, along with maintaining addition to keeping control parameters (as D.O) to the required levels.

1. Chemical Oxygen Demand
2. Mixed liquor Volatile suspended Solids.
3. Sludge volume Index (SVI)

According to the results obtained in bench scale study Hydraulic Retention Time (HRT) was determined as 08 hours and along with a High Retention time, following factors will increase,

1. Cost factor for construction, operations and Maintenance.

2. Required-Land Space for treatment facility

3. Aeration tank Volume

4. Oxygen required to maintain desired level of Dissolved Oxygen

5. Required Energy to run motors and aerators

However, according to the bench scale study, F/M ratio obtained was at a level of $2.4d^{-1}$.

According to the Microscopic analysis carried out at 8 hrs time, it was observed that Protozoan Population were active and fairly high.

Rate Coefficient (K)

Rate Coefficient (K) was computed using the graph at Fig 4.5

Aeration tank volume was determined as 30 m^3, using Hydraulic Retention time and Chemical Oxygen Demand removals. However, following parameters are important to determine the volume of aeration tank. (V_a) W Wesley (1989)

Solids Retention Time (SRT) - θ

Waste Water flow (exclusive of return sludge) - Q_a

Total BOD to aeration, - C_i

Solids Yield - Y

Mixed Liquor Suspended Solids - X_a

$$V_a = \theta Q_a C_i Y / X_a$$

5.2 Operations and Maintenance of the Plant

The primary aim of waste treatment plant operation is the maintenance and running of the plant efficiently and economically, so that the effluents from the plant meets the regulatory standards and could be discharged safety on land or into water bodies.

Following basic requirements are needed for successful operation and maintenance of the plant.

1. A through knowledge of the processes and equipments

2. Proper and adequate tools

3. Adequate stock of spare parts and chemicals

4. Assignment of specific maintenance responsibilities to operating staff.

5. Training of all operating staff in proper operating procedures and maintenance practices.

6. Good house keeping

Process Control

Process control is a key factor in better plant operations. Following variables have to be maintained at set points and monitoring of them are required at pre determined time intervals.

Wastewater flow rate into units

Treated waste water flow rate

Return Activated sludge flow rates

Waste flow rates

Temperature and pH values at different units

Aerator performances

Quality Control

Quality control is also essential to maintain required water quality at different treatment units. A well equipped laboratory with qualified staff is needed to analyzed water and sludge characteristics growth and activation of Microorganisms.

Better plant operation is possible only when the operator is fully conversant with the characteristics and composition of waste handled and results achieved during each stage or unit of the treatment process.

Preventive maintenance for flow measuring devices, meters, pumps, valves, Aerators is to be adopted all the times to achieve design targets of the plant.

Also, preventive maintenance of several treatment units and frequency of cleaning, lubrication of mechanical equipment etc are to be strictly adhered to if optimum results are to be expected.

5.3 Economic Evaluation of the proposed plant

This design study has been concerned with the treatment of wastewater generate in the production of Desiccated coconut to standards set by regulatory bodies, is not a limiting factor and design of the necessary treatment units have not been completed. However, in the final analysis, the proposed design can only be acceptable if the process is economically viable.

Topography of the site plays an important role in the operation of plant. Generally to minimize the pumping cost the level of the ground should be sloping from the primary treatment units such as Oil trap, Neutralization tank etc. The drying beds get the sludge from the Anaerobic treatment unit as well Sedimentation tank. Hence location should be well suited so that long conveyance of sludge is avoided.

Construction of Aeration tank and final clarifier to operate as unit should also be considered in order to economise the process.

It is common practice to express the total operating cost in terms of the raw material, direct Labour, energy and fixed capital costs.

Fixed capital is the total cost of the plant ready for start up. It is the cost paid to the contractors. It includes the cost of,

1. Design and other engineering and construction Supervision

2. All items of equipment and their installation

3. All piping, instrumentation and control systems.

4. Treatment units

5. Land and civil engineering work, Labour.

Calculation of Annual benefits

For this design project, it was assumed that 50,000 nuts are used per day for the production of Desiccated coconut.

According to the Coconut Conversion factor, (coconut statistics, CDA 1990) 6800 nuts equivalent to 1 M.T. of Desiccated Coconut, and hence amount of Desiccated coconut production is approximately 7 M.T./day.

According to Coconut Development Authority Sources,

85% of operating cost for raw materials
5% of operating cost for power
5% of operating cost for Labour
5% of operating cost for Overheads

For a wastewater treatment plant

Annual Cost for power	(P)	=	0.3 m
Annual Cost for Labour	(L)	=	0.1 m
Annual Cost for Overheads	(O)	=	0.1 m
:. Total Cost		=	0.5 m

Selling price of 1 M.T. of

Desiccated coconut = Rs 74200

For 7 M.T. of Desiccated Coconut it is Rs 519400

:. Annual benefit from selling of Desiccated Coconut= Rs 162 m (Source, CDA)

If a Court Case is filed under the National Environmental Act, court ruling will be to construct a waste water treatment plant within 3 months period & may probably be shut down until the treatment plant is commissioned.

Annual benefit from the Wastewater Treatment Plant= 3m (Source, CEA)

Considering above annual benefit for a Desiccated Industry is approximately Rs. 165 Million.

Calculation of annual cost

Row material cost	=	Rs 62.4 m (for 50,000 nuts/day)	
Power (P)	=	3.9 m + 0.3 m	= 4.2 m
Labour (L)	=	3.9 m + 0.1 m	= 4.0 m
Overheads (O)	=	3.9 m + 0.1 m	= 4.0 m
Total Cost	=	Rs. 12.2 million	

Required initial investment (CEA)

For Desiccated Coconut mill = Rs. 60 m

For wastewater Treatments Plant = Rs. 2 m

Since industrialist is eligible to obtain a soft loan under pollution abatement fund.

N = 10 i = 4% .: (A/P,i,n) = 0.12329

Equivalent annual cost = (initial investment) (A/P,i,n)

+ other annual cost. (O+P+R)

=

:. **Equivalent Annual cost** =

= (62) (0.12329) + 12.2

= 7.64 + 12.2 = 19.8m

Therefore proposed project is economically viable and environmentally sound.

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS.

6.1. Conclusions.

The proposed treatment plant consist of a number of processing units and the important part of the design has been essentially the determination of the size of the various units in order to achieve design performances.

According to the pilot plant study carried out for anaerobic treatment of coconut water in a fixed bed type reactor, 72% removal of COD has been recorded in three days of hydraulic retention time.

According to the aerobic treatment bench scale study carried out for partially treated coconut water, it was observed that, organic load could be brought down to an acceptable value in eight hours Hydraulic retention time. It has been proposed in industrial pollution control guidelines for desiccated coconut industry. prepared by the Central Environmental Authority, to relax Chemical Oxygen Demand of final treated effluent to 300 mg/l.

It should not be thought that the work outlined in report covers all the functions of environmental engineer, or that sufficient detailed information has been evaluated and given for the plant to be built. If the plant was being erected detailed placing of units would have to be considered and the necessary schedules of pipes, electrical fittings, vales, liquid flow meters prepared.

In conclusion it should be stated that the following design features should essentially be included in the final form of the design.

1. Fixed bed type anaerobic reactor having a minimum three days hydraulic retention time for a waste water flow at a rate of $10m^3$/day.

2. organic lording rate should be controlled to a level of 9.3 kg COD/m^3day.

3. An aeration tank having a minimum eight hours or more hydraulic retention time for waste water flow at a rate of 70 m^3/day.

4.F/M ratio should be maintain in a range of 1.0- 2.0 D-1

6.2 Recommendations for further study

The following issues were not well addressed during this attempt and recommended for further study.

1. Amounts of oxygen and nutrients required, and the quantity of biological sludge they produce.
2. Coefficients related to biodegradation. A full scale study should be carried out to ascertain the coefficients of a, a^1, b and b^1.
3. Presence of Filamentous microorganisms which lead to bulking in Aerobic treatment process. As well as Anaerobic treatment process. However, in Aerobic process the effect of Filamentous bulking may reduce due to mixing of partially treated wastewater with chlorinated water to make 1:6 dilution ratio.
4. Specific microorganisms involve in biodegradation of Coconut water should be identified and cultured.
5. Sludge handling and its fertilizer value
6. A mathematical model of dynamic type should be developed.
7. Using Methane as a fuel and supplying of heat for Anaerobic treatment process to obtain better performances.

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6. ஆண்டின் போது மத்திய சூழல் அதிகார சபைக்குச் சமர்ப்பிக்கப்பட்ட கண்காணிப்பு அறிக்கைகள் பற்றிய விபரங்கள் :

7. வேறேதேனும் மேலதிகத் தகவல் :

இவ்விண்ணப்பத்தில் என்னால் கொடுக்கப்பட்ட விபரங்கள் உண்மையானவையும், செம்மையானவையும் என இத்தால் சான்றுபடுத்துகிறேன். இதனகத்துள்ள எவையேனும் விபரங்கள் பொய்யானவையாக அல்லது செம்மையற்றவையாகக் காணப்படின் எனது விண்ணப்பம் மறுக்கப்படும் என்பதுடன், உரிமம் வழங்கப்பட்டிருந்தால் அது இல்லாதாக்கப்படும் என்பதையும் நான் அறிவேன்.

விண்ணப்பதாரியின் ஒப்பம்

தேதி :————

அலுவலக பயன்பாட்டுக்கு மட்டும்

1. உரிமம் புதுப்பிக்கப்பட்டதா : ஆம் /இல்லை.

2. புதுப்பிக்கப்பட்டால் :
   உரிம இலக்கம் :
   உரிமத் தேதி :
   செல்லுபடிக்காலப் பகுதி :
   காலாவதியாகும் தேதி :

இணைக்கப்பட்ட நிபந்தனைகள் (எவையேனுமிருப்பின்)

3. உரிமத்தைப் புதுப்பித்தல் மறுக்கப்பட்டால், மறுத்தமைக்கான காரணம் :

அதிகாரமளிக்கப்பட்ட அலுவலரின் ஒப்பமும், பதவிப் பெயரும்

தேதி :————.

அட்டவணை III

உரிமமளித்தல் கட்டணம்

சூழற் பாதுகாப்பு உரிமம் வழங்கப்படுவதற்கான ஒவ்வொரு விண்ணப்பம் தொடர்பிலும் ரூபா 750 கட்டணம் ஒன்று அறவிடப்படும்.

புதுப்பித்தல் கட்டணம்

உரிமத்தைப் புதுப்பிப்பதற்கான ஒவ்வொரு விண்ணப்பம் தொடர்பிலும் 750 ரூபா கட்டணம் அறவிடப்படும்.

1 - 503

PART I : SECTION (I) – GENERAL

Government Notification

NATIONAL ENVIRONMENTAL ACT, No. 47 OF 1980

REGULATIONS made by the President under section 32 of the National Environmental Act, No. 47 of 1980, as amended by Act No. 5[6] of 1988, read with Article 44(2) of the Constitution.

R. PREMADASA,
President.

Colombo, 08.01.1990

Regulations

1. These regulations may be cited as the National Environmental (Protection & Quality) Regulations, No. 1 of 1990.

2. No person shall, on or after the relevant date discharge, deposit or emit waste into the environment which will cause pollution, or cau[se] noise pollution, except:

   (a) under the authority of a licence issued by the Central Environmental Authority (hereinafter referred to as "the Authority"); and

   (b) in accordance with the standards and criteria specified in Schedule I hereto:

   Provided that, where a licensee who does not conform to the standards or criteria specified herein, is at the discretion of the Author[ity] directed to implement a programme of action within a specified period, so as to conform to the aforesaid standards and criteria [or] to observe certain conditions during such period such licensee shall, so long as he observes such conditions, be deemed to comp[ly] with the preceding provisions of this regulation.

3. Notwithstanding anything contained in regulation 2, the Authority may, by a direction issued under regulation 13, impose more stringent standards and criteria than those specified in Schedule I hereto in respect of any particular industry, operation or process, having regard to the need to protect the receiving environment.

4. Where an activity in respect of which an application for a licence is made is not covered by the standards and criteria specified in Schedule I hereto, the Authority will decide on such application on its merits and the applicant shall comply with all such directions as may be issued to him by the Authority for the protection of the environment.

5. The licence issued under these regulations shall be known as the "Environmental Protection Licence" (hereinafter referred to as "the licence").

6. (1) *An application for the licence shall be made :-*

(*a*) separately, in respect of each premises at which the acts authorized by the licence are carried out;

(*b*) Substantially in Form A in Schedule II hereto ;

(*c*) accompanied by a receipt for the payment of the fee specified in Schedule III hereto;

(*d*) at least 30 days prior to the relevant date or to the date on which the applicant is required to have the licence, whichever is earlier.

(2) For the purpose of these regulations "premises" means the totality of buildings and installations used separately or in combination to carry out the acts authorized by the licence.

(3) Every applicant shall furnish all such particulars as may be required to be stated in the aforesaid Form A and any other information that may be called for by the Authority for the purpose of deciding on the application.

7. *Every licence issued by the Authority shall be :–*

(*a*) in Form B in Schedule II hereto;

(*b*) valid for a period of one year, subject to any suspension or cancellation of the licence under section 23D of the Act; and

(*c*) renewable.

8. *The Authority shall issue the licence only if it is satisfied that:–*

(*a*) the licence will not be used to contravene the provisions of the Act or these regulations;

(*b*) no irreversible damage or hazard to man and environment or any nuisance will result from the acts authorized by the licence;

(*c*) the applicant has taken adequate steps for the protection of the environment in accordance with the requirements of the Law.

9. (1) *An application for a renewal of a licence shall be made:–*

(*a*) at least one month before the date of expiry of the licence or one month before effecting any changes, alterations, or extensions to the premises at which the acts authorized by the licence are carried out, as the case may be ;

(*b*) substantially in Form C in Schedule II hereto;

(*c*) accompanied by a receipt for the payment of the fee for the renewal of licence specified in Schedule III hereto.

(2) Every applicant for a renewal of the licence shall furnish all such particulars as may be required to be stated in the aforesaid Form C and any other information that may be called for by the Authority for the purpose of deciding on the application.

10. The Authority may, before issuing an order suspending or cancelling a licence under section 23D of the Act give the holder of the licence an opportunity to show cause why such order should not be issued:
Provided that, where, since the issue of the licence, the receiving environment has been altered or changed due to natural factors or otherwise or where continued discharge, deposition or emission of waste into the environment under the licence will or could affect any beneficial use adversely, the Authority shall forthwith issue an order suspending the licence for a period to be specified in the order or cancel such licence.

11. (1) Any applicant for a licence who is aggrieved by the refusal of the Authority to grant a licence, or, any holder of a licence who is aggrieved by the suspension or cancellation of a licence or the refusal to renew a licence may, within thirty days after the date of notification of such decision to him, appeal in writing against such refusal, suspension, cancellation or refusal to renew, to the Secretary of the Ministry in-charge of the subject of Policy Planning and Implementation.

(2) Such applicant shall be given an opportunity of making representations in person or by authorized representative in connection with his appeal.

(3) The Secretary may set aside, vary or confirm the decision appealed from, and the Authority shall give effect to the Secretary's decision.

(4) The decision of the Secretary shall be final and conclusive.

12. *The holder of a licence shall forthwith notify the Authority of :-*

(*a*) any changes made or proposed to be made in the particulars furnished in connection with his application for a licence ;

(*b*) any decision to terminate any activity to which the licence relates;

and shall comply with any directions that may be issued by the Authority to prevent or mitigate environmental pollution and hazards

13. Every applicant or every holder of a licence shall comply with any direction given by or on behalf of the Authority for the purpose of protecting the environment.

14. Every person who acts in contravention of any regulations commits an offence punishable under section 31 of the Act.

15. *In these regulations :-*

"The Act" means the National Environmental Act, No. 47 of 1980 as amended by Act No. 56 of 1988:

SCHEDULE I

GENERAL STANDARDS FOR DISCHARGE OF EFFLUENTS INTO INLAND SURFACE WATERS

No.	*Determinant*	*Tolerance limit*
1.	Total Suspended Solids, mg/l, max	50
2.	Particle size of total suspended solids	shall pass sieve of aperture size 850 micro m.
3.	pH value at ambient temperature	6.0 to 8.5
4.	Biochemical Oxygen Demand-BOD_5 in 5 days at 20° C, mg/l, max	30
5.	Temperature of discharge	shall not exceed 40° C in any Section of the Stream within 15 m down stream from the effluent outlet.
6.	Oils and greases, mg/l max	10.0
7.	Phenolic Compounds (as phenolic OH)mg/l, max	1.0
8.	Cyandes as (CN) mg/l, max	0.2
9.	Sulfides, mg/l, max	2.0
10.	Flourides, mg/l, max	2.0
11.	Total residual chlorine mg/l, max	1.0
12.	Arsenic, mg/l, max	0.2
13.	Cadmium total, mg/l, max	0.1
14.	Chromium total, mg/l, max	0.1
15.	Copper total, mg/l, max	3.0
16.	Lead, total, mg/l, max	0.1
17.	Mercury total, mg/l, max	0.0005
18.	Nickel total, mg/l, max	3.0
19.	Selenium total, mg/l max	0.05
20.	Zinc total, mg/l, max	5.0
21.	Ammoniacal nitrogen, mg/l, max	50.0
22.	Pesticides	undetectable
23.	Radio active material	
	(*a*) Alpha emitters micro curie/ml	10^{-7}
	(*b*) Beta-emitters micro curie/ml	10^{-8}
24.	Chemical Oxygen Demand (COD), mg/l, max	250

Note 1 : All efforts should be made to remove colour and unpleasant odour as far as practicable.

Note 2 : These values are based on dilution of effluents by at least 8 volumes of clean receiving water. If the dilution is below 8 times, the permissible limits are multiplied by 1/8 of the actual dilution.

Note 3 : The above mentioned General Standards shall cease to apply with regard to a particular industry when industry specific standards are notified for that industry.

TOLERANCE LIMITS FOR INDUSTRIAL EFFLUENTS DISCHARGED ON LAND FOR IRRIGATION PURPOSE

No.	*Determinant*	*Tolerance Limit*
1	Total dissolved solid, mg/l, max	2100
2	pH value at ambient temperature	5.5 to 9.0
3	Biochemical Oxygen Demand (BOD_5) in 5 days at 20 °C, mg/l, max	250
4	Oils and grease, mg/l, max.	10.0
5	Chloride (as Cl), mg/l, max.	600
6	Sulfate (as SO_4), mg/l, max.	1000
7	Boron (as B), mg/l, max.	2.0
8	Arsenic (as As), mg/l, max.	0.2
9	Cadmium (as Cd), mg/l, max.	2.0
10	Chromium (as Cr), mg/l, max.	1.0
11	Lead (as Pb), mg/l, max.	1.0
12	Mercury (as Hg), mg/l, max.	0.01
13	Sodium adsorption ratio : (SAR)	10 to 15
14	Residual Sodium Carbonate, mol/l, max.	2.5
15	Radio active material :	
	(a) Alpha emitters, micro curie/ml	10^{-9}
	(b) Beta emitters, micro curie/ml	10^{-8}

TOLERANCE LIMITS FOR INDUSTRIAL AND DOMESTIC EFFLUENTS DISCHARGED INTO MARINE COASTAL AREAS

No.	*Determinant*	*Tolerance Limit*
1.	Total Suspended Solids, mg/l, max.	
	(a) For process waste waters	150
	(b) For cooling water effluents	Total suspended matter content of influent cooling water plus 10 per cent.
2.	*Particle size of –*	
	(a) Floatable Solids, max	3 mm
	(b) Settlable solids, max	850 micro m.
3.	pH range at ambient temperature	6.0 – 8.5
4.	Biochemical Oxygen Demand (BOD_5) in 5 days at 20°C, mg/l, max.	100
5.	Tempeature, max	45°C at the point of discharge
6.	Oils and grease, mg/l, max.	20
7.	Residual Chlorine, mg/l, max.	1.0
8.	Ammonical Nitrogen mg/l, max.	50.0
9.	Chemical Oxygen Demand (COD) mg/l, max.	250
10.	Phenolic compounds (as phenolic OH) mg/l, max.	5.0
11.	Cyanides (as CN) mg/l, max.	0.2
12.	Sulfides (as S), mg/l, max.	5.0
13.	Fluorides (as F), mg/l, max.	15
14.	Arsenic (as As) mg/l, max.	0.2
15.	Cadmium (as Cd) Total, mg/l, max.	2.0
16.	Chromium (as Cr) Total, mg/l, max.	1.0
17.	Copper (as Cu) total, mg/l, max.	3.0
18.	Lead (as Pb) total. mg/l, max.	1.0
19.	Mercury (as Hg) total, mg/l, max.	0.01
20.	Nickel (as Ni) total, mg/l, max.	5.0

Appendix 2

DATA SHEET - 1

Date of Samples :

Date of Analysis :

Location of Samples :

pH

Temperature (°C)

Total Suspended Solids (mg/L)

Chemical Oxygen Demand (mg/L)

Biochemical Oxygen Demand (mg/L)

Mixed Liquor Suspended Solid (mg/L)

Ammonia - Nitrogen (mg/L)

Nitrate - Nitrogen (mg/L)

Nitrite - Nitrogen (mg/L)

Alkalinity (Bicarbonate) (mg/L)

COD : N : P

F/M Ratio (d^{-1})

Sludge Volume Index (ml/g)

Analysed by : Approved by :

PLANT OPERATION - DATA SHEET 2 Appendix 3

Date of Sample :

Date of Analysis :

Location of Sample :

Parameter	Measurement	Sampling Point
TSS	WT. Dish, Filter Residue	
	WT. Dish, Filter	
	WT. Residue	
	Sample Used (ml)	
TVSS		
RSS		
RVSS		

Prepared By : Approved By :

Appendix 4

DATA SHEET - 3

DISSOLVED OXYGEN AND TEMPERATURE

Parameter	8 hrs	12 hrs	16 hrs	20 hrs	24 hrs
DO (mg/L)					
Temperature (°C)					

Date :

Operator's Name :

Appedix 5

DISTRIBUTION OF MICROORGANISMS

Location Date

MICROORGANISM	FIELD NUMBER	TYPE — TOTAL
GROUP 1 AMOEBAE	1 2 3 4	
A Radiosa		
Euglupha Lewis		
Amoebae SPS Spc		
GROUP 2 FLAGELLATES		
GROUP 3 F S CILIATES		
Paramecium		
GROUP 4 STALKED CILIATEC S		
Vorticella		
GROUPS 5 ROTIFERS		
GROUP 6 OTERS		