REVIEW OF ENVIRONMENTAL IMPACTS OF PAPER CORPORATION AT EMBILIPITIYA AND RECOMMENDATIONS OF MITIGATORY MEASURES

A DISSERTATION SUBMITTED TO

THE

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Eng. D.M.W. Dasanayaka

SUMMARY

This research study on "Review of Environmental Impacts of Paper Corporation at Embilipitiya and Recommendations of Mitigatory Measures" was performed as a part of the course programme designed for Master of Engineering Degree in Hydraulic Engineering conducted by University of Moratuwa.

Industrial Development is an integral component of the Development of a country. Since industrial revolution various methods were introduced and the technology towards development has been improved tremendously. The objective of the development activities is proclaimed as to improve the quality of human life by the use of earths resources. The short term goals of human beings cause irreparable damage to the finely balanced ecological environment built up over long periods.

All the earths resources have been a free gift to mankind. Therefore it is a must to handle it with care and share it with responsibility.

In this respect the pollution causing from industrial activities should control by improving the methods of pollution control to mitigate the environmental impacts.

To day there is a lot of scope for industrial development in Sri Lanka. We are equally very much concern about the environment.

Recently the environmental impacts of the pulp and Paper Corporation was highlighted in the media.

Therefore this project has been selected for my research study.

The research study has performed under the following areas.

The description of the project - Pulp and paper industry with particular reference to process types of the Embilipitiya mill.

Description of the environment - Physical, physico-chemical ecological and socio economic environment of the area.

Description of environmental impacts - Process description of the mill.

Mitigatory measures.

Monitoring programme.

Conclusion and recommendations.

CONTENTS

CHAPTER 1

INTRODUCTION

The Environmental Impacts of the Pulp and Paper mill at Embilipitiya was recently high lighted in the media.

The objective of this research study is to Review the Environmental Impacts of the Pulp and Paper mill at Embilipitiya and to Recommend appropriate mitigatory measures and pollution monitoring programme to enhance the environment.

In 1952 the Department of Industries set up a pulp and paper mill at Valaichcheanai in the east coast of Sri Lanka. The rated capacity was 12 tons per day and commercial production commenced in 1956.
In 1957 the pulp and paper mill management was transfered to a Coporation established under the State Industrial Corporation act No. 49 of 1957. Presently this corporation is called "The National Paper Corporation". The general control of the affairs of the Corporation is vested in a Board of Directors appointed by the Ministry of Industries.
In 1964 modifications were made to the plant inorder to increase the production capacity to 10,500 tons per annum.
In 1967 a second paper machine with a capacity of 12,000 tons per annum was installed along side the first machine to produce paper boards. This machine commenced commercial production in 1972. The pulp mill was integrated to produce the straw requirement of 35 tons per day by the sulphite process.

The Pulp and Paper mill is situated at Embilipitiya in the Southern part of Sri Lanka, which was commissioned in 1977. The production of the factory commenced in 1978. The chemical recovery system was commisioned in 1983 with the aim of regaining 80% of the chemicals used in the process. The pulp mill has a capacity to produce 36T/day of pulping from rice straw by the soda process.The production capacity of the plant is 15000 tons/annum of fine paper for writing and printing.

Originally it was planned to locate the pulp and paper mills at Hambantota. The reasons may be the availability of local transport and to dispose the effluent conveniently by a sea out fall, thus minimising environmental damage. However the original idea of the planners had not been materialised and the pulp and paper mill was shifted to Embilipitiya.

Basicaly the paper mill has two types of effluents. The normal effluent resulting from washing of straw and the black liquor resulting from cooking of straw in caustic soda. The former is relatively harmless and may amount to 18000 m^3/day. A major fear is the contamination of drinking water pumped to Ambalantota and Hambantota towns. River water is also used by the people along its way. Impacts on aquatic life in the river and in the estuary is another area of concern.

The black liquor containing caustic soda and lignin presently constitutes a major problem. Lignin is the "Glue" keeping the fibres together in the living plant. Lignin contains chromophoric groups giving the fibre a more or less coloured appearence.

High yield pulp does not generally form a strong paper. It is necessary to remove the major part of the lignin from the fibres in order to improve the strength characteristics of the pulps.

The effluent is now stored in open ponds to the extent of 34 acres and discharges at intervals via a pipe to the Walawe River. While this is by no means the perfect solution it would be necessary to pursue research and development towards a rational solution, so that large quantities of paddy straw available in the Walawe basin can be readily utilised and those dependent on the water resource will not be deprived of a legitimate right.

CHAPTER 2

DESCRIPTION OF THE PROJECT

2.1 Pulp and Paper Production

Pulp and paper have a very important position in society. They are used for many purposes in the home, commerce, industry and education. The raw material is normally virgin plant fibres but an increasing amount is recycled fibres.

The pulp and paper industry occupies an important position in the chain which links a vast primary resource, the forest ecosystem, to an essential commodity, paper.

Whilst it is critically important that paper be available to meet cultural, information and other human requirements, it is equally essential to protect and enhance the human environment.

A major share of the world production of pulp was produced in Europe and North America ie. around 85% of the pulp and 78% of the paper.

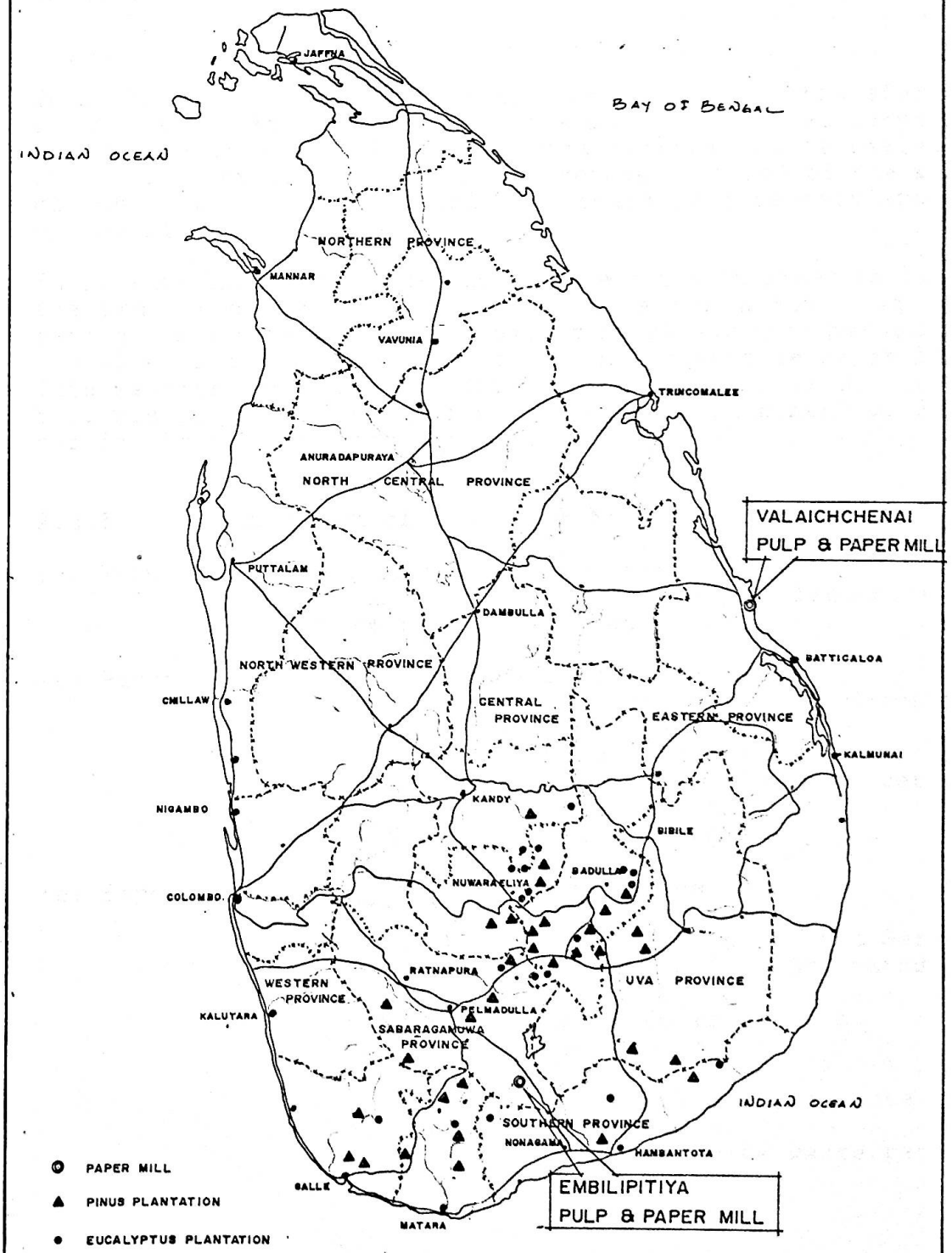
The growth rate of the industry of Asia (including Oceania), Latin America and Africa is high, however, and the relative share of Europe and North America is decreasing.

Most of the pulp is today produced from temperate zone softwood. But the utilization of hardwoods including those from tropical forests with broad leaved trees, has increased rapidly over the last decade and a future growth is foreseen. Today approximately 30% of the total amount of wood used for industrial purposes is hardwood.

Another source of raw material is recycled paper. An increased use of recycled paper can be foreseen in view of the rising cost of virgin fibres but the growth rate will probably be modest and declining.

Non wood fibres like Bagasse, Bamboo, Straw etc in 1977 supplied less than 5% of the total fibre consumption for conversion to paper. Many of the mills producing pulp from non wood fibres are small. ie capacity less than 10,000 tonnes/year and relatively old. It should be noted, however, that in certain regions non wood fibres constitute an important raw material for the pulp and paper industry.

MAP OF SRI LANKA



2.2 National Paper Corporation

In 1952 the department of industries set up a pulp and paper mill at Valaichcheanai in the east coast of Sri Lanka 270Km from Colombo and accessible by road and rail transport. The rated capacity was 12 tons per day and commercial production commenced in 1956.

In 1955/57 the pulp and paper mill management was transferred to a corporation established under the state industrial corporation act no. 49 of 1957. Presently this corporation is called "The National Paper Corporation". The general control of the affairs of the corporation is vested in a board of directors appointed by the ministry of industries.

In 1964 modifications were made to the plant in order to increase the production capacity to 10,500 tons per annum. In 1967 a second paper machine with a capacity of 12,000 tons per annum was installed along side the first machine to produce paper boards. This machine commenced commercial production in 1972. The pulp mill was integrated to produce the straw requirement of 35 tons per day by the sulphite process.

2.2.1 Description of the Paper Mill at Valaichcheanai

(a) Pulp Mill : The pulp mill has two streets one for bleachable pulp and one for high yield pulp from rice straw by the sulphite process.

(b) Paper Machine 1 : Fourdrinier type machine
Make - M/S J.M.Voith of West Germany
Capacity - 35mt per day
Grades - cheap printing and writing
Basis weight - 60 to 150 grams per sq.m
trim width - 2640 m.m.
Speed - 30 to 180 m/mt.

(c) Paper Machine 11 : Fourdrinier machine
combined with four vats
Make - M/S J.M. Voith of West Germany
Grades - Paper boards, Box boards
Capacity - 40mt per day
Basis weight - 80 to 550g.sm.
Trimwidth - 2285 mm
Speed - 12 to 144 m/mt
Raw materials - Rice straw,waste paper imported U.B.K.
imported B.K. and white waste paper.

2.3 The Embilipitiya Mills

The Pulp and Paper Mill situated at Embilipitiya in the southern part of Sri Lanka, 170Km from Colombo is accessible by road. The construction and erection of pulp and paper mills was done by State Engineering Corporation from 1969 to 1977 and commissioned in 1977. The production of the factory commenced in 1978. Construction and erection of chemical recovery system was being done from 1976 to 1982 and commissioned in 1983.

The pulp mill has a capacity to produce 36T/day of pulping from rice straw by the soda process. This plant has a capacity of 15,000 Tonnes/Annum of fine paper for writing and printing.

2.3.1 Description of the Embilipitiya Mills

(A) Pulp Mill - Supplier - Krauss Mafffei Munchen of West Germany

Principle Raw Materials :- 1. Rice Straw
2. Local Pulp Wood
Eucalyptus,Finus or Albissia

Other raw materials :- 1. Waste paper Gr 1 and 11
2. Imported long fibre pulp

Output :- 10,200 M.T. of bleached pulp per annum.

Cooking :- Soda process

Washing :- Three stage counter current washing

Bleaching :- Three stage Chlorine/Extraction Hypochlorite bleaching

(B) Paper Mill - Supplier :- M/S J.M.Voith of West Germany

Maximum deckle width of the machine 3575mm

Maximum machine speed 400m/min

Raw materials:- Rice straw white waste paper
imported bleached kraft
imported C.T.M.P.

Additives - Rosin, Alum China clay Oxidised Starch, retention agent, Anti-former Agent, Slime killer

Output - 17000 Mt of finished paper per annum

Paper grades - Printing and writing white coloured bank/bond
White and coloured manifolds
Type writing
Offset printing
Cartridge and Ledger
White and Coloured
Duplicating
Wrapping

Basis weight of the paper - 30 to 140 g.s.m.

(C) Chemical Recovery System

Supplier - Babcock Krauss Maffei

(a) Evaporation Plant

Inputs -14.5Mt/hr. of weak black liquor (10% D.S) from the pulp mill.
4Mt/hr. of steam (at 3.5 BAR)

Out puts - Strong black liquor (40% D.S)

(b) Liquor burning plant.

Inputs -4.7 Mt/hr. of strong black liquor from evaporation
200 Kgs/hr of furnance fuel
(at the start up)

Outputs - Na_2CO_3 solution - green liquor - strength 120Gms/Lit, 10Mt/hr steam (at 12.5 bar) from waste heat boiler.

(c) Recaustiazing plants

Inputs - Green liquor from liquor burning 0.5Mt/hr. Burnt lime as 85% CaO

Outputs - 5.2Mt/hr white liquor(NaOH)

(d) Steam generating plant

Manufacturer - Standard Kessel of West Germany

Type of the boiler - Fire tube,horizontal,Oil fired,package boilers (02 Nos.)

Output - 18Mt. of steam (at 14 bars)/hr

Fuel - 1170 lits/hr furnace fuel (1500sec)

(e) Process water treatment plant

Supplier - Federal construction corporation of Pakistan

Raw water input - $500m^3/hr$

Capacity of the water tower - $450m^3$

(f) Power Distribution

Rated power input at the Paper Mill - 5.25 MVA

Rated power input of the Pulp Mill - 2 MVA

Rated power input of the chemical

Recovery steam generation and water - 2.5 MVA
Treatment plants

2.4 Background of Embilipitiya Mills

Originally it was planned to locate the Pulp and Paper Mills at Hambantota. The reasons may be, the availability of local transport and to dispose the effluent conveniently by a sea out fall, thus minimising environmental damage.

However the original idea of the planners had not been materialised and the Pulp and Paper Mill was shifted to Embilipitiya.

Some possible reasons for shifting the location of the paper mill are;

1. Embilipitiya, almost a jungle area at the time of planning.
2. Less population.
3. Not many project were in the area.
4. Pulp and Paper industry consume more water other than other industries in the area.
5. Construction of Udawalawe Dam may have had a direct bearing for the intake water levels at Hambantota and Embilipitiya.
6. Availability of seasonal labour.
7. Environmentally not much concerned.
8. Government may have planned to provide employment for the rural youth in its point of view of emancipating them from abject poverty.
9. No significant impact from the people living around due to illiteracy or lack of awareness.

2.5 Procurement of paddy straw

At the inception of the Embilipitiya Paper Mill it has been decided to collect about 30000 Mt of paddy straw per year for pulping, which is the total annual requirement to run the pulp mill in full capacity. To achieve this requirement it has been planned to collect paddy straw from the following areas and this expected collection of straw per year has given against each area.

Area	Acreage	Straw output per year Mt	Expected collection per year M/T
1.Uda Walawe region	63000	25000	19000
2.Tissa region	24000	14000	8500
3.Matara region	12000	7000	2500
	99000	56000	30000

Collection under Uda Walawe area is done mainly by private contractors appointed by mills management who have to bring the material to the mill at the rate of Rs.475.00 per M.T. In other areas collection is done by operating mobile purchase units. In this operation officers of the mill go to the threshing floor or to the place where farmers have collected straw, with baling equipment and purchase after baling and either transport them to the mill or stacked and store them in the collecting centre of the area. In this instance the price paid is Rs.125.00 per M.T.

At the start there were four collecting centres in Uda Walawe area, three in Tissa area and three in Matara area. The collection in most of these centres were poor and uneconomical. The management decided to do away with all the collecting centres except for the centres at Ambalantota, Weerawila and Yodakandiya. At present only two collecting centres are maintained. Viz. Ambalantota and Weerawila.

Although resources are available within 30 - 40 miles from the mill to collect the total requirement of straw, this operation is not possible mainly because most of the areas under paddy cultivation are without proper road ways to approach threshing floors or paddy fields and some areas are completely cut off by irrigation canals. Paddy cultivators are more interested in harvesting and threshing their harvest during the season than collecting straw. As such it is difficult to motivate the farmers to collect straw in places where good roadways are available. The farmers have gradually switched on to cultivate new varieties of paddy introduced by the department of agriculture as they get much better harvest than the traditional paddy they used to cultivate earlier. The stem of the new varieties are very much shorter than the traditional paddy plant

and the straw output in the new variety is about 0.35 Tons per acre, and in traditional variety it is about 0.5 Tons per Acre.

In some areas farmers do not sell their straw but burn them in the paddy field to enrich the soil. Propaganda to this effect is carried out by the Mahaweli Authority. Unfavourable weather conditions during harvesting season also has badly affected straw collection. In some years heavy rain during peak period of the season has completely diminished the expected collection of straw.

Further, with the introduction of new technique for harvesting with portable threshing machine, collecting straw has become more difficult. This machine could easily carried to paddy fields and threshing is done in the field itself. Thereby, straw is left in the field. Earlier threshing was done on a firm ground which is always closer to a roadway and straw could be easily collected after threshing. Another drawback is non availability of required baling and haulage equipment to cope up with a rapid collecting programme.

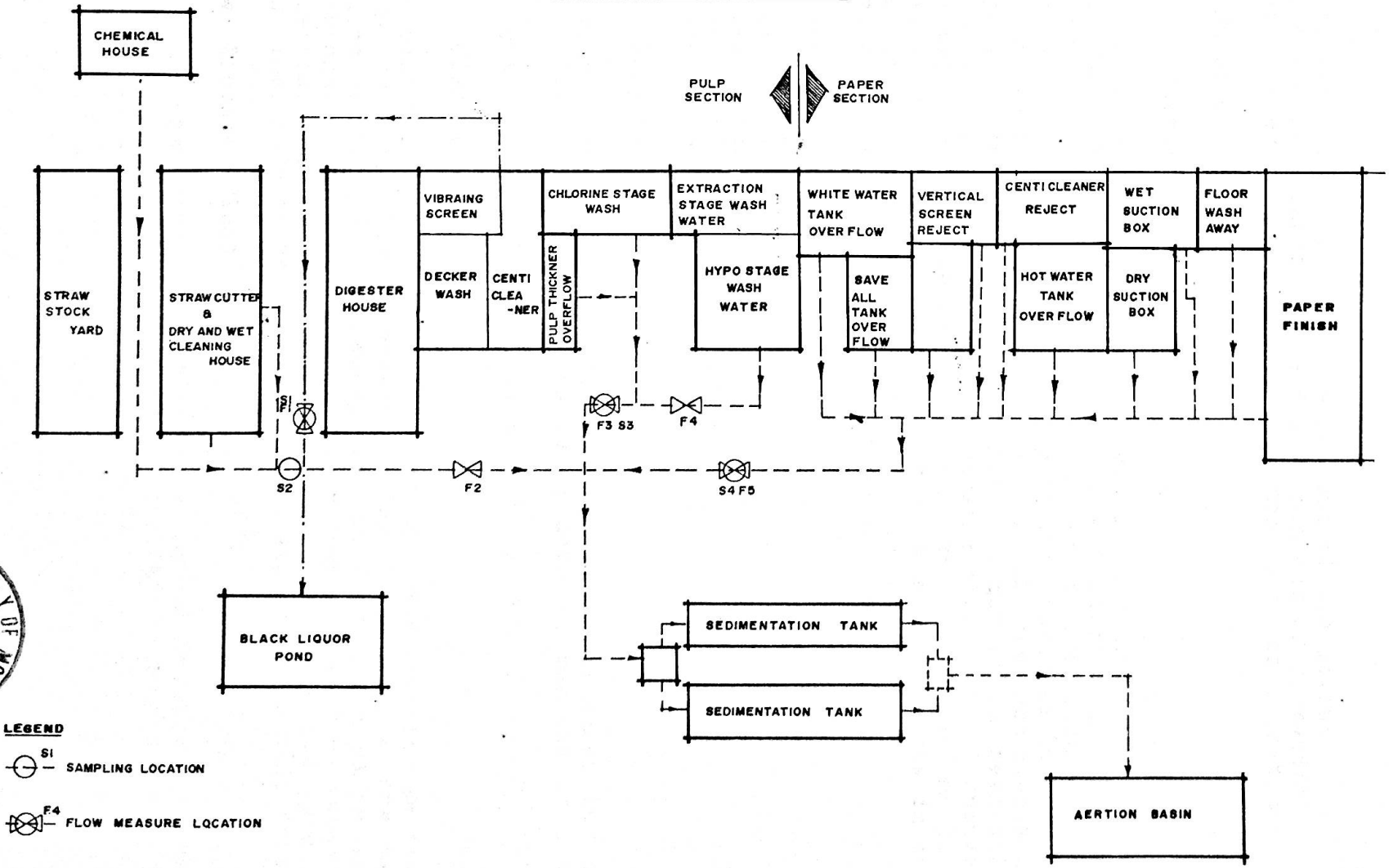
When straw is purchased separate representative samples are drawn from each lot and forwarded to the laboratory for moisture testing. When moisture content is above 10% the percentage above that limit and a further 4% for impurities is deducted from the lot and payment is computed accordingly. Moisture up to 10% is allowed as straw under normal dry contains moisture up to that extent. However, straw that contains more than 20% of moisture will not be accepted as it is subject to rapid decay and cannot be stored for a long period.

Immediately after purchase, straw is baled with automatic balers. Average weight of a bale is about 40Kgs and average output per baler is about 30Tons or 750 bales per 8 hour shift.During peak period there is an inflow of about 100 - 150Mt of straw, to the mills yard and have to use about 4 balers to bale them up before the end of the day.

Immediately after baling, straw is stored on "Stack Beds" built with rubble and filled with sand , to a shape of pyramid and outer surface is covered with a thick layer of loose straw to avoid seepage during rainy weather. Normal size of a stack is 40' x 40' x30' in height, contains about 2500 bales, weighing around 100Mt and could be kept for about 02 years, if the roofing is undisturbed. To build up a stack of above dimensions around 80 man days are needed.

Average fibre yield of straw is about 32%. The fibre yield percentage varies depending on the conditions of the straw, at the time of pulping.

SCHEMATIC DIAGRAM OF PROCESS DRAINAGE PATTERN



Baling and haulage equipment available for straw procurement work is listed below.

1. Automatic balers : 12 nos (4 nos out of operation)
2. Four wheeled tractors : 14 nos.(6 nos.out of operation)
3. Two wheeled tractors : 22 nos.(8 nos. out of operation)

2.6 Pulping

2.6.1 General

The pulp mill was supplied erected and commissioned by the voith - krass maffeei of west germany. It was started in 1978 and during the trial run 38.8 Mt.of B.D. bleached rice straw pulp was produced. The capacity of the pulp mill is taken as 36 M.t. of B.D.bleached pulp per 24 hours. The pulp mill has been specially designed to use rice straw as raw material but it has been able to do mill trials with Gini grass bagasse etc. A small chipper plant which can handle about 90 Tons of B.D. wood has been installed and wood pulping has been done several items in the mills whenever there was a shortage of rice straw.
The pulp mill mainly consists of four sections .

They are

1. Straw preparation plant
2. Digester house
3. Washing and screening plant
4. Bleaching plant

2.6.2 Pulping method

Soda pulping method is adopted in this mill and about 10% of Caustic Soda on O.D. basis is being used in cooking of rice straw.
It is possible to obtain a pulp with K no.10

2.6.3 Cleaning of straw

Dry cleaning is followed by wet cleaning. Wet cleaning section can be by passed if necessary, since 1983 October the wet cleaning section is by passed due to high maintenance and operational cost. The plugs and the cones of the screw presses are getting worn of very frequently due to high Silica in rice straw. They have to be weldified using expensive welding rods.

2.6.4 Digester Plant

Except the maintenance in blow tank including target plate, agitator, blow tank pump etc no significant comments could be made with regard to the digester plant.

2.6.5 Washing and screening

Brown stock washing efficiency is low due to high SR value of the pulp. At present there are three brown stock washes and if rice straw is to be continued 4th stage washing may be necessary. The suction head of the vaccum washers frequently subject to repairs.

2.6.6 Bleaching

Bleaching is done using conventional C.E.11 sequence bleaching. Chemical consumption is high to bad washing efficiency.

2.7 Description of the pulping process

2.7.1 Straw preparation

The baled straw at 10 - 12% moisture is fed into the cutter (6B DMT/hr) by a bale conveyer from which the cut straw is blown in to the dedusting cyclone. The dust from the cyclone goes out through the top and is blown into wet separator through a suction fan. Dust is mixed with water and sent down the drain. The dust free straw from the cyclone drops in to a reversible conveyor which can either by pass the whole wet cleaning process or drop in the pulper (36m^3) which has an agitator at the bottom.

This mixture overflows into the dewatering drums (1.5m x 5.5m) where the dirt water to be drained out.

Washed straw from the dewatering drums falls in to the scraper conveyor which can either feed the straw into either of the screw presses or by pass them and send the straw to the silo. The straw from the scraping conveyor is fed into screw presses where it is pressed and some of the water is squeezed out.The moisture content of the cleaned straw at this point is about 64%. The straw can be fed to the preparation plant at 6Mt per hour and losses after the cleaning operation is about 12.5%

From the screw press the squeezed straw at 64% moisture drops on to a conveyor which takes it to the top of the silo from where it drops on to another small conveyor which can either drop the straw into the silo or by pass the silo and send it to the digester house. From the silo the straw is discharged by means of a discharged screw and drops it on to a conveyor which in turn drops it into another conveyor which conveys it to the digesters.

The washed water from the system flows into a dirt water chest and this water is recycled. The over flow from the chest is passed through an arc screen where the solid impurities are removed.

In the straw preparation plant no chemical charge is occurred but dirt and silica are removed due to physical action and also the severe vortex action in the pulper disintegrates the leaves which does not contain any fibres.

2.7.2 Digester plant and heat recovery.

There are five (5) cylindrical tumbling digesters and volume of each is 43m^3 straw from the silo comes up to the digester house top floor through a conveyor and drops on to another conveyor which rest on wheels movable on rails.

The conveyor can be positioned to fill any one of the digesters. Straw falls from the conveyor through a feed tube into the digester. Caustic Soda is pumped from the storage tanks in the digester house into the digester. Once the required amount of caustic soda and straw are fed into the digesters the lid is closed, steam opened and rotation is started. When the required pressure is reached the steam valve is throttled and left slightly opened to compensate heat losses. In order to minimise the heat losses all the digesters have been lagged.

2.7.3 Data pertaining to the cooking of rice straw

1. Charging time of a digester	60min
2. Heating time	60min
3. Cooking time	150min
4. Degassing and blowing time	30min
5. Weight of straw in a digester	5-5.5Mt bone dry
6. Percentage of caustic by weight	10-12%
7. Cooking temperature	170^0 c
8. Cooking pressure	7 bars
9. Pressure after degassing	3.5bars
10.Cooking liquor strength	120Gms/Litre

The amount are based on the fact that moisture percentage of straw is 64% as it enters the digester. Cooking cycle is about 5hrs. It is possible to do 20 digesters easily and even 21 has been achieved during the trial run of chemical recovery plant.

Once the cooking is completed the rotation of the digester is stopped and degassing is done by opening the degassing valve. When the pressure is reduced to 3.5 bars the degassing valve is closed and the blow pipe is connected to the bottom of the digester. As the blow valve is open cooked pulp will get blown into the blow tank which is 110m^3 in volume. An agitator is installed vertically through the bottom of the tank for mixing purposes.

2.7.4 Heat recovery

During degassing and blowing, hot vapours will be blown into the blow tank from the digester. These vapours comes out of the top of the blow tank and passes into the condenser where it is sprayed with water from the condensate tank. Amount of water sprayed is controlled by a temperature of condensate flowing out of the condenser.

The condensate tank is divided into two sections called upper chamber and lower chamber. The upper chamber is at a higher temperature than the lower chamber. Condensate from the condenser flows into the upper chamber of the condensate tank and from there it is recycled by spraying in the condenser. The fresh water addition to the heat exchanger is controlled by a temperature controller which actuates according to the temperature of the condensate flowing out of the heat exchanger. Heated water from heat exchanger flow into the hot water tank. From this tank hot water is pumped through an injection steam heater to the pulp mill.

2.7.5 Pulp washing and screening

There are three cylindrical rotary brown stock vaccum washers each having a filtering area of 28.8 m^2. Counter current washing method is used to wash the unbleached pulp. Pulp from the blow tank is pumped to the 1st stage vaccum washer through a metal trap and mixing tube where it is diluted with 1st stage black liquor. The washed pulp from the washer drops on to a screw conveyor where it is diluted with thickener back water and sent down to the washed stock chest. Pulp pumped from the washed stock chest flows to flat screen through a mixing tube and a head box. This vibration screen has a capacity of 42 tons of pulp/day with a inlet consistency of 1.8-2.5%. It has a screen area of 1.5m^2 with 5mm perforations. The rejects from the flat screen drops into the rejects chest and the accepts to the accepts chest. The pulp from here is diluted to 1.5% consistency with thickener back water and pumped to the cowan screen through a head box. The cowan screen has 1.5mm perforations. The rejects which are too small to be separated in the flat screen are removed in the cowan screen and it flows into another flat screen. Rejects from this screen drops into the rejects chest and the accepts drop into the pulp flat screen accepts chest. The accepts from cowan screen drops into the cowan screen accepts chest gets diluted by the thickener back water and is pumped to the centi-cleaner system where very fine rejects such as sand etc are separated. The centicleaner system has a capacity of 40Mt B.D.pulp/day. The system consists of 03 stages and the number of cleaners in each stages are ten, three and one respectively. The inlet consistency of the pulp is 0.6%. The accepts from the centicleaners flow into the thickener with barometric legs where its consistency is increased by removal of water. The thickner has a filtering area of 40m^2. The thickned pulp has a consistency of 12% and it is pumped into the high density unbleached storage tank. The excess black liquor from the black liquor no. 1 chest is pumped to the chemical recovery system through the arc screen. The solids separated from the arc screen drops into the flow tank. The pulp is tested to obtain various parameters like S.R.K.No. etc. in the laboratory. The washing efficiency is very low due to high SR value of the pulp.

2.8 Bleaching

Rice straw pulp is bleached by conventional C.E.11 sequence to obtain a brightness of about 75 G.E. At the chlorination stage 4 to 5 % chlorine is added in to the line. Just before the chlorine mixes through a chlorine injection nozzle. The pulp from the chlorine mixer enters the chlorine tower at the bottom and it comes out of the tower by over flowing from the top. The retention time of the pulp in chlorine tower is one hour. Consistency is maintained at 3% temperature. Final Ph is 30°c and 2.0°C respectively. The diluted pulp from the chlorine tower is washed in the chlorine washer. All the washers in the bleaching stage have barometric legs. For filtration plastic wires seems to be more durable than stainless steel wires. The causticized pulp drops in to a steam mixer where it is mixed with steam and the temperature of pulp is brought up to 50°c. The retention time in the caustic tower is about 90 minutes and the caustic consumption is 2% on O.D.pulp. Steam consumption in the bleaching stage is about 1.0 Mt/ton of O.D.pulp. After the addition of caustic and hypo chlorites the pulp is dropped into steam mixer where temperature is controlled to about 40°c and pumped into the hypo tower. The retention time in the hypo tower is about 2 hrs. The pulp from hypo tower is washed on the hypofilter using paper machine white water. This is done in order to bring down the Ph of bleached pulp, as the SR value of rice straw, pulp is very high (about 60-65SR). It is not possible to bring down the ph due to bad washing efficiency.

Normally it has been noted that alum consumption of the paper making process is higher when the straw pulp is used in the furnish. When fresh water is used on the hypo washer the ph of the pulp is about 8 - 8.5. This could be brought down to about 7.5 if paper machine back water is used.

The mill has been using calcium hypo chlorite since the inception (1978). But it was found that the mesh of the hypo washer is frequently getting block with unsettled lime in the hypo liquor. Due to this reason sodium hypochlorite is used in the bleaching section at present. The three barometric leg type washers in the bleaching section are not very efficient but guaranteed production or 38.8 mt. of bleached pulp/day has been achieved. There are two storage towers in which about 40 tons of B.D bleached pulp can be stored.

The chlorine usage in the hypo stage is about 2.5% and a pulp of 75 GE brightness could be produced with 7.5-8% of chlorine. This figure is quite high compared to laboratory results. The variance is mainly due to bad washing efficiency. As a result of high SR value (60SR) of unbleached pulp. The rice straw used in this mills has a abnormally high silica content of about 17% and also due to high ratio of leaves/stem of straw the rice straw pulp contains high fraction of small fibres and fines.

2.9 Consumption figures pulping and bleaching.

1.	Unbleached pulp yield	33%
2.	Yield per cook	2 Mt.
3.	Caustic consumption	9-10%
4.	Water consumption(pulping and bleaching)	250 m3/ bleach BD ton
5.	Steam consumption	2.2-2.5 Mt/ton of unbleachedpulp
6.	Steam consumption (bleaching)	1.0 Mt/ton of B.D bleached pulp
7.	Power consumption(pulping and bleaching)	520 Kwn/ton of bleached pulp
8.	Chlorine consumption	7-8%
9.	Caustic soda for extraction	2%
10.	Caustic soda for hypo	3%

2.10 Chemical recovery plant.

The chemical recovery plant of the Embilipitiya pulp and paper mill was constructed in April 1975 with the aim of eliminating the effluent poluting black liquor resulting from rice straw pulping and at the same time to recover 75% of the pulping chemicals.

The contract was awarded to Babocock kraussmaffei industrieanlagen GMBH, Munich federal republic of Germany. BKMI's system has been designed with the specific aim to suit the particular requirements of a small rice straw pulp mill for which the standard soda pulp mill recovery system is not suitable.

The chemical recovery of the Embilipitiya mill mainly consists of the following units.

1. Evaporation plant
   2-Forced circulation evaporators and two falling film evaporators.
2. Rotary kiln
3. Waste heat boiler (12 tons/hr.14 bars)
4. Cyclone evaporator
5. Causticizing plant

The chemical recovery plant was readily erected in May 1979 but due to pilot character of the system a number of modifications to the process and equipment became necessary until a first performance trial run was carried out in February 1982. Embilipitiya mills and the contractor did not agree on the results of this test and further modifications (through - going scraper in the kiln etc) were made until second trial run was arranged in September 1982. The results were that the test had to be interrupted before scheduled termination as the kiln material did not properly discharge. Finally another set of modifications were done and final test run was carried out in October 1983.

The recovery efficiently was very low and the cost recovered caustic soda was about 4 1/2 times the locally purchased caustic soda.

2.11 Services of the mill.

2.11.1 Power supply.

Power supply to the mills is from 35 Km long 33 Kv line. A 10 MVA, 33Kv/11Kv transformer is installed at the mills. The incoming voltage of 33Kv is transformed to 11Kv, 3.3Kv, 440 Volts and 380 Volts. The total electricity requirement for the mills is about 4,600 Kva. There are seven A.C. motors in the paper machine work on 3.3 Kv. All the other low tension motors and the thyristor controlled system work on 440V, while 380V is used for the mill lighting systems. The power factor is maintained at 0.9 by using three sets each 800 Kvar of automatic capacitor banks connected only 440 V supply.

The approximate power consumption of the mills sections are

paper making plant	50,000 KWH/day
pulping plant	20,000 KWH/day
steam generation	1,500 KWH/day
water supply and treatment	9,000 KWH/day
housing colony	900 KWH/day

Power supply to the Mills is quite satisfactory. The mill had not experience any low voltage problem or frequent power cuts during the past. Power supply and controlling equipments, including transformers had been supplied by M/s Siemens A.G. of West Germany. All the electrical spare parts are being purchased directly from them. Some years ago the 10 MVA Main transformer got busted due to lightening and the inner core was replaced with a new one. The Mill was stopped for few weeks due to this problem.

Spares for thyristor control system specially printed circuits (Modules) are not available with the supplier ex-stock and as such orders for these items have to be placed well ahead of time for them to manufacture and supply.

2.11.2 Steam generation.

There are two automatic fire tube package type boilers for generation of saturated steam in Embilipitiya Mills. Each boiler has capacity of 18 Tons/Hour.

2.11.2.1. *Technical data for each boiler unit*

Heating surface	350 m^2
Maximum per missible operating pressure	14 Bars
Feed water temperature	102° C
Water capacity up to low level	29.75 m^3
Fuel - heavy oil 1500 Sec. (Red wood)	
Present operating pressure of the Boiler	11 Bars

The average consumption of oil per ton of steam is about 65.72 liters and the average cost of production of a ton of steam is about Rs. 390/-. Oil cost is Rs. 4450/1000 litre at the Mills including transport costs. Steam distribution per hour (approx. at full capacity)

Pulp Mill (digesting)	4 Tons at 7.5 Bars
Paper Machine	7 - 8 Tons at 3.5 Bars
Feed water preparation, Oil preheating, Bleaching and Other process	4 Tons at 3.5 Bars

2.12 Feed water treatment.

Feed water treatment is done in three stages

- De-aeration
- Sending through ion exchanger
- Phosphate internal treatment

Even with this type of treatment scales are forming on the tubes and boiler has to be descaled at least once a year. This is mainly due to high hardness of the incoming raw water. Overhauling and calibrating of the air-fuel ratio control equipment may increase the combustion efficiency of the boiler.

2.13 Paper mill.

The Paper Machine was erected and commissioned in the latter part of 1977. The Machine was supplied by M/s J.M.Voith of Heiderheim, West Germany. The guaranteed production is 59 M.T. of 50 Gsm per day. The capacity of the Mill is taken as 50 MT/day and 15,000 M.T. per annum. The Mill has been designed to use Rice Straw pulp with admixing of Bleached Kraft long fibred pulp. Two pulpers each having a capacity of handling 30 Tons of pulp have been installed to dissolve long fibred pulp and broke from the finishing house.

2.13.1 Technical specification of the wire section.

The wire section is a foudrinier Section of cantilever type with shaken breast roll.

Wire Width	:	4050 m.m.
Wire length	:	34000 m.m.
Machine prospher Bronz wire	:	33950 x 4050 m.m/26 mesh
Retensioning capacity	:	425 mm (1.25)
Maximum wet web width	:	3950 mm
Trimmed web width	:	3556 mm
Operating speed	:	90-450 meters/Min
Design speed	:	550 Meters/Min
Drive	:	Left hand when viewed from machine direction.
Paper grades and grammages	:	30-120 gsm, Writing and that could be manufactured: printing papers (white and coloured)

All the sectional drives are thyristor controlled. All the Electrical Equipments such as transformers motors, Switch gears, thyristor control system etc have been supplied by M/s Siemens A.G. of West Germany.

The machine is equipped with closed type Head box with an air cushion supplied by a blower. The wire table consists of the following.

1 No. Forming board (505 mm x 4250 mm)
8 Nos. Foil Boxes
3 Nos. Wet suction boxes
7 Nos. of dry suction boxes
suction couch roll

The dandy roll had been installed at the beginning and it has been removed and kept due to unknown reason. The forward drive roll is a raising and lowering unit which makes contact with the 1st press suction pick up roll and serves to act as a pick up for the wet sheet.

2.13.2 Stock preparation.

The stock preparation system is mainly equipped with 4 Nos voith 2R type conical refiners, one machine refiner, 2 deflakers, High density cleaner, Fan pump, Vertical screen and 3-stage centricleaner system. The power consumption of 2R type refiners are extremely high (240 kw each 3.3. kv) and it is worthwhile to consider replacing them with 2 disc refiners. This is a viable project and provisions have been made in the next years budget. The centricleaner cones are getting worn off very frequently due to high silica in rice straw pulp for which the manufacturers are not to be blamed.

The machine has two presses and they are,

(1) Suction pick up press (1st press)
(2) Venta nip groove press (2nd press)

The suction pick press consist of hard rubber bottom roll with 3 m.m. perforations and a micro rock plain top roll.

The suction pick up roll has a total crown on the diameter 2.25 m.m. at a nip pressure of 45 kp/cm (operating nip pressure).

The second venta nip a Microrok cover top roll and bronze covered bottom grooved roll. The depth of the groove is 2.5 mm and width is 0.5 mm. The grooved roll has a camber of 1.6 mm on the diameter at 75kp/cm of linear pressure. One suction pick up roll shell, one steel microrok roll and a groove roll are available as spares in the Mill.

Suction pick up roll holes are getting blocked with fines, clay, alum etc. and it has to be replaced with spare shell once in six month intervals. The plugged shell is drilled and kept ready in the meantime. The plugged second press grooved roll is cleaned manually as there is no special attachment to the existing roll grinder for this purpose. This cleaning work could be simplified if a groove cleaning attachment could be purchased and mounted on to the roll grinder. There is a provision for a third press nip but so far no action has been taken to study the viability of the project. The modern presses are very expensive and the Mills staff is doubtful whether it is viable to have a third press nip on the existing machine.

Mostly synthetic european felts are used in the press sections and their lifetime varies 1500 tons to 2000 Tons/felt. The Mills staff has an idea of improving the water removal capacity of the press section by introducing a steam box just before the second press.

The roll grinder which is one of vital workshop equipments (for grinding of rolls) is not functioning properly due to defective thyristor controls and it is expected to rectify the defect with the help of M/s Siemans AG of West Germany.

2.13.3 Dryer section.

The paper web which leaves the press section with a moisture content about 65% enters the dryer section. The dryer section has 26,1500 mm x 4050 mm cylinders. The dryer section can be divided in to three groups. They are as follows.

(1) First dryer group
(2) Second dryer group
(3) Third dryer group

The above groups belong to the pre dryer section and after the size press, starts the after dryer section.

The first dryer group consists of 7 drying cylinders, four at the top and three at the bottom. There are two felt dryers at the top and one at the bottom. Each drying cylinder in this group is equipped with a mechanically oxcilated doctor.

Second dryer group consists of 6 drying cylinders, three each on top and bottom row. This group dryer screens need no separate dryer cylinder to dry the screen as today very open efficient long lasting synthetic dryer screens are available for this purpose. The blow boxes are supplied with hot air from tender and drive side.

Third dryer group consists of 6 drying cylinders. As in the second group this group also does not have any felt dryers. This group too has not air blow boxes for pocket ventilation. The hot air blowing system is not in a position to maintain the required temperature of the air as the heat exchangers (Radiators) are corroded and leaking. Action has been taken to turn out these radiators have to be replaced with new ones in order to bring down the specific steam consumption.

From the third dryer group the paper is passed in to the size press, where the web is treated with starch solution. After dryer section starts after the size press. The chrome plated bottom dryer No. 20 and 21 are driven by a D.C.Motor. Soon after the size press the paper web come incontact with the chrome plated surface of the dryer. These cylinders do not have any felts or screens.

The fourth dryer group consists of five dryer cylinders, two drying cylinders on the top and third drying cylinders at the bottom. After the dryer section there is cooling cylinder which is also called sweat dryer. This dryer is similar in construction to the paper dryers, over which the fourth group top dryer screen is running.

2.13.4 Rope system.

This type of rope systems are found only of fast moving machines. In this machine the rope system consists of two ropes and is divided into five rope groups. They are; First, second, third dryer groups and the size press and two chrome cylinders. The rope system begins ahead of the dryer cylinder number one and paper web has to be blown by the compressed air in between these ropes. Before the size press also the Tail has to be blown again by compressed air.

2.13.5 Heating system.

The pre dryer section is divided into three cascade type heating stages. The steam is supplied at 3.5 Bars (Saturated) through a separator and prematically actuated valve. The first heating stage consists of 9 Nos. cylinders. (cylinder No. 11 to 19 and two first group felt dryers).

The system has been so designed to use flash steam very effectively and also the condensate removal system is working very satisfactory. The dryer section is covered with a vapour hood.

2.13.6 Calender stack.

After leaving the cooling cylinder, at the after dryer section the paper is run between the calender stack. The calender that is installed consists of four rolls. The bottom roll or the king roll is a swimming roll (system kuster). The roll above this swimming roll is called Queen roll and third roll is intermediate roll. The roll above the intermediate roll is again a swimming roll. Two rolls or four rolls operation is done according to the required quality of paper. The queen roll is connected to the drive motor, which drives the calender stack.

2.13.7 Comments on paper machine.

In general performance of the machine is excellent. Even though the rated capacity is 50 Tons/day, the machine has been able to produce 75 Tons/day without any difficulty when heavy papers such as 64 gsm was made. Due to lack of trained people and high turnover of skilled personnel the specific consumptions of chemicals and energy were on the higher side some years ago and the mill staff has been able to bring the situation under control. In 1982 the specific steam consumption was 7.5 Tons/Ton of paper at the paper machine and this has been now brought down to about 2.7 Tons/Ton of steam by way of operating the machine efficiently. The alum consumption has been brought down from 10% (1983) to about 6% (1987). Rosin consumption in 1983 was 2.7% and presently only 1.2% is used. Clay usage has been increased from 2.7% (1983) to about 6% and it can be further increased.

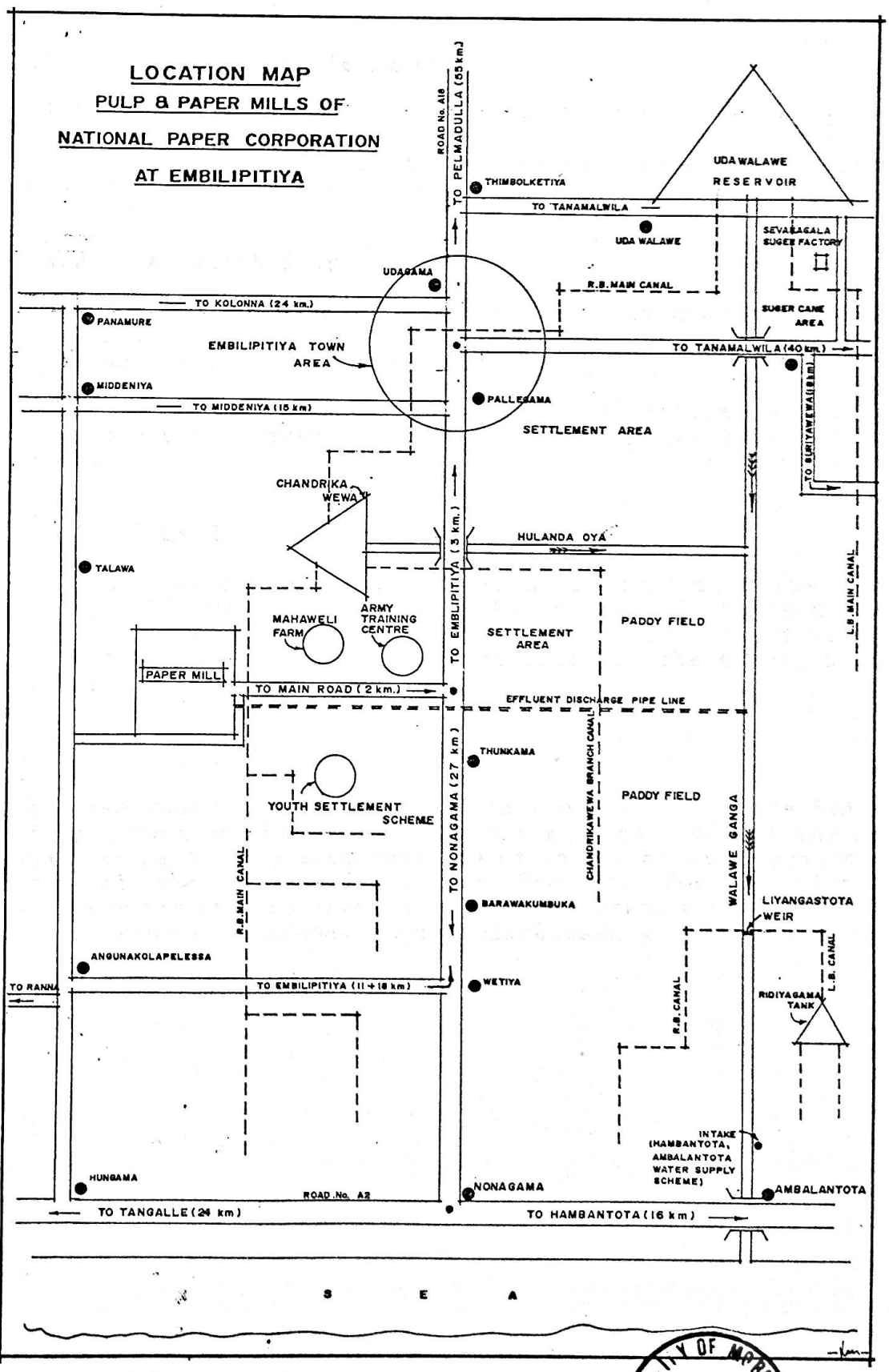
Saveall was not in operation for some years and most of the chemical savings are mainly because of functioning of save all and recirculation of white water wherever possible.

Stock metering system has to be completely overhauled as it is not possible to set the furnish accurately. Once this is done most of the quality variances could be minimized. Basis weight and moisture variations are very common. Most of the complaints on quality are due to these two factors. This could be eliminated by installing a on line B/M gauge and controlling system. It seems this is very important as the customers are more concerned about quality and there is a competitive market under the liberized imports. The mill has already initiated action on this but the project is still in the planning stage. This is a viable project as it can save, raw materials, Energy and reduce the broke percentage, down time, and also quality of the product can be considerably improved.

Machine does not have a waste paper treatment plant even though it uses some time up to 50% of waste paper in the furnish. Various problems have been experienced such as malfunctioning of consistency controllers etc due to untreated waste paper. A waste paper treatment plant is very essential as the Mill is going continue the usage of waste paper.

Since the inception the Mill has been using phosphor bronze wires on the machine and recently some plastic wires have been tried. The results are encouraging according to the Mills staff except for high rate of wear on foil boxes and suction box tops. If plastic wires are to be used in future the foils and suction box covers have to be replaced with high weare resistant materials. Also it is very essential to install a high pressure cleaning shower in the wire plant.

The full advantage of the size press is not taken. Size press is by passed when low grade printing and duplicating are made in order to cut down specific steam consumption. The following paper grades are mainly manufactured on the machine. Ordinary white printing (50 gsm - 74 gsm) offset printing (64 gsm - 74 gsm), Duplicating (75 gsm) Manifold (30 gsm), Bank and Bonds (51 - 61 gsm), Type Writing (52 gsm) Catridge (98 gsm - 102 gsm). The production programme consists of about 60% of ordinary white printing paper which is being used for printing of school books etc.



CHAPTER 3

DESCRIPTION OF THE ENVIRONMENT

3.1 Physical Environment

3.1.1 Location

The pulp and paper mill of the national paper corporation is located at Embilipitiya in the dry zone of the island.

3.1.2 Accessibility

The major access road to the paper mill is highway A-18 which runs from Pelmadulla to the Nonagama junction at Matara, Kataragama highway via Embilipitiya.

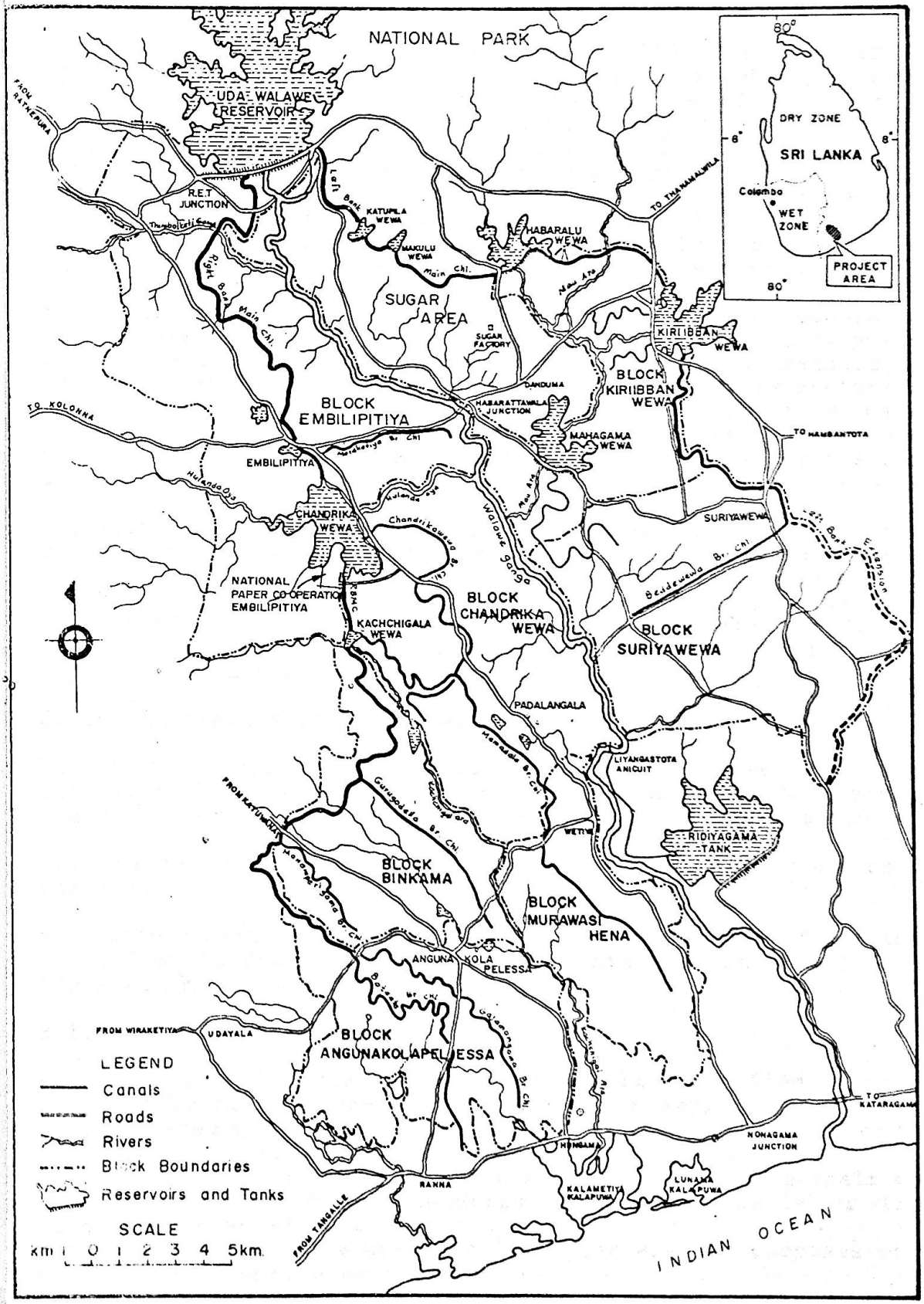
The paper mill situated 5km away from Embilipitiya town, of which 3km along the highway towards Nonagama and 2km interior to the right.

3.1.3 Land

The total extent of land is 690 acres including the housing colony. This was a barren land. Major part of the land belongs to the crown and some parts to private owners which have been acquired by the paper corporation prior to the erection of the factory.

3.1.4 Area

The area under review falls within the administrative districts of Ratnapura and Hambantota and has a terrain of rolling slopes and flat land. This area consists of the right bank canal command area of the Walawe Irrigation Project. For administrative purposes the area is divided into five blocks. viz. Embilipitiya, Chandrikawewa, Binkama, Angunukolapelessa and Murawasihena.


NATIONAL PARK
UDA WALAWE RESERVOIR
FROM RATNAPURA
R.E.T JUNCTION
Thambelitti Ganga
Left Bank Main Chl.
Right Bank Main Chl.
KATUPILA WEWA
MAKULU WEWA
Main Chl.
HABARALU WEWA
TO THANAMALWILA
New Arr.
SUGAR AREA
SUGAR FACTORY
KIRIIBBAN WEWA
BLOCK KIRIIBBAN WEWA
DANDUMA
HABARATTAWILA JUNCTION
BLOCK EMBILIPITIYA
TO KOLONNA
Hankenuga Br. Chl
MAHAGAMA WEWA
TO HAMBANTOTA
EMBILIPITIYA
Nilkandoya
Walawe Ganga
New Arr.
SURIYAWEWA
Left Bank Extension
CHANDRIKA WEWA
Chandrikawewa Br. Chl
Beddewewa Br. Chl
NATIONAL PAPER CO-OPERATIVE EMBILIPITIYA
KACHCHIGALA WEWA
BLOCK CHANDRIKA WEWA
BLOCK SURIYAWEWA
PADALANGALA
Hamedde Br. Chl
LIYANGASTOTA ANICUT
FROM KATUMURAI
Gurugodde Br. Chl
WETIYA
RIDIYAGAMA TANK
BLOCK BINKAMA
BLOCK MURAWASI HENA
ANGUNA KOLA PELESSA
Boiseen Br. Chl
Boiseen Ganga Br. Chl
FROM WIRAKETIYA
UDAYALA
BLOCK ANGUNAKOLAPELESSA
LEGEND
Canals
Roads
Rivers
Block Boundaries
Reservoirs and Tanks
SCALE
km 1 0 1 2 3 4 5km
TO KATARAGAMA
NONAGAMA JUNCTION
HONGAMA
RANNA
KALAMETIYA KALAPUWA
LUNAMA KALAPUWA
FROM TANGALLE
INDIAN OCEAN
80°
8°
DRY ZONE
SRI LANKA
Colombo
WET ZONE
PROJECT AREA

3.1.5 Walawe Irrigation Project

Development of Udawalawe scheme began in 1959. The Construction of Udawalawe dam was begun in 1963 and completed in 1967. Udawalawe reservoir which has a live storage of 250 M.cm is supplied by the Walawe river with a catchment of 1,152 Sq.km and an average perennial flow of 1,100 M.cm. Two canals abstract water from the reservoir. One supplying the right bank has a design capacity of 18.4 Cu.m/s and was intended to irrigate about 12,000 Ha. The other with a design capacity of 28.3 Cu.m/s was expected to irrigate about 20,000 Ha. on the left bank. In 1969 the Asian Development Bank financed a three year programme for the improvement and extension of existing irrigation facilities and social and agricultural development. Project implementation was not carried out as planned and the project was not completed until 1979. The performance was disappointing because of settlement and operational problems, with the farmers preferring to grow rice irrespective of soil types. Excessive water consumption and inequitable distribution limited the irrigated area to about 8000 Ha.on the right bank and 3000 Ha. on the left bank.

The Walawe Irrigation Improvement Project is focused on improving the physical infrastructure by rehabilitation and rationalisation of this irrigation system and strengthening water management on the right bank to enable irrigation supplies to be provided more efficiently. This should both increase agriculture production on the right bank and allow further development of irrigated agriculture on the left bank.

3.1.6 Rainfall pattern and weather

The rainfall occurs in two distinct periods. One over the period October to December at the start of the Maha Cultivation season and the other in March and April prior to Yala cultivation.

Dry weather prevails through out the year except those rainy seasons.

Mean annual rainfall varies from 1650 mm in the North of the area to 1000 mm in the South. The mean rainfall at Embilipitiya is 870 mm in Maha and 570 mm in Yala.

3.1.7 Potable water

For the residents of Embilipitiya town limit purified water is supplied by house connections. The water supply and drainage board located its intake to abstract water from Chandrikawewa for domestic water supply to the town.
Drinking water facilities for those who do not possess their own wells are either by neighbouring wells, tube wells or from irrigation channels and rivers.
Most of the tube wells are restricted for washing purposes only due to high fluorine concentration.

Irrigation channels and rivers provide the main source of water for bathing. Less than 5% of the households use well water for bathing.

3.1.8 Extent of land

The total area under the right bank of the Walawe Project covers an extent of 40,000 Ha. Out of this total extent 26,000 Ha. comprises the total settled area. Fifty three percent (53%) of the settled area comprises irrigable land.
In each block the irrigable land has been allocated to settlers for the cultivation of either paddy or subsidiary crops and the un-irrigable land to serve as homesteads. Paddy lots vary in size from 0.2 Ha. to 1.2 Ha. Subsidiary food crop lots from 0.2 Ha. to 1.0 Ha and homestead lots from 0.1 Ha to 0.8 Ha.

3.1.9 Settlers

As per the figures released by the Mahaweli Project Office at Embilipitiya approximately 32,000 families settled in the area out of which 90% classified as legal settlers and the balance as encroachers.

3.1.10 The left bank area

The area is located on the left bank of the Walawe River mainly in Southern Province, although small parts of the North lie in the Sabaragamuwa and Uva province as well. It extends South East from the Uda Walawe dam and comprises two distinct contiguous areas broadly equal in size.

The area to the North is the developed area benefiting from Walawe waters in left bank canal. Here 5000 Ha. have received irrigation benefits.

The area to the South referred to as the extension area is largely under developed because there are no irrigation facilities except for old minor irrigation tanks dependent on rain fall.

The total area is approximately 32,000 Ha. in extent.

3.1.11 Udawalawe National Park

The Udawalawe National Park situated off Walawe reservoir is 110sq.miles in extent. The park was opened to public since 1980 and administered by Wild Life Department. The terrestrial and Aquatic fauna and endemic and migrant birds could be seen in the park frequently. Local and foreign tourists often visit the park.

3.2 PHYSICO - CHEMICAL ENVIRONMENT

3.2.1 Soil

The natural vegetation had been removed in the area by the implementation of Walawe Project. Approximately 45% of Embilipitiya area and approximately 60% of Chandrikawewa area composes reddish brown earth soils.(RBE), in which seepage losses persists, due to permeability. According to the original cropping plan rice had been restricted to the heavier low humic gleys (LHG), with dry food crops else where, so as to avoid excessive seepage losses. Nevertheless farmers preferred to grow rice throughout and generally tended to be wasteful in their irrigation practices. Soil loss due to rain in the monsoon months of October, November, December and January and loss due to wind erosion during dry months also possible. Continued working had been depleted the physical properties of soil.

3.2.2 Water quality

The Walawe River is the major source of domestic water for the inhabitants. Surface water in the area could be affected by fertilizers and agrochemicals, industrial effluent and faecal pollution. Surface water pollution from industrial effluent is not very significant except during the period of effluent discharge in to the Walawe river. The main component of the effluent is organic matter evaluated by high COD(Chemical Oxygen Demand) and BOD3 (Biological Oxygen Demand after 3 days). Cognizance should be taken of the presence of such potential impact that could be of a significant nature in the quest for a pollution-free river basin.

3.2.3 Ground water

The main source of ground water recharge is rainfall. In the Walawe area percolation rate is extremely high. According to field surveys about 80-100 percent of percolated water reappears in the immediate down stream drains. Unlined canals in the irrigation network may allow the recharge of ground water.

There is no evidence to suggest large scale impact on ground water quality and quantity. Nevertheless most of the tube wells located in the southern region were restricted to use for drinking purposes due to high fluoride concentration.

3.2.4 Salt water intrusion

The Walawe river enters the sea at Amblantota, while some distance from the river mouth, the water flow branches off eastward into a lagoon at Godawaya. This water does not enter the sea because of a sand dune. Sea water enters the lagoon by seepage through the dune affect the surrounding land.

Between the river mouth and the lagoon about 1214 Ha. of paddy land are affected.

The river mouth is closed during the dry season due to the formation of a sand bar. During the wet season the sand bar is breached by the higher river flow.

Sea water can enter the river during times of low flow unless the mouth is closed by sand dunes. Generally the mouth closes in August.

With the on set of the North-East monsoon and with increase in river flow the sand dune-gets cleared.

The intake for the Ambalantota and Hambantota water schemes is located about 5.0 km upstream from the estuary in order to prevent pumping of saline water.

Analysis of the river water a little upstream of the river mouth in November 1991 indicated an electrical conductivity of 236 Umhos/cm

Ground water samples taken from six wells on the project area show high levels in terms of electrical conductivity and dissolved chloride and fluoride ions making such water unfit for irrigation and drinking purposes.

Unless drainage is effective salinization of irrigated fields can take place over time.

Therefore it is important that drainage be given adequate recognition in project planning.

3.2.5 Flooding

The Walawe river does not have an extensive flood plain.No major floods have occurred within the basin.

It appears that sediment transport in the river is not high. As it traverses forested mountain stretches before dropping on to the plain.

However flooding along the coastal plain in proximity to the river mouth has occurred not so much due to the river overflowing but due to heavy rain.

Flooding of the area around Karagan Lewaya causes problems to about 300 settlers in the Alokapura Housing Scheme.

Hambantota had gone under water in 1957, 1969, and 1990. It appears that a major flood occurs in this area every 10 years. Ninety six houses were affected of which 31 were temporary and 65 permanent.

3.3 ECOLOGICAL ENVIRONMENT

3.3.1 General

The clearing of the existing vegetation in the area and its replacement with a vegetation of domesticated crops is the major change that had occurred in the area due to the implementation of the Walawe Irrigation Project.

Aside from the loss of the natural plant cover there had been an overall impact on the soil micro climate and animal populations.

Some of these were of a temporary nature. For example the likely loss of soil due to wind and water during canal construction and initial field preparation. This was however compensated by subsequent agronomic practices. Micro-climatic changes had been compensated when the water begins to flow. New niches and ecological associations had been established when perennial water supply was instituted.

3.3.2. Terrestrial Flora

The largest impact of the area was the elimination of scrub jungle which also was served as wild life habitat. As a result of the project wild life habitats were eliminated. A void had been created in provision of fuel wood due to elimination of scrub jungle.

Nevertheless a more luxuriant vegetation could be seen over the area adjacent to water courses due to a beneficial of water table and paddy and subsidiary crops grown by the settlers.

3.3.3 Aquatic Flora

Other than what naturally grows on canal banks and on the edges of other water bodies a proliferation of water weeds could be experienced. Floating weeds such as salvinia eichhornia and pistia choke water bodies interfere at cross canal structures provide habitat for disease vectors,increase evapotranspiration losses reduce fish and other organisms and interfere with human use of water bodies.

3.3.4 Terrestrial fauna

Walawe area had been the natural habitat for a number of endemic animals. In addition relatively common large mammal species were known to occur in the project area. They include wild boar, deer and sambur.

3.3.4.1 Elephant

The elephant which is listed as an endangered species due to the long drawn out struggle between man and elephant had been separated by moving elephants to safe locations particularly in Udawalawe National Park. Thus the impacts resulting from the conflict is minimised.

This was a vital necessity to reap maximum benefits of the objectives of the project implementation. More over in view of the historical and cultural importance, the plight of the elephant merits close attention.

It appears from emerging trends in natural resource management, that man and elephant can co-exist without serious conflicts only on low densities.

The elephants are confined to the Udawalawe National Park. The carrying capacity of the area after project implementation would have not been supported for continued survival of the elephants. Hence in LB area they sneak into village tanks for water and forage in cultivations and home gardens.

More often they were pushed to find refuge in Uda-Walawe National Park and Bundale sanctuary.

They also take refuge in the uncleared jungle pockets like Madunagala in Left Bank area and Ridiyagama and Karambagala and also in the eucaliptus plantation of forest department in the Southern edge of the project area.

As sugar cane cultivation is a high priority keeping elephants away from such crops is difficult. The resulting economic losses are tremendous. The elephant considered a national treasure happen to be the victim of a losing battle with man in an environment that gradually become more and more inhospitable to both parties.
The conflict with the elephant will be the major environmental issue needing resolution of very early stage in the left bank area.

3.3.4.2 Other wildlife resources

Project area had been the natural habitat for a number of endemic animals.

The land use changes have resulted in the creation of barriers and the isolation of some wildlife habitats with the elimination of large areas of scrub jungle pushed in to near by Udawalawe and Bundala sanctuaries and Madunagala and Karambagala forests.

Animals that seasonally migrate and the animals those who are reluctant to move were seriously affected by agricultural barriers Viz. sambur wildboar, spotted deer, muntjae.

Animal species which were totally dependent on trees and forests were also affected by agricultural barriers. Viz. purple faced langur, Ceylon grey langur, porcupine, giant squirrel, flying squirrel, rock squirrel.

The prevention of emigration and immigration for these species resulted in the reduction of their population.

A few species which adapt readily to habitat change related to agricultural development are rats, wild pig and tilapia.

The terrestrial species could breed fast and assume pest proportions damaging crops such as sager cane and paddy. The wild pig predated by the leopard and have a free range to multiply rapidly in the absence of the leopard.

3.3.4.3 Birds

The removal of the existing vegetation had an impact to some degree on the bird population both resident and migratory. While some of the affected resident species had been moved to new grounds others such as the parakeet and munias had been adapted to the new habitat remarkably well. They even changed their usual feeding habits viz. parakeets had been switched from being fruit eaters to grain eaters.

A majority of 251 resident bird species found in Sri Lanka could be observed in the area. viz. cormorants, pelicans, egrets, herons insects and butterflies.

Birds were reduced due to the elimination of villus. Livestock grazing areas and carrying capacities also had been reduced.

Migratory birds in category of forest dwellers had been found and considerable reduction in there usual habitat. On the other hand breeding grounds in aquatic habitats enhanced as a result of implementation of the Walawe Project. The area to be located at the Southern most point in the migratory route along the Indo-Asian Flyway, far beyond to the South is the vast Indian Ocean.

During the winter months in Europe and other north temperate regions at least seventy five more bird species migrate in to the area.

3.3.5 Aquatic Fauna

The impacts on the aquatic fauna mostly relate to the presence of agrochemicals fertilizers and sewage in detrimental quantities. The use of chemicals both pesticides and fertilizers increased with more land being brought under cultivation. With more people settling human and livestock pollution also increased.

Information inadequate on the presence on absence of chemical residues in the receiving waters.

The fauna which had been adversely affected by habitat changes due to development include those dependence upon villus. The decreased size of these habitat particularly affect a number of resident waterfowl species as well as some migrant birds and herbivores which rely on the villus for dry season grazing.

3.3.6 Cattle

Cattle in large herds generally occur in the area at streams and canals.

3.4 SOCIO ECONOMIC ENVIRONMENT

3.4.1 General

People are also an integral component of the environment and just as much as their actions impact on the environment their plight vis-a-vis their environment also needs careful consideration.

Suffice it to say that emancipation of these people from abject poverty should be the concern of all right thinking institutions and people not to mention it as responsibility of government.

3.4.2 Demographic Characteristic

The population comprises both original settlers and those who have moved into the area from other part of the island. Around 45% of the population were apparently living in the area, at the time the Udawalawe settlement programme began. Most of the other settlers are from Hambantota, Matara and Ratnapura districts and a few from Gampaha, Anuradhapura and Kurunegala districts.

3.4.2.1 Average household size

The average household size of the settlers amounted to 6 to 7 persons.

3.4.2.2 Sex composition

The number of males exceeds the number of females in the area. As per the figures released by the project office 57% are males and 43% females.

3.4.2.3 Age structures

A little over 50% of the populations below 25 years of age; 30% is below 14 years of age and another 23% between 15 and 25 years.

Those falling within the working age group of 15 to 65 years are approximately 80%.

3.4.2.4 Dependency Ratio

The dependency ratio, the no of persons dependent of each person of the age group 15 to 65 years of the population is 0.7. This means that approximately 100 persons between 15 and 65 years of age have to support an extra 70 persons in-terms of basic needs.

3.4.2.5 Ethnic and Religious composition

The area is homogeneous from the point of view of ethnicity and religious composition. Most of the households are sinhala buddhist households. Less than 2% are sinhala, catholics and the tamils and muslims are limited to less than 10 in numbers.

3.4.2.6 Educational level

The education level in the area was rather low prior to the implementation of Walawe project. At present less than 15% of the households are illiterate. Another 70% have proceeded beyond Grade 8 in school and the remaining have studied up to grade 5.

3.4.2.7 Migration

Outward migration within the past five years has been negligible. Very few members of the household were residing outside the project area. The majority of these persons are below 20 years of age and have left the area temporarily to pursue studies. Less than 15% have gone in search of employment.

3.4.3 Household characteristics

3.4.3.1 Residential Land

Residential land in the area comprises both legally allocated and encroached land. Although the intention of the project planners was to utilise only un-irrigable land for residential purposes there are some who have located their homes on irrigable land. The majority of the persons occupying encroached land have constructed their houses on irrigable land, a part of which has been converted into residential land.

3.4.3.2 Housing

Most of the houses in the area are of the traditional type with mud walls and thatched roofs. Less than 45% of the houses have brick walls, cement floors and tiled roofs. The majority of the houses are relatively small in size.
Sanitary arrangements in the area are not very satisfactory. The majority of toilets are of the pit type. A very few households have water seal toilets.
Drinking water facilities equally appears to be unsatisfactory with only, a few of the house holds have their own wells.
Of those who do not possess wells rely either on neighbouring wells, project wells, tube wells and irrigation channels and rivers.
Irrigation channels and rivers provide the main source of water for bathing.

3.4.3.3 Accessibility to services

Because of the well developed road network nearly 80% of the houses are accessible by a motorable road.
State owned buses and privately owned buses and vans are the most popular means of passenger transportation. Approximately 75% of the households are satisfied with the services provided. The majority of those who were dissatisfied are located away from the main towns and main roads particularly in Murawasihena, Binkama and Angunukolapelessa. The main reasons for their dissatisfaction were the erratic nature of the services and the overloading of vehicles.

Fever including malaria and diarrhoea are the common illness in the area and persons suffering from these ailments usually seek treatments from private Western Medical Practitioners, Ayurvedic Practitioners and Hospitals. These services however are not easily accessible to many of the households. Some have to travel over 4 miles to consult a private Western Medical Practitioner or an Ayurvedic Practitioner and to receive treatment from a hospital.
Other basic services such as schools, Co-operative stores and Post offices are easily accessible to most of the households since those are generally located within 2 to 3 miles of the residences.

Food items are obtained from a variety of sources. Rice is usually purchased from local shops and mills, fish from itinerant traders and village fairs, meat from local hunters and near by towns and vegetables from village fairs and near by towns.

Household items such as textiles for daily wear, kitchen utensils and torch batteries are generally obtained from local co-operative stores and variety stores located in most service centres. More expensive household items, such as furniture, jewellery, grocery and cutlery, sewing machines, textiles for special occasions and special items such as school books are available only in the large towns particularly at Embilipitiya.

3.4.3.4 Ownership of Household items

Basic house hold articles such as chairs, tables and beds are owned by most of the households. Many households also own radios, bicycles and even gold jewellery, particularly earrings. Items such as wristwatches, petromax lamps, sewing machines and wall clocks and television sets are owned by a fair number of households.

3.4.3.5. Ownership of farm equipments

The most common items of farm equipment owned by farmers are mammoties and ploughs. Besides these some also own sprayers, tractors, threshing machines and water pumps. The number owning such items however is relatively small.

3.4.3.6. Food habits

Rice is the staple food of the community. Rice is eaten most of the time with vegetables and at times with dried fish or fresh fish. The most popular form of protein is dried fish. Fresh fish is also a popular form of protein but unlike dried fish it is less frequently consumed. Consumption of tinned fish, eggs and meat is less popular. Eggs and meat are consumed by nearly 50% of the households and milk and fruit are not consumed regularly.

3.4.4. Land use

3.4.4.1 General

Paddy cultivation, subsidiary crop cultivation and homestead gardening represent the major types of land use within the project area. Paddy and subsidiary crops are grown under irrigation on low land holdings and homestead gardening is practised on the un-irrigable highlands.

3.4.4.2 Utilization of low land

All the un-irrigable low land is not utilized in any one season. Around 4% to 5% of the holdings remain unutilized.

The majority because of the inadequate supplies of water and the remainder because of a variety of factors such as recent acquisition, unsettled title, lack of cash and salinity.

All of the owned lowland is not cultivated by the owners. Around 8% of the holdings were cultivated by the others under different tenurial arrangements.

3.4.4.2.1 Paddy cultivation

Paddy is the major crop grown on the low lands. Of the households that grew paddy both in Yala and Maha some cultivated paddy on the entire holding and some only on a part of the holding. Walawe Project has been made a record on the highest yield of paddy per acre in the island exceeding 100 Bushels per acre and maintained that record over a decade.

3.4.4.2.2 Subsidiary crops

Subsidiary crops are grown both in Maha and Yala. The extent cultivated vary from less than 0.1 Ha.to over 1.0 Ha. Various crops are grown and of these Plantains, Chilies, Vegetables, Pulses are the most popular. A part of the produce is sold and the remainder is retained for domestic consumption.

3.4.4.3 Utilization of highland

Most of the homesteads are located on the un-irrigable highland, but a few who do not own highland have located their residences on paddy land.

Of those who operate in highlands some cultivate their own land some state land and others on both.
Some of the homesteads carry only permanent crops, some only temporary crops and others a mixture of permanent and temporary crops.

Temporary crops are relatively more important in Maha than in Yala. The popular temporary crops are green gram, vegetables and chilies while the more important permanent crops are coconut, jak, mangoes and plantains.

3.4.4.4 Market crops

Recently several private companies introduced some crops which have a market out side the island. Gherkin plantation has given a high priority amongst those crops which are grown in Chandrikawewa and Suriyawewa area widely and small scale in the other blocks. In addition malbery and asparagus are grown in Murawesihena and Binkama respectively.

3.4.4.5 Livestock farming

Livestock farming is not a major economic activity within the Walawe area but could be observed at a small scale.

Most households do not raise livestock mainly because of the absence of suitable veterinary facilities, pasture land and adequate credit.

Besides these there are also several other restraining factors. Some do not wish to raise livestock for religious reasons; some because of the fear of damage to crops; some because of the shortage of labour; some because of inadequate time & some because of inadequate cash.

Cattle and buffaloes are the most popular types of livestock. Animals are raised partly for commercial purposes and partly for domestic uses. Cattle are kept mainly for milk and buffaloes partly for milk and partly for farm work. A part of the milk was sold fresh and the other part sold in processed form as curd. Poultry is reared only for eggs

Most of the produce from livestock are sold either to the neighbours or to local traders. A few households also sell milk to the National Milk Board at its collecting centres established at Embilipitiya and Angunukolepelessa.

Those who sell livestock products, particularly milk derive a fairly substantial income from their produce.

It is noteworthy that many of the households raising cattle and buffaloes are not aware of the existence of veterinary facilities in the area.

The cattle and buffalo development project of Mahaweli Economic Agency introduced an awareness programme to this effect and assisted farmers in numerous ways.
Nearly all of the house holds had made use of the immunization facilities that were made available to them.

3.4.4.6 Homestead cultivation

Homestead gardening is practised by the majority of the households. Most of the homesteads are given to the cultivation of permanent crops. Of which the more important are Coconut Jack Mangoes and Plantains. Unlike those that grow permanent crops fewer households grow temporary crops and that too during the Maha season.

The more popular temporary crops are Green gram, Vegetables, Long Beans, Brinjals, Chilies and Manioc.

A part of the produce from the homesteads is retained for domestic consumption and a part is sold. Of the permanent crops Plantains, Coconut and Mangoes have a commercial value.

3.4.5 Economic Activities

3.4.5.1 Agriculture

Agriculture is the most important economic activity in the area and consists of the cultivation of paddy and crops on the irrigated lowlands and homestead gardening on the un-irrigable highlands. Paddy is the most popular crop on the irrigated lowlands and is grown both during the Maha season and the Yala season. Subsidiary crop cultivation on the irrigable lowlands is less widespread and is confined mainly to Muravesihena and Angunukolepelessa. The most important subsidiary crops grown are plantains, chilies and vegetables.

Homestead gardening includes the cultivation of both permeant and temporary crops. The more popular crops are coconut, jak and plantains. Fewer persons cultivate temporary crops and that too mainly during the Maha season. The more popular temporary crops are green gram, chilies and vegetables.

Livestock farming is also practised but is not very popular. Cattle and buffaloes are the major livestock types and are reared mainly for milk and draught purposes.

3.4.5.2 Industries

Industrial development in the area is negligible. Nearly all the major industries are state-owned industries and these include the Paper Mill at Chandrikawewa, the Tile Factory at Uswewa and the Rice Mills at Moraketiya, Kachchigala and Uswewa. The other industries in the area include a few small scale state-owned cottage industries such as textiles and some privately-owned service industries such carpentry work shops, rice mills, cycle repair shops, bakeries and motor repair shops.

3.4.5.3 Towns

The services required by the local population are provided by a few towns. Embilipitiya the largest, is located on the main Ratnapura, Hambantota road approximately 13 km from the Udawalawe Reservoir. The other towns are Angunukolepelessa, Thimbolketiya, Udawalawe, Tunkama, Pallegama and Barawakumbuka. All of these towns are essentially small service centres catering to the basic needs of their hinterland populations.

3.4.6 Labour force and employment

3.4.6.1 Labour force

The total families are 32126 and the population amounted around 156,000. The majority of the members of the labour force are males. Females comprise about 40% of the labour force. The labour force is markedly youthful.
There are more people in the younger age groups amongst the females.
The educational levels of the members of the labour force are quite high.

3.4.6.2 Employment

Less than 50% of the population between 18 and 65 yrs is permanently employed. Permanent employment is more wide spread amongst the males.

Agriculture provides the principle source of employment particularly to the chief householders. Around 10% of the chief householders have permanent jobs outside agriculture.
Because of the dearth of secondary activities all of these persons are employed in a variety of tertiary activities such as trading, teaching, security services, transport services and government institutions.

Some of the chief householders have subsidiary occupations. Most of the chief householders who are permanently employed outside agriculture take to farming as a subsidiary occupation. On the other hand for those who are permanently in agriculture the most important type of subsidiary employment is casual labour. Many of these persons work as agricultural labourers particularly during the periods of peak farming activity. The other important types of subsidiary employment are trading, carpentry, gemming and government services.

In some households a few members of the family are also employed, some permanently and others temporarily. Of those who were permanently employed some were in agriculture and others in non agricultural activities such as teaching, government services, security services, garment factories, footwear factory, sugar factory, Paper Corporation and labour work.

The majority of those who were temporarily employed worked as casual labours mainly in agriculture.

3.4.6.3 Unemployment

Nearly 40% of the members of the house holds between 18 years and 65 years are unemployed. As is to be expected the levels of unemployment are considerably higher amongst the females than amongst the males. The majority of the unemployed particularly amongst the males belongs to a younger age group. The educational levels varied considerably as between unemployed males and unemployed females.

3.4.7 Sources of income

The members of the households derive an income from a variety of sources. The most important source of income is the lowland. Off-farm earnings provide the next major source of income. A substantial number of households depend on food stamps. Homesteads provide a source of income to approximately 30% of the households. There are several other sources of income such as rent, pension and buying and selling of gems.

3.4.8 Liabilities

Some of the households have liabilities such as debts and mortgages. The majority of those who had liabilities were in debt either to private individuals or government institutions.

In addition to debts some households have also pawned items such as jewellery, watches and bicycles and mortgaged their land. But mortgaging of land was not common.

3.4.9 Communications

The area is accessible only by road. Highway A-18 which runs from Pelmadulla to the Nonagama Junction traverses the area and functions as the major access road. The area is also served by two minor roads one running from Timbolketiya to Thanamalwila and the other from Tunkama to Hungama via Angunukolapelessa. The other roads are mainly gravel roads. Although classified as fair weather roads they are motorable even during the rainy season and hence provide access to most of the settlements in the area.

3.4.10 Infrastructure

3.4.10.1 Schools

The educational needs of the area are supplied by 64 schools, of which one Madhya Maha Vidyalaya, 13 senior schools, 36 junior schools and 14 primary schools.

The teaching staff in the schools comprises graduates, trained teachers, untrained teachers and teachers having the necessary qualifications.

3.4.10.2 Hospitals

The area is served by 04 hospitals and two government dispensaries and two ayurvedic hospitals and one ayurvedic dispensary.

3.4.10.3 Banks

The necessary banking services are provided by 24 banks of which 03 are rural banks.

3.4.10.4 Other Infrastructures

The area is served by 05 post offices, 20 sub post offices, 52 co-operative regional, 11 co-operative rural banks, 12 weekly fairs, 05 police stations, 03 divisional secretary offices, 77 grama niladari offices and 03 courts.

3.4.10.5 Places of Religious Worship

The area has 80 temples of which the cultural and archaeological value is considered in high esteem and two catholic churches.

3.4.11 Fuel Wood Supply

Fuel wood is a widely used source of energy in the area and will continue to have future demand as well. But the availability of fuel wood will decrease. The fuel wood is not a fundamental problem at present since many families obtain their fuel wood from the secondary forest which is transported mostly on bicycle by the men. Women do not venture out over long distances but gather fuel wood more within reasonable walking distances of their homes. In town areas people purchase fuel wood for ordinary day to day needs but the purchase figure is not that significant.

3.4.12 Domestic Water Supply

Domestic water supply is a fundamental problem now and will be so in the future. Analysis of well water in several places has indicated its unsuitability for human consumption due to high electrical conductivity and dissolved ions of fluorine and chlorine.

3.4.13 Diseases

Environmental changes associated with the development of irrigated agriculture and human settlements are known to have a great impact on vector and water- borne diseases. The network of irrigation canals had been created good breeding grounds for mosquitoes. Gem miners in the area left uncovered pits which collect water.

These effects arise from project related changes such as increased volume of open water, the creation of new areas of standing water changes of the annual water level in the small tanks and changes in the ratio of domestic animals to the human population.

Malaria and diarrhoea are the major diseases in the area. Other health hazards encountered are snake bite, poisoning, agricultural accidents and water-borne diseases associated with sanitation.

Chapter 4

4.1 Environmental Impacts of the Pulp & Paper Industry

Production of pulp & paper affects the environment in a number of ways. Basically they are

Air pollution
Water pollution
Land pollution
Noise pollution
Thermal pollution

Pollutants are discharged into the air and water, noise is generated & the mill buildings & stacks constitute a feature of the landscape.

Noise from the process equipment & from internal & external means of transport being features of all mills. Moreover the land scape picture is affected, especially by pulp & paper mills. The process equipment can be 50-100m in height, with chimney stacks rising to between 100 & 150m.

The air & water pollutants originating from the wood & non wood components & from the normal process chemicals may be included in the process discharge.

In addition, the mills emit & certain amount of auxiliary chemicals like chelating agents & slimicides.

Most of the solid water pollutants from pulp & paper mills consists of fibres escaping from the process. The rest consists of solid inorganic salts bark & wood fragments mineral fillers etc. These form deposits mainly close to the point of discharge. However, the finest particles are carried long distances by water, making it turbid.

The dissolved water pollutants from the process can be classified into coloured material, easily & slowly biodegradable material, toxic material & salts. The coloured material originates mainly from the wood lignin. Highly coloured effluent are those from the bleaching & screening departments in a pulp mill.

The coloured compounds are relatively stable to biodegration. Under certain conditions they reduce the penetration of solar rays into water & thereby reduce the biological activity in the water and on the bottom.

Part of the material emitted from pulp & paper mills is rapidly degraded by the micro - organisms in the water. The biological degradation of organic material, dissolved oxygen is consumed.In extreme cases this can lead to oxygen depletion, which severally affects aquatic life.

Example of toxic components in the effluent are free chlorine from the bleach plant & resin & fatty acid soaps from mechanical as well as chemical pulping & bleaching.
Gases and dust are emitted from pulp & paper mills. Sulphur dioxide, some hydrogen sulphide & other malodorous compounds are emitted from sulphate mills & sulphur dioxide from sulphite mills. Small amounts of chlorine & chlorine dioxide are also emitted from the bleach plants, but will normally not cause any effects outside the mill area. The solid material consists mainly of inorganic salts. It should be pointed out, however, that by far the greater part of the chemicals including the sulphur compounds are recycled & reused within the process in modern mills.

The main environmental impacts of pulp & paper industry comes from the pulping & bleaching of chemical pulp. The pollution load from mechanical pulping & paper making process is usually lower. However the pollution arising from the sources described in this para could not be destroyed but should control.

4.2 Process Descriptions of the Embilipitiya Mill

The fibrous raw material wood / straw is composed principally of cellulose, hemi cellulose & lignin $\{C_5H_7O_2(OCH)_3\}$. Cellulose is composed of long chains of identical chemical units. Lignin is the glue keeping the fibres together in the living plant. Lignin contains chromophoric groups giving the fibre a more or less coloured appearance.

High yield pulp does not generally form a strong paper. It is necessary to remove the major part of the lignin from the fibres in order to improve the strength characteristics of the pulps. In the process a large part of the hemicelluloses are also removed. Depending on the amount of lignin removed the characteristics of the pulp change & the pulp yield drops. There are no well defined yield limits between various groups of pulps. The following table gives a rough indication of the yields for the main pulp groups.

Pulp group	Pulp yield %	Process example
mechanical	90-97	stone
chemimechanical	85-95	cold soda
semi chemical	60-85	NSSC
chemical	40-60	sulphite, sulphate
dissolving	30-45	sulphite, sulphate

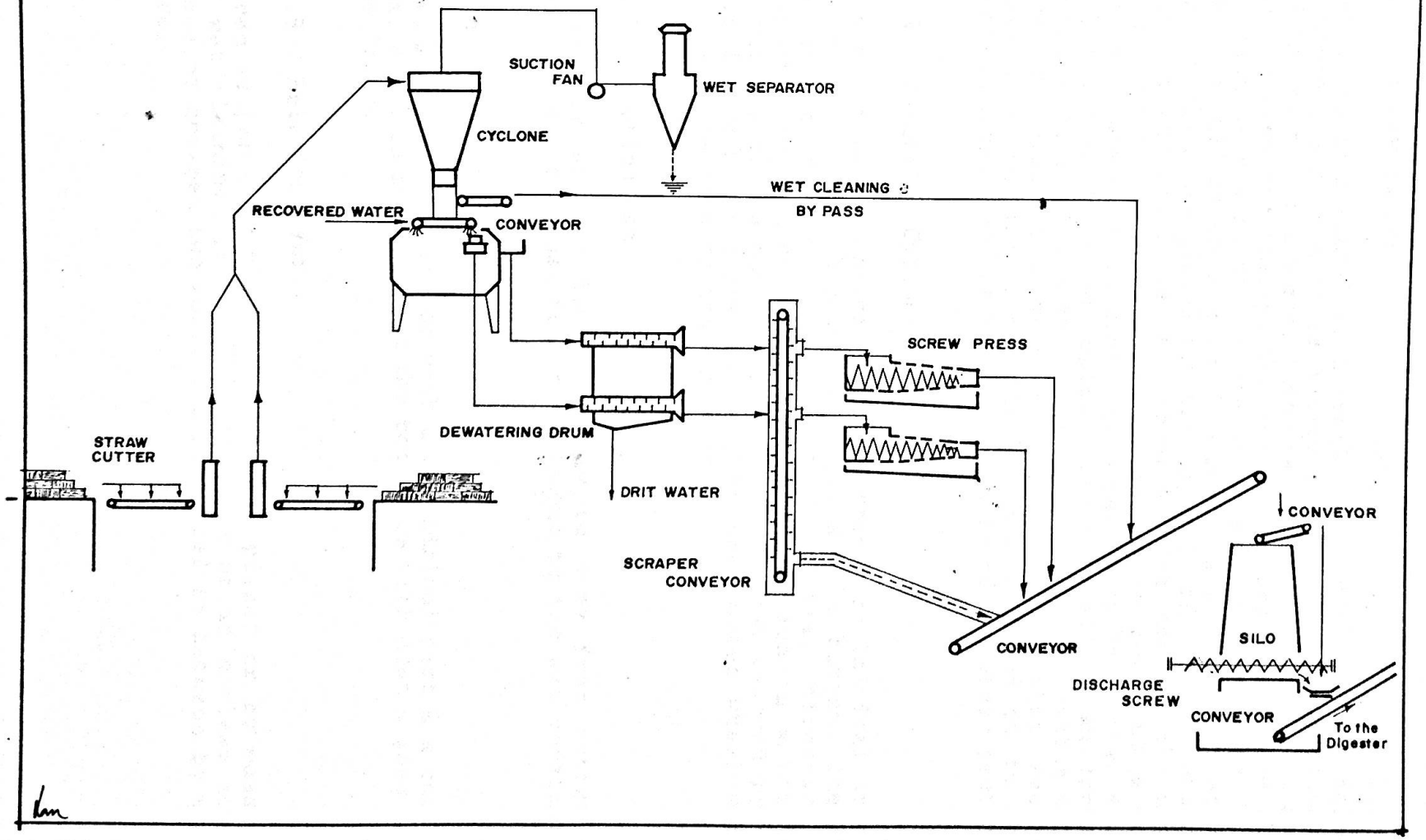
Chemical & dissolving pulps are both of the chemical pulp type which means that the fibres are liberated by chemical dissolution of the lignin middle lammella. Thus no mechanical action in refiners or beaters is required for fibre separation; except possibly for the treatment of knots & rejects.
The chemical recovery is common practice in the manufacture of chemical & dissolving pulps. In developed countries it is said if there is no chemical recovery there is no viable process of pulp & paper.

4.2.1 Straw preparation

The baled straw is fed into the cutter by a bale conveyor from which the cut straw is blown in to the deducting cyclone. The dust from the cyclone goes out through the top & is blown in to the wet separator through a suction fan. Dust is mixed with water & sent down the drain. The dust free straw from the cyclone drops on-to a reversible conveyor which can either by pass the whole wet, cleaning process or drop the straw into the pulper. The straw is mixed with water in the pulper which has an agitator at the bottom. This mixture over flows into the de-watering drums where the dirt water is drained out. Washed straw from the de-watering drums falls in to the scraper conveyor which can either feed the straw into either of the screw presses or by pass them & send the straw to the silo. The straw from the scraping conveyor is fed into screw presses where it is pressed & some of the water is squeezed out. From here the straw drops on to the conveyor which takes it to the top of the silo where it drops on to another small conveyor which can either drop the straw into the silo or by pass the silo & send it to the digester house. Straw is discharged out of this silo by means of a discharge screw & drops it onto conveyor which in turn drops it into another conveyor which conveys it to the top of the digester house. The washed water from the system flows into a dirt water chest & this water is recycled. The overflow from the chest is passed through an arc screen where the solid impurities are removed.

The basic change which occur in this system is physical. The size of straw is brought down & relived of its dirt.

CUTTER HOUSE



4.2.1.1 Straw cutter

This consists of a shovel roll (roll with radial plate paddles) which opens the bale & it is seized by the devil roll situated behind the shovel roll & sent into the feed chain. The devil roll can be adjusted vertically. The adjustment depends on the size & condition of the bales. If the bale is of bigger height then this roll should be brought up. The feed chain is made of strips of small angle irons linked together by rollers. The rollers run on circular wheels. There is a lower & upper chain & the upper chain is pivoted at one end & the other end moves up & down according to the material flow. Straw passes to the cutter knife through the toothed press rolls. These consists of an upper & lower rolls which presses the straw by means of the movable upper roll which moves on a vertical guide. The cutting section consists of a six arm rotor with six knives fixed on to it & there dead knives fixed at the exit opening of the press section.

4.2.1.2 Dedusting Cyclone

This is a big vessel conical at the bottom & cylindrical at the top made of steel with a bucket wheel at the bottom. The cut straw enters the cyclone, in a tangential direction & consequently the straw performs a vortex motion in which the light dust particles move towards the top & get removed by the suction fan and the straw drops on to the bucket wheel which pulls the straw down to the conveyor.

4.2.1.3 Suction Fan

This produces suction for the straw to come from cutter to cyclone & blows the dust from the cyclone to the wet separator.

4.2.1.4 Wet Separator

This is a steel construction with a cylindrical part & a conical bottom. Water is sprayed from the top mixes with dust & goes down to the drain.

4.2.1.5 Belt Conveyor

This can either drop the straw into the pulper or by pass the whole wet cleaning system. This consists of an endless rubber belt moving between two rollers & supported in between by small rollers.

4.2.1.6 Pulper

This is a cylindrical steel vessel with an agitator fixed vertically from the bottom.
When the straw is mixed with water & agitated, the mixture performs a forced vortex motion.As the cut straw falls from the conveyor into the centre of the vortex. The heavy impurities get sucked down into the vortex & settles down at the bottom. The straw water mixture over flows tangentially out into the dewatering drums.

4.2.1.7 Dewatering drum

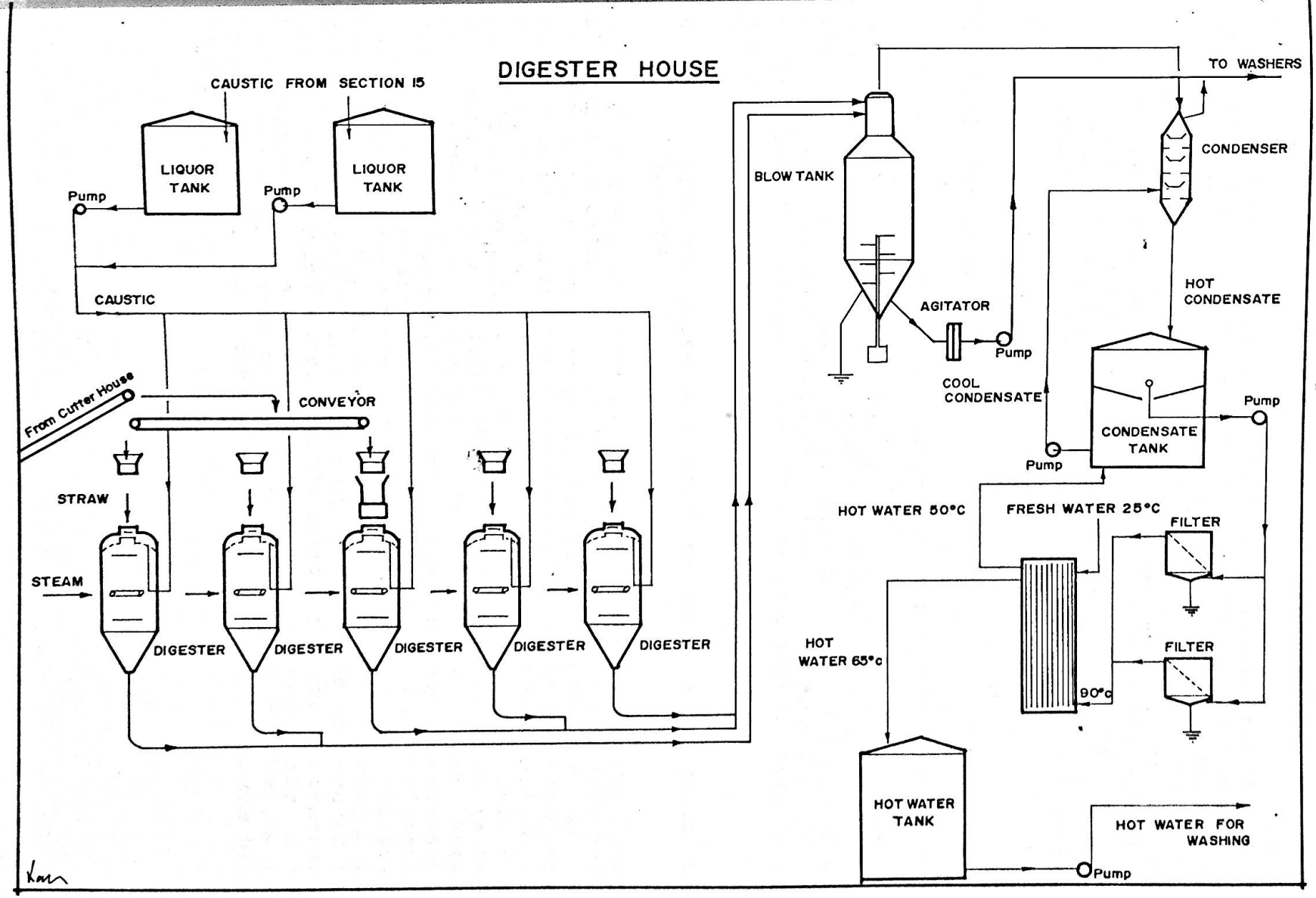
This is a mild steel cylindrical perforated drum which rotates, resting between two wheels at both ends of the drum like a rotating kiln. The over flow from the pulper enters into the drum through one end & discharges into the scraper conveyor through the other end, during which time the dirt water is drained out through the perforations in the shell of the drum. The removal of dirt is facilitated by water sprays on top of the drum.

4.2.1.8 Scraper Conveyor

This consists of two chains running horizontally on sprocket wheels with plates fixed between the chains vertically like paddles & whole unit is fixed inside a box with two openings at the bottom for discharging. When the straw drops on the conveyor it gets pushed on by the paddles & as the chain goes round the sprocket & comes back, The paddles scrape the straw along the bottom of the box & discharge it through the openings into the screw presses. If the presses needs to be by passed, these two openings would be closed by a hand wheel & straw gets scraped to the end of the box where thorough a third opening it drops on to the belt conveyor to the silo.

4.2.1.9 Screwpress

This consists of conical screw conveyor made of alloy steel completely covered by a casing of cast steel. As the straw passes through the screw it get compressed & squeezed out water flows out through the openings on the casing. The straw from straw preparation to the silo conveys by a belt conveyor.


DIGESTER HOUSE
CAUSTIC FROM SECTION 15
LIQUOR TANK
LIQUOR TANK
Pump
Pump
CAUSTIC
From Cutter House
CONVEYOR
STRAW
STEAM
DIGESTER
DIGESTER
DIGESTER
DIGESTER
DIGESTER
BLOW TANK
AGITATOR
Pump
TO WASHERS
CONDENSER
HOT CONDENSATE
COOL CONDENSATE
CONDENSATE TANK
Pump
Pump
HOT WATER 50°C
FRESH WATER 25°C
FILTER
FILTER
HOT WATER 65°c
90°c
HOT WATER TANK
HOT WATER FOR WASHING
Pump

4.2.1.10 Silo Discharge Screw

This discharges the straw from the silo which consists of a long screw at the bottom of the silo going right across the silo & supported both ends on wheels which move on rails. The drive side of the screw is fixed on to a wagon which comprises the motor gear box & chain drive unit which rotates the screw as well as give a transverse movement both thorough separate motors & drives. Straw discharged from the silo conveys to the digester house by a series of belt conveyors. The water from the dirt water collecting chest to the pulper is pumped by a centrifugal pump.

4.2.1.11 Arc Screen

This removes the solid impurities from the dirt water over flowing from the dirt water collecting chest. This is made up of a perforated stainless steel plate fixed at a very steep angle.Water flows over the top of it and goes through the screen leaving the dirt to slide down the screen. The screen should be cleaned from time to time to avoid blockage of holes with dirt. Dirt falling from the arc screen conveys to a waiting trailer by a belt conveyor.

4.2.2. Digester house and heat recovery description of process

Straw from the silo comes up to the digester house top floor through a conveyor and drops on to another conveyor which rest on wheels that are movable on rails. This conveyor can be positioned to fill any one of the digesters. Straw falls from the conveyor through a feed tube, in to the digester. Caustic is pumped from the storage tanks in the digester house, into the digester. When the required amount of caustic and straw is fed into the digester, the digester lid should be closed, steam opened and rotation should be started. When the required pressure is reached the steam valve should be throttled and left slightly opened to compensate for the heat losses after the required amount of time has passed, the digester rotation should be stopped, the pressure inside the digester should be reduced by opening the degazing valve. When the desired pressure is reached, the degazing valve should be closed and the blow pipe should be hooked onto the bottom of the digester. As the blow valve is opened the stock inside the digester will get blown into the blow tank.

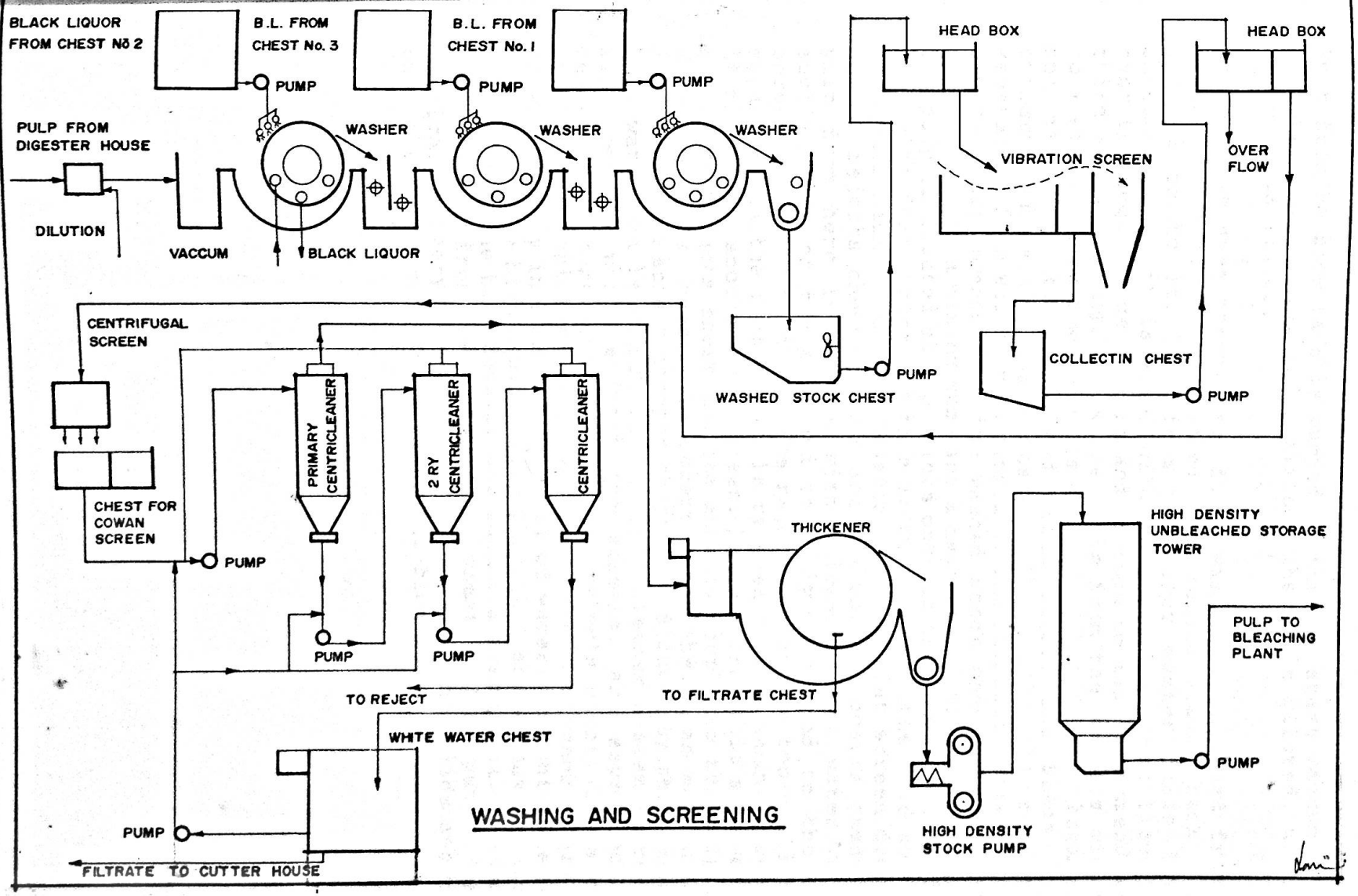
4.2.3 Heat Recovery

During degazing and blowing hot vapours will be blown in to blow tank from the digester. These vapours comes out of the top of the blow tank and passes into the condenser where it is sprayed with water from the condensate tank. Amount of water sprayed is controlled by a temperature controller which controls it according to the temperature of condensate flowing out of the condenser. The condensate tank is divided in two, upper chamber and a lower chamber. The upper chamber is at a higher temperature than the lower chamber. Condensate from the condenser flows into the upper chamber of the condensate tank from where it is pumped to the heat exchanger through a filter and comes back to the lower chamber of the condensate tank from there it is recycled by spraying in the condenser. The fresh water addition to the heat exchanger is controlled by a temperature controller which actuates according to the temperature of condensate flowing out of the heat exchanger. Heated water from heat exchanger flows into the hot water tank. From this tank hot water is pumped through an injection steam heater, to the pulp mill. Steam is added to the hot water through the injection steam heater and it is controlled by temperature controller which maintains the temperature of hot water flowing out of the heater. The straw into the digesters fed through a feed tube by a belt conveyor.

4.2.4 Digester

The main body of the digester is cylindrical in shape and it changes smoothly into a conical shape at both of its ends. At one end it has the opening for the filling (1000mm dia.) and at the other end is flange for the ball valve 200mm dia. This is supported by two shafts welded on to the out side face of its body at two diametrically opposite points on the middle plane of the digester. A big gear wheel is bolted to one side of digester which is driven by a small pinion wheel of a reduction gear box driven by a motor. Steam is sent through one of the shafts whose inner end is joined to a perforated pipe which runs along the inner side of the digester in the form of a circle. Steam is injected through to the perforation on this pipe. The inner side of the other journal is joined to a pipe which runs up along digester wall towards the mouth of the digester and is welded on to a perforated chamber around the mouth of the digester. This pipe is used for degazing.

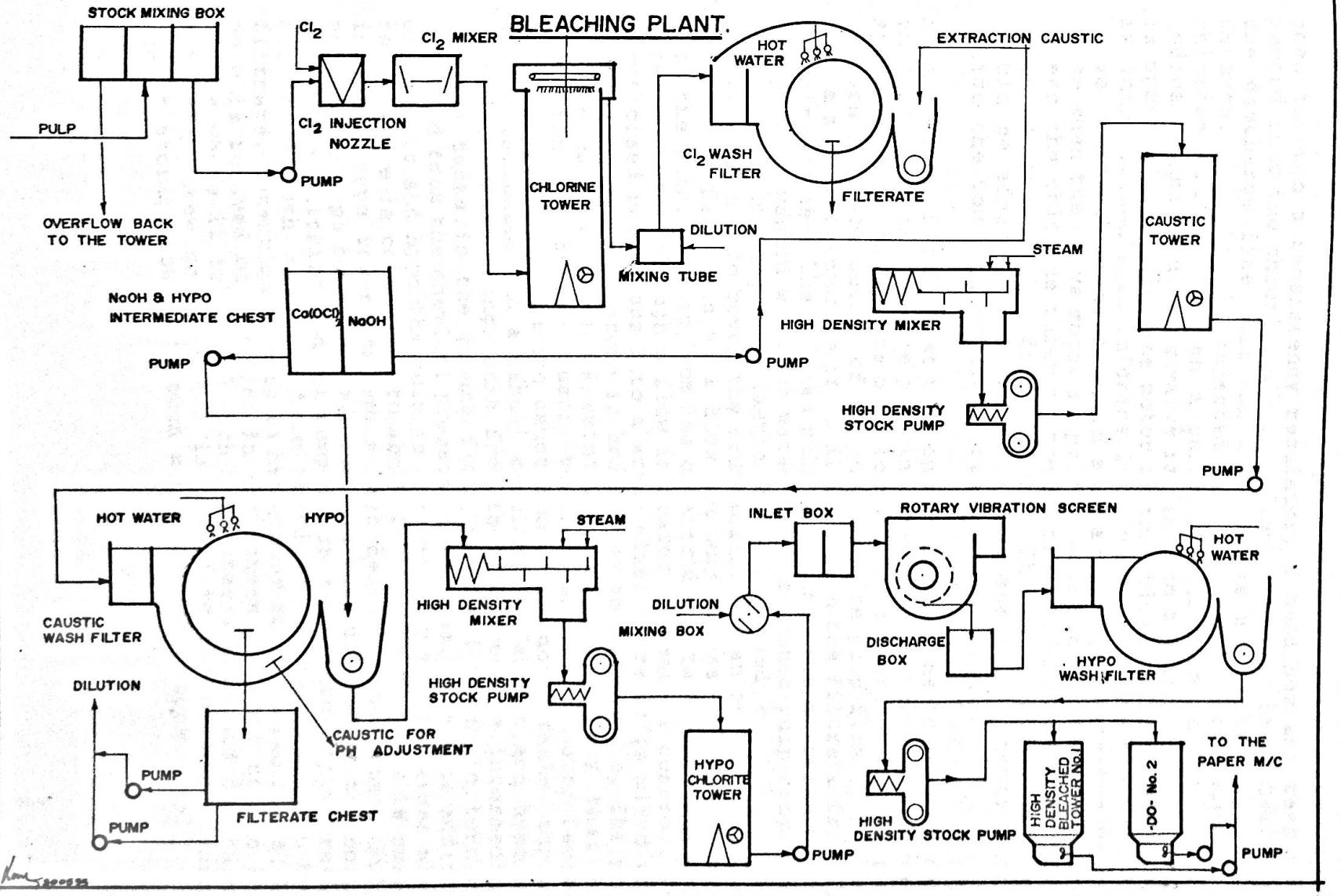
The perforated chamber will allow only the vapours to go through, thus preventing any pulp going into the degazing pipe. Further more during degazing the digester must be in a vertical position with mount facing the top, so that black liquor will not go into the chamber and the degazing pipe. A provision is made in the pipe line to add cooking liquor also through this pipe.


BLACK LIQUOR FROM CHEST Nō 2
B.L. FROM CHEST No. 3
B.L. FROM CHEST No. 1
PUMP
PUMP
PUMP
PULP FROM DIGESTER HOUSE
WASHER
WASHER
WASHER
DILUTION
VACCUM
BLACK LIQUOR
HEAD BOX
HEAD BOX
VIBRATION SCREEN
OVER FLOW
CENTRIFUGAL SCREEN
PRIMARY CENTRICLEANER
2 RY CENTRICLEANER
CENTRICLEANER
WASHED STOCK CHEST
PUMP
COLLECTIN CHEST
PUMP
CHEST FOR COWAN SCREEN
PUMP
PUMP
PUMP
THICKENER
HIGH DENSITY UNBLEACHED STORAGE TOWER
PULP TO BLEACHING PLANT
PUMP
TO REJECT
TO FILTRATE CHEST
WHITE WATER CHEST
PUMP
FILTRATE TO CUTTER HOUSE
HIGH DENSITY STOCK PUMP
WASHING AND SCREENING

4.2.5 Washing and Screening

Pulp from he blow tank is pumped to the 1st stage vacuum washer through s metal trap and a mixing tube it is diluted, with 1st stage black liquor.

As the pulp goes through the first washer it is freed from the black liquor and it is washed with second stage black liquor sprayed on to it. Pulp from the first washer falls into a shredder where it is mixed with second stage black liquor and sent to second stage washing and in turn to another shredder for third stage washing. The washed pulp from the washers drops on to a screw conveyor where it is diluted with thickener back water and sent down to the washed stock chest. The black liquor extracted from all three washers flows into the respective separators from which it is pumped to the respective black liquor chests. Pulp pumped from the washed stock chest flows to flat screen through a mixing tube and a head box. During this transfer the pulp is diluted at two points once at the suction side of the pump with fresh water and then at the inlet to the head box with thickener back water. The rejects from the flat screen drops in to the rejects chest and the accepts to the accepts chest. The pulp from here is diluted with thickener back water at the suction side of the pump and the pulp is pumped to the cowan screen through a head box. The rejects which are too small to be separated in the flat screen is removed in the cowan screen and it flows into another flat screen. Rejects from this screen drops in to the rejects chest and the accepts drop into the pulp flat screen accepts chest. The accepts from the cowan screen drops into the cowan screen accepts chest gets diluted by the thickener back water and is pumped to the centricleaner system where very fine rejects which escaped the screens, are separated. The rejects from here is dropped in the rejects chest. The accepts from the centricleaners flow in to the thickener where its consistency is increased by removal of water. The thickened pulp drops into the high density pulp through a screw conveyor and is pumped into the high density unbleached storage tank. The excess black liquor from the black liquor chest No.1 is pumped to the chemical recovery system through arc screen. The solids separated from the arc screen drops in to the blow tank.


BLEACHING PLANT.
STOCK MIXING BOX
PULP
OVERFLOW BACK TO THE TOWER
PUMP
Cl_2
Cl_2 INJECTION NOZZLE
Cl_2 MIXER
CHLORINE TOWER
DILUTION
MIXING TUBE
HOT WATER
Cl_2 WASH FILTER
FILTERATE
EXTRACTION CAUSTIC
NaOH & HYPO INTERMEDIATE CHEST
$Ca(OCl)_2$
NaOH
PUMP
PUMP
STEAM
HIGH DENSITY MIXER
HIGH DENSITY STOCK PUMP
CAUSTIC TOWER
PUMP
HOT WATER
HYPO
CAUSTIC WASH FILTER
DILUTION
PUMP
PUMP
FILTERATE CHEST
CAUSTIC FOR PH ADJUSTMENT
STEAM
HIGH DENSITY MIXER
HIGH DENSITY STOCK PUMP
HYPO CHLORITE TOWER
PUMP
INLET BOX
DILUTION
MIXING BOX
ROTARY VIBRATION SCREEN
DISCHARGE BOX
HOT WATER
HYPO WASH FILTER
HIGH DENSITY STOCK PUMP
HIGH DENSITY BLEACHED TOWER No.1
-DO- No. 2
TO THE PAPER M/C
PUMP

4.2.6 Bleaching

The pulp pumped from the Brown Stock High Density Storage Tower goes through a consistency regulator, a head box and then gets pumped into the chlorine mixer. A flow indicator is installed on the discharge line head box which gives amount of pulp going through. Chlorine is injected into the line just before the chlorine mixture through a chlorine injection nozzle. A flow indicator and regulating valve is fixed on the line and the valve is operated manually. The motor of the chlorine mixer inlet pump is inter locked with chlorine inlet valve and the stock outlet valve of the chlorine mixer in such a way that these two valves close when the above motor stops. The pulp from the chorine mixer enters the chlorine tubes at the bottom and it comes out of the tower by overflowing from the top. The rate of flow of pulp should be adjusted in such a way that the pulp retention time inside the tower is about one hour.

A scraper is installed at the top of the chlorine tower to scrape the overflow and drop the pulp into the overflow chamber. A water spray is fixed inside the overflow chamber to facilitate the pulp to flow into the outlet of the chamber. The pulp flows from here into a mixing tube where it is diluted with the filtrate from the chlorine washer. The diluted pulp flows into the chlorine washer where it is washed with hot water and the washed pulp drops into the screw conveyor. A plastic hood is fixed on top of the chlorine washer to cover the drum and it has an outlet duct with an exhaust fan. This will blow out any excess chlorine coming with the pulp. Caustic from the caustic doing tank flows into the screw conveyor through a flow indicator and manual control. The causticised pulp drops into a steam mixer where it is mixed with steam and the temperature is brought up to about 60° c. The pulp in the caustic tower is maintained in such a way that the retention time in the caustic tower is about one hour. Caustic and hypo is added from the caustic and hypo doing tanks, through a flow indicator and a manual regulator. Caustic and hypo are pumped to these doing tanks from their respective intermediate storage tanks in the ground floor/pulp mill which in turn are supplied from the chemical preparation system. After the addition of caustic and hypo the pulp is dropped into a steam mixer where temperature is controlled to about 40° c maximum and it is pumped into the hypo tower through a high density stock pump. Pulp enters the hypo tower through the top, gets diluted at the bottom with hypo filtrate and is pumped out to the rotary vibration screen through a mixing tube where it is diluted with hypo filtrate. Retention of pulp in hypo tower is about two hours. The pulp is removed of any dirt in the screen and sent to the hypo filter where it is washed with hot water sprays and discharges into the screw conveyor and is pumped to one of high density bleach storage towers through a high density stock pump.

4.3 Air Pollutants

The delicate balance of the atmosphere is effected by the emissions to the atmosphere from the pulp & paper industry. The main emissions to the atmosphere can be classified as listed below.

Sulphur compounds
Chlorine compounds
Inorganic dust
Organic dust
Flue gas

These emissions come out from cooking, washing, bleaching plant, boilers, evaporation plant, lime kiln & from recovery boilers.

The main environmental impacts of the pulp & paper industry caused by the emissions from the pulping, bleaching of chemical pulp & from the recovery plant.

4.3.1 Sulphur compounds

The emissions of sulphur compounds to the air are of two types.

1. Malodorous compounds, such as hydrogen sulphide(H_2S), Methyl Mercaptan(MN), CH_3SH,Dimethyl Sulphide(DMS),CH_3SCH_3 & Dimethyl Disulphide(DMDS),CH_3SSCH_3

2. Sulphur Dioxide(SO_2)

The malodorous compounds are formed mainly in the sulphate cooking process. The sulphur dioxide is liberated in the acid sulphite process but also in the neutral sulphite & bisulphite processes. In the sulphate processes some SO_2 is formed in the recovery boiler. Nevertheless by the soda process being used at Embilipitiya mills, emits neither malodorous compounds nor sulphur dioxide provided that the chemical system can be kept free from sulphur. However this has proved to be very difficult.

Sulphur Dioxide is emitted from the recovery furnace & the lime kiln. In soda process with very low sulphur to sodium ratio normally $NOSO_2$ is emitted from the black liquor burning. From the lime kiln the SO_2 emission is mainly caused by the sulphur in the fuel. Still, most of the sulphur dioxide is absorbed in the lime & transferred to the white liquor. Low Ph of the liquors used for washing increases SO_2. Sulphur containing gasses are toxic to man.

Further sulphur dioxide can be converted in to sulphuric acid in the atmosphere which could contribute to acid rains.

By the soda pulping process used at Embilipitiya mill the SO_2 emissions are very low (which emits only by the furnace oil for steam production at boilers). Thus the danger of acid rains are irrelevant to discuss.

Nevertheless in major pulp producing countries like Sweden the acid rains had been experienced. It is learnt that by using modern emission control techniques & methods polluting emissions are maintained within the acceptable limits (Threshold values).

4.3.2 Chlorine Compounds

The chlorine compounds are emitted in minor amounts from the lignin dissolving bleaching processes. The aim of the bleaching process is to increase the visual qualities like the brightness or whiteness of the pulp. When bleaching chemical pulps the dark coloured lignin residues are removed by applying chlorine containing chemicals like chlorine, chlorine dioxide, hypochlorite.

The emissions are mostly of the so called "Diffuse"type which means that the emissions are not located to any particular point source but originate as fumes from tank vents, wash filters, sewers etc. The gasses are chlorine or chlorine dioxide.

At Embilipitiya mill for bleaching the pulp free chlorine injects to the pulp, Thus emitting free chlorine from the bleaching section. Chlorine gas it self is toxic to man.

Further the Cl_2 gas react with organic compounds in the wood resins & organically bounded chlorine comes out from the bleaching section which is more toxic to human body. This includes total organically bounded in the washed liquor.

4.3.3 Inorganic and Organic Dust

Inorganic dust is emitted from recovery boilers oil or coal fired boilers & from lime kiln. With efficient dust filters especially electro filters & scrubbers the atmospheric emissions can be brought down to very low values. The dust consists mainly of sulphates & carbonates.

In Embilipitiya mill inorganic dust emitted mainly from raw material preparation section & from the black liquor burning kiln. The latter is not in operation at present.
But in the straw preparation section the scrubbing system is used to minimise the dust emissions.

In the raw material preparation department of the mills some dust of organic nature is often formed, for instance at dry debarking of wood in barking drums, or in the dry depithing of bagasse or in dry cleaning of straw. Chipping & handling of bamboo also create large amounts of organic & inorganic dust. In the case of bagasse dry depithing, the dust has been found to cause bagassosis a respiratory illness.

Organic compounds other than those containing sulphur, are emitted from various sources in the process. The major types of compounds include Terpenes, Hydrocarbons, Alcohols & other organic compounds released when pulp producing with wood species or straw in the chemical process.

The emission rate and significance of these compounds has not been very well investigated although it is well known that some of them can act as odorants.

The flue gases from the recovery furnace & the lime kiln contain minor amounts of polyaromatic hydrocarbons. Polyaromatic Hydrocarbons form a group of compounds containing several aromatic rings and many of the compounds are known to cause cancer.

However in Embilipitiya mill since debarked woods are used in the process emission of organic dust is very less.

4.3.4 Flue gas.

In Embilipitiya mills flue gas emits from the furnace oil burning in the steam producing boiler & the black liquor burning kiln. This may contain carbon monoxide (CO) carbon dioxide, nitrogen oxides(NOX) sulphur dioxides(SO_2). All volatile compounds.

The environmentalists jargon "the green house effect" is the result of the delicate balance of atmospheric oxygen & carbon dioxide being upset by human activities.
The increase in the layer of Co_2 is estimated to be responsible for an increase in global temperature by 2°C in year 2015 affecting the ecological balance. Even though no findings were made regarding the amount of carbon dioxide emission in the Embilipitiya mill. Those emissions may contribute to the increase in the layer of Co_2 of the atmosphere, as a whole.

Nitrogen oxides are formed during all types of thermal combustion. This formation occurs, either through reaction between the atmospheric nitrogen & oxygen or through a reaction between nitrogen in the fuel & atmospheric oxygen. The major compound resulting from the combustion is nitrogen monoxide. Smaller quantities of nitrogen dioxide, normally less than 5% are also formed.

The amount of nitrogen oxides formed depends on several factors. The most essential being the flame temperature & the oxygen concentration in the flame. The formation of nitrogen oxides increases rapidly with temperatures above 1300° C, particularly when the oxygen concentration is above 2%. In addition to these two parameters, the nitrogen content of the fuel & the configuration of the combustion unit influence the nitrogen oxide formation.

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Emissions of nitrogen oxide subject to a reversible reaction by sunlight & presence of hydro carbons depleting ozone in the atmosphere causing damage to the ozone layer protecting us from ultraviolet rays

$$NO \xrightarrow[\text{Hydrocarbon}]{} NO_2 \longrightarrow O + O_2 \longrightarrow O_3$$

In Embilipitiya mill the boiler temperature is 1500° C. Therefore emissions of nitrogen oxides could be expected though investigations have not been made so far.

In pulp and paper Industry steam generation processes also emits toxic compounds. Nevertheless at Embilipitiya mill steam generation process has been a complete process thus emissions are negligible.

4.4 Water Pollutants

Basically the paper mill has two types of effluent, the normal effluent resulting from washing of straw & the black liquor resulting from cooking of straw in caustic soda. The former is relatively harmless and may amount to 18,000 m^3 per day. The main component is organic matter as revealed by high chemical oxygen demand (COD) & biological oxygen demand after 3 days (BOD3) values. A major fear is the contamination of drinking water pumped to Ambalantota & Hambantota. River water is also used by the people along its way. Impacts on aquatic life in the river and in the estuary is another area of concern.

The black liquor containing caustic soda & lignin, presently constitutes a major problem. The effluent is now stored in an open ponds to the extent of 34 acres & discharges at intervals via a pipe to the Walawe River. While this is by no means the perfect solution it would be necessary to pursue research & development towards a rational solution, so that large quantities of paddy straw available in the Walawe basin can be readily utilized & those dependent on the water resource will not be deprived of a legitimate right.

The main parameters of pulp and paper mill waste water are PH suspended solids, BOD5 and COD, colour sulphide phosphorous, nitrogen, sodium, mercury and toxicity. All those pollutants comes out from the raw material preparation plant, cooking, washing & bleaching plants paper machine & chemical recovery plant.

The discharges to water may be classified according to the following scheme.

Suspended solids
Slowly biodegradable compounds
Easily biodegradable compounds
Toxic compounds
PH changing compounds
Inorganic salts

4.4.1 Suspended Solids

The major part of the suspended solids in the mill effluent usually consists of fibres or fibre particles. The fibres are of the same type as those in the final products. Fibres are detrimental because they tend to settle in the receiving water forming fibre banks in which fermentation may occur. This may cause oxygen depletion. Suspended fibres in the water cause turbidity. It also causes stress symptoms to fish and influences their respiration rate, growth rate, blood composition, ability to find food, avoid enemies etc. It has been concluded that low concentrations (below 25 mg/l) of suspended material is not harmful to fish life. Chemical pulp fibres decompose more rapidly in comparison to other pulps.

4.4.2 Slowly Biodegradable Compounds

Slowly biodegradable compounds in the mill effluent mainly consist of high molecular substances of lignin & carbohydrate origin. The amount of such compounds in the mill effluent could be estimated by measuring the COD value (chemical oxygen demand) & subtracting the BOD value (biological oxygen demand) from it. The lower the ratio BOD/COD the higher is the fraction of slowly biodegradable compounds.

Such compounds are usually coloured & originates mainly from wood lignins. Highly coloured effluent are those from the bleaching & screening sections in the pulp mill. The coloured compounds reduce light penetration into the water. They also affect the drinking water. Living organisms may absorb slowly biodegradable compounds which may cause them biological changes.

4.4.3 Easily Biodegradable Compounds

The content of easily biodegradable compounds is usually measured by the BOD test. A considerable part of the wood components dissolved in the pulping & bleaching processes is easily biodegradable. Examples of such compounds are low molecular hemicelluloses, methanol, acetic acid, formic acid, sugars etc.

4.4.4 Toxic compounds.

Examples of toxic compounds in the effluent are free chlorine from the bleaching plant & rosin & fatty & acid soaps from pulping. The Tocl which are severe toxic compounds come out from bleaching section since free chlorine is used at Embilipitiya mill for bleaching the pulp.

The toxic effects of pulp mill discharges have been studied intensively in recent years. Investigations of the toxicity of effluent from various mills in the world have shown that black liquor & the liquor condensates co tain the components most toxic to fish. From bleach plants the chlorination & first alkaline extraction stages often account for the largest amounts of acute toxic substances. The chlorination stage effluent contains some free chlorine & is thus subject to rapid chemical changes which makes it difficult to evaluate its toxic effects.

A substantial part of the acute toxicity of black liquor is caused by resin acids & unsaturated fatty acids. It has been confirmed that accidental discharges of black liquor cause an increase in the toxicity of the mill effluent.

4.4.5 pH changing compounds

The discharges from the pulp industry may have Ph changing effects in the receiving waters. Generally it can be stated that high (over 9) as well as low (below 5) Ph-values influence the biological life & reinforce the toxicity of the effluent. In a marine environment the buffering capacity of the salt water drastically reduces any Ph-variations.

4.4.6 Inorganic Salts

Dissolved inorganic salts in the effluent originate mainly from the cooking liquor, from the bleach plant (mostly chlorides) & from the chemical recovery area. They are usually harmless to aquatic life. Salts containing nitrogen (N) & phosphorus (P) act as fertilizers in the recipient.

4.4.7 Possible environmental effects of water pollutants

The discharges into the environment by the pulp & paper industry are complex mixtures of substances. Substances discharged in to the atmosphere will fall out or be washed out & thus be deposited on to the soil & surface waters. The substances emitted directly in to the water are mainly suspended solids such as fibres bark & wood particles & soluble & colloidal material such as wood extractive, lignin degradation products, organic acids, sugars, alcohols, phenolic compounds & inorganic salts.

In waters affected by the pulp & paper industry the biochemical & total oxygen demand (BOD & TOD) will be increased mainly by four groups of substances of different origin.

a. Mud & organic material from erosion caused by logging.

b. Wood chips & straw dust from preparation of raw material

c. Fibres from pulping & paper making

d. Dissolved organic matter such as sugars, organic acids, alcohols, lignin degradation products, phenols etc from the production of pulp.

With the exception of lignins most of the dissolved & non settleable suspended oxidizable material will be relatively rapidly degraded (within one to two weeks) using the oxygen that is dissolved in the water. Upon reaching the receiving water, volatile reduced divalent sulphur compounds will be emitted to the atmosphere or oxidized.

Lignins contribute to the long term oxygen consumption in the water.

The discharge of settling & colloidal organic substances into surface waters resulted in a considerable accumulation of such material in the sediments.

Such deposits will often be the most decisive factor for the quality of the receiving water. The degradation of the organic material will be accomplished both through anaerobic & aerobic processes.

During the microbial respiration in aerobic sediment layers also during the direct oxidation of reduced material from deeper anaerobe layers, dissolved oxygen in the overlying water is consumed. This may lead to totally oxygen deficient sediments & bottom waters & the formation of methane & hydrogen sulphide, the latter being extremely toxic to higher organisms. Release of organic matter from the sediments in to the overlying water will also increase the BOD of the water.

The amount of dissolved oxygen consumed per unit time by polluted sediments is directly related to the extension of the area covered by settled material, but fairly independent of the thickness of the layer of deposited organic material.

The content of dissolved oxygen in the water & in the sediments is an essential parameter for water quality. The discharge of organic oxidizable matter into surface waters will lead to a number of environmental changes. Organic pollution may change different parameters & affect bottom fauna. Also fish & other marine organisms may be severely affected by a reduction of dissolved oxygen. Different species show different sensitivity to decreases of the oxygen content.

The activities of the pulp & paper industry give rise to emissions of suspended & settleable solids. Suspended settleable & non settleable solids in the free water mass may cause symptoms of stress in fish. Feeding behaviour, ability to avoid enemies, growth, respiration rate etc may be affected leading to lowered chances for survival.

Even though fish might tolerate several grams per litre of suspended solids for a few hours or days high levels even for a short period of time should be avoided. The clogging of gills with particulate material has been found to be an important cause of fish deaths. It is recommended that the concentration of suspended solids must not exceed 25 mg/l for an optimal protection of fresh water fisheries.

The discharge of easily settleable solids may lead to the accumulation of such material at the bottom. Thus spawning grounds may be covered & the supply of food organisms may be reduced. In an evaluation of the effects on the aquatic environment caused by settleable solids. The bottom fauna must be taken specially into consideration since these organisms are unable to avoid a polluted area & thus are continually exposed. Another series effect caused by water borne solids is the deterioration of the quality of irrigation water. The slowly degradable dissolved organic emitted from the pulp & paper industry mainly consists of residual lignin & high molecular carbohydrates. The residual lignins which are the most resistant to microbial degradation greatly affect the transparency of the water. Their absorption of light waves in the visible region is high & thus lignins reduce the penetration of light into the water & there by the amount of light available for photo synthesis. Suspended fibres also absorbs & scatter a part of the incoming light.

A decrease in phytoplankton production is typical near the outlet; where as more distant areas may show an increase in primary production especially in nutrient deficient receiving waters. The long term net effect can probably be expected to be detrimental to the ecosystem. Both stimulation & depression of the primary production can change the structure of the phytoplankton populations & affect higher tropic levels such as zooplankton & fish productivity.

The discharges from the industry may have Ph - changing effects in the receiving waters. Generally high (over 9) as well as low (below 5) Ph - values influence the biological life & increase the toxicity of the effluent. The effluent from the bleaching section have very variable Ph-values.

Acute toxicity of effluent from pulp & paper mills to fish & other aquatic organisms had been reported in paper producing countries.

Combined effluent from pulp mills even without treatment may be classified as " practically non - toxic" according to a system of classification proposed by a joint IMCO/FAO/UNESCO/WHO group.

However, a potential problem of stress to the aquatic eco system exists with pulp & paper effluent, because even if the inherent toxicity is low, the discharge volumes are large.

For natural reasons the impact or industrial effluent on streams, lakes, estuaries or the sea is highly complex & dependent upon the characteristics of the effluent. The compositions of the receiving water, relative flows & the dispersion of the wastes.

It should be noted that physical parameters in the aquatic environment may strongly influence the toxicity of pollutants. The influence of environmental temperatures on the physiology & the ecology of aquatic organisms is well known. For example, toxicants that act on cellular enzymes involved in energy metabolisms or that cause changes in uptake rates, such as inhibition of respiratory gas exchange at the gills of fishes, may have their effects intensified by temperature increases. The organisms also may receive greater amounts of the toxicants because of the increased diffusion or the active uptake associated with higher rates of water & solute movements across gills or other cell membranes. Therefore, it is tempting to generalize that temperature rises always increase toxicity to some extent.

Most of the current knowledge concerning effects of mill effluent on productivity & growth of aquatic plants comes from laboratory experiments. Both stimulation & inhibition of the growth of algae have been shown to occur in waters receiving mill effluent. The effects seem partly to be related to the concentration of effluent. Inhibition of photosynthesis can be caused by increased light absorption altered Ph or toxic properties of the effluent. However the substances responsible for the latter effect have not yet been identified. Only black liquor was very inhibitory or toxic. The discharge of inorganic Phosphorous & Nitrogen from pulp & paper industries is significant. It has been calculated that the discharge of phosphorous from a pulp mill producing 250,000 Tonnes/year is equal to that contained in untreated sewage from a town with about 20,000 inhabitants.

Growth tests on algae have shown that mill effluent sometimes enhance growth, depending on the amount & variety of effluent. The content of carbohydrates & organic acids in pulp & paper mill effluent may also act as growth stipulators & colony forming bacteria (sphaerotilus) or fungi, which can be found as yellow or brownish grey slimy covers on suitable substrates or floating on the surface downstream from an effluent outlet. This often causes increased mortality of fish eggs, an aerobic conditions & difficulties in handling fishing gear.

4.4.8 Summary of aquatic pollution

It is a difficult task to make an evaluation of the overall impact in the aquatic environment caused by mill effluent. It is important to note that no water pollutants acts by itself. It acts & manifests itself as a part of a complex of several other agents, both physical & chemical. The final effect of a water pollutant in the aquatic environment is the result of many factors acting together & of the interactions between them. The way towards a deeper understanding of the nature of these complex interaction is through a better knowledge of the structure & function of aquatic eco-systems.

In this context it should be noted that an "ecological effect" is defined as a departure from an original equilibrium of the ecosystem. ie A disturbance of the equilibrium.

The "seriousness" of an effect is judged by the time required from when the disturbance take place until the original equilibrium is restored. Effects, causing irreversible changes in the aquatic eco system should consequently be regarded as the most serious ones, where as reversible damages should be regarded as less serious. The total area affected is also important. Environmental effects in a vast area are considered to be more serious than those affecting a small area. A first condition for prediction of environmental impact is to know how the pollutants are disturbed in the system ie. between water, aquatic organisms & bottom sediments. Similarly, a knowledge of the distribution after a few days, a few weeks & a few years is necessary. Further more, it is desirable to know the rate of metabolism of the pollutants by microorganisms & higher aquatic animals.

Most of the research concerning effects on plants & animals caused by pulp & paper mill effluent has been carried out in canada, USA & the Scandinavian countries. Almost nothing is known about ecological effects in receiving waters in tropical & sub tropical areas of the world where these kind of pollutants are discharged.

Therefore the need for effect oriented investigations in receiving waters where pulp & paper mill industries are discharging has to be emphasized since these effects to a large extent has to be based on experiences & on theoretical ecological principles.

In table 4.4.8.1 some environmental effects are grouped according to ecological principles, where the flowing assumptions are made.

- The local area is defined as having a water mass with a relatively short turn over time & the average turnover time for refractory compounds is not longer than 10 days. However, the turnover time for sediments is more than a year.

- The distant area is defined as having a longer turnover time of its water mass, up to several years is equal to the area where any effect can be detected.

- Short term effects are reversible within a period of up to a few weeks if the discharges cease. Intermediate effects are reversible within a year. Long term effects are irreversible for up to a year or more.

Table 4.4.8.1

Time Area	Short term, reversible effects	Intermediate effects	Long term, irreversible effects
Local	- Death(fish,plankton) - Decreased light transmission(plants) - Avoiding reactions(fish) - pH-change (fish) - Oxygen deficiency in water mass (fish) - Growth stimulation (heterotrophic organisms)	- Accumulation of toxic substances(fish,molluscs) - Bad taste(fish,molluscs) - pH-change(benthic animals) - Oxygen deficiency in sediment-water-interface (benthic animals)	- Sedimentation of solids, i.e.fibres (benthic animals) - Formation of hydrogen sulphide (benthic animals) - Destruction of fish spawning grounds (fish)
Distant	Growth	- Decreased light transmission (plants) - Hampering of photosynthesis (algae) - Avoiding reactions (fish)	- Accumulation of toxic substances (fish, molluscs) - Bad taste (fish, molluscs) - Growth stimulation (algae) - Persistant genotoxic substances in drinking water (higher animals)

The Embilipitiya paper mill has two types of effluent the normal effluent resulting from washing of straw & the black liquor resulting from cooking of straw in caustic soda. The former is relatively harmless & may amount to 18,000 m3/day. The main component is organic matter as revealed by high chemical oxygen demand & biological oxygen demand after 3 days (BOD)values. It was reported that the effluent contains about 2.2g of Sodium Hydroxide per litre & has a Ph of around 10 & the daily discharge is around 10,000 m^3. Even though no findings were made todate the major fear is the contamination of the drinking water pumped to the towns Ambalantota & Hambantota. River water is also used by the people for drinking along the 35 Km.stretch, from the discharge outfall to the estuary. Impacts on thee aquatic life in the river & in the estuary is another area of concern.
Further the over crossing across the irrigation canal has been damaged by the farmers with the intention of getting straw washout to their farm lots which they consider as an influential factor to increase the harvest. Irrigation with sanitary sewage has a long history. Traditionally the irrigation technique has been used to improve crop yields. In some countries irrigation has been practised using effluent from the pulp industry. The technique has normally not been employed primarily for crop improvement, but rather as a method of waste water disposal. Here, the soil is used as a treatment system to accomplish either total exclusion of waste water from receiving waters on removal of organic pollutants by soil filtration & microbiological decomposition prior to entry into receiving waters. But here it is not so, people with their belief of increasing harvest use this straw washouts. This washouts may contain substances which increase salinity(Chlorides, Sulphate). Therefore it has to be used with caution so as not to disturb the ion balance of the soil.

The black liquor effluent containing caustic soda & lignin presently constitutes a major problem. The effluent is now stored in a series of open ponds & discharges at intervals during high flood periods via a pipe to the Walawe river.

Consultations with River Valleys Development Board & Mahaweli Economic Agency along with river discharge & rain fall data suggest that Udawalawe reservoir would be able to provide continuous dilution of water in the Walawe river for two months in a year. The month may shift between November & January & again between March & June. The conservative estimate is that 12 month long black liquor at the rate of 200 Cum a day is to be discharged in a 2 month period. It means the discharge rate would be 6 times 200 Cum = 1200 Cum a day during the 2 month discharge period. The problem of black liquor discharge needs to be studied further. Which is by no means the perfect solution, It would be necessary to pursue. Research & development towards a rational solution, so that large quantities of paddy straw available in the Walawe basin can be readily utilized, & those dependent on the water resource will not be deprived of a legitimate right.

4.5 Land Pollution

Land pollution may occur as a consequence of

1. Fall out of atmospheric pollutants & emission of harmful gases especially sulphur dioxide.

2. Irrigation with waste water having considerable amount of sodium ions causing salinity.

3. Dumping of sludge.

The emission of sulphur dioxide to the atmosphere may cause adverse effects to the vegetation surrounding the mill.
The straw washouts are mixed with the canal water used for irrigation, through the damaged pipe. The farmers believe that the yield of their cultivation increased due to the mixing of straw wash outs with the canal water. Even though the short term affects to the paddy cultivation is favourable to the farmer, this water may contain substances like chlorides & sulphates which increases the salinity of water. Their by the ion balance of the soil may disturb.

At present the sludge of the black liquor ponds & solid wastes from the mill which contain materials of inorganic & organic origin metal parts & (organic origin) polythene, stone, grit fibres etc. are pumped to the barren land in close proximity to the mill.

However there is a risk of leaching of toxic & odorous substances into the ground & surface waters.

4.6 Noise pollution

Noise is generated from the process equipments mainly from wood chipping & boiler section & from internal & external means of transport.
However impacts of noise pollution is not of a significant nature.

4.7 Thermal Pollution

Heated effluent discharges into surface water which is under normal temperature may cause serious impacts on aquatic life in the river and in the estuary, in addition to the contamination of drinking water for the inhabitants. However the present arrangement to store the effluent in an open pond & discharge it at intervals via a pipe to the Walawe river, relieve the danger of releasing heated effluent to the surface water cause, while this is by no means the perfect solution.

4.8 Physical Damages

The discharge sewer line is damaged due to sulphide attack. In several locations the effluent over flows. No proper action has been taken by the mill management for the maintenance of sewer line. Strong odours are emitted from the openings of manholes & damaged sections of the pipe. The people living along its way from the mill to the Walawe river may subject to health problems.

During rainy seasons the effluent mixes with rain water flow through the damaged section of the pipe line & over flows over the roads. Some compounds of the inhabitants also get flooded. Strong odours are generated.

Some people used to put their domestic waste into the pipe line through the damaged section, which causes blocking of the pipe flow. Some manholes lids also were damaged & effluent over flows. It was reported by the people in close proximity that their well water also contaminated by absorbing the effluent in to the ground water course & subsequent leaking to their domestic wells through the fountains.

The aerators installed at the effluent ponds are not in operation.

The earth bunds of the ponds which were constructed over 15-30 years ago are in a critical condition, since no action has been taken for the maintenance of these bunds.

The safety of those dams are in question. Unless immediate action has not been taken there is a threat for the life of the people living down stream of the ponds.

4.9 Safe Working Practices at Mill

The recent incident involving the death of a mill worker & hospitalisation of another at Embilipitiya mills due to inhalation of chlorine gas is a glaring instance, which indicates the safe working practices had not been adhered to. This state of affairs could be due to either ignorance or carelessness on the part of mill workers & or safety requirements being over looked by the mills supervision.
It is observed that despite a large number of victims of chlorine gas in the past viz more than 100 cases in 1990, no action had been taken by the mills management to provide the basic needs of safety equipment & protective clothing to the employees, which is a serious lapse.

4.10 Beneficial Environmental Impacts

Farmers use straw washout for cultivation through the damaged pipe line. It is said the paddy harvest improved remarkably due to the usage of straw washouts for cultivations. The Mahaweli Authority of Sri Lanka introduced new varieties of paddy to improve the harvest. In most of this new varieties the stem of the paddy plant is comparatively low in height against the traditional varieties thus the production of raw material has been reduced. Waste paper has become a major economic factor in the paper industry, since waste paper is an increasingly important raw material for production of news print, tissues, printing & writing papers, magazines & boxboard. The greatest portion of waste paper is not chemically treated but is pulped mechanically. Processing with chemicals (deinking) is however necessary for newsprint & writing paper. There are two main methods of deinking, floatation & washing. The washing deinking methods of deinking, floatation & washing. The washing deinking method is used mainly in the united states, while floatation deinking remains the dominant process in all other areas.

The Embilipitiya mill uses waste paper for the production of pulp & for the long fibre requirement. At present they import waste paper since it is not possible to collect waste paper in the island to satisfy the requirement. However they have introduced collecting centres so that the people could earn some money by selling their waste paper thus contributing to the exercise of cleaning the environment.

4.11 Chemical Recovery System

When the construction of Embilipitiya mill began in 1974 the management was faced with a serious problem of pollution of the region. It was thought possible to find a way to recover the chemicals used in the process by installing a chemical recovery system. Once the contractors commenced erection of the Embilipitiya paper mills they were requested to assist the National Paper Corporation by providing a chemical recovery system to recover chemicals from rice straw pulping. The contractors offered a prototype plant and it was installed at a cost of Rs.150 million in 1979. By the end of 1983 the performance run of the chemical recovery plant proved to be a total failure. The funding agency (KFW West Germany) appointed neutral observers at their cost to assess the performance of this plant. They have reported that there is an inherent design fault in the plant & it could not be efficiently operated.

The wood & plant fibres consist of the following main components: cellulose, hemicelluloses, lignin, extractives & inorganic. The distribution of these components varies between wood & plant species, within various parts of the tree & within various parts of the fibre. There are also differences between different plants within the same species because of variations in the composition of the soil. The content of lignin, the "GLUE" between the fibres is relatively constant in softwood & highly variable between hardwood species. The lowest valves are found in annual plants. In chemical pulping the fibres are liberated by breaking down & dissolving the lignin by chemical reactions. After the cook the spent liquor contains the dissolved part of the fibrous raw material & the residual cooking chemicals.

Wood contains only 0.4 - 0.5% of lignin where as rice straw contains about 15 - 17% lignin. The recovery of chemical used for rice straw pulping has not so far been successful in any where in the world. It was reported that the removal of lignin from the black liquor has not been successful. Experiments had been conducted in a few-mills such as Rakta mills in alexendria, Egypt & paper mills in Indonesia. So far no success had been reported.

The chemical recovery plant designed to take place the following chemical reaction.

Black liquor (sodium lignate) contain 90% water & 10% total solids. By evaporation the black liquor is concentrated from 10% of total solids to 55% of total solids.

Black liquor (90% Water+ 10% total solid) $\xrightarrow{\text{evaporation}}$ Total solid (55%)

Concentrated black liquor is burnt to obtain.
Sodium carbonate smelt.

Black liquor (burning) $\longrightarrow Na_2Co_3$ + Other impurities

Sodium carbonate smelt dissolved in water & the impurities are removed.

Sodium carbonate reacts with burntlime (CaO) as follows.

$Na_2Co_3 \longrightarrow Ca(OH)_2 + NaOH + CaCo_3$

After filtering NaOH is separated & recycled to the straw cooking digester.

The residual $CaCo_3$ is wasted. But should be returned & recycled to the process.

Like a biblical plague for seven days part of the Walawe Ganga turnes black. Most of the fish dies. People stood on the edge of the river gazing as their life-sap turned into a harmful gush & rushed to the sea.

Those who are quick to fish in troubled waters do not hesitate to sell fish killed by chemicals. Dead fish logged up in the canals in the area soon hit the fish stawds at the market. The long term effect or black liquor would be to enter the human body through mans food cycle which includes fish as well.

The rusty black liquid harmful to people plants & animals never ended up in the plant for recovery but has been stored for months in five tanks outside the mill, waiting for heavy rains to take them to the sea.

Once the black liquor was absorbed by the sea the people return innocently to drink bathe & irrigate their land.

It has been the endless cycle of threat and pain for thousands of families living on & around the banks of Walawe Ganga for many years.

With a 300 million rupee chemical recovery plant permanently bed-ridden after a short spell of action the doom fell on the mill & the people in the surroundings.

The plant was originally meant for regaining 80% of the chemicals used for cooking pulp which would have saved a massive sum for the government.

But the plant remains inoperative as unforseen silica crystals in the straw clogged the evaporator tubes, & paralysed the plant.

Further evaporation could not be done since when the total solid content increase beyond 55% non transferable liquor is formed. Which obstruct the liquor burning system & efficiency is reduced. Burning efficiency could be remarkably improved if the total solid content could be maintained at the range of 65% to 75%.

As long as the residual $CaCo_3$ is not re-burned & recycled the efficiency of the plant could not be improve
ed.

Due to the presence of silica, $CaCo_3$ & $Casio_3$ are coagulated & forms $CaCo_3$ lumps. Therefore $CaCo_3$ could not be re-burnt in the chemical recovery plant.

Collecting black liquor for a long time without releasing in to the river also hits the out put of the mill.

Although the black liquor holding ponds came into existence as a temporary measure these ponds will remain functional till an alternate improved disposal method for black liquor is obtained. Chemical recovery from black liquor of rice straw has still remained as a challenge to researchers because of excessive silica in the rice straw stem.

The main input of silica is usually the fibre raw material, but the make up lime can also be a considerable source. The silicates give heavy scaling problems in evaporators & also cause problems in the causticizing section. The rice straw contains 10-13% of silica.

During the cooking of the raw material the silica is dissolved in the cooking liquor. As the alkai is consumed, silica compounds are precipitated on within the fibres & follow the pulp through the washing & screening plants.

However, the ability of the pulp to carry the silica with it appears to be limited. The surplus silica, accumulates in the chemical cycle of the mill.

Until a long term decision is taken about the chemical recovery plant at least six days a year the mill should be allowed to dump the waste in order to keep the mill running.

Otherwise the closure could mean a death blow to thousands of villagers who eke out a living by supplying the straw & another thousand employee who earn a living employing in the mill.

CHAPTER 5

MITIGATORY MEASURES

5.1 General

Industrial development is an integral component of the development of a country. Since industrial revolution, various methods were introduced and the technology towards development has been improved tremendously. The objective of the development activities is proclaimed as to improve the quality of human life by the effective use of earths resources. The short term goals of human beings cause irreparable damage to the finely balanced ecological environment built up over long periods.

The environmentalists jargon "The green house effect" is the result of the delicate balance of the atmospheric oxygen and carbon dioxide being upset by human activities. The increase in the layer of carbon dioxide is estimated to be responsible for an increase in global temperature of 2°C in 100 years affecting the ecological balance.

Disposal of massive quantities of solid waste and harmful nuclear waste, the industrial by products, has become a major problem in industrialised countries.

Unwanted sophistication and senseless desires even in the third world countries have resulted in colossal waste of precious resources of the earth.

All the earths resources have been a free gift to mankind. Therefore it is a must to handle it with care and share it with responsibility.

In this respect the pollution causing from industrial activities should control by improving the methods of pollution control to mitigate the environmental impacts.

The methods to be introduced to mitigate the environmental impacts of the Embilipitiya paper mill are discussed below.

5.2 AIR POLLUTION

5.2.1 CUTTER HOUSE

The dust emission from the raw material preparation unit has been controlled already introducing a de-dusting cyclone. This vessel conical at the bottom and cylindrical at the top made of steel with a bucket wheel at the bottom. The cut straw enters the cyclone in a tangential direction and consequently the straw performs a vortex motion in which the finer dust particles move towards the top and get removed by the suction fan. The straw drops on to the bucket wheel which pulls the straw down to the conveyer. The suction needed by the straw to come from the cutter to the cyclone and to blow the dust from the cyclone to the wet separator is produced by the suction fan. The wet separator is a steel construction with a cylindrical part and a conical bottom. The dust mixes with the water sprayed from the top and drains out.

If the whole wet cleaning system is by passed ref. para 4.2.1.4, due to the high elevation of the belt conveyor the straw chips and particles shall be blown out by the wind. Therefore it is suggested to spray water at the start which inturn increase the weight of the straw. Nevertheless this solution is superior since the blow out of straw shall drop at effluent canals and increase the suspended solid, otherwise.

5.2.2. FLUE GAS

The flue gas emits from the furnace oil burning in the steam producing boilers and the black liquor kiln. The fuel burning flue gas may contain carbon monoxide (Co) carbon dioxide (Co_2) nitrogen oxides (Nox), sulphur dioxide (So_2) all volatile compounds and steam (H_2o). The main emissions are carbon dioxide and water vapour. Emission of reasonable amount of sulphur dioxide would be expected since the fossil fuel contains considerable amount of sulphur. Nitrogen oxides are formed during all types of thermal combustion of fossil fuel. The most essential factor for the formation of nitrogen oxide is the flame temperature and the oxygen concentration in the flame.

To refrain from black smoke fuel should be completely burned and the air supply should be properly maintained. Further using fossil fuel containing low content of sulphur and maintaining the flame temperature below 1300°C and concentration of oxygen below 2%, formation of sulphur dioxide and nitrogen oxide could be mitigated.

5.2.3. BLEACHING PLANT

In the bleaching plant free chlorine is used as the bleaching media. Emission of free chlorine and the organically bounded chlorine generated in the process could be mitigated with the use of substitutes, such as chlorine dioxide (Cl_2o), oxygen (O_2) and hydrogen peroxide (H_2O_2) and ozone (O_3), thus replacing more hazardous chemicals by the less hazardous.

5.2.4. SETTLING TANKS

Micro organisms consumes oxygen in the effluent. Once the dissolved oxygen content in the effluent is completely consumed anaerobic reactions take place. Emission of methane(CH_4) and hydrogen sulphide(H_2S) could be expected when anaerobic reactions occur at the settling tanks. The methane gas contribution to the green house effect and the H_2S is odorous. The settling tanks to be maintained such that the anaerobic reactions does not take place. By adding nutrients and removing the sludge using pumps these emissions could be mitigated.

5.2.5 AERATION PONDS

Floating type aerators have to be used in the aeration lagoon to improve the dissolved oxygen content in the effluent.

However the aerators had been removed a long time back. These aerators to be reinstalled to maintain the effluent parameters until it reaches to the tolerance limits specified by the Central Environmental Authority.

5.3 WATER POLLUTION

The paper mill has two types of effluent. They are the normal effluent resulting from washing of straw and the black liquor resulting from cooking of straw in caustic soda.

5.3.1 WASTE WATER

The main parameters of pulp and paper mill waste water are pH, suspended solids, BOD5 and COD colour, sulphide, phosphorous, nitrogen, sodium, mercury and toxicity. All these pollutants comes out from the raw material preparation plant, cooking, washing and bleaching plants paper machine and chemical recovery plant.

Process designed for saving of raw material, reuse of chemicals proper treatment of effluent and the choice of suitable areas for location of pulp and paper mills are the most efficient ways of minimizing hazards to the environment and man.

The main environmental hazard in the Embilipitiya paper mill is the water pollution since soda process is used for pulp making.

The incoming raw water after the process discharges as effluent. The pollution of effluent should be measured regularly and has to be controlled until it complies with the Environmental Authority standards. As a mitigatory measure the effluent load shall be reduced as much as possible. This could be done by reducing the fresh water consumption. The recycled water could be used for floor washing.

Some waste water lines are connected to the effluent stream of the pulp and paper mill in the prevailing system of effluent discharge to the settling ponds. Those are of the types fibre containing waste water, cooling water, rain water and sanitary waste water. These water lines should be separated prior to discharge to the settling ponds by which the effluent load could be reduced considerably.

Biological treatments should be carried out if the drainage lines are connected to the effluent stream.

Spillage of pumps and pipes should be minimised by improving the operation system.

Coarse screening should be done in sewer lines by which the suspended solids, BOD and COD values could be mitigated. Further a water clarification system to the process to be introduced to reduce the suspended solids.

At present the only treatment of the effluent is the sedimentation at the settling ponds and natural aeration. The only advantage is the high retention time inevitably occurred due to the restriction of releasing the effluent to the Walawe river, only at high flood season and the large surface area of the ponds. The floating aerators are not in working order. The

existing primary and secondary treatment system is very crude and are not properly functioned. A tertiary system is not in operation. The treatment process should be modified and rehabilitated.

The biological treatment plants for pulp and paper mills effluent that currently in operation are normally of the following types.

Stabilization pond

Aerated lagoon

Activated sludge

Trickling filter

The chemical and physical treatment methods of bleach plant effluent include a large number of processes like absorption methods, flocculation and chemical precipitation methods, membrane methods and oxidation methods.

These are advanced methods and the chemical treatment methods usually combined with a mechanical pretreatment to remove suspended solids.

Literature dealing with chemical and physical effluent methods is voluminous.

The mill does not have an environmental protection licence which is a must for dumping industrial waste into the surface water ways.

It is learnt that the environmental protection licence has not been issued to date by the central environment authority since the present effluent disposal system regarded unsatisfactory.

The over crossing across the irrigation canal has been damaged by the farmers with their belief of increasing harvest using the straw washouts for irrigation. The farmers should be educated on this issue since these washouts may contain substances like chlorides and sulphates which increase salinity of the soil.

The fibrous material, silica etc are deposited in the ponds. Some device should be introduced to remove the sludge from the settling ponds to reduce the BOD. The sludge could be reused as a fuel in the boiler after squeezing out water by introducing a screw press device to the process.

Sludge from waste water treatment which cannot be reused can be incinerated, disposed as landfills or composed depending on sludge quality and local conditions. Sludge composition varies considerably. The ash content of the sludge from pulp mills normally 10-30% while sludges from paper mills can have 50-70% ash content.

sludge with an ash contents above 50% are commonly associated principally with the manufacture of board, de-inked pulp and paper integrated and non-integrated fine papers.

Incineration is normally considered as a disposal alternative for sludges of less than 10% of ash content in mills with existing incineration capacity such as boilers. Composting of secondary sludges from biological treatment requires an additional porous material such as bark. The product is valuable for soil improvement. Except recovery of by products, land disposal remains the only feasible alternative.

5.3.2 BLACK LIQUOR

The black liquor containing caustic soda and Lignin presently constitutes a major problem. Black liquor is the gravy that is collected once the straw is cooked in to paper pulp. The rusty black liquid harmful to people plants and animal never ended up in the plant for recovery but has been stored for months in the ponds waiting for heavy rains to take them to the sea. The liquid is very harmful as it immediately deprives the river water of oxygen and kills the fish once it is released to the river at a high concentration. To flush off the river considerable volume of water has to be released from the Walawe reservoir which could be saved for the Walawe Irrigation Project continuously demanding for more water, otherwise.

The black liquor (Sodium Lignate) though it is allowed to flow in to the river is very valuable in the process of the mill if sodium lignate is separated and sodium hydroxide is formed for which the chemical recovery plant has been designed. Sodium hydroxide is a chemical used in the process.

If the chemical recovery plant could be restarted it would serve both economically for paper production and as a mitigatory measure to reduce the pollution load. However it is proclaimed that the chemical recovery plant could not be efficiently operated due to an inherent design fault. Unforeseen silica crystals in the straw has been clogged the tubes and paralysed the plant built with German expertise. It is reported that the recovery of chemical used for rice straw pulping has not so far been successful any where in the world. Chemical recovery from black liquor of rice straw has still remained as a challenge to the researchers because of excessive silica in the rice straw stem. Therefore de-silication of black liquor should be researched. Following areas are suggested to carry out a research study of de-silication of rice straw in black liquor.

1. Centrifugal vortex motion of the black liquor
2. Reduction of pH value of the black liquor

By passing the boiler flue gas which contains carbon dioxide through black liquor in the reactors pH value could be maintained in the range of 8 to 9. But to ascertain the pH value in this required range very sensitive approach is needed. However it is said that experiments have not been performed in large scale for any straw pulping process in the world. In case of de-silication the mill shall be benefited economically by selling silica for the manufacturing of glass ware.

If no success has been achieved in the research study in de-silication of the black liquor and rehabilitating the whole chemical recovery process of the Embilipitiya mill the only other alternative to reduce black liquor is to change the raw material from straw to wood.

Until a long term decision is taken about the plant at least twice a year the mill should be allowed to dump the waste in order to keep the mill running. Otherwise changing the raw material could mean a death blow to thousands of villagers who eke out a living by supplying the straw.

5.4 LAND POLLUTION

The straw washouts are mixed with the canal water used for irrigation through the damaged pipe. This water may contain substances like chlorides and sulphates which increase the salinity of water and disturb the ion balance of the soil. The farmers should literate in this respect. The use of straw washouts in paddy land could be mitigated by erecting clear sign boards warning the farmers not to use the pipe water as it contains substances effecting the ion balance of the soil.

Any disposal site has a potential for environmental contamination. Land fill sites are designed in-order to prevent contaminants from reaching the receiving waters. A suitable site for a land fill is a place where the area is designed and the water sheds are distinct. In addition the dump should be located on soil types which allow very little infiltration so that there is no danger of ground water contamination. Where non-porous ground cannot be found such conditions could be created by compacting the land fill bottom material to a fermeability of less than 10^{-3} cm per second or by using a layer of impervious clay or synthetic material.

The basic objective of engineering sludge disposal land fills is to consolidate and confine the material and stabilize its behaviour.

The sludge of the black liquor ponds and solid wastes from the mill are dumped in the barren land of the mill premises without flushing off to the normal surface water. These pollutants are highly biodegradable. There may be some chemical contaminants in the land filled solid waste, but significant amount of chemicals would not be expected the land fillings since excess chemicals are not used in the process. The land filling should satisfy the tolerance limits of land filled waste specified by the Central Environmental Authority.

However there is a risk of leaching of toxic and odorous substances into the ground and surface waters.

This land fill waste could be reused in the fire wood boilers. To mitigate the land fill waste fire wood boiler should be designed for the steam generation.

Long term effects of the solid waste land fill is more hazardous than water pollution since the soil structure is effected by the former, but the latter run-off to the sea.

5.5 NOISE POLLUTION

As long as bark wood is used in the paper manufacturing process not much noise is generated. Heavy machineries are not deployed for the transport of raw material and preparation of the raw material for the pulp and paper manufacturing process. Internal and external means of transport also very much limited. Noise is generated only from wood chipping and boiler section. Even though the impacts of noise pollution is not that significant, action has been taken to provide safety equipment to the employees.

Further human settlements are not in the close proximity to the mill. The housing colony for the mill also is situated considerable distant a part from the mill.

5.6 THERMAL POLLUTION

The temperature of the effluent released by the mill is 80°c. The present arrangement to store the effluent in the settling ponds for a period of six months to one year relieve the danger of releasing heated effluent to the surface water course, while this is by no means the perfect solution.

5.7 PHYSICAL DAMAGES

The discharge sewer line should be repaired in a proper manner. It is suggested to remove the top half of the pipe to a length of four feet and clear the bottom at the damaged sections and replace the crest of the pipe. A programme should be organised to test the water samples of the dug wells where ever the contamination of well water is surfaced.

Damaged manhole lids to be replaced.

The floating aerator should be reinstalled. Maintenance programme should be launched for the earth bunds in critical condition.

CHAPTER 6

MONITORING PROGRAMME

A suitable monitoring programme should be evolved to monitor the changes of the effluent disposal and implementation of mitigatory measures narrated in chapter 5.

The monitoring programme which should be carried out in the pulp and paper disposal system of Embilipitiya paper mill is discussed below. This monitoring programme is planned with a view to introduce or even inculcate the culture of conserving water.

Further this monitoring programme is introduced with the idea of recording the performance of the treatment systems comprising flotation, plain settling and aeration lagoon.

6.1 PARAMETERS

The parameters chosen to be checked at each sampling points located in the drawing 6.1 are as follows.

Discharge
Temperature
pH
Suspended solids
Total solids
Colour
Residual chlorine
BOD_5
COD
Dissolved oxygen
Phenolic compounds

6.2 SAMPLING POINTS OF THE MILLS EFFLUENT CANALS

6.2.1 WASTE WATER

A Straw preparation unit (cutter house, digester house)

B Bleaching section

C Paper machine process water

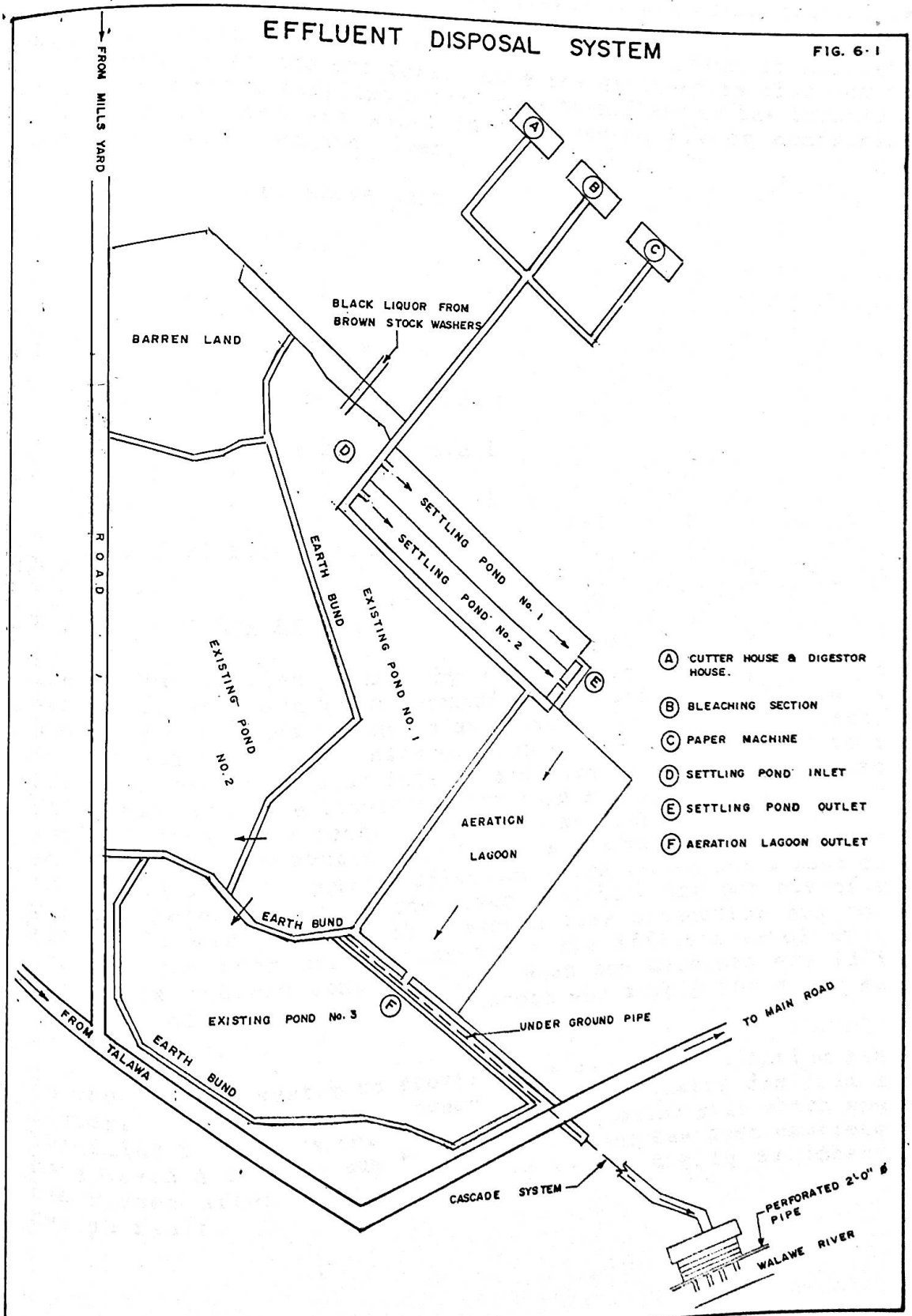
D Combine effluent (settling ponds inlet)

E Settling pond outlet (inlet to the aeration lagoon)

F Aeration lagoon outlet

EFFLUENT DISPOSAL SYSTEM

FIG. 6·1



The farmers of the Walawe Project living in the neighbourhood of the effluent disposal line use the waste water for irrigation purposes which has been contributed the reduction of effluent considerably at the out fall. Once the effluent is disposed to the Walawe river sampling points have been fixed at the locations listed below and are shown in the drawing 6.2 of monitoring locations along Walawe river.

1. 3 miles above outfall
2. At outfall
3. 1/2 mile below outfall
4. 3 miles below outfall
5. 7 miles below outfall
6. 10 miles below outfall
7. 15 miles below outfall
8. 20 miles below outfall

6.2.2. BLACK LIQUOR

The major problem causes by the production of pulp is the discharge of black liquor containing caustic soda, lignin, and phenolic compounds to the Walawe river. The liquid is black in colour and visible in nature. Dumping of black liquor to the Walawe river is done at intervals during the high flood season. Until such time the liquid is stored in shallow ponds of 34 acres surface area in extent. The large surface area itself is an advantage for the evaporation factor since the factory is located in the dry zone. However collecting black liquor for a long time without releasing in to the river also hits the out put of the mill. It was reported that many a time production has to be stopped for over three weeks until the effluent level of the ponds are reduced considerably. When the machines are idling majority of the people in Hambantota who supply the straw earn nothing.

In the present system no provision is made for monitoring black liquor. The chemical recovery system originally designed for regaining 80% of the chemicals used for cooking pulp which would have saved a massive sum for the government has been completely bed-ridden after a short spell of action due to an inherent design fault.

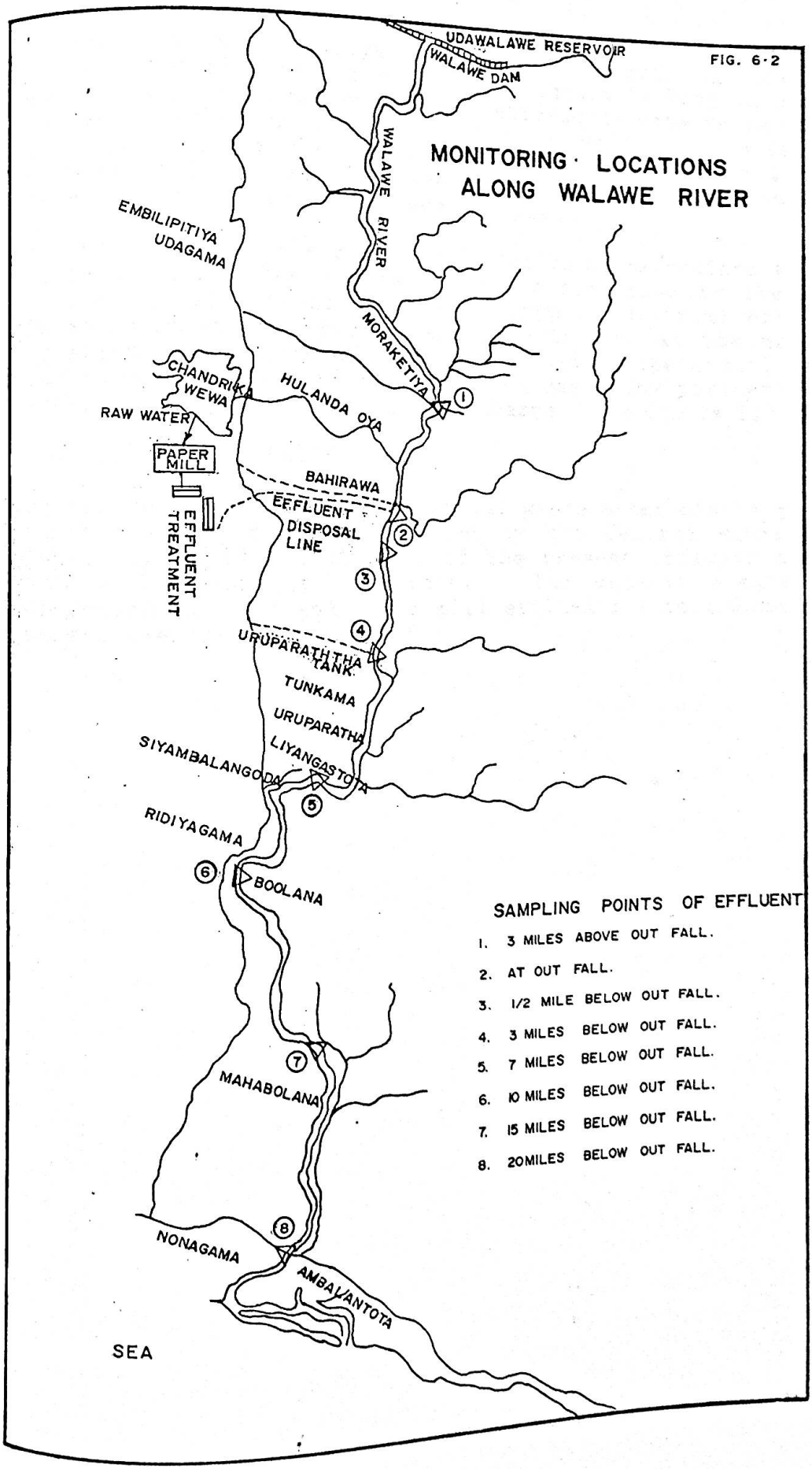


FIG. 6-2
MONITORING LOCATIONS ALONG WALAWE RIVER
UDAWALAWE RESERVOIR
WALAWE DAM
WALAWE RIVER
EMBILIPITIYA
UDAGAMA
MORAKETIYA
CHANDRIKA WEWA
HULANDA OYA
RAW WATER
PAPER MILL
EFFLUENT TREATMENT
BAHIRAWA
EFFLUENT DISPOSAL LINE
URUPARATHTHA TANK
TUNKAMA
URUPARATHA
LIYANGASTOTA
SIYAMBALANGODA
RIDIYAGAMA
BOOLANA
MAHABOLANA
NONAGAMA
AMBAVANTOTA
SEA
SAMPLING POINTS OF EFFLUENT
1. 3 MILES ABOVE OUT FALL.
2. AT OUT FALL.
3. 1/2 MILE BELOW OUT FALL.
4. 3 MILES BELOW OUT FALL.
5. 7 MILES BELOW OUT FALL.
6. 10 MILES BELOW OUT FALL.
7. 15 MILES BELOW OUT FALL.
8. 20MILES BELOW OUT FALL.

However the Embilipitiya paper mill, the only factory in the island producing high quality paper should be kept in operation even though no solution has been arrived to date to recover the chemicals in black liquor. The only solution remains is to dump the effluent to the Walawe river during high flood season, inorder to keep the mill running until a long term decision is taken about the chemical recovery plant.

For this propose the dilution factor to be maintained at 1:4000 while ensuring the tolerance limits specified by the Central Environmental Authority for discharging industrial effluent to inland surface water courses are achieved, at the monitoring locations along the Walawe river. Further the liquid level in the lagoons should be measured each day. The parameters to be analyzed are COD, lignin and discharge. The COD is 120000 mg/l.

6.3 TOLERANCE LIMITS

Tolerance limits of the industrial waste water discharge to the surface water course specified by the Central environmental Authority could be achieved if the present effluent discharge system is properly functioned. The general standards for discharge of pulp and paper mill effluents into inland surface waters are shown in table 6.1.

TABLE 6.1

GENERAL STANDARDS FOR DISCHARGE OF PULP AND PAPER MILL 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 in five days(BOD_5) at 20°c, mg/l max	30
5.	Temperature of discharge	Shall not exceed 40°c in any section of the stream within 15m down stream from the effluent outlet
6.	Phenolic compounds (as phenolic oH) mg/l	1.0
7.	Sulfides, mg/l max	2.0
8.	Total residual chlorine mg/l max	1.0
9.	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 atleast eight volumes of clean receiving water. If the dilution is below eight times, the permissible limits are multiplied by one eighth of the actual dilution.

NOTE 3. The above mentioned general standards shall ease to apply with regard to a particular industry when industry specific standards are notified for that industry.

6.4 FREQUENCY OF MONITORING

6.4.1 WASTE WATER

The monthly report on effluent disposal to Walawe river based on the figures of an analytical report compiled in the month of September 1980 is shown in the table 6.4.1.

It is evident that even as far back in 1980 the results did not satisfy the tolerance limits specified in para 6.3. The main reason for this was the improper functioning of the aerators.

The frequency of this monitoring programme should be once week in order to ensure the standards for the environmental point of view.

6.4.2 BLACK LIQUOR

This monitoring programme is suggested for observing the change of quality in the Walawe river prior to, during, and after completion of the black liquor discharge for 12 hour period on the scheduled day.

TABLE 3.4.1. MONTHLY REPORT ON EFFLUENT DISPOSAL TO SEA VIA WALAWE RIVER

	Mills effluent treatment			Walawe River Samples							
Determinant	Settling Pond Inlet D	Aeration Lagoon Inlet E	Aeration Lagoon Outlet F	1	2	3	4	5	6	7	8
Temperature °C	36	36	32	27	31	33	33	31	30	30	30
pH	8.1	6	7.2	7.7	7.6	7.6	7.4	7.5	7.2	7.6	7.4
Colour Hazen	750	1000	3000	50	750	280	150	150	100	75	75
Tot. Solids ppm	840	400	1280	188	380	200	600	140	100	300	670
Suspended solids ppm	748	200	516	40	67	40	46	60	44	43.2	71.6
Dissolved solids ppm	92	180	764	148	313	160	544	80	56	257	598
Dissolved 0 ppm	2.4	NIL	NIL	7.3	3.1	3.4	5.1	7.3	8.1	11.1	11.1
B.O.D. ppm	360	790	210	0.9	110	120	1.3	1.8	2.5	5.3	5.6
C.O.D. ppm	300	650	800	275	400	375	325	275	275	250	250
Chloride ppm	200	175	225	16	24	30	36	40	48	46	48
Alkalinity (M.O) M.Val/L	5	10	12.5	3.4	5.1	4.1	3.9	4.2	3.6	3.8	3.7
Alk.(pH)M.Val/L	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
Tot. hardness as $CaCo_3$ ppm	276	-	-	180	216	200	216	232	224	216	226

* AERATORS ARE NOT IN OPERATION

CHAPTER 7

CONCLUSION AND RECOMMENDATIONS

7.1 General

Processes designed for saving of raw material, re-use of chemicals, proper treatment of effluent and the choice of suitable areas for location of pulp and paper mills are the most efficient ways of minimizing hazards to the environment and man. Generally mills should be located where conflicts with other activities are less likely. Examples of risks that should be considered before decisions are made of suitable areas of mills are

- Pollution of drinking water
- Decrease in fish catches
- Accumulation of persistent and toxic compounds in animals and people living near mills
- Pollution of water for irrigation
- Eutrophication of water areas resulting in changes of aquatic habitats and communities
- Disturbance of areas important for fish re-production

Effluent disposal system of the Embilipitiya paper mill has not been functioned properly. The suggestions modifications and recommendations to mitigate the environmental impacts of the Embilipitiya paper mill narrated in Chapter 4 are discussed below.

7.2 AIR POLLUTION

7.2.1 Water to be sprayed to the straw chips at the cutter-house prior to the straw chips are conveyed by the belt conveyor to avoid blown out of the straw particles by the wind due to the high elevation of the belt conveyor.

7.2.2 To refrain from black smoke fuel should be completely burned at the steam producing boilers and the black liquor kiln, the air supply should be properly maintained.

7.2.3 To mitigate the formation of sulphur dioxide fossilfuel containing a low sulphur content should be used.

7.2.4 Bleaching agent preferably be changed by using either chlorine dioxide (cl_2o), oxygen (o_2), hydrogen peroxide (H_2o_2) or ozone (o_3)

7.2.5 The settling tanks to be maintained such that the anaerobic reactions do not take place. This could be achieved by adding nutrients and removing the sludge using pumps. If the sludge is to be reused it should be pumped to the screening department to mix with the pulp. A sludge recirculation often affects the drainage properties of the pulp negatively.

Re-use of primary sludge cannot be recommended for production of high quality products. Sludge from waste water treatment which could not be re-used could be incinerated in the boiler as a fuel.

7.2.6 Floating type aerators should be used in the aeration lagoon to improve the dissolved oxygen content in the effluent.

7.2.7 Precautions should be taken to avoid any leakages of poisonous gases such as chlorine to atmosphere.

7.3 WATER POLLUTION

7.3.1 The effluent load should be reduced as much as possible. This could be done by reducing the fresh water consumption.

Some possible methods are

a. Use of thickener back water as make up water to the digester

b. Use of thickener back water instead of fresh water to wet logs which are to be fed to the wood chipper

c. Use of thickener back water instead of fresh water to wash the floors

d. Use of thickener back water instead of fresh water for preparation of cooking liquor

e. Use of white water instead of fresh water in the additive preparation section.

7.3.2. The employees of the mill should be educated on the methods of reducing the fresh water consumption. However the employees would not make any interest in reducing fresh water unless they are economically benefited by that. Therefore an incentive scheme should be implemented for the reduction of fresh water consumption of the mill.

7.3.3. Disciplinary action should be taken by the paper mill against the employees who bathe at high pressure water tapping points which discharge water through a 1 1/2" dia pipes.

7.3.4. Spillage from pipes and pumps should be controlled by improving the operation system. Using of fresh water for washing purposes should be avoided. The recycled water like thickener back water could be used for floor washing.

7.3.5. Cooling water at some places could be reused for floor washing instead of fresh water by storing in 750 cum capacity tank which had been constructed to store black liquor of the chemical recovery system and abandoned.

7.3.6 Proper shut down maintenance programme should be launched to avoid the spillage of chemical contaminated water.

7.3.7. The sewer lines are of the types fibre containing waste water, cooling water, rain water which contribute in large quantity during maha season over the large roof area of the mill, and sanitary wastes. These sewers should be separated thus biological treatment could be avoided.

7.3.8. The waste water is being used for irrigation by the farmers residing in the neighbourhood of the disposal line to the Walawe river. The standards for irrigation water should be ensured at the factory battery limit so that the water abstract from Chandrikawewa of the Walawe project could be used by the farmers of the project without any hindrance who are continuously complaining for inadequate supply.

7.3.9. A coarse screening system should be installed to the sewer lines to remove the large particles of the suspended solids.

7.3.10. Present effluent treatment system should be modified by installing a waste water clarification system, removing sludge at the settling ponds and installing aerators in the lagoon. The clarification system reduces the suspended solids and the sludge could be used in the boiler as a fuel and BOD of effluent is reduced while the dissolved oxygen content in the effluent increases by the aerators.

7.3.11. The effluent from the raw material preparation section should be diverted to the land directly since chemical contaminated water is not being used at this section, to reduce the effluent load.

7.3.12. The mill should obtain an environmental protection licence for dumping industrial waste into the surface water ways.

7.3.13. Sludge from waste water treatment which could not be reused should be incinerated disposed as land fill or composed depending on sludge quality and local conditions.

7.3.14. The effluent treatment plant should be maintained in good working order at all times to ensure that the treated effluent conform to the relevant standards.

7.3.15. The black liquor though it is allowed to flow in to the river is very valuable in the process of the mill if sodium lignate is separated and sodium hydroxide is formed. For this purpose chemical recovery system to be re-started for recovering and reusing of chemicals. The capital cost for the chemical recovery plant is Rs. 150 million in 1979. Funds should be allocated for research studies of desilification of black liquor. Following areas are suggested to carry out a research study of desilification of rice straw in black liquor.

1. Centrifugal vortex motion of the black liquor.

2. Reduction of pH value of the black liquor.

For this purpose assistance from National Engineering Research and Development centre could be requested. If no success has been achieved in the research study the only other alternative to reduce black liquor is to change the raw material from straw to wood. In such an circumstances the farmers who supply straw to the mill should made aware on using rice straw for the manufacture of a very rich and valuable organic fertilizer which gives biogas and manufacturing of ropes for which the technology had been developed a long time ago in Japan, to earn a living for them.

7.3.16. The state of art on desilification has been studied and concluded that although there existed reported success on laboratory scale desilification, the question of desilification and the paper mill to operate the chemical recovery system efficiently cannot be undertaken unless semi-commercial plant on desilification is installed, operated, and demonstrated for commercial marketing. Till then the present concept of mothballing the chemical recovery system at the pulp and paper mill remained justified. The Embilipitiya paper mill may negotiate with Sevanagala sugar mills for concentrating and incinerating spent wash from distillery with a view to recover potash present in spent wash and sell as fertilizer using the chemical recovery system of the mill.

7.3.17. It is recommended that the black liquor should be stored for a year to be discharged in a period of 12 days or so in the Walawe river using 12 hours during each day of discharge under the supervision of a co-ordinating committee.

7.3.18. The KFW team of West Germany who was here to study the rehabilitation of paper industry in SriLanka in January 1985 has mentioned in their report that the Embilipitiya mills process should be changed to chemi-thermo-mechanical pulping using wood as a base raw material, which would result in the production of cheap paper acceptable to the market and also eliminate the usage of straw which causes a major pollution problem in the region. Nevertheless wood base pulp would cost more than straw based pulp.

7.3.19. Several methods of desilificating the black liquor had been proposed and tested. The silicate is precipitated by the addition of lime, iron salts, sulphuric acid or treatment with carbon dioxide. Among these iron salts appear to hold better possibility in removing the silicate. A semi-commercial plant for chemical recovery from rice straw pulping black liquor with silica removal facility preceding the recovery system should be installed.

7.3.20. The black liquor from blowdown tanks is discharged through a 200 mm pipe into a sump from where an underground pipe leads the liquid in to the black liquor holding ponds operating in series. The present system of negotiated discharge in the Walawe river through the 10 km long concrete pipe line needs rethinking. In the first place the concrete pipe should carry only black liquor and not waste water all the time and black liquor occasionally, as it is practised today. This would avoid agreed and also surreptitious tapping of the effluent carrying concrete pipe for using the waste water for irrigation and there by creating a sense of distrust in the mind of agencies and people in the neighbourhood.

7.3.21. The black liquor pipe line should preferably be coloured black with liberal use of sign board displaying in sinhalese, the avoidance of use of the black liquor as it will spoil the productivity of agricultural land. Further more considering the available dilution water in the walawe river during certain days in a year and with the planned co-ordination and complete understanding of Mahaweli Economic Agency, Embilipitiya paper mills, Central Environmental Authority. The black liquor needs to be discharged for some 12 days in a year. On the day of discharge 3750 cum of black liquor could be discharged in 12 hour period, and the down stream users are required to be given a notice of not using the river water for the next 24 hours from the initiation of the discharge. It is assumed that the flow through, period between Embilipitiya paper mill outfall and the sea is about 12 hours.

7.3.22. The down stream users are required to build extra storage space for storing 24 hour water requirement for the day when black liquor is required to be discharged. It is required to organize mass awareness campaign explaining the method of disposal to gain peoples confidence. Further, water quality monitoring including ensuring the availability of the analyzed data to public, re-assure the people on the absence of any significant adverse effect.

Under the present operating conditions of the pulp and paper mill following working parameters would be more realistic.

Daily production of black liquor	- 200 cum
Number of days pulp mill work	- 200 days
Total production of black liquor/year	- 40,000 cum
Depth of black liquor holding pond	- 2 m
Surface area for black liquor holding pond	- 34 acres
Rate of evaporation a day	- 6 mm
Rate of evaporation in a year	- 2.2 m

7.3.23. Although average annual evaporation equals the total accumulation of black liquor the evaporation factor has not been considered, while estimating the discharge of black liquor in to the Walawe river in a planned manner. Because liquid volume may reduce due to evaporation but the COD load would remain unaffected.

COD of black liquor	120,000 mg/l
Discharge from Udawalawe Reservoir during high rainfall	15 million Cum/day
Dilution available at Walawe river	in 4000
COD of river water in receipt of black liquor	30 mg/l
One year storage of black liquor may be emptied in	- 12 days or less

Thus it is possible to discharge the black liquor through the existing concrete pipe line at a rate of 3750 m^3 in 12 hour time in a day. Because the pipe could discharge a maximum quantity of 4500 cum in half a day. The Walawe river water during black liquor discharge will assume a quality of COD 30 mg/l and sodium 0.5 mg/l.

7.3.24. The quality of effluent arising from the operation of the industry should be treated to conform to the general standards for discharge of effluent into the inland surface waters prior to the disposal into the Walawe river.

7.3.25. Oil and liquid chemicals should be stored and dispensed in an area with a well cemented floor. Any accidental spillage must be cleaned up immediately using suitable absorbent material and fuel oil should be stored in a covered area with a well cemented floor.

7.3.26. A publicity programme should be launched to encourage the public in collecting waste paper. Waste paper collecting centres should be opened island wide. A programme should be implemented to receive the waste paper in Government institutions, thus straw input could be reduced and environmental hazards by the used paper is minimised.

7.4 LAND POLLUTION

7.4.1. The effluent may contain substances like chlorides and sulphdies which increases the iron balance of the soil. Farmers should literate on this respect unless the required standards for irrigation water were not met. In such circumstances clear sign boards should be erected warning the farmers.

7.4.2. Landfill site should be designed in order to prevent contaminants from reaching the receiving waters. Solid waste should not be disposed of into a water body or at a site where it is likely to enter a water body. Water sheds should be distinct. Where non porous ground cannot be found such conditions should be created by compacting the land fill bottom material to a permeability of less than 10^{-5} cm per sec or by using a layer of impervious clay.

7.4.3. The land fillings should satisfy the tolerance limits of land filled waste specified by the Central Environmental Authority.

7.4.4. The land use area of the black liquor holding ponds as reported by the Mahaweli Economic Agency is proposed to be for wild vegetation cover. It should not be converted to any high value use such as paddy or sugarcane cultivation. The human settlements are away from the area and no ground water tapping. Obviously the appearance of the black liquor holding ponds in such an area would not conflict with the environment. However, the holding pond should be built using polythene lining with proper treatment of the bottom using appropriate quality of clay.

7.4.5. The land fill waste could be reused in the fire wood boiler. The fire wood boiler should be designed for steam generation.

7.4.6. The sludge could be used to make fire brickets which could be fed to the fire wood boilers. Thereby the mill is economically benefited in saving the boiler fuel.

7.5. NOISE POLLUTION

Action should be taken to reduce the spread of noise at source. At Embilipitiya mill noise is generated only from wood chipping and boiler section. The impacts of noise pollution is not that significant.

7.6. THERMAL POLLUTION

The present arrangement to store the effluent in the settling ponds for a period of six months to one year relieve the danger of thermal pollution.

7.7. PHYSICAL DAMAGES

7.7.1. The floating aerator should be re-installed.

7.7.2. The discharge sewer line deteriorated due to sulphide generation should be repaired in a proper manner. The top half of the pipe to a length of 4'-0' ft to be removed and clear the bottom of the damaged sections and replace as shown in the drawing No. 7.1. Damaged manhole lids to be replaced. Sign boards should be installed warning the farmers not to use the pipe water containing black liquor. The pipe should preferably be coloured black.

7.7.3. A programme should be launched to test the water samples of the dug wells, where ever the contamination of well water is surfaced.

7.7.4. The perforated humepipe installed at the outfall to, ensure proper mixing of the effluent to the surface water course has been damaged and the effluent discharge to the river directly at present.
The perforated humepipe of 2'-0 diameter to be installed at the outfall for efficient mixing.

7.7.5. Precautions should be taken to avoid any spillage of oil, grease and liquid chemicals on ground which could lead to the pollution of surface or underground waters. Provision should be made to collect any accidental spillage of soil so that it would not lead to surface or ground water pollution.

7.7.6. The bunds of the black liquor ponds are in a dilapidated state and breaching is imminent. This would result in contaminating the irrigation canals and reservoirs in the area and would cause public unrest. Following measures are recommended.

a. Cracks should be filled with suitable material and well compacted employing a roller or compactor.

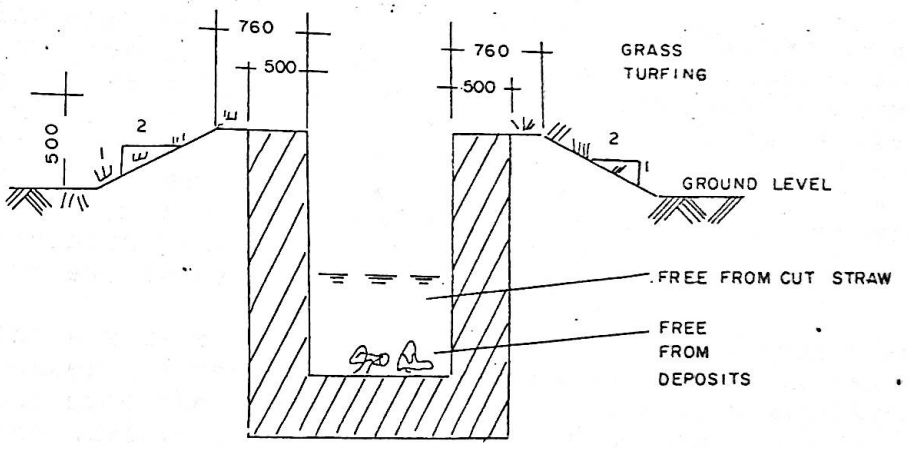
b. Free board should be maintained when storing the effluent ponds.

c. Maintenance programme should be launched for earth bunds and routine inspection of black liquor ponds should carried out.

d. Trespassing of cattle should be prohibited.

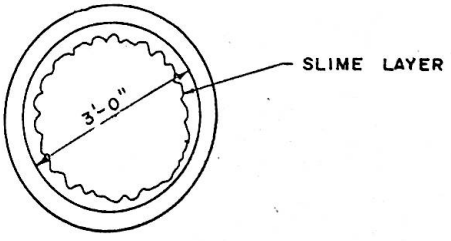
FIG. 7·1

PROPOSED REPAIRS TO EFFLUENT DISPOSAL SYSTEM

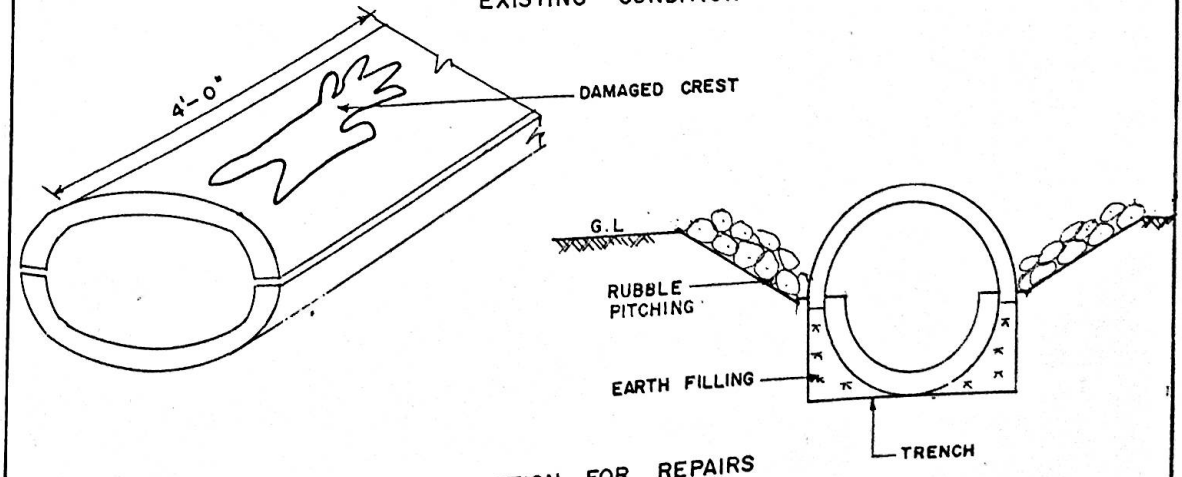


PROCESS DRAIN SECTION INSIDE THE MILL

SECTION OF EFFLUENT DISPOSAL LINE



EXISTING CONDITION



TYPICAL SECTION FOR REPAIRS

7.7.7. All process drains outside the shops imperative to be kept free from receiving rice straw cut pieces, free from deposits and be raised by 500 mm above the ground level, and the top drain must have a width for easy walking during inspection as detailed in fig. 7.1.

7.7.8. The drainage system so raised, having grass turfing at top protected from smear of rice straw cut pieces all over the place. Drains should be repaired wherever and whenever they are broken. Drain discharge free from floating straw and deposits would improve the waste water quality and also the appearance of the back yard of the factory. The quality control division of the mill should ensure the cleanliness of the entire back yard of the factory.

7.7.9. The effluent of drains from chemical house and straw cutter and wet and dry cleaning house should be taken out side the factory battery limit and be discharged. The quality of discharge should be monitored.

7.7.10. Process drains should be monitored to make shop foreman aware of the water use and waste water generation drains should be realigned at locations to facilitate monitoring specially, the discharge.

Annexture 1

SOURCES OF DATA AND INFORMATION

1.	Mills Manager	: Mr. J.C.A. Abeyratna
2.	Assistant Mills Manager	: Mr. J.K.P.Piyathilaka
3.	Envionmental Engineer	: Mrs. Ghana Nimalaratne
4.	Chief Engineer	: Mr. W.A. Senaka
5.	Chief Chemist	: Mr.B. Gurusingha

Annexture II

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   43, Rue Schnapper.78100-St German-En-Laye
   France.(1990)

   Report on National Paper Corporation

Annexture III

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