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PROGRAMME ON PURIFICATION OF INDUSTRIAL WASTE WATER

COUNTRY PAPER: UGANDA*

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*The views expressed in this document are those of the author and do not necessarily reflect the views of the Secretariat of UNIDO. This document has not been edited.

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PURIFICATION OF INDUSTRIAL WASTE WATER

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BACKGROUND AND TERMS OF REFERENCE

The United Nations Industrial Development Organization (UNIDO) plans to implement a project on the purification on industrial waste water. This project will enable the eight developing countries selected in Africa to formulate and implement appropriate policy measures to deal with the potential long-term environmental problems related to the purification of industrial waste water.

A prerequisite to participation in this project is for the country to appoint a national expert in industrial waste water management to conduct initial research and report on the industrial waste situation in the country.

The waste waters concerned will be effluents from industries such as tanneries and leather, breweries, textile industries, slaughter houses, sugar industries and Pesticide formulating plants. From these the national expert will choose those which are the most relevant to his country and make a priority list there after. The national expert will specifically be expected to present the characteristics of the waste water chosen together with an extensive description of the situation for each type of water with regard to the number of plants, environmental impact status of waste water treatment, equipment etc.

Following the completion of the report, the national expert will be expected to:

(1) Prepare a programme for the two UNIDO Consultants who will visit the country for approximately two weeks to further evaluate the situation.

(2) Assist and guide the two visiting UNIDO consultants during their evaluation which will focus on:

- a review of the technological options available for reducing waste water quantity and improving effluent quality.

- a determination of the level of regulatory measures for industrial waste waste treatment, appropriate for adoption by the country.

- an identification of training needs on methods/facilities for waste water treatment.

(3) Participate in an evaluation meeting to be held during the second half of 1990.

This report presents the initial findings of the National Expert in Uganda. It in addition presents the essential background information on the infrastructural set up and available legislation relating to industrial waste water disposal. The conclusions and recommendations of the study are at the end of the report.

SECTION 1
INTRODUCTION AND SUMMARY

1.1 Introduction

Industrial activity in the country has suffered greatly in the past due to political turmoil. Many industries closed down while others were producing at a very low capacity. Of the country's gross domestic product of about 514 billion Uganda shillings (U.S. 1.381 m) only 5% is contributed by manufacturing industry. There is now a policy of rapid industrialization and exporters have been directed to process raw materials, where possible, in the country before export. While the national growth rate in 1988/89 was 7.2% p.a. the industrial growth was an average of 25.5% p.a. A lot of the growth in industrial output in the last year was recorded in the areas of brewing, soft drinks, sugar, oil and soap, textiles, food processing, leather and tobacco manufacturing, most of which produce very offensive waste water. Of the total of 134 odd significant manufacturing establishments in the country, over 40% produce very offensive waste water. In pursuing this policy, it is of utmost importance to increase awareness, both in government an private sector, of the possible undesirable short and long-term effects of uncontrolled industrial waste water discharges into the environment. There is need to establish a workable policy for the regulation of the industrial discharges, and develop the manpower and technology necessary to evolve and implement the policy, both by government and industry. It is also necessary to develop the know how on environmentally safe technological processes, and technology available for dealing with industrial waste water discharges.

UNIDO is executing a project to help the country to formulate and implement such a policy. This report forms the initial stages of this project. It identifies all industries in the country that produce environmentally unacceptable waste waters in terms of both quantity and quality., explains and presents the characteristics of the waste waters form these establishments, describes the present environmental consequences of these waste water discharges. Some data is also provided on the available infrastructure i.e. administrative, legal, laboratory services etc. for the regulation of industrial waste water discharges. These industries are briefly discussed below:

1.2 Breweries

There are two breweries in the country located at Jinja and Kampala respectively. Both produce very large quantities of concentrated waste water originated mostly from the bottle washer, and the cleaning of fermentation vats. the BOD and suspend solids concentration sometimes exceed 3500 mg/l and pH sometimes rises to 11. Both factories provide no treatment for their waste water which they discharge raw into natural water bodies. The Kampala plant is causing enrichment of the Murchison Bay water thus endangering the source of water supply for Kampala and its environs.

1.3 Textiles Industries

There are seven major textiles industries in the country of which six are operating. They produce very concentrated waste waters, originating from the dying and maceration. process. Suspended solids and BOD of over 1000 mg/l have been observed and pH may rise to 12. The waste waters also have very intense coloration. None of the industries provide an real treatment for their waste water. three of the industries discharge their raw waste water into natural water courses located in highly populated urban centre of Kampala and Jinja, endangering sources of water supply. The rest of the factories discharge into pubic sewers. These waste waters are causing considerable problems at the waste water treatment plants. they exert excessive organic loading, and the high colour and pH are interfering with the natural biological treatment processes.

1.4 Sugar Industries

Of the three sugar industries in the country, tow are in operation. they produce concentrated waste waters with BOD in excess of 100,000 mg/l and sometimes as high as 200,000 mg/l, comprising mainly of residues form the crystalization process. the operating factories do not treat their waste water. They discharge their raw waste water into small streams. These streams are completely de-oxygenated and are devoid of life of rover 20 kms.

1.5 Soft Drinks Industries

The soft drinks industries produce large quantities of waste waters with organic loads comparable with domestic waste water, the BOD sometimes reaching 450 mg/l. The pH may sometimes be high, reaching a value of 11. These waste waters originate from the bottle wash line and washings from the syrup rooms. There are a total of nine soft drinks factories, and none of them provide any treatment beyond inadequately designed septic tanks and/or soak always. Discharge of such organic loads are detrimental to natural waster courses. With some pH correction, they would be acceptable to public waste water treatment plants.

1.6 Meat and Fish Processing Industries

The meat processing plant in the country consist mainly of abattoirs which are located in every urban centre, one meat canning factory and one fish processing plant. the fish processing industry has high economic potential and there are several others under construction already. They produce very strong wastes resulting from washings of blood, offals, bits of meat, scales, bones, etc. The BOD of the waste water is 2000 - 3000 mg/l and the fine suspended solids may be as high as 800 mg/l.

The existing fish processing plant has an ultra-modern activated sludge type waste water treatment plant that contains too many electro-mechanical plant to be reliably operated in this country. The abattoirs have no waste water treatment plants of their own. They simply discharge into the public sewerage or to natural water courses, where they exert excessive load, resulting in nuisance or malfunction of treatment works.

1.7 Leather Processing Industries

Tanneries produce some of the worst waters in the country. There is one big tannery located at Jinja. The raw sewage has a very high BOD (approaching 30,000 mg/l) and has a high level of toxicity resulting from tanning chemicals such as acids bacteriocides and chromium. The factory has a pretreatment plant that attempts to oxidize and precipitate the toxic chemicals and reduce the pH and BOD of the waste water. The effluent from the plant that is pumped to the public waste water treatment plant is still very strong, having a BOD of about 660mg/l and possibly higher now that the operation and maintenance standards have dropped. The waste water treatment plant was originally designed to reduce the waste water to a level that can be handled by the public waste water treatment system. With some improvements in the operation and maintenance procedure and some chemical treatment, it should theoretically be able to carry out the functions. It presently falls short of that.

1.8 Oil & Soap Industries

The most numerous industries in the country producing waste water of interest are the edible oil and soap industries. There are about 22 factories scattered all over the country. They produce comparatively small quantities of very strong waste water. The BOD, suspended solids and oil/grease concentrations can be as high as 25,000 - 30,000 mg/l, 800-1000 mg/l and 5000 - 6000 mg/l respectively. the pH of the wastes may be as high as 12. Most of the plants produce both oil and soap and this has greatly cut down on the waste water quantities. None of these provides any form of treatment to their waste water. many of these industries are old and in a run-down conditions, and are producing a t a very low capacity.

1.9 Miscellaneous Industries

There is one paper industry in the country, producing sheet paper from waste paper and imported pulp. Due to the break down of machinery, the point that has originally designed to recycle virtually all its waste paper now discharges all of it raw in the river. Nile. The waste water has high BOD and suspended solids. It is related to the growing problem of the pollution of the river. Nile. There are several dairy industries in the country, the most major one being in Kampala. The wastes form these plants arise from milk spillage and washings and exert a very high BOD, sometimes approaching 2500mg/l. Their wastes decompose rapidly, exerting a high load on the oxygen resources of the public treatment works or natural water courses.

There is one battery manufacturing plant in the country. It produces small amounts of toxic wastes, containing acids (resulting in low pH) and lead. Lead is toxic.

There are numerous garages in the country. The waste water has a high content of grease and oil, that are dangerous to the environment. The larger installations recover the oil and grease using grease traps for.sale or for reuse. The smaller ones simply discharge into the stormwater system. This is a rapidly growing problem area that is going to be of some importance in future. The points of discharge are wide spread and usually small, difficult to identify and police.

There is an unoperational chemical factory in Tororo (TICAF) designed to produce phosphate fertilizers and sulphuric acid. It is due for rehabilitation and expansion. The waste from its plant will include acids and fumes of oxides of sulphur going into the air.

Dumps of ores of cobalt copper etc. resulting from mining operations at Kilembe Mines are leaching away into the environment and causing serious degradation of the flora and fauna in the region. A clean up operation is necessary.

These are two cement factories in the country. These factories have very dusty operations resulting in air pollution. The dust maybe washed back by rain into natural water courses. They also have high concentration of suspended solids in their waste water.

Agricultural activity in the country leaches pesticides and fertilizers into natural bodies of water. The pesticides are toxic while the fertilizers contribute to nutrient enrichment of natural waters eventually leading to eutrophication. The scale of this problem is bound to increase in future.

The steel industry produces very large quantities of fairly clean but hot waste water. These industries may cause significant temperature pollution. There is a major steel plant in Jinja.

1.10 Management and Organization and Infrastructure

There are several government ministries and departments having an interest in the area of industrial waste water production, treatment and managemer.. The principle ones being Ministries of Water and Mineral Development, Industry and Technology, and Local Government and Labour. They may be directly involved or through their parastatal organizations or local authorities. The Ministry o Environment Protection has over all responsibility for the environmental consequences of these waste waters. For a successful and beneficial programme in industrial waste water control, it will be necessary for massive exchanges of information between these various government departments, and between government, and the public and the private sector, so that the programme is not viewed as an additional avoidable cost but rather as a long term investment. The technological developments in the area of safe industrial processes and industrial waste water treatment have to be made available, and the beneficiaries have to be trained to understand them. Fair regulatory procedures need to be developed. UNIDO's task in this project is to among other things, help Uganda to address these problems and attempt to solve them. Before the project begins, and of equally great importance as the project itself, there is need to organize so as to reap maximum benefits from this project while the opportunity exists.

The legal framework for the regulation of industrial waste water discharges exists. It however has great deficiencies. There are no clear and rational stan. ds to follow; and there is no provision for appeal by either party should they consider that they are unfairly treated.

There are three public testing laboratories in the country. These are operated by the National Water and Sewerage Corporation, the Water Development Department (of the Ministry of Water and Mineral Development) and the government Chemist (of the Ministry of Internal Affairs). The first one above is reasonably well equipped, while the other two are in a desperate need of re-equipping. All of them need extra staff and restocking of reagents if they are with extra duties. Makerere University Department of Chemistry also has a laboratory that can carry out similar functions. Its problems are similar to those above.

The public waste water treatment plants that receive industrial waste waters are described. Except for the Kampala Works, all the public waste water treatment works the waste stabilization ponds type. These ponds operate well even under poor operation and maintenance conditions. They are sensitive to toxicity and excessive organic loadings. The pre-treatment of industrial waste water is essential before discharge into these units. The only conventional plant receiving industrial waste water exists in Kampala. It consists of detritus channels, settling tanks, sludge digesters, trickling filters, sludge drying beds etc. It is in very poor condition. This emphasizes the need for simpler methods of treatment.

SECTION 2

BREWERIES

2.1. Introduction

The country is served by two breweries both producing lager type beers. The Uganda Breweries are located at Port Bell in Kampala and the Nile Breweries is located at Njeru near Jinja.
The brewing process is a biochemical process involving the fermentation of barley, sorghum, etc., usually in large fermentation vats. The fermented brew is then subjected to filtration, pasteurization and other processes to make beer.

Waste water largely arises out of the following operations:

(i) Bottle wash line, where large quantities of hot water is used daily to clean out the bottles. The usual cleaning agents are caustic soda and acetone, which will be contained in the waste water stream together with stale beer, all types of dirt, chemicals etc. brought in, or on, the empty bottles, paper labels. and some times detergents. The waste stream may also contain stale/spoilt beer being discharged to waste. The waste stream will thus be caustic with a high pH but will have a low BOD and suspended solids. The flow will not fluctuate too widely during normal operation.

(ii) The cleaning out of fermentation vats. This wastewater stream will only occur periodically and will contain fermented barley, and is usually frothy foaming and malty. It has a high BOD and suspended solids. This is the biggest single source of pollution in the industry.

(iii) Washing out of yeast, barley, sorghum etc. from storage bins. This waste stream will also contribute to suspended solids and BOD.

(iv) Cleaning out of various beer storage vessels and conduits within the plant. This flow is also periodic and will basically contain beer. This is a source of mostly BOD.

(v) Waste discharges from boilers. This would be periodic and clean but of high temperature.

The waste waters from the brewing industry are thus characterized by high suspended solids, BOD and depending on how the different waste streams are mixed, they may have a high PH, and a high temperature. The wastes contain high concentrations of long chain hydro carbon compounds as well. These industries are also characterized by irregular waste water releases, leading to shock hydraulic and organic loads in receiving waters and waste water treatment works.

These factories have been visited on several occasions and the findings are described below:

2.2 Uganda Breweries, Port Bell, Kampala

2.2.1 General Information

The factory is located at Port Bell in Kampala. IT currently produces about 10,000 crates of beer per day and it is operating at almost full capacity. It takes its water supply from the public system. The main raw materials are barely, yeast, and possibly sorghum, all of which except sorghum are imported.

2.2.2 Waste Water Production and Characteristics

The plant currently produces an average of 3750 m3/day of waste water. The waste water was sampled in 1970 and was found to have the following average characteristics:

BOD - 600mg/l

SS - 150 mg/l

The wastes water was further investigated and results reported in 1989. This time the various waste water streams were independently sampled and were found to have the following characteristics:

Storage bins washout:

SS: 1490 mg/l
BOD: 735 mg/l
Electrical conductivity: 110-620 µs/cm
pH: 4.9 - 6.3

Bottle washer:

Electrical conductivity: 43 - 795 µs/cm
SS: 17 mg/l
BOD: not possible due to excessive toxicity
pH: 10.2 - 11.6
Electrical conductivity: 418-795 µs/cm

Fermentation vat washout:

SS: 3033 + 299 mg/l
BOD: 3494 mg/l
Electrical conductivity: 213 - 386 µs/cm
pH: 5.4 - 6.5

The flow in these streams, especially from the fermentation vats varies widely in the same day. From the available evidence, it is clear that the hydraulic and organic load from the factory is highly variable.

2.2.3 Waste Water Treatment and Environmental Impact

The waste water is currently discharged untreated into inner Murchison Bay. The waste stream finds its way through the papyrus swamp fringing the bay (about 100-150m wide) to the open body of water in the bay.

There is evidence of fish kills in the immediate locality o the outfalls at the times when the fermentation vat wash water and storage bins wash water are discharged. This is obviously the effect of de-oxygenation of the water due to heavy organic load and the effect of high pH and temperature. Th wider and long term environmental impact of these discharges on the inner Murchison Bay are discussed in Section 12.

2.3 Nile Breweries, Njeru

2.3.1 General Information

The factory is located in Njeru, near Jinja. IT currently produces about 5000 crates of lager a day and is operating at the installed capacity. The main raw materials are barley, sorghum and yeast. All of these, other than sorghum are imported. The factory obtains its water supply from the Nile and has a private treatment unit.

2.3.2 Waste Water Production Characteristics

The plant produces 600-700 m3/day of waste water. Laboratory analyses indicate that the waste has the following average characteristics:

BOD: 400mg/l
SS: 60 mg/l

2.3.3 Waste Water Treatment Environmental Impact

The waste water is currently discharged untreated into the Nile. The environmental consequences of this discharge are discussed in Section 12.

SECTION 3

TEXTILE INDUSTRIES

3.1 Introduction

Uganda is a cotton growing country and therefore has numerous cotton processing industries. There are over 50 registered cotton ginning industries. Cotton ginning is a dry process and these industries are not therefore considered any further in this report. There are several weaving and garment manufacturing industries in the country as well. Like the ginning industries, they are dry industries and are not considered further in this report.

The textile industries that produce waste waters that have significant environmental consequence are those involved in spinning, weaving and dying. There are a total of seven of them in the country as follows:

(i) Rayon Textile Manufacturers, Kampala
(ii) Nyanza Textile Industry, Njeru/Jinja
(iii) Uganda Blanket Manufacturers, Kampala
(iv) African Textile Mill, Mbale
(v) Uganda Spinning Mill, Lira
(vi) Uganda Bags and Hessian Mills, Tororo
(vii) Mulco Textiles, Jinja

The basic processes in the manufacture of cotton textiles are essentially similar. These processes and their relationship with wastewater characteristics and quantity are discussed below.

The first process in the manufacture of textiles is the cleaning of the cotton yarn. This involves cudding of the yarn until the fibres are clean and parallel. This process is essentially dry.

The second stage in the manufacture is the spinning of the yarn into thread. Chemicals are usually added to the spun thread to improve its strength and resistance to abrasion during weaving (the next process). This process is generally called sizing. The usual sizing agents are starch, caustic soda, glycerine, glucose etc. This is a wet process and some of these chemicals will enter the wastewater stream. These will contribute to the BOD, colloidal suspended matter, and raising of the pH of the wastewater.

The third stage is the weaving of the thread into cloth. This is an essentially dry process. The only use of water is in the humidifying of the weaving room. The condensate from steam ends up i the waste stream and is a source of temperature pollution.

The fourth stage is one of printing and dying. This is the source of the most pollution in the industry. First the sizing agents applied at the weaving stage are wasted off to waste. This is followed by the washing of the cloth in a cold solution of 20-30 % caustic soda, a process called maceration. The resulting liquor is discharged to waste. The cloth, is then boiled in 5% solution of caustic soda. Wetting agents and fabric softness (these are chemicals) are added. The waste liquor is discharged to waste. The cloth is then bleached. The usual bleaching agent is hydrogen peroxide but there are several others on the market as well. Sodium silicate and soda ash are also added during this treatment and the resulting liquor is washed to waste.

The cloth that is destined for printing is now removed and printed. Pigment emulsions are applied to usually dry cloth. The process generates almost no waste except washouts from pigment mixing process, where some of the chemicals will go into the waste stream. The balance of the cloth is then dyed. The dyehouse liquors contain heavy metals, of types depending on the origin and type of dye, plus various chemicals including soap, salt, soda, ash, caustic soda, soda bicarbonate, wetting agents, sodium hydrosulphite, hydrogen peroxide, sodium sulphite, sulphuric acid, etc. The dyehouse liquor is washed to waste. The waste stream from here has a high pH, and is heavily coloured.

The final stage will be the finishing of the fabric. Special additives to give final desired properties to the textiles are added. These may include stiffening agents (e.g. starch), brightening agents, softners, flame retardants, insect repellants etc. The resulting liquor is washed to waste.

In general, the wastewater from the textile industry contains a large variety of chemicals. These will frequently change as the source of supply changes or processes are varied. The waste is expected to have a high pH and have caustic properties. The waste will also have colour, and high concentrations of organic matter. Most of the suspended solids will be of fine colloidal nature.

Any attempts to reduce the damage to environment by these industries by changes in production process will have to focus on and to address these wastewater producing processes. Reduction of pollution through waste water treatment will need to deal with the heavy metals and remove them from solution, as ell as dealing with the pH, dissolved and suspended organics in the waste water.

Some of these industries were visited during the course of the field work. The relevant literature available on the wastewaters from these industries and the findings during the field work are reported herein.

3.2 Rayon Textile Manufacturers, Kampala

3.2.1 General Information

The factory has an installed capacity of over 6000 linear metres of cloth per day. It is currently producing at 30% of installed capacity. It procuces both printed and dyed cloth The dying process slightly differs from that described in Section 3.1 above. Firstly, the factory does not carry out any marceration; secondly, the factory dyes the thread before weaving. Apart from this and some minor variations here and there, the basic processes are the same as described above.

3.2.2 Waste Water Production and Characteristics

The factory can use up to 360 m3/day of water obtained from the NSCW system. Most of this becomes waste water. The wastewater from the factory was sampled several times during the time of peak production and was found to have the following average characteristics:

Suspended solid (SS) - 960 mg/l
Biochemical Oxygen Demand (BOD 5) - 1060 mg/l

3.2.3 Waste Water Treatment and Environmental Impact

The factory does not have a wastewater treatment plant. The raw wastewater is discharged into the R. Nakamiro and the adjoining papyrus swamps, causing de-oxygenation of the water and considerable aesthetic problems. The immediate locality is a heavily populated area and uses the river as a source of water supply. Many edible crops, especially tubers are grown in this valley and sold in the market. The heavy metals in the waste water could easily be transmitted to animals and human beings in this way.

There is a strong case for the preservation of the papyrus swamps in the river valley. The role of papyrus swamps in environmental preservation, especially of the waters of inner Murchison Bay in L. Victoria is discussed in Section 10. Continued discharge of pollution will endanger the survival of these swamps.

3.3 Nyanza Textile Industry, Njeru/Jinja

3.3.1 General Information

This is the largest textile industry in the country. It has a labour force of 3,500 people, operates 24 hours a day and has an installed capacity of about 400,000 linear metres per day. It is currently producing a 60% of installed capacity. It obtains its water supply from the River Nile, and has its own water treatment plant.

3.3.2 Waste Water Production and Characteristics

Process waste water discharges of up to 10,000 m3/day have been recorded from the factory. The waste water from the factory has been previously sampled and was found the following average characteristics:

pH - 11
Temperature - above ambient
Suspended solids 140 mg/l
Biochemical Oxygen Demand (BOD 5) - 600 mg/l

At the time of the visit, the waste water was found to be brightly coloured (green) and of a high enough temperature to steam.

3.3.3 Wastewater Treatment and Environmental Impact

The factory used to have a pretreatment plant to reduce toxic metals, pH, suspended solids, colour and some of the BOD through chemical coagulation, pH adjustment, and sedimentation. It also provided balancing storage to mix the wastes and cool them. This plant has been out of operation for over two decades.

The factory at present discharges the waste water untreated into the River Nile. The minimum flow in the Nile of 630m3/s provides a huge dilution to the waste. Even at this level of dilution, streams of colour can sometimes be seen in the R. Nile. The whole question of the pollution of the Nile is discussed in Section 10.

3.4 Mulco Textiles, Jinja

3.4.1 General Information

The factory has an installed capacity of 45,000 linear metres of cloth a day. It is currently producing at 20-30% of installed capacity. It presently has a labour force of 700-800 people. The plant obtains its water supply from the Nile and has its own water treatment plant.

3.4.2 Waste Water Production and Characteristics

It produces about 4500 m3/day of industrial wastewater. The wastewater from the factory has been previously sampled and analyzed. Average results of the analyses are as follows:

pH - 10
Suspended Solids - 150 nm/l
Biochemical Oxygen Demand - 900 mg/l
Alkalinity - 1350 mg/l

3.4.3 Waste Water Treatment Environmental Impact

The factory has no wastewater treatment plant. All its wastewater is therefore discharged raw into the R. Nile. At the time of the design and construction of the factory, it was hoped that the big dilution provided by the Nile (flow of 630 m3/s) will effectively eliminate the possible pollution of the environment. The question of pollution of the Nile at this location is discussed in Section 10.

3.5 African Textile Mill, Mbale

3.5.1 General Information

The factory has an installed capacity of 50,000 linear metres of cloth per day. It is at present producing at 12% of installed capacity. The current labour force is 700, due to rise to 1500-2000 at full production capacity. The factory obtains its water supply entirely from the public water supply system (of National Water and Sewerage Corporation)

3.5.2 Wastewater Production and Characteristics

The exact water usage of the factory, at full production is unknown, but it is expected to be around 4000-5000 m3/day, most of it becoming wastewater. A grab sample of the wastewater was taken during the site visit, and the results of the analyses were as follows:

pH - 12
Suspended Solids - 78 mg/l
Biochemical Oxygen Demand - failed due to excessive toxicity
Alkalinity - 1150 mg/l

At the time of the site visit, the wastewater was coloured deep blue and was a steaming temperature estimated at 70-80 °C. It was caustic enough to cause irritation of the skin.

3.5.3 Wastewater Treatment and Environmental Impact

All the waste is normally discharged into a reinforced concrete underground holding tank of capacity 50-60 m3. The exact purpose of this tank was not immediately clear. It was probably intended as a holding tank for the waste water, a convenient point for the addition of pH reductio chemicals, and also to serve as a sump for the sewage pumps. These pumps were used to deliver the sewage into the public sewers. this system in my view provides virtually no treatment. At the time of the visit, it was out of operation, and probably had been for a long time. All the wastewater now by-passes this tank and gravitates to the new public sewers located below this site. These sewers lead to new public sewage treatment ponds located at Doko.

The details of this treatment works, consisting of anaerobic, facultative and maturation ponds are discussed in Section 12 of this report. At the time of the visit, the intense colour of the textile mill was still present at the inlet to the ponds. This indicates that the dilution offered by sewage form other non-industrial sources in not very high, even at todays low wastewater production rates from the textile factory. The pond system has two treatment lines. At the time of the visit, one treatment line was not operating satisfactorily. The reasons were not immediately clear, but suspected to be linked with the industrial discharges. At full production, nearly 50-75% of the wastewater flowing into the ponds will be effluent from the textile mill. Unless pH and temperature of the textile mill wastewater is reduced and some of the heavy metals in solution precipitated, the waste stabilization ponds may completely breakdown. The outfall of the ponds is into a small water course that generally serves as a source of water supply for the population. The contamination of this, probably over long distances will be dangerous and environmentally unacceptable.

3.6 Uganda Bags and Hessian Mills, Tororo

The factory produces gunny bags and hessian cloth from imported jute. The plant has an installed capacity of 3721 tons a year. At the time of the visit, the factory was not operating. It is scheduled to resume production within two weeks of time of visit with a labour force of 538 producing at about 25% of the installed capacity. The factory obtains its water supply from both the public water supply system and a private borehole supply. It is rated to use 3-5 m3/day of water.

The production process here is slightly different form that described in Section 3.1. The fibre is impregnated with a mixture of vegetable oil water and a wetting agent before cudding, spinning and weaving. There are no dying processes. The plant is designed to produce very little waste water, that is discharged into the public sewer. It contains mostly oils and some jute fibre.

3.7 Uganda Blanket Manufacturers, Kampala

3.7.1 General Information

The factory makes blankets from imported yarn, and is currently producing at 10-20% of installed capacity. The plant takes its water supply from the public system. The plant has no dying processes.

3.7.2 Waste Production and Characteristics

At full capacity, the plant produces 11m3/day of wastewater. This wastewater has been previously sampled and the results of the analyses are as follows:

Suspended solids - 300mg/l
Biochemical Oxygen Demand (BOD_5) - 1200mg/l

3.7.3 Wastewater Treatment and Environmental Impact

The factory has no wastewater pretreatment plant. All the wastewater is discharged untreated into the public sewer system, and it eventually ends up at the public sewage treatment works at Bugolobi. Currently half of this plant is not in operation, the other half is performing very poorly. The details of the plant are discussed in Section 12.

3.8 Uganda Spinning Mill, Lira

This mill is completely out of operation and is currently being rehabilitated. Production is expected to begin in 1994.

The initial installation (which is being rehabilitated) is capable of producing thread of various sizes. It is however planned that a weaving installation be added in the near future.

Waste water issues will therefore not be of concern until the weaving section is put into production.

SECTION 4

SUGAR INDUSTRIES

4.1 Introduction

In this section, industries whose chief raw material is sugar cane are considered. Sugar beet is largely unknown in the country.

The products manufactured are varied, and the principal one being jaggery, and crystal sugar. Some plants producing sugar also produce alcohol (both consumable and industrial). The alcohol plant utilizes waste from the crystal sugar factory as a raw material.

The largest number of cane processing installations are jaggery mills one hundred and twenty (120) licensed ones all over the country and probably many more unlicensed ones. The wastewater from these mills is mainly wash water from vessels during cleaning operation. This is in small quantity, and is readily biodegradable, being made up of mostly sugar. The small quantity of the waste makes land disposal (the usual method of disposal) very convenient and simple. The second waste matter from the process is bagasse, a solid waste. The management of this is outside the scope of this report. These jaggeries are not of serious environmental significance and are not considered further in this report.

There are three major crystal sugar producing industries in the country as follows:

i) Sugar Corporation of Uganda, Lugazi
ii) Kakira Sugar Works, Jinja
iii) Kinyala sugar Works, Masindi (currently out of commission)

The processes in sugar making can be listed as follows:

i) Cane wash, to clean the cane; this is not done on routine basis.
ii) Cane crushing to extract the juice
iii) Boiling and chemical treatment of the juice, usually with caustic soda and sulphur dioxide.
iv) Separation of the juice into clean syrup and waste muddy liquid
v) Crystallization of syrup

The waste products in this process are form muddy juice and molasses. These are discharged to waste or used in the alcohol production or sold. A further by-product is bagasse, a solid waste.

The sources of waste water can thus, be summarized as follows:

i) Cane wash water, which will contain cellulose based organic materials, colour formed form chlorophyll, small animals and insects. It will have high suspended material, and some organic material (BOD).

ii) Pans, drains and conduits was water, which will contain mainly sugars and suspended material. This has a high BOD.

iii) Waste (muddy) juice resulting from the syrup formation process. This will have a high sugar content, and will contain soil, chlorophyll, plant matter etc. and will have a high biochemical oxygen demand (BOD) and suspended solids (SS). This waste is highly polluting and unstable.

iv) Molasses discharged to waste if not utilized in alcohol production, or sold. This will be of very high BOD.

v) Discharges form alcohol distillation lines, if this process is incorporated in the same industry. These will be washings from fermentation vats, and waste liquor from the distillation line. This will contain high organic materials (BOD) and suspended material, and may be of high temperature.

vi) Waste water from the boilers. This is generally recycled with small amounts being wasted periodically. This would be clean but high temperature water.

The sugar factories thus produce large quantities of wastes with high concentrations of dissolved biodegradable material (BOD) and suspended material, and are of serious environmental consequences. These industries are discussed here-in.

4.2 Sugar Corporation of Uganda, Lugazi

4.2.1 General Information

The chief products from the factory are sugar crystals, industrial alcohol, and molasses. A new factory has just been commissioned (in 1988) and produces 100 tons of crystal sugar per day and operates 24 hours a day. The old alcohol plant produces to orders. The molasses not used for alcohol production is sold to local liquor distillers or discharged to waste. There are a total of 700 people working in the factory (excluding sugar estate workers).

4.2.2 Waste Water Production Characteristics

The factory uses about 436 m3/day of process water. It also periodically uses 87 m3/day for cane wash. A big proportion of all this water becomes waste water.

A brief study of the waste load from the factory was conducted and the pollution load was estimated as 51,000 kg of BOD per day, and the estimated waste water organic load concentration was estimated as 130,000 mg/l of BOD This is an extremely high BOD (compared with BOD of raw sewage of 400mg/l). Thee is need for a comprehensive sampling of waste water to give more details for the waste water characteristics.

4.2.3 Waste Water Treatment and Environmental Impact

All the wastewater is discharged untreated into the R. Musambya. This is a small river where dry weather flow has been estimated as 11400 m3/d. The industrial waste water flow of 523 m3/day thus forms a substantial proportion of the flow in the river. Without going into the complex calculations for oxygen balance in the river (i.e atmospheric and algal re-oxygenation and biochemical de-oxygenation etc.), it is quite clear that the organic pollution load imposed on the river is far above what the stream can safely handle, and the oxygen resources of the river should be completely deplored.

Previous studies have indeed described the river as dead for at least 20 km, bubbling hydrogen sulphide all along the stretch, and devoid of all animal and plant life. A site visit revealed this to be the case now. Three are extensive mal-odourous sludge banks, floating material, and the stream is very offensive to the sense of sight. In consequence, this river cannot be used as a source of water supply, recreation or fishing.

4.3 Kakira Sugar Works, Jinja

4.3.1 General Information

The factory at present produce only crystal sugar. The plant operates for 24 hours a day. The factory takes its supply from Lake Victoria and privately treats it for its won use. The factory does not have an alcohol distillation plant.

4.3.2 Waste Water Production Characteristics

The factory can use up to 440 m3/day of water for the manufacturing process. Most of this becomes wastewater. The waste has been found to have the following average characteristics:

BOD - 224,000 mg/l
SS - 1,200 mg/l

There is need for comprehensive sampling of the waste water from the plant.

4.3.3 Waste Water Treatment Environment Impact

All the waste water is discharged untreated and finds it sway to the R. Kiko. The flow in this river has not been previously estimated but it is clear that the wastewater flow from the factory forms a significant part of the river flow, especially in the dry season when the river flow is low. As in the case of River Musambya in Lugazi, the R. Kiko is depleted of all its oxygen resources and is devoid of any life for a reported 30 km of its length. The river can not be used for water supply, or fishing.

4.4 Kinyala Sugar Works, Masindi

This factory is presently out of production, and plans for its rehabilitation are underway. The production processes are the same as in the two factories described above, and the waste waters are expected to be similar.

SECTION 5

SOFT DRINKS INDUSTRIES

5.1 Introduction

Industries considered in this group are those that make pop soda and fruit juices. There are a total of ten registered industries in this area, all located in Kampala, Jinja and Masaka areas. These are listed below:

(i) Masaka Food Processors, Masaka
(ii) Lake Victoria Bottling Company, Kampala
(iii) Kampala Bottlers, Kampala
(iv) Uganda Mineral Waters, Kampala
(v) Century Bottling Company, Kampala
(vi) Allison Company, Jinja
(vii) Crystal Springs, Jinja
(viii) Pop Soda Bottling Co., Masaka
(ix) Masaka Bottling Co., Masaka
(x) Jubille Ice and Soda Plant

Masaka Food Processors make fruit juice and canned fruit and all the others make pop soda. Besides the above, there are several other small unlicensed establishments that make juice. Their waste production is negligible. The available information on these plants are discussed below.

5.2 Masaka Food Processors, Masaka

5.2.1 General Information

The factory is located at Kyabakuza, just outside Masaka town. It is designed to produce fruit juices, mainly passion fruit concentrates and pineapple juice. It can also produce sliced pineapples. It currently operates for 8 hours a day and can produce 1000 crates of juice a day (approx. 7200 l/d). Depending on the availability of fruit, production could be trebled when the plant operates for 24 hours a day. It currently employs 120 people.

5.2.2 Waste Water Production and Characteristics

The factory at present uses 120 m3/day of water. The water is supplied from the National Water and Sewerage Corporation system. The manufacturing process is basically as follows:

(i) Fruit wash, at the start of the production line.
(ii) Peeling, decoring and slicing of pineapples.
(iii) Juice extraction by a squeezing/pressing procedures
(iv) Blending of juice
(v) High temperature sterilization and cooling
(vi) Bottling

The main sources of waste water can now be clearly identified as follows:

(i) Fruit wash water, consisting of vegetable matter, chlorophyll, soil, insects, etc. this will contain organic matter (BOD) an suspended solids. This stream should be continuous throughout the production period.

(ii) Wash water from the juice extractor and the various vessels and conduits. This will contain fruit juice, seeds, bits of fruit matter, sugar syrup etc. It will be high in BOD. This stream occurs periodically, only during cleaning up time.

(iii) Bottle washer waste water. This stream has a high temperature and a high pH, and contains caustic soda (sodium hydroxide), and may contain detergents. It should have a low BOD, and flow should be steady throughout the day.

(iv) Boiler and cooling waste water. This will mostly be clean although it may have a high temperature.

The waste water from the plant are thus expected to have high BOD, suspended material, and high pH and temperature.

An inspection of the waste water confirmed the high concentration of suspended material, consisting mainly of fruit peelings, seeds and fruit matter. The waste water was warm, the temperature being estimated as 50-60 ^{o}C.

This is a new factor. There has been no previous analysis of the waste water. A comprehensive sampling programme, including flow measurement is necessary to establish the complete characteristics of the waste water and the pollution load.

5.2.3 Waste Water Treatment and Environmental Impact

All the waste water streams are combined into one flow that leaves the plant through a concrete channel. The water flows into two ponds, connected in series, with a total estimated volume of 60-70 m3. These are not intended to be treatment ponds but holding vessels to permit the percolation of the water into the ground. The quantity of waste water is obviously too high to be so simply treated and there is evidence it actually overflows into the adjacent swampy river Nabajuzi. This situation is expected to worsen when production is increased beyond the present rate.

Part of the problem is the coarse suspended matter consisting of peelings etc. that seal the base of the pond. some form of treatment is necessary here, and the treatment of the liquid should be preceded by a solids separation process. At the time of the visit, there was heavy algae growth in the ponds indicating that the waste is amenable to biological treatment The effect of caustic soda has probably ben diluted out.

It should be added that this type of soft drink factories are bound to increase in numbers in future an same form of waste water treatment needs to be incorporated into their design if they are not gong to have adverse effects on the environment. The quantity of waste produced per unit of production is much higher than the waste produced by the ultra modern Lake Victoria Bottling Co. examined in Section 5.3. There is considerable scope for reduction of water usage and waste water production, particularly by recycling of boiler water and cooling water. There is also potential for use of the wastewater for irrigation, especially since this fruit factory grows its own fruits.

5.3 Lake Victoria Bottling Company, Kampala

5.3.1 General Information

the company has just commissioned a new ultra modern factory at the Nakawa/Ntinda Industrial area. It produces the Pepsi Cola group of pop sodas. It currently operates 10 hours a day and produces 7000 crates of drinks per day, and employs over 400 people.

5.3.2 Waste Water Production and Characteristics

The factory currently takes 200 m3/day of water from the National Water and Sewerage Corporation system, of which 130 m3/day becomes wastewater. the water usage, and hence the wastewater production is expected to double this year. The basic raw materials in this industry are water, syrup and concentrates. The manufacturing process for pop-soda basically involves the re-treatment of the water supply to required quality, mixing/blending with syrup and concentrates, addition of additives, sterilization, and bottling.

There are two main sources of pollution. Firstly, the bottle washwater. this wastewater is hot an contains caustic soda (the usual cleaning agent), remains of soft drinks, and all types of dirt brought in or on the bottle. It has a high pH but a low BOD and suspended solids content.

Secondly, there are washings from the syrup room. This will contain sugar, food colourings etc. It will have a high BOD and large quantities of flow will occur periodically.

Analysis of the wastewater gives the following average results:BOD - 450 mg/l

SS - 50 mg/l

5.3.3 Waste Water Treatment and Environmental Impact

The factory treats its wastewater in a septic tank and discharges it into a soak away. This treatment is hardly satisfactory for a plant that is subject to hydraulic and organic shock loads. The high pH and caustic nature of the waste makes the functioning of septic tanks doubtful. The large quantity of waste water and the poor soils in the swampy area where the plant is located makes this treatment very difficult. The waste in fact does break through and discharges untreated to the Kinawataka swamp and river.

The environmental consequences of this flow is in mainly endangering the life of the papyrus swamps. The importance of these swamps in polishing waste water and minimizing the pollution of Lake Victoria water at inner Murchison Bay is discussed in Section 10.

5.4 Century Bottling Company, Kampala

5.4.1 General Information

This plant produces the Coca-Cola group of soft drinks. The factory is located in Nakawa/Ntinda Industrial area. it currently produces 4000 crates of soft drink a day, and employs 60 people. It is producing at 65% of installed capacity. It takes its water supply from the National Water and Sewerage Corporation system.

5.4.2 Waste Water Production and Characteristics

The factory uses 178 m3/day of water of which about 150 m3/day becomes wastewater. The production processes are similar to those described in Section 5.3.2. The average characteristics are similar.

5.4.3 Waste Water Treatment and Environmental Impact

The factory treats its wastewater in a septic tank and disposes it through a soakaway. The same comments as in Section 5.3.3 are equally applicable here. The two factories are adjacent to each other.

5.5 Kampala Bottlers, Kampala

5.5.1 General Information

The plant produces the Schweppes group of soft drinks. It has an installed capacity of over 6000 crates a day and is currently producing at nearly full installed capacity.

5.5.2 Waste Water Production and Characteristics

The production process is the same as described in Section 5.3.2 and the wastewaters are similar. the factory produces 120 - 150 m3/day of wastewater. Analyses of the wastewater give the following average characteristics: BOD - 300 mg/l

SS - 30 mg/l

pH - 10

5.5.3 Waste Water Treatment and Environmental Impact

The factory discharges all its wastewater into the public sewer from where it finds its way to the public sewage works at Bugolobi. The strength of the sewage, in terms of the BOD is similar to domestic sewage but the pH is high. The dilution in the general public system is thus expected that the public sewage treatment ponds should be able to handle this if they are operating normally. The operation of this plant is described in Section 12.

5.6 Uganda Mineral Waters Ltd., Kampala

5.6.1 General Information

The factory has an installed capacity of about 800-900 crates of soft drinks a day and is currently producing at about 20% capacity.

5.6.2 Waste Water Production and Characteristics

The production processes are similar to those described in Section 5.3.2 and the wastewaters are similar. Their average characteristics are as follows: BOD - 400 mg/l

SS - 40 mg/l

5.6.3 Waste Water Treatment and Environmental Impact

All the wastewater is discharged untreated into the stormwater drainage system and this eventually finds its way into the inner Murchison Bay of Lake Victoria. The pollution of the Murchison Bay is discussed in Section 10.

5.7 Other Factories

The Jubilee Ice and Soda plant is in operation but was no visited due to time limitations. The other soft drinks factories listed in the Section 5.1 are reported to be currently out of production or producing in a sporadic manner.

SECTION 6

MEAT AND FISH PROCESSING INDUSTRIES

6.1 Introduction

This group of industries covers beef, pork/bacon, lamb, fish and other meat processing plant. It includes slaughter houses, butcheries, abattoirs and plants that make various meat products. May of these installations are small and produce very small quantities of wastes that do not pose very serious environmental problems. there are however a few that are rather large and may cause some environmental problems. The principal ones are as follows:

(i) Municipal Abattoirs (at least one each in every municipal centre in the country)
(ii) Uganda Meat Packers, Kampala
(iii) Uganda Meat Packers Factory, Soroti (out of commission)
(iv) Uganda Fisheries Enterprise, Jinja
(v) Gomba Fish Factory, Jinja (to be commissioned)
(vi) Victoria Fresh Fish, Kampala (due to be commissioned)

Some of these industries have been visited and are described below:

6.2 Uganda Fisheries Enterprise, Jinja

6.2.1 General Information

The factory produces fresh, salted, dried and smoked fish. It has a capacity of 10 tons of fish per week. At the time of the visit, the plant had just been completed and trial runs were being carried out.

6.2.2 Waste Water Production and Characteristics

The plant uses about 80m3/d of water, most of it being process water that eventually becomes industrial waste. It obtains supply from the public system and has an alternative emergency water treatment line.

The basic manufacturing processes and their relationships to wastewater production are as follows:

(i) Preparational work, involves removing gut, scales, bones, skin and splitting the fish. This is a manual operation and a lot of water is used for flushing and washing of fish and utensils. most of the waste is thus loaded with scales, has a high BOD and suspended solids. This si the principle source of waste water from the plant.

(ii) Salting and drying - this is mostly a dry process. Some periodic wasting of salt solution to waste may occur. This contributes mainly to salinity.

(iii) Smoking and refridgeration are largely dry processes.

The waste water thus results from the preparation stage and has coarse and fine suspended solids and high BOD. A grab sample of the screened raw sewage was taken during a trail run of the factory for analysis and the results are as below. These results are not typical and a fresh sampling during proper operation will need to be taken.

BOD_3 - 19 mg/l
Suspended solids - 35 mg/l

Besides the scales, guts, and bits of meat which are carried away in the wastewater, there is considerable quantity of fish left over after the filleting. For every ton of fish produced there is 2 tons of waste. Currently this plant does not have a feed ill plant to utilize this waste for making animal feed. There is thus a solid waste disposal problem. This si beyond the scope of this report.

6.2.3 Waste Water Treatment and Environmental Impact

The plant has a wastewater treatment plant comprising of the following unit operations:

- Screening
- Percolation bed
- Aeration basin
- Settling tank
- Chlorination
- Mixing chamber

The figure 6.1 over leaf is a flow diagram through the plant with all the relevant sizes of the units indicated.

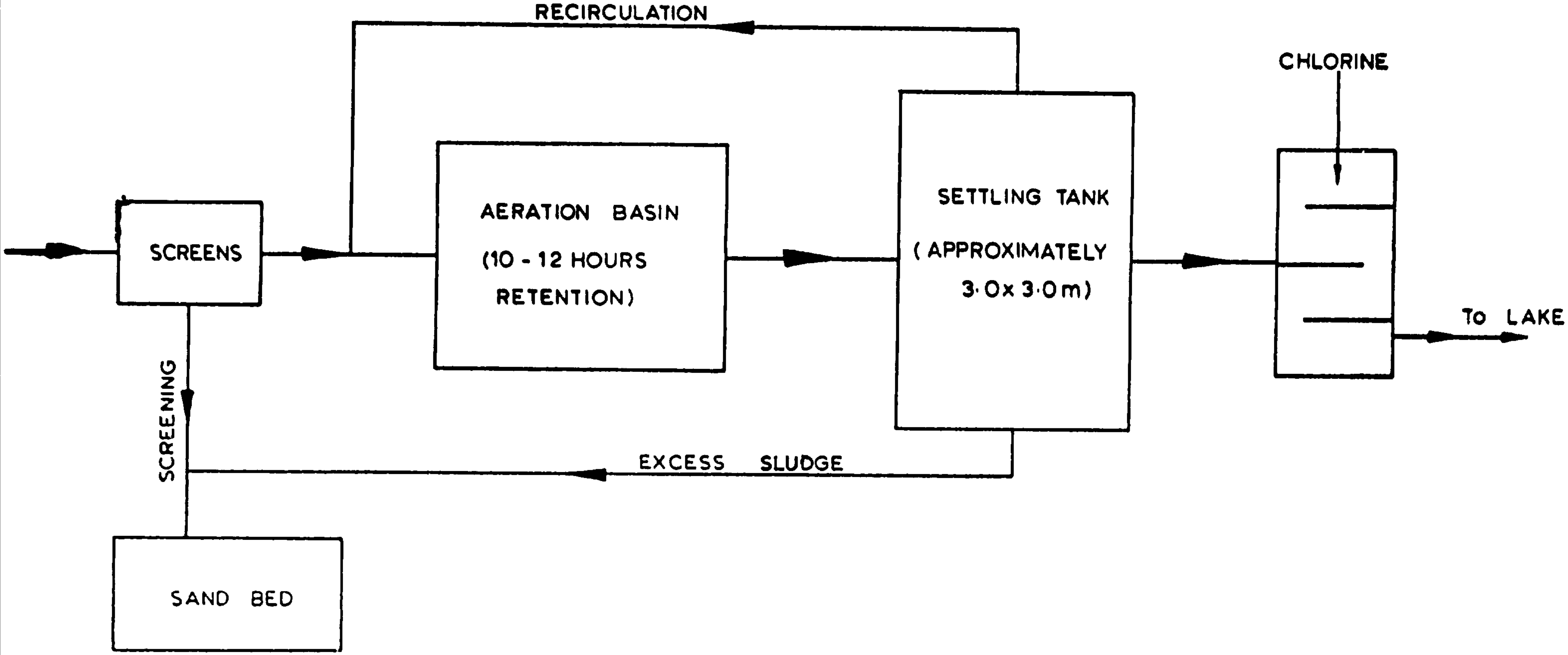
The screening arrangement appeared to be reasonable. there will probably be a problem with the cleaning of the screens. They are located in a covered pit and it will therefore be difficult to keep it clean all the time since the cieaning operation is manual. The higher operation and maintenance standards in industry as compared with public systems should hopefully ensure that they are cleaned regularly.

The aeration basin has a retention period of 10 to 12 hours. The aeration is achieved by compressors located adjacent to the basin. The purpose of the unit is to provide the conditions for micro-organisms to feed on the organic material, thus reducing the BOD. Recirculation is practiced, and in the process, bacterial biomass builds up as sludge.

The effluent from the aeration basin is settled in a vertical flow settling tank of 12 ms area. On the basis of 24 hour a day plant operation, the surface overflow rate is 0.3 - 0.4 m3/m2/hr. Most of the sludge is returned to the aeration basin, and a small amount is disposed of through the sludge/solids disposal system described below.

The effluent from the plant is chlorinated and disposed into the L. Victoria. The chlorination of the waste water introduces new problems. The chlorine may combine with some of the organic compounds in solution to produce chlorinated organic compounds. Some of these are injurous to health. They are not easily removable by conventional water treatment works. Such practice should be discontinued. The sludge to be wasted is discharged over a bed of sand equipped with an under drainage system to collect the liquid percolating through while the solids are trapped on the surface. Site observations indicated that the percolation bed is already of inadequate size at less than 20% production capacity. The plant settleable wastes production is very high and bigger and duplicate units would be preferable.

At the time of the trial run, the effluent BOD_3, conductivity and suspended solids was 16 mg/l, 1045 µs/cm and 53 mg/l respectively. These results are not representative at all, and should be treated as such. The plant is adequate if it si operated on a 24 hours a day basis. If however, all the operations of the plant are carried out in 8 hours or less, the plant will definitely be overloaded and the organic load will break through to the lake. This would be disastrous since the public water supply intake is located not more than 200m from the outfall. Waste water from fish plant may cause offensive odours in public water supply and this is unacceptable.



FLOW THROUGH FISH WASTE TREATMENT PLANT

FIG: 6·1

6.3 Municipal Abattoirs

6.3.1 General Information

Every major urban centre in the country owns and operates an abattoir where animals are slaughtered, dressed, inspected and the meat sold. The water use in abattoirs is for cleaning and washing out of dirt. It will contain blood, washings from offals, bits of meat, bones fats, and grease. The water usage and the strength of the wastewater vary according to the number of animals slaughtered daily and whether the blood is recovered or simply discharged to waste. The general practice now is to discharge the blood in the waste stream.

The waste water characteristics from the three major abattoirs in the country are discussed below:

Municipal Abattoir, Kampala

Waste water discharge - 45 m3/day
BOD - 2,500 mg/l
Suspended solids - 800 mg/l

The waste water is discharged untreated into the public sewers and finds its way to the public sewage treatment works at Bugolobi. The performance of these wastewater treatment works are discussed in Section 12.

Uganda Meat Packers, Kampala

Waste water discharge, 68 m3/day
BOD - 2,750 mg./l
Suspended Solids - 800 mg/l

The waste water is discharged untreated into the public sewer, and finds its way eventually to the public wastewater treatment works at Bugolobi. The performance of these works are discussed in Section 12.

6.4 Victoria Fresh Fish, Kampala

The Victoria Fresh Fish Factory is quite close to the Kampala water supply intake. Its waste water, unless properly treated may cause nuisance at the water works. No evidence to suggest the existence of a waste water treatment plant was observed at the factory under construction.

SECTION 7

LEATHER AND TANNING INDUSTRIES

7.1 Introduction

There are numerous establishments that deal in hides skins, and leather. Most of them deal in making leather wears or packing hides/skins for export. Some of the hides exporting establishments preserve the hides in chemicals that contain Arsenic, and generally discharge the liquor to stormwater drainage or foul sewers. Arsenic is toxic. These are small establishments that will become significant as their number increases.

Of more important environmental significance are leather tanning industries. There is currently one i operation in Jinja (the Uganda Leather Tanning Industry). There is one small in-operational one at the Veterinary Training Institute in Entebbe, and two new ones still under construction in Kampala. The number of these industries is bound to increase since government intends to put a ban on the exportation of unprocessed hides. Their importance is bound to increase in future.

These industries produce very offensive waste water. These wastes result from various manufacturing processes. These processes are as follows:

(i) Soaking and cleaning of hides; detergents and bacteriocides are added, and resultant liquor is drained to waste. The waste stream will contain detergent, animal hair, bits of meat and fat. It has a high BOD, suspended solids, and is toxic to micro-organisms.

(ii) Unhairing of hides; sodium sulphide and lime are added. this completely dissolves the hair. The waste liquor has a high pH (12-13), a very high BOD resulting from dissolved hair. The waste is also dangerous and toxic to animals and plants, due to the high pH and the sodium sulphite content.

(iii) Fleshing; to remove remains of meat and fats on the hides. The hides are treated with ammonium sulphate to reduce fats and proteins from the hides. The resulting liquor is washed to waste. The waste stream has a high BOD resulting from dissolved organic materials (fats and proteins), and unstable suspended material consisting of fleshings.

(iv) Tanning process; water, salt, acid and chromium sulphate are added. The pH of the liquor drops to about 3. The resulting liquor is drained to waste. The waste stream will be toxic (from the chromium), highly saline, corrosive and acidic.

There are various processes including shaving, splitting, drying, conditioning, kneading, dyeing, printing, etc. The main wastes here include dye house liquor. This contains heavy metals, colour, and possibly dissolved, and suspended organic material.

It can be seen from the above that the waste water from the tanning industry will have a very high BOD, suspended solids, high salinity, toxicity and is corrosive. The only operational factory in the country was visited and is discussed below.

7.2. Uganda Leather Tanning Industry, Jinja

7.2.1 General Information

The factory was commissioned in 1979 and has capacity to produce 630,000 m2 of leather of year. It is currently operating at 50% capacity.

7.2.2 Waste Water Production and Characteristics

At full capacity, the plant uss 420 m3/d of water and virtually al' of it is discharged as waste water. The factory and the National Water and Sewerage Corporation used to monitor waste water characteristics regularly. Only the results of the effluent from the treatment plant were available. These are given in Section 7.2.3. A raw water sample was not taken, mainly because the National Water and Sewerage Corporation laboratory is unable to carry out analysis of the principal, toxicant, chromium.

The waste water from the industry is toxic, corrosive, of very high BOD and suspended solids, and very high salinity. This wastewater is highly dangerous to the sewer, sewage treatment works and the environment. It should never be discharged from the factory without prior treatment.

7.2.3 Waste Water Treatment and Environmental Impact

The factory has a wastewater treatment plant. The flow diagram through the plant is given in figure 7.1 and the basic unit operations are described below.

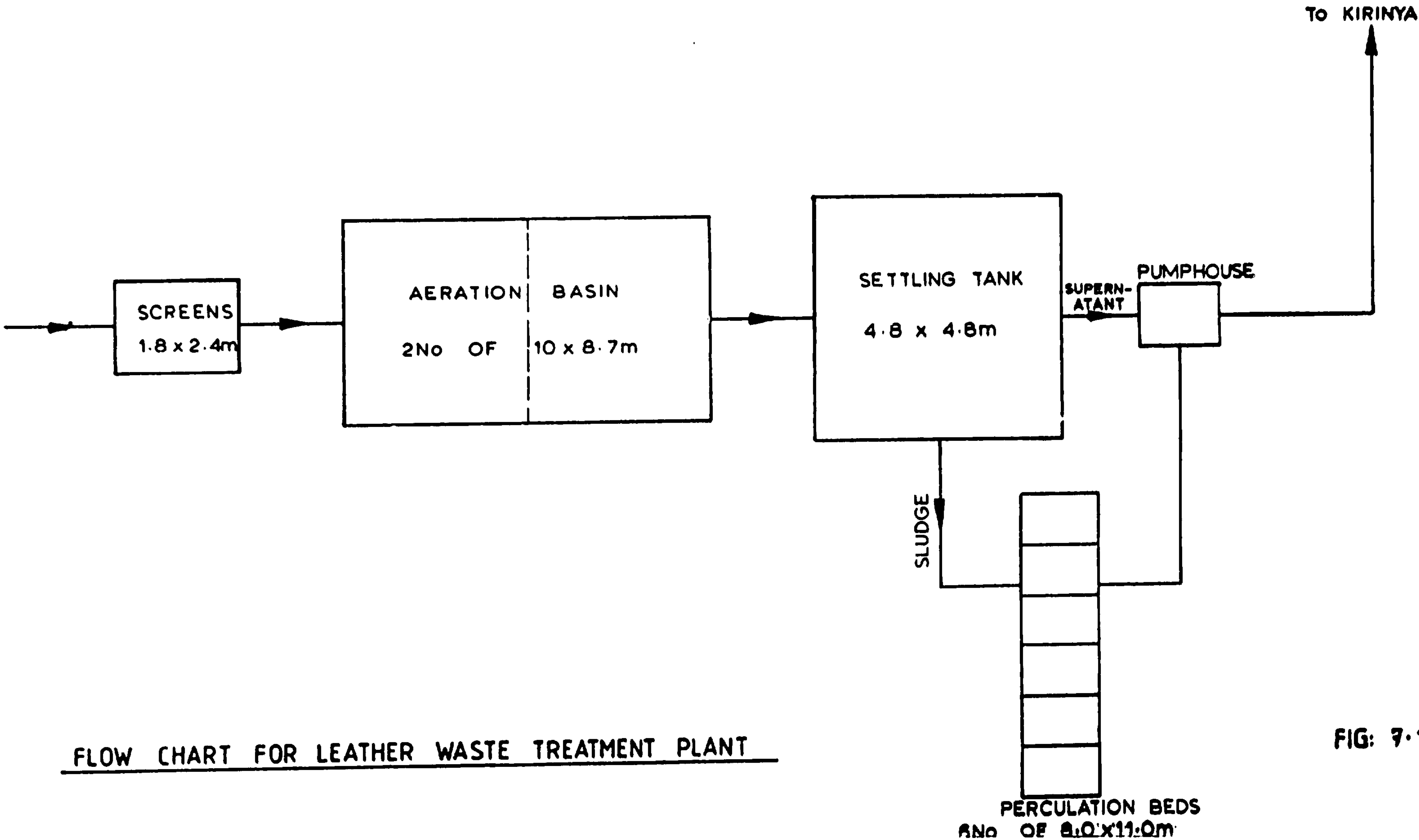
Screens of size 1.8 m x 2.4 m and 5 mm clear opening.

This removes the course suspended material, made up of fleshings, bits of hides and leather. These are dried and buried. The screen cleaning is mechanical.

Aeration Tank, of two compartments each of size 8.7 m x 10 m, each equipped with ten spurgers that bubble air through the wastewater. Lime is added to the wastewater to bring the pH to 7. This unit operation oxidizes the unstable sulphites to sulphates and precipitates the chromium as chromium hydroxide. The tank gives a retention period of nearly one day, assuming continuous release of waste in 24 hours. This tank is quite adequate, and the only variable to keep in check is the rate of aeration.

Settling tank of size 4.8 m x 4.8 m. This is a vertical flow settling tank, and provides a surface overlow rate of less than 1m3/m2/hr, assuming 24 hour operation and waste release. The supernatant from the tank is pumped to the public sewage treatment ponds at Kirinya.

There are six percolation beds of size 8 m x 11 m used for treating the sludge from the settling tank. These are beds of sand and gravel with subsurface wastewater collection pipework. The sludge from the settling tank is discharged into the bed, and the liquid portion percolates through the bed and is collected by the sub-surface drainage system and is pumped to the public sewage treatment works at Kirinya. The sludge on the surface is dried and buried.



FLOW CHART FOR LEATHER WASTE TREATMENT PLANT

FIG: 7.1

At the time of the visit the plant was operating normally except for the sludge bleed pipes of the sedimentation tanks which was jammed close. The waste water effluent frcm the sewage treatment plant was milky grey, and mal-odourous obviously still has a very high BOD and suspended solids. this effluent has been analyzed on a few occasions and the average characteristics were as follows:

Sulphides - present
Colour -blue/grey
Permanganate Value - 80 mg/l
Biochemical Oxygen Demand BOD_3 - 6(X) mg/l
pH - 6.5
Chromium - present

Most of the suspended material, including the precipitated chromium forms colloidal suspensions that are note easily removable by settling. In many leather tanning industry wastewater treatment plants, chemical coagulation and flocculation usually suing ferric chloride, is applied to help in the removal of these colloidal particles. The absence of chemical coagulation and flocculation has resulted in the poor effluent from the plant. There is now every danger that in the reducing environment of anaerobic treatment, the colloidal chromium could easily go back into solution, and the waste would be toxic again, thus nullifying all previous attempts to treat the wastewater. Such conditions do in fact exist at the Kirinya Anaerobic stabilization ponds which receives these effluents.

The other problem with the plant is that it accepts and treats the wastewater as it comes. Many of the operations in the factory are batch processes and are thus capable of giving shock organic chemical and hydraulic loads to the sewage treatment plant. In the absence of balancing tanks or recirculation, these shock loads will break through the plant. Unit operations capacities based on 24 hour plant operation would also not be applicable in situations like this. In fact the reduction of the operation time of the plant below 24 hours will immediately result in overloading of the plant.

The treatment still leaves a very strong effluent that is discharged into the public sewage treatment ponds. A biological treatment unit would be necessary to make the sewage effluent quality acceptable. The discharge of this waste into natural water courses would still be unacceptable.

The public ponds receiving these effluents seem to be operating normally. Probably the huge dilution in the ponds (total waste flow is 6(XX) m3/d) makes the impact of this wastewater from the tannery negligible. This may not remain so in future when the plant operates at full capacity and/or is expanded.

SECTION 8

OIL AND SOAP INDUSTRIES

8.1 Introduction

Oil and soap industries are spread all over the country, with most of them outside the major townships. This is to be expected since their principal raw materials are abundantly produced all over the country. These raw materials are basically all the oil bearing vegetable seeds, including cotton seed, groundnuts, simsim, soya, sunflower etc. The oil industry is closely related to the soap industry, and in almost all cases, oil and soap are produced in the same factory. As will be seen later, this is in fact beneficial from the stand point of minimizing waste water production. The principle licensed oil/soap industries in the country are as follows:

(1) New OK Oil Mill, Jinja
(2) Iganga Industries, Jinja
(3) Busoga Growers Oil Mill, Busembatia
(4) Emco Oil Mill, Jinja
(5) Anguruma Oil and Soap Works, Kampala
(6) East African Oil Industry, Kampala
(7) Edible Oil and Soap Industry, Mill No.7, Jinja
(8) Edible Oil and Soap Industry, Mill No.8, Jinja
(9) Edible Oil and Soap Industry (Budangira Oil), Mbale
(10) Akanyokori Oil Mill, Lira
(11) High Energy Foods, Kampala
(12) Nyange Cooperative Society Oil Mill, Kampala
(13) Bundibugyo Palm Dealers, Bundibujyo
(14) New Budama Ginneries, Mbale
(15) New Alliance Oil Mill, Mbale
(16) Edible Oil and Soap Industry Mill No.10, Mbale
(17) Nyakesi Oil Mill, South Bukedi Cooperative Union, Tororo
(18) Madi Cooperative Union, Moyo
(19) Edible Oil and Soap Industry Mill No.1, Soroti
(20) Mukwano Industries, Kampala
(21) Nakasero Soap Works, Kampala
(22) Nakivumbi Ginnery, Jinja

Besides the above mentioned major industries there are numerous domestic and cottage type oil extraction plants scattered all over the country, most of them not registered and/or licensed.

The oil and soap industry, like most industries in this country, has had a lost of problems i the last 20 years, that have resulted in very low levels of production, and complete close down in some of them. The problems include old machinery, and difficulty in getting oil seed, principally cotton seed following decline in cotton production. There is therefore great difficulty in obtaining up to date waste water characteristics.

The basic processes in most of the oil and soap industries in the country and their relationship to wastewater production are as follows:

(i) Extraction of the oil from the seeds. This is essentially a mechanical process, and produces no wastewater.

(ii) Neutralization of the oil; the extracted oil contains organic acids and caustic soda is added to neutralize them. This is usually a high temperature process (approx. 75°C). The main by-product is soap stock that is the chief raw material in the manufacture of soap. The soap stock is washed away in the wastewater if the plant does not have a soap manufacturing line as well. The soap stock has a very high BOD, suspended solids and pH.

(iii) Washing of the oil; water is used to wash out the impurities in the oil; and the wastewater may be discharged to waste. This is the main use of water supply in the edible oil manufacture industry. this wastewater stream will contain oil droplets, bits of see material, and will have high concentrations of suspended solids and dissolved organic material (i.e. BOD).

(iv) Bleaching and de-odourization; these are high temperature process (110 - 150°C) and may be under partial vacuum. Activated carbon or other agents are used to remove impurities before the oil is filtered. This process generates almost no wastewater.

(v) Soap manufacture, involved the addition of more caustic soda to the soap stock, and washing with water. The wastewater stream will therefore have a high pH, and high BOD and suspended solids, resulting largely from carry-over of soap stock, oil and bits of organic material from the seeds. Some industries may recycle this waste stream.

These industries generally produce quantities of concentrated wastewater containing high BOD, suspended solids oil and grease, and high pH.

Some of these industries were visited while others have data from previous studies. The wastewaters are discussed below. Most of the industries are out of production or are simply producing in a sporadic manner. Many are in a run-down condition. Due to this, their pollution problems don't appear to be major now but they will be a big source of problems in future.

8.2 New OK Oil Mill, Jinja

8.2.1 General Information

The mill has an installed capacity of 14.6 million litres of edible oil a year, and 1.36 million bars of soap a year. It would normally have a labour force of 800 people. It is an old mill and the machinery is old, and some of it obsolete. It is currently producing at less the 5% capacity. Its chief raw materials are vegetable seeds (cotton, sunflower, groundnuts etc.), caustic soda, activated carbon, and other minor chemicals.

8.2.2 Waste Water Production and Characteristics

At full production, the plant produces 45m3/day of wastewater. At the peak of the production, the waste characteristics were as follows:

BOD - 27,000 mg/l

Suspended solids - 1000 mg/l

pH - up to 13 sometimes

Oil and grease - 6000 mg/l

At the time of sampling, the plant was not producing any soap. All the soap stock was discharged to waste. At the time of the visit, the plant had capacity to produce soap from the soap stock as well, but was out of production.

It can be seen that the waste is of very high BOD, pH and contains oil and grease, all factors which are prejudicial to proper functioning of wastewater treatment plants and dangerous to the natural aquatic environment.

8.2.3 Environmental Impact

The factory discharges all it wastes into the public sewer, and the waste finds its way to the public sewage treatment ponds at Kirinya. At present, the discharge is very low, approximately 1-2m3/day and has a negligible effect of the ponds. At the peak of production, this industry alone was known to raise the pH of the sewage in the ponds from about 8 to 10-11, and the organic load from 400 mg/l to 750 mg/l. There are over four oil mills in Jinja and if all are in full operation, the sewage treatment ponds will probably completely breakdown. The combination of high pH, oils and grease is very harmful to aquatic flora and fauna.

8.3 Iganga Industries, Jinja

8.3.1 General Information

This mill produces both oil and soap. It is an old mill that is in a run down condition. At the time of the visit, the mill was not in operation, and the staff available did not know the exact water consumption and installed capacity. Previous studies on this plant give the capacity as approx. 7-8 million litres of edible oil a year. It utilizes the soap stock to produce soap. Its raw materials are vegetable seeds, caustic soda and various bleaching agents. The scarcity of seeds, and old machinery are responsible for its problems now.

8.3.2 Waste Water Production and Characteristics

At the peak of its production some years ago, the mill was discharging 7m3/day of waste water. It had a very strong waste with the following average characteristics:

BOD - 30,000 mg/l

Suspended Solids - 800 mg/l

Oil and grease - 6,000 mg/l

pH - 10 - 12

The waste is small in quantity but of high concentration. The high pH alone is enough to cause complete breakdown of biological systems in sewage treatment works.

8.3.3 Waste Water Treatment and Environmental Impact

The factory does not pre-treat its wastewater, nor does it have a balancing tank to regulate the rate of discharge. All the wastewater is discharged into the public sewer as it is produced, and eventually finds its way to the public sewage stabilization ponds at Kirinya. The performance of these ponds is discussed in Section 12.

The nature of the waste makes it toxic. Toxicity arises mainly from the high pH and excessive oils and grease. The very high BOD is far above what a normal treatment works designed to treat domestic sewage can handle. Unless the wastewater is regulated to allow for small but steady discharges to enhance dilution from other waste streams in the system, it can cause considerable problems at the treatment works.

8.4 Mukwano Industries, Kampala

8.4.1 General Information

This is a new and ultra modern factory producing both soap and oil. The oil production line is not commissioned yet. The factory is producing at a rate of 42,000 tons of soap a year. Its raw materials are tallow, palm oil, caustic soda, soda ash, sand and sodium chloride. The current labour force is about 500 people.

The production line for oil is to be commissioned soon and the raw materials will be vegetable seeds and the other standard raw materials for oil extraction.

8.4.2 Waste Water Production and Characteristics

The water usage at the plant is not clear. Evidence available from the water bills paid and present tariff indicates a consumption of 45m3/day. Estimate of water usage for sanitary purposes is about 15m3/day. This would result in process water of about 30m3.day. Factory management claims that they do not produce any wastewater since they recycle all their water supply, and only experience small losses through steam. This does not sound very convincing, and it would appear the factory may be concealing some information. A closer scrutiny of the operations of the plant is necessary.

8.4.3 Waste Water Treatment and Environment Impact

The National Water and Sewerage Corporation claims that they have not given the factory a connection to the sewer. It would appear the plant either discharges into the sewer illegally or is discharging into the storm water drainage system. This would contribute to the pollution of the inner Murchison Bag as described in Section 10.

8.5 Other Oil Mills

Most of the other oil mills have similar problems as the ones described in Section 8.2 and 8.3 and are either out of production or produce in a sporadic manner. Some of them do have some historical data about their wastewater characteristics, dated to the time when they were in good production. This data is summarized below:

Anguruma Oil and Soap Mills, Kampala

Waste flow - 2.5m3/day

BOD 25,000 mg/l

SS 1,000 mg/l

Oil and grease - 12,000 mg/l

Untreated waste is discharged into swampy river Nakamiro where it causes nuisance, endangers the papyrus swamps, and pollutes local water supply sources.

East African Oil Industry, Kampala

Waste flow - 3 m3/day

BOD 25,000 mg/l

SS 1,000 mg/l

Oil and grease 12,000 mg/l

Discharges untreated into the same river Nakamiro. It endangers the papyrus swamps and local drinking water sources.

Nyange Cooperative Society Oil Mill, Kampala

Waste flow 25 m3/day

BOD 12,000 mg/l

SS 800 mg/l

Oil and grease 6,000 mg/l

Untreated wastewater discharges into the same river Nakamiro. It endangers papyrus swamps and local drinking water sources.

SECTION 9

MISCELLANEOUS INDUSTRIES

9.1 Introduction

There are a few other industries that deserve mention in this report. Some of them produce waste waters of some importance to this project.

9.2 Paper Industry

9.2.1 Introduction

There are several establishments in the country that deal with paper and paper products. Most of these are dry industries. The wet industries in this area are those that make pulp and paper. There is no pulp manufacturing plant in the country at present. There is one industry that produces paper from imported pulp and waste paper, namely Papco Industries, located at Jinja. This industry was visited and is described below:

9.2.2 Waste Characteristics at Papco Industries

The factory at full production uses 1200 m3/d of water and produces 10 tons of paper per day. At the time of the visit, it was only producing at 50% capacity. At normal operation, this water is usually recycled, and the waste ultimately disposed of through irrigation. Currently no recycling or irrigation takes place. The waste is discharged raw into the Nile. The basic manufacturing process involves hydrolysis and defibrating of the pulp, and addition of various chemicals as follows:

- Abiatic Acid and caustic soda to improve paper impermeability to liquid;
- Starch to bind the pulp fibres together;
- Fillers (usually types of clays) and sodium silicate to give opacity to the paper;
- Alum (aluminium sulphate), reacts with the sodium abiate to give gelatious substance that is necessary in the sheet paper forming process;
- Dye, to give the appropriate colour.

The liquid, containing fibre and chemicals is discharged over a wire fabric to form sheet paper. The water is removed from the sheet by vacuum extraction. This water carries a variety of chemicals and pulp fibre that fails to get trapped on the wire fabric to form sheet paper. This waste water would normally be recycled through the system. Due to failure of machinery, it is now continuously discharged to waste. The waste water is thus expected to have high suspended materials, pH and biochemical oxygen demand. There are no records found of analyses of the waste water. A comprehensive sampling and analytical programme is required at this plant.

The impact of this waste water on the Nile has not been assessed. To date, it has been assumed that the high dilution offered by the Nile should be adequate to prevent any nuisance from occurring. The future situation here is discussed in Section 10.

9.3 Dairy Industry

There are several milk cooling plants scattered around the country and one major industry located in Kampala, namely the Dairy Corporation. The factory packs milk for local sale. Most of the waste water arises from the washing of vessels and various conduits etc. and from straight forward milk, spillage. At full production, the factory may use up to 220 m3/d of water and discharge up to 100 m3/d of waste water. The waste water has the following characteristics:

BOD	25,000 mg/l
SS	600 mg/l

The waste water consisting mostly of milk is highly unstable. It is discharged untreated into the public sewer system and finds its way to the public sewage treatment works at Bugolobi. The performance of these works are described in Section 12.

9.4 Battery Manufacture

There are several establishments that deal in battery repair, reconditioning and re-charging in the country. These discharge small quantities of wastewater containing mainly acids (low pH) and lead. There is one big scale battery manufacturing plant in the country, namely Chloride (U) Ltd.located in Kampala. The waste water from the plant is strongly acidic and contains lead. The quantities vary but are generally less than 5 m3/day. The problem with this wastewater is mainly the lead content which is toxic and has the ability to concentrate in the food chain. There is currently no treatment. All the wastewater is discharged into the public sewer. The high dilution rate has neutralised the effects of low pH. There is need to carry further analyses to estimate the actual load of lead in the wastewater, and suggest methods of treatment.

9.5 Garages

There are several engineering workshops and garages all over the country. The wastewater coming out of these plants will contain high concentrations of oil and grease. Sometimes there may only be discharges of used up engine oil only. These are highly toxic, form unsightly streaks, and cause odour and taste in the water that is very difficult to remove. There is also the problem of spillage of petrol from these sites. Some of the petrol contains lead and is toxic.

Many of the major garages, like the Nalukolongo locomotive depot, Uganda Transport Company, Spear Motors, etc. collect the oil and grease for re-sale or re-use. This is a practice that needs to be encouraged.

9.6 Mining

There is a larger copper mine located at Kilembe, near Kasese. It is currently out of production. During the time of its operation, huge heaps of cobalt and copper and other ores were dumped outside the town. These heaps have been leaching away various chemicals including copper, cobalt, iron, etc. that find their way through the storm water drainage system into the countryside and eventually into Lake George. There is now a big danger to the environment in this area, and a large scale operation to save this region is now necessary.

9.7 Chemicals and Fertilizers

There are several industries that deal mostly in packaging chemicals in the country. There is only one actual chemical manufacturing plant in the country. This is the Tororo Industrial Chemical and Fertilizers Plant (TICAF) located at Tororo.

TICAF was visited during the course of the field work. It is currently out of production but a massive plan is underway to transform it into a regional chemicals plant for the PTA (Preferrential Trade Area) area of Africa. It is planned to produce 50,000 tonnes/year and 80,000 tonnes/year of phosphate fertilizers and acids respectively. The plant will use massive amounts of water (6,000 m^3/d) for cleaning the phosphate ore.

The possible pollutants from factory include gaseous sulphur compounds (sulphur dioxide, sulphur trioxide etc.) that get released into the air and will contribute to acid rain. There will also be high suspended material in the waste water from remains of the ore, as well as acids in the waste.

9.8 Cement Industry

There are two cement industries in the country, located at Tororo and Hima near Kasese. The Tororo plant was visited during the field works. It has a capacity to produce cement (2500 tonnes/month) lime (450 tonnes/month), asbestos sheets (2500 tonnes/year), asbestos pipes (2500 tonnes/year), PVC pipes (200 tonnes/year) and PVC sheeting (160,000 m2/year). It currently only produces cement at 60% capacity.

The cement production process is a relatively dry process involving the grinding of limestone to form raw mill. Water is added to the raw mill and the mixture heated to 1400^{o}C to form clinker. Some additives, including gypsum are added and the clinker is grounded to cement.

The main problem that is immediately apparent at the plant is one of air pollution from dust. The dust settles on roofs and after a few years accumulates to exert load that may lead to roof failure. This cement dust can be washed down by rain into the environment. There is also a problem of suspended solids washed out from the plant.

The manufacture of PVC products involves a dry extrusion process. Water is used for cooling and this will contribute to temperature pollution.

Asbestos products are formed from a mixture of asbestos fibre and cement. It is a wet process and asbestos fibre ends up in the waste stream. Asbestos fibre is dangerous to health.

9.9 Plastics

The plastic industry in the country consists mainly of factories that make form mattresses and various plastic and PVC products such as plates, buckets etc. They are largely dry processes with small quantities of waste water containing chemicals that may be periodically washed away in the waste water.

9.10 Distilleries

There is only one industrial scale distillation plant for consumable alcohol located at Port Bell in Kampala (i.e. the East African Distilleries). The factory re-distills traditionally distilled liquor (enguli). It discharges about 135 m3/d of hor cooling water wash and bottle wash water. It has the same bottle wash operations as in the brewing industry. It discharges the distillation residues to waste. These are in small quantities (usually less than 5 m3/week) since the plant essentially re-distills liquor. The waste characteristics are as follows:

Residues:	BOD - 20,000 mg/l
	SS - 30 mg/l
Was water:	BOD - 80 mg/l
	SS - 100 mg/l

The "enguli" distillation is carried out all over the country and the residues which contain very concentrated organic materials are disposed of on land in small quantities all over the country.

9.11 Agricultural Wastes

These consist mostly of pesticides and fertilizers washed away from farms, and animal waste. These usually result in nutrient enrichment of natural bodies of waters and may result in entrophication. This problem will build up as intensive agricultural production picks.

9.12 Steel Mills

There is one large steel mill currently under rehabilitation in Jinja (the Masese Steel Mill). It will produce large quantities of waste water originating from the cooling process. The mill cause temperature pollution.

SECTION 10

SPECIAL ENVIRONMENTAL PROBLEMS

10.1 Introduction

The largest concentration of industries in the country are in Kampala and Jinja. There are two areas close to these centres of major industrial activity where rather serious environmental problems, caused by, among other things, industrial waste water discharges, will begin to emerge very soon. The first is the inner Murchison Bay in Kampala. This bay receives almost all the industrial (and domestic) waste water in Kampala. Kampala has the largest concentration of industries in Jinja. Jinja is the industrial headquarters of Uganda and the industries with the most pollution waste waters discharge into the Nile. These two problem areas are discussed in detail below.

10.2 Inner Murchison Bay

There are five areas in Kampala officially zoned for industrial activity and are actively growing. These are as follows:

(i) Central Industrial Area

(ii) Nakawa/Ntinda Industrial Area

(iii) Port Bell Industrial Area\

(iv) Kawempe Industrial Area

(v) Masaka Road Industrial Area

The first three are growing most rapidly and all discharge their waste water into inner Murchison Bay.

Central Industrial area has a waste water treatment plant that is in a very poor condition as can be seen in the table overleaf. This plant is discussed in detail in Section 12. Besides this problem, a substantial number of industries do not discharge their waste water into the sewer but rather into the storm water drainage system and thus finds its way to the bay through the Nakivubo Channel untreated. in fact the channel is seriously polluted as shown by the data in Table below

WASTE WATER CHARACTERISTICS AT BUGOLOBI - PLANT

Waste Water Characteristics at Bugolobi Plant

Source	BOD_3 (mg/l)	Temp (°C)	pH	EC (μ/cm)	Turbidity (NTU)
High Level Raw	1133	25.5	6.8	933	160
Low Level Raw Sewage	365	24.5	6.3	530	150
Treatment Plant Effluent	89	24.0	6.8	719	65
Nakivubo Channel (storm drainage) - up stream of stream of sewage works outfall	95	25	6.7	660	110

There are over 200 industries located in the Central Industrial Area. The major and most polluting ones are as follows:

(i) 2 no. Soft drinks factories

(ii) 2 no. Textile Industries

(iii) 2 no. Abattoirs and Meat Processing Industries

(iv) 3 no. Oil and soap Industries

(v) Over 20 no. garages and engineering workshops

The total estimated industrial wastewater discharge from this industrial area is over 5000 m3/day.

The Nakawa/Ntinda industrial area is the most rapidly growing industrial area. There are over 20 manufacturing concerns already in operation and several being built. The major ones are as follows:

(i) 2 no. soft drinks industries

(ii) 4 no. Major garages and engineering works.

There is currently no serious waste water treatment in the area. The waste production is estimated at about 2000 m3/day and this all ends up in inner Murchison Bay.

The Port Bell industrial area has some of the wettest industries in the country, and produces some of the worst waste waters. The industries located here are as follows:

(i) 1 no Brewery

(ii) 1 no Distillery

(iii) 1 no. soft drinks factory

(v) 1 no. Leather tanning factory (due to be commissioned)

The estimated present day waste water production is over 4000 m3/day, all discharged untreated directly into Murchison Bay.

The inner Murchison Bay is the source of water supply for Kampala (see intake location in Figure 12.1). It is also extensively fished by local fishermen as well as being used for recreational purposes. The pollution of this bay raises serious health problems. The pollution problems need to be addressed now before any serious and irreversible damage is caused to the bay.

A few scanty studies have been carried out in the bay and they all found that the bay was not yet seriously polluted. This has been partly attributed to the ability of the extensive papyrus swamps existing on the fringes of the bay to clean the waste water of its pollution.

The effectiveness of the papyrus swamps to polish the waste water effluent and their mode of operation needs to be studied and the limit of pollution it can take established. A sudden disappearance of the swamps after excessive pollution cannot be ruled out, and such an event has serious ecological consequences.

The long term effect of nutrient enrichment within the bay needs to be studied. This interchange of water has been previously assumed to be partly responsible for the low level of pollution in the bay despite the high level of pollutant discharge into bay. This needs further investigation. This will determine whether excessive growth of aquatic weeds resulting in nuisance is likely.

The hydraulic interchanges between the bay and main body of the lake needs to be determined. This interchange of water has been previously assumed to be partly responsible for the low level of pollution in the bay despite the high level of pollutant discharge into the bay. This needs further investigation. This should determine if the changes in quality occurring locally within the bay remain localized all the time or not.

If pollution to the bay is to be reduced, industry will have to carry out its share of pollution control. This means that the following steps need to be taken:

(i) Factories discharging into storm water drainage channels need to be identified and stopped from doing so:

(ii) The Legislation will need to be detailed out to give standards of waste water discharges and penalties for failure to meet the standards. For waste water discharging into public waste water treatment system, a tariff system tp take the pollutional load as well as quantity of waste water into account will need to be devised.

(iii) Polluting industries will need to be advised on treatment of wastewater and/or changes in production process to reduce pollution. Many of the existing industries will probably have difficulties in fitting in wastewater treatment units within the existing premises or changing the manufacturing process. Many will need some technology advice.

(iv) There is need for a licensing procedure that ensures that all necessary measures to prevent pollution have been considered in the planning for new industries. This could for example be a compulsary environmental impact assessment report.

10.3 River Nile, Jinja

The wettest and most polluting industries in the Jinja area are all located on the banks of the river Nile. The industries are listed below:

(i) Nile Breweries

(ii) Nyanza Textile Industry

(iii) Papco (Paper Industry)

(iv) Mulco (Textile Industry)

(v) Mulbox (Paper Industry)

The industries together discharge over 13,000 m3/day of industrial waste water into the Nile untreated.

No serious questions have so far been asked because it is assumed that the flow of the Nile is so high (630 m3/s) and therefore provides such a high rate of dilution (for this waste flow dilution is 1 in 4000) that treatment of the waste water is not necessary. The impact of the waste on the Nile wold be negligible.

The issues that may need attention here are not related to the organic load (BOD) but rather with faecal matter in the case of domestic waste, and toxic metals and substances in the case of industrial waste water. Besides this, there is the aesthetic issue of floating matter and colour in this water. Low concentrations of toxic metals do get concentrated in the food chain and may eventually reach toxic levels by the time it gets to human beings.

There is therefore urgent need to set standards of discharge into the Nile. The laxity in discharge requirements at this location will probably encourage highly polluting industries to locate here to avoid treatment costs. This mushrooming of polluting industries at this place may eventually lead to pollution at a time when it is costly to alter the production processes or introduce waste water treatment. The critical question here is whether the assimilative capacity of the Nile should be taken into account in deciding the treatment required by the industries. This is a question where there is a wide difference of opinion.

SECTION 11

LEGISLATION

11.1 Introduction

The existing legislation relating to discharge of wastewater (domestic, industrial, commercial, etc.) into public sewers, natural water courses, on the land etc., are contained in the following acts:

(i) The Public Health Act of 1935 (1964 Revision);

(ii) The Public Lands Act of 1962 and 1969;

(iii) The Mining Act of 1949;

(iv) Lands (Conveyance) Rules;

(v) The Factories Act (1964).

The relevant clauses of these acts are given in Appendix B.

11.2 Summary

All the acts in essence provide for the following:

(i) Prohibits the discharge into public sewers of any material harmful to the sewer, harmful to the sewage treatment works, of general nuisance, and dangerous to health;

(ii) Prohibits the discharge of any industrial waste water into a public sewer except by agreement with the local sanitary authority. It provides for the local sanitary authority the power of setting the terms and conditions to be fulfilled before discharge is permitted into the public sewer.

The current guidelines for permissible levels of pollution discharged into public sewers in the towns of Mbale, Tororo, Jinja, Kampala, Masaka, Entebbe and Mbarara are given in Appendix C. These are strictly for the use of the local sanitary authority and have never been agreed with the Ministry of Environment Protection;

(iii) Prohibits the discharge of any noxious waste water into any natural or artificial water course and empowers the local sanitary authority to take measures to abate this;

(iv) Prohibits population of any spring, river, stream, water course, pond, lake, on public land except by permission from the Minister. It empowers the Minister to set standards of purity of waste water effluents before discharge into water courses or on land;

(v) Provides the Minister with powers to stop the establishment of industrial and trade activity that may result in pollution or stop the operation of any industry that is causing pollution;

(vi) The licencing of industry is regulated by the licencing Act of 1969. The act establishes a licensing Board within the Ministry of Industry. The members of the board are drawn from the Ministries of Industry, Finance, Planning, Housing, Commerce, Uganda Development Bank and the national Chamber of Commerce.

The requirement for issuance of an industrial licence by the board are simple and straight forward. These include availability of land, feasibility studies, financial arrangements and the details of the nature of the products to be produced. The board should issue a licence to a developer when it is satisfied with the above arrangements. The developer then clears the industrial plans through several departments responsible for various building by-laws, pollution control, labour welfare, etc., in the same way as any development is implemented. The departments responsible for checking pollution control are detailed in Section 12.

11.3 Legislative Short-comings

The intention of the government to prevent pollution of natural water courses and protect the local sanitary authority's sewerage system from damage is quite clear. As it stands, the law is quite adequate in preventing pollution, but it requires to be made for relevant to the present day environmental issues.

The legislation has some implementation problems however. It does not provide the machinery for determining the reasonableness or otherwise of the terms and authority of the Minister. It does not give a clear idea to a new industrialist of what level of pollution is acceptable and/or permissible. There needs to be standards established. This problem is of great significance to the environment and of economic importance to industry. Should there for example be uniform regulations irrespective of the local circumstances of a polluting situation? It is however considered more prudent that there should be uniform guidelines which every industry should follow. An industry which believes that the regulations are unfair for its particular set of circumstances should be able to appeal to have them waived for its particular case. The industry will have to show evidence, probably an environmental impact study to backup the case. There is therefore need to have an appeal tribunal, with all industrial and environmental interests represented to serve as an appeal forum. In the same way, the local sanitary authority or the Minister should be able to appeal for more stringent measures for any particular industry if a special cause can be demonstrated.

The simplest point for the implementation of legislation is at the licencing stage. Organizations that are responsible for pollution control (see Section 12) should be included in the licencing board. The result of the present licencing procedure is that industry attempts to circumvent pollution control procedures largely because they were not made aware of the requirements and therefore the costs well in advance. The worst situation is one of completed industries that can not operate for the simple reason that the pollution processes were not anticipated in the planning stage.

Another difficulty in enforcing legislation arises our of general awareness of pollution problems. Industry views it as an avoidable cost while the general public concern does not generally go beyond the immediate effects, i.e colour, odour, toxicity, etc. Some publicity and education is necessary.

SECTION 12

INSTITUTIONAL INFRASTRUCTURE

12.1 Introduction

In this section, the existing public and private institutions with interest in industrial wastewater are discussed. The status of the existing public laboratories responsible for the analysis of industrial wastewater is discussed, and public wastewater treatment plants receiving industrial wastewater are briefly described. All private wastewater treatment plants have already been discussed in previous sections.

12.2 Distribution of Responsibility

The Ministry of Environmental Protection has the total responsibility for matters related to the protection of the environment from harmful industrial wastewater discharges. It co-ordinates all government activities directed to protecting the environment, and as such, it liaises with all public institutions which have specific tasks in environmental protection. The breadth of its responsibility is discussed later in this section.

There are several government departments with specific tasks and interests in industrial wastewater pollution control. The major ones with specific interests in industrial wastewater production and control are as follows:

(i) Ministry of Industry

(ii) Ministry of Local Government

(iii) Ministry of Water and Mineral Development

(iv) Financial Institutions

(v) Labour

The Ministry of Industry has overall responsibility for industrial policy in the country. It sets policy in the industrial sector, processes applications for the establishment of new industrial installations, and provides investors with technological information and advice on government policy, regulatory measures etc. It should therefore have advance information on expected industrial wastewater pollutants, and should have information on environmentally safe manufacturing processes, and advise on when it is necessary for industry to have a wastewater treatment plant etc.

Many industries are located in towns, and are thus in the jurisdiction of local authorities. The local authorities all fall under the Ministry of Local Government. All industrial establishments have to abide by the local authorities by-laws. In some cases, the local authorities are responsible for the enforcement of the legislation designed to prevent pollution by industrial wastewater. The local authorities are also responsible for the issue of occupancy certificates for all new industrial establishments, and the issue of trading licenses for existing industries. In the case of any breach of regulations, they have powers to close down any industrial establishment through withdrawal of licenses and denial of occupancy certificates.

The Ministry of Water and Mineral Development through its Water Development Department is responsible for the management of the surface and groundwater resources of the country. Its duties among others include the granting of water abstraction permits, development of water supplies for public use, collection and treatment of sewage, and the prevention of the pollution of surface and ground waters. Together with its parastatal, the National Water and Sewerage Corporation, it is responsible for all water supplies and wastewater disposal in the country. These two bodies have a responsibility for enforcing legislation pertaining to prevention of pollution of natural water courses, and prevention of industrial discharges into public sewers.

Many financial institutions, and especially development banks play a key role in the setting up of industries. Many crucial decisions relating to industrial process and therefore future pollution load are made with their approval. A clear appreciation of the importance of prevention of industrial wastewater pollution by these institutions would save a lot of problems in this sector.

The Ministry of Labour through its Occupational health and Hygiene Unit, and the Factories Inspectorate monitors the activities of industries, especially their relationship to workers' health and the health of any other people who may come into contact with the industrial operations. The department is staffed with people who are very knowledgeable in the area of pollution and its relation to health.

The task of the Ministry of Environment Protection in coordinating these activities requires knowledge on a variety of subjects and government procedure, and involves the handling and analysis of massive amounts of information. A lot of skilled personnel in a variety of disciplines is required to be able to carry out the following principal tasks:

(i) Co-ordinate the activities of various bodies in this sector with a view to establishing environmental safety and achieving optimal use of existing and future resources;

(ii) Set policy and advise on legislation in this sector;

(iii) Analyze all plans, activities, etc., with a view to assessing the environmental impact;

(iv) Keep abreast with the scientific, technological and management development in this sector.

A considerable amount of education and training is required to get the correct personnel for these duties. These will not only be required by the Ministry of Environment, but the other government departments as well as industry. The details of the sources of personnel, the necessary training and their deployment is beyond the scope of this report.

12.3 Status of Analytical Laboratories

There are three major analytical laboratories with duties and capability to analyze industrial wastewaters in the country. The Central Testing Laboratory located at the Bugolobi Sewage Works site is owned by the National Water and Sewerage Corporation. It is very well housed and is staffed with a small but competent well-trained and experienced staff. It was recently re-equipped and re-stocked under World Bank and EEC financing and it is capable of carrying out all the routine tests necessary for analysis of industrial wastewater monitoring. Analyses for some parameters such as certain heavy metals etc. may not be possible.

The Water Development Department of the Ministry of Water and Mineral Development has a similar laboratory. Most of the equipment is old and in need of replacement. It lacks a proper accommodation and currently has no reagents. It is basically out of operation. The staff may need retraining and refresher courses. Additional staff is necessary to make it competent.

The Government Chemists Laboratory is owned by the Ministry of Internal Affairs. It has old equipment and needs to modernized. It does carry out the analyses of most industrial wastewater parameters. Additional staff as well as training is necessary to make it efficient and competent.

The Department of Chemistry at the Makerere University has a good laboratory that can carry out most of the tests required, especially the more complicated and rarely conducted ones. It has competent but ill motivated staff. It will need restocking to carry out its duties.

12.4 Status of Wastewater Treatment Works

There are three towns in the country that have public sewage treatment works that receive industrial wastewaters of interest to this study. These are located in Mbale, Jinja and Kampala and are discussed in the subsequent sections.

12.4.1 Mbale Waste Water Treatment Works

There are two wastewater treatment plants in Mbale, namely Namatala and Doko Treatment Works. The Namatala works does not receive industrial wastewater of interest to this report and are therefore not considered further.

The Doko Treatment Works consist of waste stabilization ponds and will receive an estimated 880 m3/day of industrial wastewater most of which will come from the African Textile Mill factory (see Section 3.5). The layout of the pond system and the important dimensions are given in the Figure 12.1 over-leaf. These ponds were constructed some three years ago and are in very good condition.

The design of the pond system assumed the following parameters:

Total wastewater flow - 2502 m3/d (40% industrial)

Strength of average strength (BOD5) - 439 mg/l

Strength of industrial waste - 700 mg/l

The treatment action in the ponds is natural biological action involving bacteria and algae. The ponds can smoothly handle wastewater within the limits of its design organic loading and as long as there are no inhibiting agents. The usual inhibitants are toxic metals, pH (too high or too low), excessive colour, etc.

An analysis of the raw and treated sewage was carried out in 1989. At that time the textile factory was virtually out of operation. Results are as follows:

Parameter	Raw Sewage	Treated Sewage
Temperature (°C)	25.5	26
pH	7.1	7.3
Conductivity (µs/cm	718	667
BOD_5 (mg/l)	397	93
Suspended Solids (mg/l)	640	152

This was a good performance although much better performance is expected. At the time of site visit, one treatment line was performing satisfactorily but there was definite malfunction of one treatment line, evidenced by odour, extensive sludge banks and absence of abundant algae in the ponds. This is suspected to be due to the influence of textile mill effluent, and a frantic effort was being made to establish the cause. The textile mill waste has several inhibiting properties.

12.4.2 Jinja Waste Water Treatment Works

There are two sewage treatment works in Jinja. These are located at Kirinya and Kimaka. The Kimaka plant receives virtually no industrial water and is thus not considered any further.

The Kirinya works consist of waste stabilization ponds, and handle a high amount of industrial waste water. The Figure 12.2 shows layout of these works. The anaerobic ponds were constructed in 1987 and are in good condition. The other ponds are in desperate need of emptying. The design of the ponds assumes the following:

Flow - 6746 m3/d (23% industrial waste)

BOD - 400 mg/l

All industrial plants are assumed to treat their waste water to the above level and remove all inhibitory agents before discharge into the sewer. The plant receives the following industrial wastewaters of interest to this report:

(i) Pre-treated tannery waste (Section 7.2);

(ii) Raw Waste Water from two Oil Mills (Section 8.4 and 8.5);

(iii) Raw Waste Water from the Municipal Abattoir (Section 6.3).

As can be seen from the preceding sections, most of these industries do not pretreat their wastes at all. An analysis of the performance of the plant was carried out in 1989 and the results were as follows:

Parameter	Raw Sewage	Treated Sewage
BOD (mg/l)	299-655	81-20
Suspended Solids	570-785	26-198

The treatment works appears to be performing very well. This is probably because the industries in question are operating at a very low capacity (0-30% of installed capacity). Their waste water quantities are probably far below the expected levels. At the peak of industrial activity in the late sixties and early seventies, the wastes from these industries completely ruined the works.

12.4.3 Kampala Waste Water Treatment Works

The central industrial area in Kampala (one of the five industrial areas in the city) is serviced at Bugolobi. The layout of this plant is shown in Figure 12.3. It is a complex conventional plant consisting of grit chambers, sedimentation basins, trickling filters, humus tanks, sludge digesters, and sludge drying beds, and several pumping stations. Only half the plant is in operation and can handle up to about 16,000 m3/day of sewage (dry weather flow).

The projected sewage treatment requirements at this plant are 34,000 - 38,000 m3/d of which about 15% is industrial wastewater. There are several industries of interest discharging into this plant as follows:

(i) One textile industry (see Section 3.7)

(ii) One abattoir (see Section 6.3)

(iii) One meat packaging industry (see Section 6.2)

(iv) Two soft drink factories (see Section 5.5)

(v) One dairy industry (see Section 9.13)

The official position regarding wastewater is that there should be pre-treatment to reduce the strength to domestic waste level (i.e. BOD - 400 mg/1) before discharge. None of the industries pre-treats its wastewater.

The performance of the plant was analysed in 1989 and the results are as in the table below:

Parameter	Raw Sewage	Treated Sewage
BOD_3 (mg/l)	365-1133	89
Temperature (°C)	24.5-25.5	24
pH	6.2 - 7.2	6.8
Conductivity (μ/cm)	1015-1598	719
Turbidity (NTU)	150-160	65

It can be seen that generally the performance of the plant is poor. This is obviously due to overloading of the plant, the poor condition of the operational units, and the excessive strength of the sewage. This excessive strength is probably due to the industrial wastewater. It will get worse as the level of production of the industries improve.

SECTION 13

CONCLUSIONS AND RECOMMENDATIONS

13.1 Conclusions

1. Industries in Uganda producing waste of serious and immediate environmental consequences are in the area of breweries, tanneries, textiles, sugar,oil and soap, meat and fish processing, and soft drinks industries. There are some that will assume importance in future, and these include chemicals and fertilizers, paper, dairy and intensive agro-business. The problems in mining are already out of hand.

2. Industry to date has not treated the problem of the management of its waste water with the seriousness it deserves. This is evidenced by the few industries that offer any meaningful pretreatment to their waste waters. Virtually all discharge their waste water raw into the environment or public sewers.

3. There are currently no acceptable and legally binding industrial effluent discharge quality standards. Industry and enforcing agencies negotiate the discharge levels on a case by case basis.

4. The current legislation is not enforced, mostly due to inadequate trained personnel in the relevant departments, and inadequate financial resources available to these departments. They lack monitoring equipment, transport, analytical facilities etc.

5. There is very little, if any, information exchange between the various government departments, resulting in duplication of effort and approval of environmentally unacceptable projects.

13.2 Recommendations

1. The existing legislation needs to be overhauled to make it more responsive to the present environmental needs. This should include setting of enforceable and reasonable standards. Pollution control agencies should be included in the industrial licencing boards, as well as environmental considerations being taken into account in licensing industry.

2. Training in waste water management should be given priority. Complete training packages should be offered to various cadres graduating from our existing institutions. This should go hand in hand with publicity drives to educate the public in these matters and enlist their support.

3. Data base for waste management needs to be built up, and a reference library established, with close association with bodies inside and outside the country with interest in this area. This bank should have information on waste water treatment, safe industrial processes, state-of-the-art technology in pollution control.

4. There should be regular inter-departmental consultations, and departments involved with enforcing regulations should be provided with the necessary financial resources to perform.

5. All new industrial plans should be accompanied by environmental impact assessment reports. The management of the industrial waste water should be seen to be receiving its due attention. All new industries with unacceptable waste water should be required to treat their wastes and all existing ones should be asked to do so.

APPENDIX A

REFERENCES

1. Resources Groups Master Plans for Water Supply and Sewerage for Greater Kampala and Jinja Areas

(i) Report No. 1 - Immediate needs

(ii) Report No. 2 - First Stage

(iii) Report No. 3 - Second Stage

(iv) Report No. 4 - Special Studies "B" Water Quality prepared for WHO

2. H.P. Gauff KG. "Kampala Water Supply Expansion Project, Water Quality Report" 1988.

3. Gauff/Parkman Joint Venture. "Seven Towns Water Supply Project, Water Quality Report" 1989.

4. Gauff/Parkman Joint Venture. "Seven Towns Water Supply Project, Technical Appraisal Reports for Mbale, Tororo, Jinja, Kampala, Masaka" 1989

5. H. P. Gauff KG. "Preliminary Design for Kampala Water Supply" 1985.

6. H. P. Gauff KG. "Preliminary Design for Jinja Water Supply" 1985.

7. Parkman Consultants. "Preliminary Design for Mbale Water Supply" 1985.

8. Parkman Consultants. "Preliminary Design for Tororo Water Supply" 1985.

9. Parkman Consultants. "Preliminary Design for Masaka Water Supply" 1985.

10. Hopkins International. "Feasibility Study for Lugazi Water Supply" 1987.

11. C.A. Liburd & Associates. "Report on Water Supply for Lugazi" 1970.

12. Ministry of Industry. "Directory of Industrial Establishments of Uganda" 1988/89.

APPENDIX B

1. The Public Lands Act, 1962, Part IV, Section 24 states: "All right in the waters of any spring, river, stream, watercourse, pond or lake on or under public land (whether alienated or unalienated) shall be reserved for the Government, and no such waters shall be abstracted, dammed, diverted, polluted or otherwise interfered with, directly or indirectly, except in pursuance of permission granted by the Minister in accordance with such procedures as may be described. Provided that nothing in this subsection shall prevent the reasonable use by an occupier of such public land of any such water for agricultural, pastoral or domestic purposes only." This section has been retained in the Public Lands Act 1969, Part 2, Section 27, but modified in the proviso, which now limits the reasonable use by an occupier of such public land to "use of any such waters for domestic or small scale agricultural or pastoral purposes only".

2. The Lands (Conveyance Rules) Section 12 states: "Now sewage, filth, or refuse shall be allowed to enter into or foul in any way any lake, pond, stream or watercourse."

3. The Mining Act 1949, Part IV, Section 59 states: "Any person who shall, in the course of prospecting or aiming operations, or work connected therewith, permit any poisonous or noxious matter to be discharged into any natural water supply shall be liable to a fine not exceeding 10,000 shillings and, in addition, a fine not exceeding 1,000 shillings for each day during which the offence continues".

4. The Public Health Act 1035 (1964 revision) Section 59 (f) states: "Any noxious matter or waste water flowing or discharged from any premises, wherever situated, into any public street or into the gutter or side channel of any street or into any gully swamp or watercourse irrigation channel or bed thereof not approved for the reception of such discharge shall be deemed to be nuisance liable to be dealt with in the manner provided in this part of the Act".

5. The Municipal or Sanitary Authority is empowered by Sections 60 to 61 of the Public Health Act to: "Serve a notice on the author of a nuisance requiring him to abate it" or "Where the author of the nuisance cannot be found, to take such steps as are necessary to remove the nuisance and prevent the recurrence thereof".

6. By Section 72 of the Public Health Act: The Minister may make rules and may confer powers and impose duties in connection with the carrying out and enforcement thereof on local authorities, owners and other as to:

- the drainage of land, streets or premises, the disposal of offensive liquids and the removal and disposal of rubbish, refuse, manure and waste matters;

- the standard, or standards of purity of any liquid which, after treatment in any purification works, may be discharged therefrom as effluent.

- the establishment and carrying on of offensive trades, factories or trade premises which are liable to cause offensive smells or effluvia, or to discharge liquid or other material liable to cause such smells or effluvia, or to pollute streams or are otherwise liable to be a nuisance or injurious or dangerous to health, and for prohibiting the establishment or carrying on of such factories or trade premises in unsuitable localities or so as to be a nuisance or injurious or dangerous to health.

7. Section 81 of the Public Health Act: "No person shall throw, empty or turn, or suffer or permit to be thrown or emptied or to pass, into any public sewer, or into any drain or private sewer communicating with a public sewer: "(a) Any matter likely to injure the sewer or drain, or to interfere with the free flow of its contents, or to affect prejudically the treatment and disposal of its contents: (b) or any chemical refuse or waste steam, or any liquid of temparature higher than one hundred and ten degrees Fahrenheit, being refuse or steam which or a liquid which when so heated, is , either alone or in combination with the contents of the sewer or drain, dangerous, or the cause of a nuisance, or prejudicial to health: (c) or any petroleum spirit, or carbide of calcium".

APPENDIX C

N.W.S.C GUIDELINES FOR COMPOSITION OF INDUSTRIAL DISCHARGES TO PUBLIC SEWERS

	Maximum, mg/l
a) Biochemical Oxygen Demand (5day, 20°C)	250
b) Settleable Solids (1 hour's quiescent settling)	400
c) Dichromate Value	600
d) Ammonia (Free, as NH3)	50
e) Grease, oil or fat	300
f) Synthetic detergents	30
g) Sulphates (as SO3)	1500
h) Sulphides (as S)	20
i) Cyanides (as CN)	20
(j) Toxic metals (Summation of: Nickel, Copper, Mercury Zinc, Lead, Tin, Sliver etc.)	50
(k) Tarry matter	10
(l) Chlorine)as CL)	10
(m) Formaldehyde (as HCHO)	10
(n) Permanganate Value	200
(o) Available Sulphur dioxide (as SO2)	10
Volume discharge per day	m3/day
Rate of discharge to the sewer	m3/hour
PH value	6-8
Temperature	43°C

APPENDIX D

ABBREVIATIONS

Milligrammes per litre	mg/l
Cubic metres per day	m3/d
Suspended Solids	SS
Five day Biochemical Oxygen Demand at 20 °C	BOD5
Three day BOD at 27 °C	BOD3
Electrical Conductivity	µs/cm
Temperature in centigrade degrees	°C
National Water and Sewerage Corporation	NWSC