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UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

18554

Distr.
LIMITED

ID/WG.507/3(SPEC.)
6 September 1990

ORIGINAL: ENGLISH

United Nations Industrial Development Organization

Regional Meeting on Management of
Industrial Waste Water

Paris, France, 10-14 December 1990

PROGRAMME ON PURIFICATION OF INDUSTRIAL WASTE WATER

COUNTRY PAPER: ZAMBIA*

Prepared by

Z. Phiri

UNIDO National Expert

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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.

V.90-87571

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EXECUTIVE SUMMARY

In many developing countries, rapid industrialisation has brought with it the problem of environmental pollution associated with industrial wastewaters. For some countries such as zambia, the nature and quantities of wastewaters generated have now reached a stage where they must be controlled and monitored. The problem is how to address the matter in a situation characterised by an alarming paucity of both information and data. How can we formulate appropriate policy/legal measures in this information vacuum? It is for these reasons that this study seeks to clarify the present industrial wastewater situation in selected industrial sub-sectors in Zambia.

The study reviews the country's present situation with regard to industrial wastewaters by firstly presenting the pertinent legal and administrative framework currently in force. This is then followed by a characterising of the industrial wastewaters in selected sub-sectors. The present situation in respect to installed pretreatment facilities, industrial technology and analytical facilities is also evaluated.It is hoped that the study will provide a background against which to deal with long-term problems associted with the generation and disposal of industrial wastewaters.

It is concluded that in the case of Zambia, lack of knowledge about the physical environment and its characteristics, lack of means and experience at the institutional and organisational level of government have all contributed to incapacitating policy, legislative, administrative and technical initiatives in pollution control, management of natural resources and environmental planning. Environmental strategies have not always been compatible with the overall planning approach by government.

The lack of commensurate administrative mechanisms and resources to give effect to existing legislation is largely responsible for the chaotic situation in as far as industrial wastewater management is concerned. Government has failed to provide guidance and advice to industry.

It is recommended that in view of the plethora of agencies that might claim some say in the management of industrial wastewaters, an environmental council be set up to coordinate actvities in this sub-sector. This should be preceded by a reorganisation and strengthening of existing regulatory agencies. In this regard, the existing gaps and overlaps in the functions must be attended to.

It is further recommended that the government have a bigger say in industrial layout and siting of industries. Industry must also be encouraged to adopt in-house methods of minimising wastes. The submission of environmental impact statements must be made mandatory for all manufacturing industries.

The question of regularly characterising wastewaters should be attended to urgently both on the government and industry side. This is in view of the fact that most industries and sewage treatment plant operators (mostly district councils) are exceeding their consents and they do not know about it. The characteristics of wastewaters generated should be known with certainly for us to be able to set up realistic environmental objectives.

The impact of industry on the environment in Zambia has already taken its toll and it is incumbent upon all concerned to cooperate in reversing a trend that leads nowhere but to environmental degradation and diminished prospects for development.

Currently, there are no pretreatment facilities worth of note in the various industrial sub-sectors. The pretreatment technology to be adopted , wherever warranted, must be tailored to each industry. It must remove at least most of the gross settleable solids, grease, toxic chemicals and provide a means for balancing hydraulic and organic loads.

It is finally recommended that the provision of laboratory analytical facilities for government and other regulatory agencies be treated as a matter of urgency. It is unrealistic to expect these agencies to perform their functions satisfactorily in the absence of basic commensurate resources.

1. INTRODUCTION

1.1 Background to the study

1.1.1 The Environment - A Global perspective

Concern for the environment first emerged as an important public issue during the 1960s.At that time it was seen almost exclusively as a concern for the industrialised countries. Developing countries saw it as another arrogant attempt to divert attention from primary needs.

But this perception was shortlived for soon the concept of the environment was broadened to include issues such as loss of productive soil and desertification , the management of ecosystems, the provision of safe water and the problems of human settlements.

Many things have happened since that time , but it is evident that most developing countries still have inadequate environmental control legislation, and no body with clear responsibility, means and authority to enforce it adequately. This is particularly true of industrial wastewater management.

The problem is compounded by the understandable desire of developing countries to industrialise rapidly and the attendant ambivalence of decision makers to large industrial enterprises. But the dilemma need not be. It is interesting to note that one major conclusion of the 1972 UN Conference on the Human Environment was that there is no inherent incompability between environment and development when seen in realistic long-term perspectives. It is against this background that the problem of industrial wastewater must be seen.

1.1.2 Industrial Wastewater and the Environment

Within the general context of environmental management, the issue of industrial wastewaters is becoming increasingly topical not only in the developed countries but also in the developing countries, in many of which industrial development is hampered by lack of suitable sources of water. Conflicts between agricultural, industrial, energy and public sector water use have already arisen.

Factors affecting industrial water use and hence the generation of industrial wastewaters are many and varied but they can be categorised as either economic or institutional. It is true therfore that the control of pollution resulting from industrial wastewaters is generally amenable to rational conbinations of economic and institutional (regulatory) measures.

Municipal ordinances affecting the disposal of industrial wastewaters are commonly designed to protect the safety of the sewer structure and the operation and performance of the municipal sewage treatment plant. The public usually has to turn to central government legislation for the prevention of

stream pollution by industrial wastes. The case of Zambia is a bit different as will be seen in subsequent chapters.

The discharge of industrial wastes into public sewers creates economic problems, deteriorates sewer structures, increases maintenance costs, adds problems in sewage treatment and may increase stream pollution. There may also be problems with the disposal of sewage sludge contaminated with metals. In the case of Zambia there is virtually no monitoring as regards industrial wastewaters consequently it is difficult to say whether the above problems have occurred or not and to what extent. It is now broadly accepted that the costs of reception, treatment and disposal of industrial wastewaters by both local authorities and their customers have to be reflected in the prices paid. In Zambia, the dual role of local authorities (councils) as enforcement agency and discharger, especially since most sewage treament works exceed consents, raises very serious questions.

It is against this back - cloth then , that the issue of purification of industrial wastewaters presents itself as a formidable challenge to the industrialist, the public and the state. Zambia should wake up to the challenge.

1.1.3 Characterisation of Industrial Wastewaters

Industrial wastewaters contain a whole array of organic and inorganic substances the individual determination of which would be an imposssible task. It is for this reason that over the years there has evolved a system of characterising wastewaters based on a few parameters which are indicative of the general quality of a particular wastewater. The magnitude of these parameters gives an idea of both the public health risk and the environmental consequences. A brief discusion of pollutants and their environmental impacts is presented in the appendix. Based on this approach then, guidelines or standards can then be formulated to govern the discharge of industrial wastewaters into sewers or receiving water bodies. These guidelines are based on either the Environmental Quality Objectives (EQO) or Uniform Emission System (UES), neither of which is fully able to cope adequately with some of the complex environmental management problems which arise in relation to the water environment.

Scientific, economic, political, technical and educational inputs have to be effectively featured in the development of guidelines. This can be a mammoth task.
It is for this reason that many a developing country, Zambia inclusive, merely resort to grafting foreign standards onto unsuitable local vehicles-with disastrous consequences.

1.2 Rationale

In many developing countries, rapid industrialisation has brought with it the problem of environmental pollution associated with these same industries. One of the most vexing of these problems is that of the treatment and disposal of industrial wastewaters

For some countries such as Zambia, the nature and quantities of wastewaters generated have now reached a stage where they must be controlled and monitored before it is too late. But how can we even begin to address this problem when there is such an alarming paucity of both information and data as regards the country's industrial wastewaters, installed treatment technologies and analytical facilities? How can we formulate appropiate policy/legal measures in this information vacuum? It is for these reasons that this project seeks to clarify the present industrial wastewater situation in Zambia.

1.3 Objectives of the Study

The general objective of the project is to assist in the indentification and examination of industrial wastewaters by:

(a) reviewing the country's present situation with regard to industry with wastewater problems and characterising these wastewaters;
(b) evaluating the present situation in respect to installed treatment facilities, industrial technology and analytical facilities.

In this way provide a background against which to develop effective means to deal with long-term problems associated with the generation and treatment of industrial wastewaters.

1.4 Organisation of the Report

This report is structured into five chapters. Chapter one consists of the general background against which this study was conceived. This chapter puts in perspestive the problem of industrial wastewaters within the overall context of environmental management.

The second chapter presents the methodology which was adopted during the course of carrying out the project and the major problems encountered.

Realising the interdisciplinary nature of effective environmental management, chapter three presents Zambia's current legal, policy and administrative framework, and a technical overview of the industrial watsewater situation.

Chapter four focuses on a few case studies in each of the industrial subsectors under study. Detailed information on industrial technology, characteristics of industrial wastewaters and the status of wastewater treatment is presented.

Chapter five is the last one. It presents the conclusions and recommendations of this report.

2. METHODOLOGY

2.1 Methods of Information / Data collection

To address the project objectives, it was imperative to review background material on industrial wastewater management in Zambia. The review sought to clarify the present legal and administrative framework vis-a-vis industrial wastewater management, government policy and other general matters pertaining to technology.

Discussions with relevant government agencies also formed a significant part of the study. Questionaires were also distributed to these same agencies in order to capture finer pieces of information; in particular the roles of the various regulatory agencies.

Discussions with and visits to industries formed another major part of the survey. For the purposes of this project, the categories of industries visited included textile plants, tanneries, breweries, slaughter houses, fertiliser plants, pesticide plants and sugar industries. It was also found necessary to distribute questionaires for the sake of obtaining detailed quantitative and qualitative information. The information collected included that relating to the characteristics of industrial wastewaters, description of industrial technology and the available analytical facilities. This gave an overview of the extent of the problem in the selected industrial sub-sectors.

The lack of data on the characteristics of the industrial wastewaters necessitated the inclusion of an extensive grab sampling programme. In this way an overview of the characteristics of the wastewaters was obtained.

2.2 Limitations of the Study

This study has been conducted against a backdrop of constraints. Perhaps the most significant of these was the general lack of information on the industrial wastewaters generated by the various industries. In this respect, there was virtually no data on both flows and the characteristics of industrial wastewaters. Other general information relating to production levels and water use was also lacking. This state of affairs necessitated making profound adjustments to the original project methodology.

This pressure, as it were, limited the coverage of the study. In order to realistically focus on the selected industrial sub-sectors, fewer industries than would otherwise have been the case were chosen.

It is evident from the above limitations that relatively more qualitative than quantitative information has been generated.

Inspite of these shortcomings, this study does serve to clarify the industrial wastewater situation in the selected industrial sub-sectors. More importantly, the study does not only clearly spell out the numerous constraints associated

with the management of industrial wastewater in Zambia, but also outlines measures to be taken to improve the situation.

3. GENERAL FINDINGS

3.1 Legal Framework

The relevant document in clarifying the above is 'LAWS OF ZAMBIA'. It is important to state right at the outset that there is no exclusive law or act pertaining specifically to the environment in Zambia at the moment. Whatever legislation there is, is inadequate, fragmented and worse still confusing to both industry and the government as the following discussion will show.

As far as industrial wastewater management is concerned, there are at least four relevant acts. These are:

(a) The Local Administration Act
(b) The Public Health Act
(c) The Natural Resources Act
(d) Water Act

The relevant bits of these legal instruments are virtually inoperative, unenforced or unenforceable. Adhoc amendments have been the usual way of increasing complexity.

The local Administration Act

The preamble to this act states thus : " An act to provide for the establishment of authorities for the purpose of local government and to define certain functions and to provide for matters incidental thereto".

Among other things , this act gives local authorities the power to prohibit and control the development and use of land and buildings and the erection of buildings, in the interests of public health, public safety and the proper and orderly development of the area of the council.

Councils are also charged with the responsibility of establishing and maintaining health services; sanitary services and the power to compel the use of such services.

As far as trade effluent is concerned, a more elaborate statement of the powers of councils is to be found in the Local daministration Act, Statutory Instrument No.161 of 1985.

This act empowers councils to give consents for the discharge of trade effluents in any water courses or any land in the council area.

Council also have powers to determine the conditions and standards for trade effluent and public sewage discharge. Councils also have powers to regulate the discharge of trade effluent into sewers. Councils have the right of access to premises for the purpose of taking samples. The statutory instruments also provides a formula for the purpose of charging those who dispose of their trade effluent into sewers.

It is apparent therefore that councils have a very onerous obligation as far as the control of the generation and disposal wastewater is concerned.

The Natural Resources Act

" An act to make new provisions for the constitution of the Natural Resources Board; to provide for the establishment of the Natural Resources Tribunal; to provide for preparation and enforcement of conservation plans in designated areas; and to provide for matters incidental to or connected with the foregoing" reads the preamble.

The Natural Resources Board may make orders for the conservation of natural resources or prevention of injury to natural resources (environmental protection).

The Board may make orders for the construction of works for the disposal and control of water including storm water and drainage water. The Board may also order the construction of works for the prevention of pollution of public water by consulting the planning authority for the area in question.

The general functions of the Board therefore are, inter alia: general supervision of natural resources, stimulation of public interest in conservation, recommending legislation for conservation, improvement of natural resources and general investigation.

The Water Act

" An act to consolidate and amend the law in respect of ownership, control and use of water ; and to provide for matters incidental thereto or connected therewith".

There is established a Water Development Board to administer this law. As far as pollution control is concerned, the relevant statutory instrument clearly states the powers of the Department of Water Affairs (DWA).

In this regard then, the Water Act, amongst many other things, forbids any person, community or association to knowingly enter into any water course or body of water any effluent occassioned by trade, industrial, irrigation or sewerage works not conforming to specifications approved by the DWA. Penalties for offences under this act are also laid down in the statutory instrument.

Under the statutory instrument, contributors to the effluent of a sewage plant which does not conform to the DWA's specifications may also be charged.

Another section reads: " Any person, community or association wishing to site any industry which would cause pollution by discharging its effluent into a water course or body of water, shall apply to the Board which may approve such industry after being satified that provision to prevent pollution has been made ". The act also forbids the wilful

or negligent pollution or foulng of any public water so as to render it harmful to man, beast, fish or vegetation.

The Water Act therefore provides for the control of pollution arising from the disposal of wastewaters into water courses or bodies of water, although there seems to be obvious overlaps with the Local Administration Act.

3.2 Administrative Framework

In order to give effect to the foregoing legal instruments, the Government of The Republic of Zambia has established various agencies including the Departments of Water Affairs and Natural Resources; the various local authorities (district councils) and other interested agencies such as the Department of Industry and Ministry of Health.

The Department of Water Affairs

The Department of Water Affairs is responsible for the general administration and management of the country's water resources in respect to ownership, control and use of water. For this there is established a Water Development Board (WDB). The depatrment of Water Affairs has a lot of legal responsibility on pollution and effluent cotrol as provided for in the Water Act and the relevant statutory instrument. The department is also involved in many rural water supply schemes.

The department could through the Water Development board be more effective if it were strengthened and reorganised as previously envisaged in the Third National Development (TNDP) particularly with regard to the formation of national and regional water authorities.For these authorities to respond to environmental problems, there should be specialised sections responsible for pollution control and monitoring of the water environment.

The department of Natural Resources

This department is vested with the duty of general supervision over Zambia's natural resources including soils, waters, plant and animal life. The department is also responsible for the preparation and enforcement of conservation plans in designated areas. The Natural Resources Board may make orders for the conservation of natural resources and other matters related to environmental protection.

Local Authorities (District Councils)

Under the local administration act, the local authorities (councils) are responsible for all matters pertaining to local government in designated areas. They have powers to make by-laws to control, prohibit and compel, and they are responsible for issuing licences, permits etc.

Sewerage and sewage disposal including industrial wastewater disposal is the function of councils. Councils are public bodies and parliament has provided them with statutory powers to issue and revise consents with restrictive conditions relating to effluent quality and powers to monitor and enforce through prosecutions for criminal offences

Councils have water pollution control powers both in terms of materials to be discharged into public sewers and water bodies. These powers appear in both the Public Health Act and the Local Administration Act. Councils have however found themselves playing the dual role of enforcement agency and 'discharger', especially since most sewage treatment works exceed consents. Extracts from " Trade Effluent Regulations" for Zambia appear in the appendix.

Councils seems quite relaxed about charging for the service they provide in terms of treatment and disposal of industrial wastewaters. They seem to appreciate the contribution they receive for general rates and the benefits for the community of the employment which companies provide. In any case, prior to the reorganisation (introduction of decentralised system of government), a sizable portion of the cost of sewage treatment was recoverable from central government. Thus prior to the reorganisation, charges for effluent discharges were often not made or they were set at rather low, economic,levels. Unfortunately the trend has continued plunging the councils into serious financial problems.

Ministry of Commerce and Industry

This ministry is responsible for approving of industries and manufacturing licences. There is established an Investments Coodinating Committee (ICC) for this purpose. The department participates in consultative meetings of the Mining and Industrial Committee at the National Council for Scientific Research (NCSR). Otherwise there is no established coordinating relationship between this department and the local authorities, departments of Water Affairs, Natural Resources etc.

Consequently it can be argued that there is virtually no environmental input in the approving of industries. Industries should be required to provide environmental impacts statements prior to their approval. The plethora of single mission agencies does not augur well for the idea of 'total environment' in this country. If only decisions could be made with adequate thought for the fact that there is an environment, and that it has definite capabilities and capacities, can we be assured of stability in our environment.

The Ministry of Health

The ministry of health naturally comes into the picture since at the end of the day, the aim of the treatment and disposal of (industrial) wastewaters is to protect public health and latterly, the environment. As with other government agencies, there is virtually no coordination with the other supposedly interested parties to the issue of industrial wastewater management.

The above then, is an overview of the scattered legal measures and the single mission administrative agencies indicating strong elements of both overlaps and gaps in functions.

3.3 Current Government Policy

The relevant document on this subject is the Fourth National Development Plan (1989-1993). A discussion of the relevant (environmental) objectives of this plan follows hereunder.

Lands, Natural Resources and Water Development

The objectives include :

(a) to ensure permanent supplies of water of acceptable quality and adequate quantity;
(b) to review the Water Act and the 1980 Local Administration Act regarding the planning, management and development of water resources;

(c) to establish a national water and sanitation authority;
(d) to work out a national water master plan.

Environmental Protection and Conservation

Zambia has adopted a National Conservation Strategy (NCS). In this regard, the Fourth National Development Plan has as some of its objectives the following :

(a) the arresting and reversing of environmental degradation;
(b) the integration of rational management and use of human and natural resources into socio-economic development;
(c) the increasing of public awareness about environmental issues;

Strategies for achieving these objectives include :

(a) a commitment to provide support services especially in respect to environmental research,management and education;
(b) creating environmental protection legislation including measures against industrial and other pollution of the environment;
(c) the control of the importation and use of chemicals
(d) the banning of the importation of destructive chemicals;
(e) the integrating of an input to planning and
(f) the provision of educational information on the environment.

Comments

The resolve and determination to protect the environment generally seems to be emerging encouragingly at the policy level-- at least on paper. But the necessary legal and administrative framework, scientific and technical knowledge and the necessary awareness on the part of industry and the public required to successfully translate this determination into tangible results are lamentably lacking.

But the time has come for a vigorous campaign to persuade decision makers at all levels that environmental management, in particular industrial wastewater management, is a matter we must pursue uncompromisingly. This is not out of choice, pride or fashion trend but out of sheer necessity and honest recognition of the need. Environmental strategies must be compatible with the overall national planning approach by government.

The various institutions involved in environmental management must be streamlined and their research and operational capacity enhanced. Given the plethora of agencies that might claim some say in the 'environment', the simplest tendency has been towards inertia. A statutory body such as an environment council must be set up to coordinate environmental planning, management of natural resources and pollution control. And there should be explicit reference to industrial wastewaters as a menacing

environmental problem. This will require environmental legislation beyond the fashionable 'amendments' and grafting of foreign laws.

Indeed Zambia's economy is under severe pressure to provide basic needs. But the real world of poverty, inadequate energy and insufficient food must be reconciled with environmental concepts as a viable basis to assist in mobilising food and energy resources to meet basic human needs and aspirations.

3.4 Overview of Industrial Sub-sectors

As with all other developing countries , Zambia is in hurry to industrialise. To do this, the government has had to accelerate the use of natural resources. In this way stirring up an environmental managemnet problem.

The dilemma is : how to industrialise without getting into the environmental crisis of developed countries. The problem is compounded by the understandable unwillingness of politicians and administrations to deter the foreign investment they seek for their country's development.

For Zambia, industrial wastewaters are virtually unmanaged despite the existence of some legislation to regulate the generation and disposal of the same. Industrial wastewaters are almost always discharged directly into public sewers with little or no pretreatment worth of note. Most of the industries visited did not have flow measuring devices, analytical facilities or pretreatment facilities. Information on water use is also non-existent.

Neither the local authorities (councils) nor industries themselves regularly monitor industrial wastewater characteristics with negligibly few exceptions. The situation needs to be addressed fully and practically.

3.4.1 Brewery Sub-sector

General

There are two types of brewery in Zambia. Those producing the 'western' style lager beer and those producing the traditional 'chibuku' beer.

The are two 'conventional' brewery plants in Zambia. They both use 'package' western technology. In view of the fact that Zambians drink quite alot of beer, the prospects are that beer consumption will continue to increase and so will the volumes of the associated wastewaters

There are over eighteen 'traditional' breweries in Zambia. Traditional beer ir relatively cheap and therefore quite popular among the lower income Zambians. As with 'conventional' beer, the comsumption is likely to continue increasing and so will the quantities of wastewaters.

Industrial Technology

The major processes in conventional brewing include malt milling, mash tunning, coppering, hop backing, wort cooling and aeration, fermentation, cellaring and filtration.

For 'traditional' breweries, the major raw materials are maize and water. The maize is cooked, converted and then strained producing a yellowish brown beer commonly called chibuku. The industrial technology basically comprises a maize hopper. cooker, a convertor, a strainer and a storage tank.

Characteristics of Brewery Wastewaters

'Convertional' brewery wastewaters arise largely from pressing and filtering and the washing of containers. Most of the polluting load is from beer, yeast, fermented starches and other deposits. Brewery wastewaters are characterised by high BOD and suspended solids. Other pollutants include sulphates.

'Traditional' brewery wastewaters arise largely from washing beer dregs and spent grains. The wastewaters are characterised by high BOD and suspended solids.

Environmental Impact of Wastewaters

Traditonal brewery wastewaters may be sterile and warm and decompose rapidly when discharged into streams or sewers thereby increasing the BOD. They contribute to the organic overloading of sewage treatment plants. Their contribution of both BOD and suspended solids may make it exceedingly difficult for municipal plants to meet their consents. They have been known to contribute to anaeboic conditions in streams particularly during low flow. When discharged into storm drains, these wastes cause abnoxious odours. Conventional breweries present similar environmental problems particularly with regard to high BOD. The sulphates may attack the sewer structure and contribute to the production of abnoxious gases.

Status of Treatment Technology

None of the breweries visited had pretreatment facilities. It is difficult to say to what extent this situation has affected sewerage and sewage treatment, and the environment genrally since nothing worth of note has been documented in this respect.

But some councils have complained about the frequency of blockages and general overloading of their plants. This is to be expected judging from the high organic solid and other contents of brewery effluents.

Analytical Facilities

None of the breweries visited had facilities for analysing their wastewaters. This situation divorces the necessary sense of responsibity from polluters.

3.4.2 Slaughter House Sub-sector

General

There are 5 major slaughter houses up and down the country. These also carry out some processing. In addition there are numerous abbatoirs run by local authorities scattered all the country.

Industrial Technology

A typical process flow diagram for one of the major slaughter houses includes stunning areas, bleeding conveyors, slaughter floors and finally cold rooms. Most of the wastewater originate from the washings.

Characteristics of Slaughter House Wastewaters

Slaughter house wastewaters are characterised by various conbinations of straw, paunch manure, blood, grease, offals etc. These wastewaters are generally high in dissolved and suspended organic matter. The strength of the wastes varies throughout the day and this may materiallly affect results of treatment. Volumes of wastewaters also vary greatly throughout the day.

Environmental Impact of Slaughter House Wastewaters

The grease and paunch manure have been known to contribute to serious blockages of sewerage systems. The high BOD resulting from the other constituents may materially affect the efficiency of sewage treatment thereby resulting in general ecological imbalances in the receiving water environment.

Status of Treatment technology

At the plants visited, either there was no pretreatment or indeed the pretreatment plant had long broken down. At one plant the only pretreatment wns coarse screening and at

another the wastes were diluted before discharge into the public sewer. None of these seemed to produce satifactory results. Both plants had problems with blockages in their sewer lines. The respective councils have also complained about the frequency of blockages.

Analytical Facilities

Again none of the plants visited in this category had facilities for analysing their wastewaters.

3.4.3 Leather and Tannery Sub-sector

General

There are 3 major tanneries in Zambia and over 30 enterprises (end users). The number is likely to increase steadily and so will the associated pollution problems

Industrial Technology

The tanneries utilise 3 basic steps, that is the beamhouse operation, the tanhouse operation and the finishing. These processes involve washing, soaking, removing meat and fatty tissue and removing hair. A lot of chemicals are used in the process, most of them proprietory.

Characteristics of Tannery Wastewaters

The composition of tannery effluents is very complex. Sulphides, the high alkalinity, the high concentration of dissolved solids, dyes and chromium compounds are just some of the potential pollutants.

Environmental Impact of Tannery Wastewasters

The major environmental problem associated with tannery wastes is the potential inhibition or interference with normal sewage plant operation due to slug discharges and concentration of certain pollutants. This results into inadequate treatment and consequently pollution of receiving water bodies.

Sludge from the treatment plant might be contaminated and turn out to be unacceptable for direct disposal and thus increase the cost of sludge disposal.

It is difficult to say with certainly the extent of these problems in Zambia but the plant visited seemed to have both the above problems

Status of Treatment Technology

The plant visited which incidentally happens to be one of the largest in the country, has a wastewater treatment facility that broke down years ago. The major problems being inadequate capacity, inappropriate technology and a general lack of maintenance and spare parts. For this particular plant, the wastewater is discharged virtually untreated into a public sewer.

Analytical Facilities

As with most other industrial sub-sectors, the Leather and Tannery Sub-sector does not have analytical facilities for analysimg wastewaters.

3.4.4 Textile Sub-sector

General

There are 3 major textile plants in Zambia and around 30 related enterprises up and down the country.

Industrial Technology

Most of the textile industries use conventional industrial Technology incorporating spinning, weaving preparation, weaving and processing. The industry uses a whole range of chemicals in the various stages of processing

Characteristics of Textile Wastewaters

Textile wastewaters are generally coloured, highly alkaline and high in BOD and suspended solids. The wastewaters also contain various chemicals from the scouring and dyeing process.

Environmental Impact of Textile Wastewaters

The variety in characteristics, quantity and polluting power make textile wastewaters a potential problem if inadequately pretreated. The extreme pH values and the colour pose problems to both the sewage treatment plants and receiving water bodies, particularly in the case of zambia were rural people drink water (untreated) from streams.

Status of Treatment Facilities

The wastewaters in the plants visited are not chemically pretreated. In one of the plants, the only pretreatment is by holding in lagoons which discharge into public sewers. This is quite unsatisfactory considering the nature of textile wastewaters.

Analytical Facilities

The plants visited do not possess laboratory analytical facilities worth of note.

3.4.5 Pesticide Sub-sector

General

There are a number of small to medium pesticide formulating plants in Zambia. Almost all of them are owned by multi-national companies. The raw materials used are usually intermediate products imported into the country. There is growing emphasis on agriculture as the country's economic mainstay, consequently it is to be expected that agriculture

related pesticides will continue to be demanded in greater quantities.

Industrial Technology

As already stated most of the plants are simply formulating plants as opposed to manufacturing plants using 'packaged' technology in its various forms.

Characteristics of 'Pesticide' Wastewaters

Most of the wastewaters arise from the washing and purification of products. These wastewaters are characterised by high levels of organic matter characterised by the benzene ring structure.

Environmental Impact of Pesticide Wastewaters

Pesticide industry wastes have been known to be toxic to bacteria and fish. The wide variety of pesticides, most of which are proprietory make it very difficult to generalise on the environmental impact. Nonetheless the toxicity of pesticide wastewaters to aquatic life is well documented.

Status of Treatment Technology

The plants visited exhibited two broad methods of treatment. At one plant, the wastes (mostly washings) are led to an evaporation tank and no wastewaters are discharged to sewers or water bodies. At another plant, neutralisation tanks are used to correct for pH extremes and then these wastes are discharged into public sewers. In other words, no pretreatment technology worth of note is used.

Analytical Facilities

As with other previously discussed sub-sectors, there is a total absence of facilities for analysing industrial wastewaters in the pesticide industry.

3.4.6 Sugar Sub-sector

General

Zambia is a major producer of sugar and in recent years has been exporting the commodity to neighbouring countries. There is a sugar estate and one refinery.

Industrial Technology

Raw sugar is delivered to the refinery by rail. The raw sugar then undergoes affination, magma mixing, melting, carbonation, saturation and filter pressing to produce a brown liquor. The brown liquor is then charred to produce fine liquor. The fine liquor is then passed through a vacuum pan, a mixer and finally a granulator to produce dry white sugar.

Characteristics of Sugar Wastewaters

Sugar wastewaters are characterised by a high level of suspended organic matter containing sugar and protein. The wastes are highly putrefactive

Environmental Impact

If not properly managed, sugar wastes can lead to the overloading of treatment plants and consequently to the deoxygenation of receiving water bodies. The extent of these problems can not be stated with certainly in Zambia.

Status of Treatment Technology

At the plant visited the wastewaters are not pretreated in any way. They are discharged directy into a public sewer

Analytical facilities

The analytical facilities available at the plant extend only as far as determining the pH and the Total Dissolved Solids (TDS).

3.4.7 Comments

The foregoing overview of the industrial wastewater situation paints a rather mixed picture of the Zambian industry suggesting that in most cases, the decision to pretreat wastewaters is voluntary and entirely dependent on the goodwill of industry.

This is even more disappointing when one considers the fact these is some legislation to regulate the practice of generating and disposing of industrial wastewaters. The law, unenforced as it may be , provides for both the local

authorities and other agencies to control pollution. These agencies should, however, also be given the resources commensurate with their functions. The lack of analytical facilities at most relevant agencies does not augur well with the stated functions.

The question of pretreatment of industrial wastewaters needs a lot of caution and economic sense. It may make sense to say that the cost of treating industrial wastewaters should lie with industries themselves. But if this cost is fully passed on to the consumer, then it may be said that society is still paying for the treatment of industrial wastewaters. This is particularly true in an economy characterised by monopolies.

The pretreatment technology adopted must be tailored to each industry, it must remove at least most of the gross and settleable solids, fats, grease, toxic chemicals and provide a means for balancing hydraulic and organic loads to subsequent treatment stages. The available dilution in recepient sewer and streams should be ascertained or at least properly estimated.

It is further recommended that councils and the department of water affairs become more responsible in enforcing the law on trade effluent by initially adopting an approach that incorporates coercion and cooperation, education and incentive. Industries must be made to take an interest in their discharges. Some of the methods of pollution control simply include good housekeeping, closer process control, process chemical substitution and internal reduction of waste loads. It need not be always be a question of constructing a treatment plant!

4.0 CASE STUDIES

4.1 Breweries

4.1.1 Zambia Breweries (Lusaka)

General

Zambia Breweries is one of two 'conventional' breweries in Zambia. It has an installed capacity of 800 000 hectolitres per year. The present capacity utilisation is about 70 per cent. The plant operates 24 hours per day. The major raw materials are malt, maize, sugar and hops. There is no recycling of waste.

Industrial Technology

The relevant process flow diagram is as indicated in figure 4.1.1

Characteristics of Industrial Wastewaters

The characteristics of the industrial wastewaters as determined from grab samples are as shown in table A 4.1.1 in the appendix. The brewery is serviced by one drain which receives seven streams of effluent from different parts of the plant.

Environmental Impact of Wastewaters

The receiving treatment plant is likely to be affected by the high BOD and Total Dissolved Solids in the Brewery wastewater. This would subsequently affect the quality and use of recipient water. The varying volumes and quality of the wastewater are also major areas of concern.

Status of Treatment Technology

The wastewaters from this plant are not pretreated in any way. They are discharged directly into a public sewer. It is recommended that they be at least screened, neutralised and equalised in sedimentation tanks prior to discharge into the public sewer. Recovery, concentration by centrifugation and evaporation should also be considered.

Analytical Facilities

There are no analytical facilities at this plant.

4.1.2 National Breweries (Lusaka)

General

National Breweries (Lusaka) is one of the many 'traditional' breweries in Zambia. It has an installed capacity of 207 200 litres per day. The present production stands at 133 200 litres. The plant operates on a 24 hour basis. The major raw materials are maize and water. There is no recycling of wastewater.

Industrial Technology

The relevant process flow diagram is as shown in figure 4.1.2. The wastewaters originate largely from washings, spillages and beer dregs from the straining process.

Characteristics of Industrial Wastewaters

The characteristics of industrial wastewaters are as shown in table A 4.1.2 in the appendix. The brewery is underlain by 3 drains which discharge into a public sewer.

Environmental Impact of Wastewaters

There is a severe odour nuisance in the plant vicinity. The high BOD and suspended solids in these wastewaters suggest the importance of some pretreatment in order to protect both the public sewage treatment plant and the general environment.

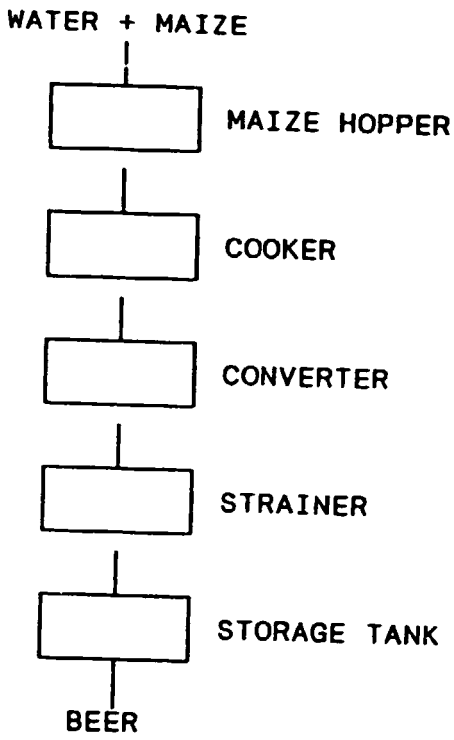
Status of Treatment Technology

The wastewaters from this plant are discharged raw into a public sewer. It is recommended that these wastes receive at least screening and sedimentation pretreatment before discharge into the public sewer.

Analytical Facilities

The plant has no laboratory analytical facilities.

Figure: 4.1.2: Process flow Diagram - National Breweries (Lusaka)



4.1.3 National Breweries (Kafue)

This plant utilises the same industrial technology as the Lusaka plant (4.1.2) except that the wastewaters are discharged directly into the Kafue river. The characteristics of the wastewaters are as shown in Table A 4.1.3 in the appendix.

It is recommended that these wastes be screened and detained in oxidation ponds prior to discharge into the Kafue river in order to lessen the likely organic pollution of the receiving water body which is a source of both fish and drinking water for the surrounding population.

4.2 Textiles

4.2.1 Kafue Textiles

General

Kafue Textiles of Zambia (KTZ) is one of the largest textile plants in Zambia. It has the capacity to process 20 tonnes of cotton per day. The present capacity utilisation is about 12 tonnes per day. The major raw material is cotton. There is some amount of recycling of waste, although the final wastage is quite significant.

Industrial Technology

The manufacturing processes executed at Kafue Textiles of Zambia consist of spinning, weaving, leaching, dyeing, printing and packing. The processes that contribute most of the wastewaters include bleaching, dyeing and printing where such chemicals as caustic soda, hydrogen peroxide, starch, azo dyes and other organic preservatives are used.

Characteristics of Industrial Wastewaters

The characteristics of the industrial wastewaters as determined from grab samples are presented in table A 4.2.1 in the appendix.

Environmental Impact of Wastewaters

The high suspended solids and BOD load and the characteristics of the various streams of these wastes make them quite difficult to manage. The risk that these wastes pose to both the public sewage plant and the environment at large are apparent.

Status of Treatment Technology

The trade effluent is settled in lagoons without any chemical treatment. The effluent from the lagoons is discharged directly into a public sewer. It is recommended that these wastewaters be screened, equalised, adjusted for pH and depending on the success or failure of inhouse wastewater controls, some precipitation or co-precipitation would be desirable prior to discharge into the public sewer.

Analytical Facilities

The textile plant does not have adequate facilities for analysing its pollution load.

4.2.2 Ndola Weaving Textiles

General

This is one of the newer textile plants in Zambia. The major raw materials to the plant are polyester, viscose and cotton. The major waste products are dyes and fibre suspended or dissolved in water.

Industrial Technology

The relevant process flow diagram is as shown in figure 4.2.2. Most of the wastewaters are generated at the washing/scouring and dyeing stages.

Characteristics of Industrial Wastewaters

The characteristics of the wastewaters are as shown in table A 4.2.2 in the appendix.

Environmental Impact of Wastewaters

Both the COD and Total dissolved Solids suggest that some further management of the waste at the source is desirable. The varying nature of the wastes in both quality and quantity is a source of concern. But at this plant horizontal flow sedimentation tanks do equalise the waste prior to discharge into council sewers.

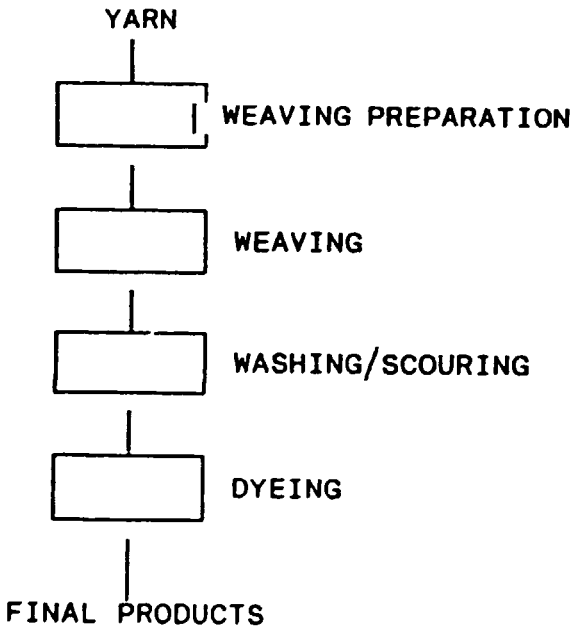
Status of Treatment Technology

The plant has a twin chamber horizontal flow settling tank which is in good working condition. But as with all textile wastewaters this is felt to be totally inadequate.It is recommended that a screening process be added prior to the equalisation/sedimentation process. In view of varying pH levels, it is also recommended that the wastes be neutralised prior to discharge. As a long term measure, ways to reduce the escape of inorganic pollutants should be investigated. Closer process control is one.

Analytical Facilities

The plant has no laboratory analytical facilities for analysing industrial wastewaters.

Figure 4.2.2: Process Flow Diagram - Ndola Weaving Textiles



4.3 Slaughter Houses

4.3.1 Cold Storage Corporation of Zambia (Lusaka)

General

Cold Storage Corporation of Zambia is one of the major slaughter house industries in Zambia. It has the capacity to handle 300 beef cattle per day. The present capacity utilisation is about 65 per cent. The slaughter house is in operation 8 hours per day.

Industrial Technology

The relevant process flow diagram is as shown in figure 4.3.1. Cattle is stunned and slaughtered in the stunning area. Blood is collected in tanks in the bleed conveyor area. This blood is used for blood meal stock-feed. Sometimes the blood is just led to waste. On the slaughter floor, a lot of water is used for cleaning the offals which normally contain a lot of manure. The blood and manure are led through drains down to a non-functional pretreatment unit and then to the public sewer after dilution.

Characteristics of Industrial Wastewaters

The wastewaters as characterised from grab samples are as presented in table A 4.3.1 in the appendix

Environmental Impact of Wastewaters

The grease and washwaters originating from this plant have the potential of affecting both the sewerage system (blockages) and the public sewage treatment plant (overloading). These effects can have grave environmental consequences. The straw, paunch manure and the wide variations in both quality and quantity of effluent can severely affect the results of treatment.

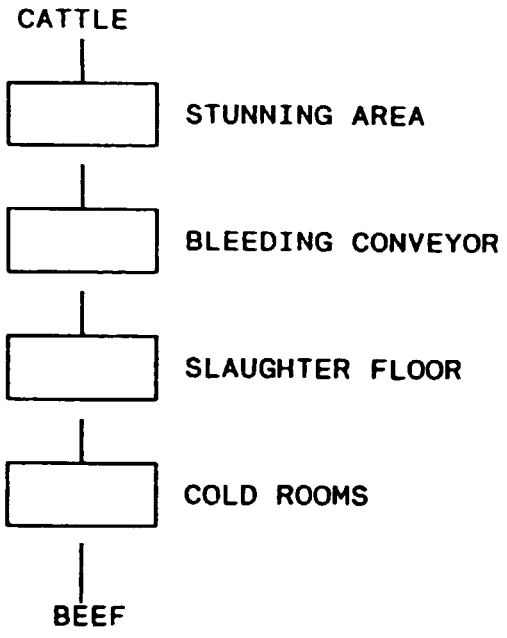
Status of Treatment Technology

The pretreatment plant originally had an aeration unit. The unit is at present completely non-functional and clogged with manure. The only 'pretreatment' that the wastewaters receive is dilution with clean water. This state of affairs was attributed to the lack of spare parts. It is recommended that these wastewaters be screened, skimmed, equalised and diluted in sedimentation basins prior to discharge into council sewers.

Analytical Facilities

There are no analytical facilities at this plant.

Figure 4.3.1: Process Flow Diagram - Zambia Cold Storage Corporation (Lusaka)



4.3.2 Zambia Pork Products

General

Zambia Pork Products specialises in slaughtering pigs and processing pork products. The plant operates on an 8 hour per day basis. The major raw materials are pigs, casings, flour and spices. There is no recycling of waste.

Industrial Technology

The relevant process flow diagram is as shown in figure 4.3.2. A great deal of waste mainly manure and washings, is generated in the receiving section. The killing process, which permits the bleeding of the pigs generates a lot of blood.

The next stage is the scalding tank, in which water is used to condition the carcas for easy hair removal. Each of the remaining stages uses water for cleaning purposes. This combined with the blood, manure and general cleaning wastes, constitutes a significant pollution load.

Characteristics of Industrial Wastewaters

The characteristics of the industrial wastewaters are shown in table A 4.3.2 in the appendix.

Environmental Impact of Wastewaters

Pork wastewaters are known for their notorious role in causing blockages in sewers if not properly managed. Their direct discharge into a sewerage system is likely to have telling environmental consequences in respect of both blocking of sewers and affecting the efficiency of sewage treatment.

Status of Treatment Technology

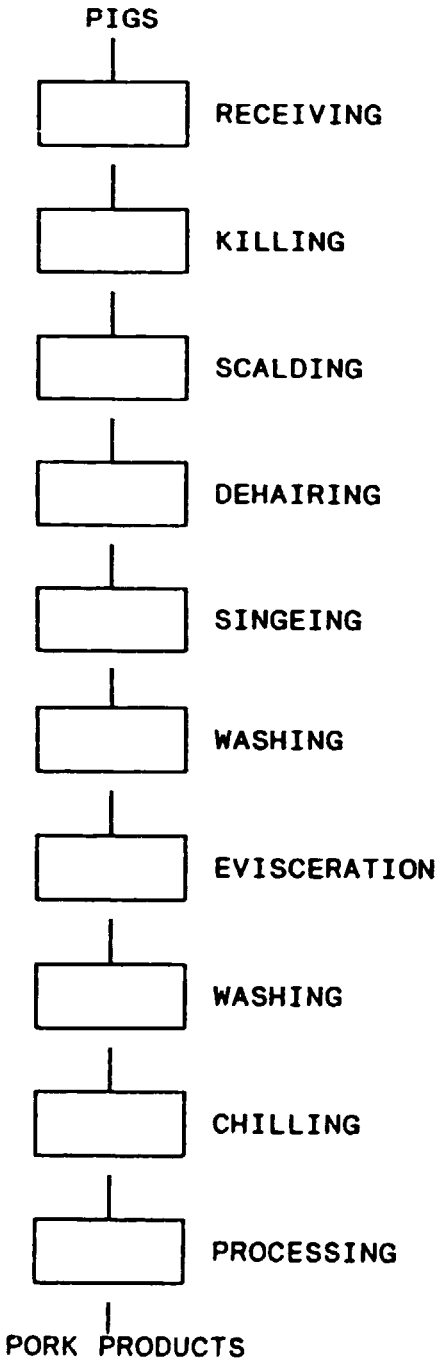
There are various streams of wastewaters from this plant. These are led to an inspection chamber and subsequently to a public sewer without any pretreatment.

Thoughout the slaughter house the drains are covered with coarse screens for the purpose of trapping the course pieces of meat etc. The plant does not seem to have been appropriately designed for its operations. It is recommended that the wastewater be screened, equalised and diluted; and skimmed prior to discharge. Some recovery of waste is also recommended.

Analytical Facilities

There are no analytical facilities at this plant.

Figure 4.3.2: Basic Process Flow Diagram - Zambia Pork Products



4.4 Tanneries and Leather

Bata Tannery

General

Bata tannery is one of the major tanneries in Zambia. It has the capacity to process 750 hides per day. The present production level is about 600 hides per day. The present production level is about 600 hides per day. The plant operates on a 24 hour per day basis. The major raw materials are raw hides and tanning chemicals. There is no recycling of waste.

Industrial Technology

The manufacturing stages at this plant consist of three basic stages namely: preliminary treatment, tanning and finishing. These processes require large amounts of water and as a result produce a lot of effluent. This is more so in the pretreatment stage which includes preservation, fleshing, liming, depilation, gran cleaning, deliming, softening, smoothing and squeezing. All wastewaters are led to a non-functional pretreatment plant.

Characteristics of Industrial Wastewaters

The general characteristics of the tannery effluent are as shown in table A 4.4 in the appendix.

Environmental Impact of Wastewaters

Tannery wastewaters are, environmentally speaking, one of the most notorious. Their high BOD and total Solids and the presence of sulphides, chromium and other materials suggest the importance of properly managing these wastes at source. The chromium can inhibit sewage treatment processes and sludge disposal can cause a big problem as well. The wastewaters from this plant are discharged virtually raw into the public sewer posing both environemntal and health risks.

Status of Treatment Technology

The wastewaters from this plant are now only settled before discharge into a public sewer. But there are plans to install a chrome (III) precipitation unit. The original plant is completely out of order due to lack of spare parts. The plant provided for equalisation, aeration, sedimentation and lagooning before discharge into public sewers. The solution to this problem lies in reactivating the broken down plant and incorporating a chemical precipitation unit for the purpose of handling the chromium. The present situation is highly hazardous.

Analytical Facilities

There are no analytical facilities at this plant.

4.5 Pesticide Plant

Cooper Zambia Ltd (Lusaka)

General

Cooper Zambia is one of the largest pesticide formulating companies in Zambia. The installed capacity of the plant is about 12 000 litres per day. The present production level is 8 000 litres per day. The plant is operational for 5.5 hours per day. The major raw material is organo-phosphate. There is no recycling of waste materials.

Industrial Technology

It is not possible to list the processes for the formulation of the various proprietory products. There is no manufacturing per say but just formulation in the narrow sense of the word.

Characteristics of Industrial Wastewaters

The characteristics of the wastewaters as determined from a grab sample are as presented in table A 4.5 in the appendix.

Environmental Impact of Wastewaters

The presence of pesticides in water per se does not in itself present a risk to the consumer. The extent of exposure and the toxicology of the chemical need to be taken into account in order to estimate the risk. The risk, in the case of Zambia, is increasing, due to increasing and abusive use of pesticides.

Status of Treatment Technology

There is no pretreatment of wastewaters except a neutralisation process. From the neutralisation unit, the wastewaters are discharged into a public sewer.

Analytical Facilities

There are no laboratory analytical facilities for wastewaters at this plant.

4.6 Sugar Sub-Sector

Zambia Sugar Company

General

Ndola Sugar Refinery has an installed capacity to 1 300 tonnes of melt per week. The present process capacity utilisation is such that 600 tonnes of melt are being processed per week. The plant operates on a 24 hour basis. The major raw material is raw sugar and the major waste products are molasses, drum water from blowdowns and wash water.

Industrial Technology

The simplified process flow diagram is as shown in figure 4.6

Characteristics of Industrial Wastewaters

The wastewaters from this plant are characterised by a very high COD. The value exceeds the maximum permissible value (Zambia) of 1 800 mg/l for discharge into sewers. This suggests the importance of further recycling as an inhouse solution. Alternatively the wastes could be detained in either lagoons or oxidation ponds prior to discharge into public sewers. The putrefactive nature of the waste needs to be carefully taken into account in the design of pretreatment facilities. Refer to table A 4.6 for the characterisation of these wastewaters.

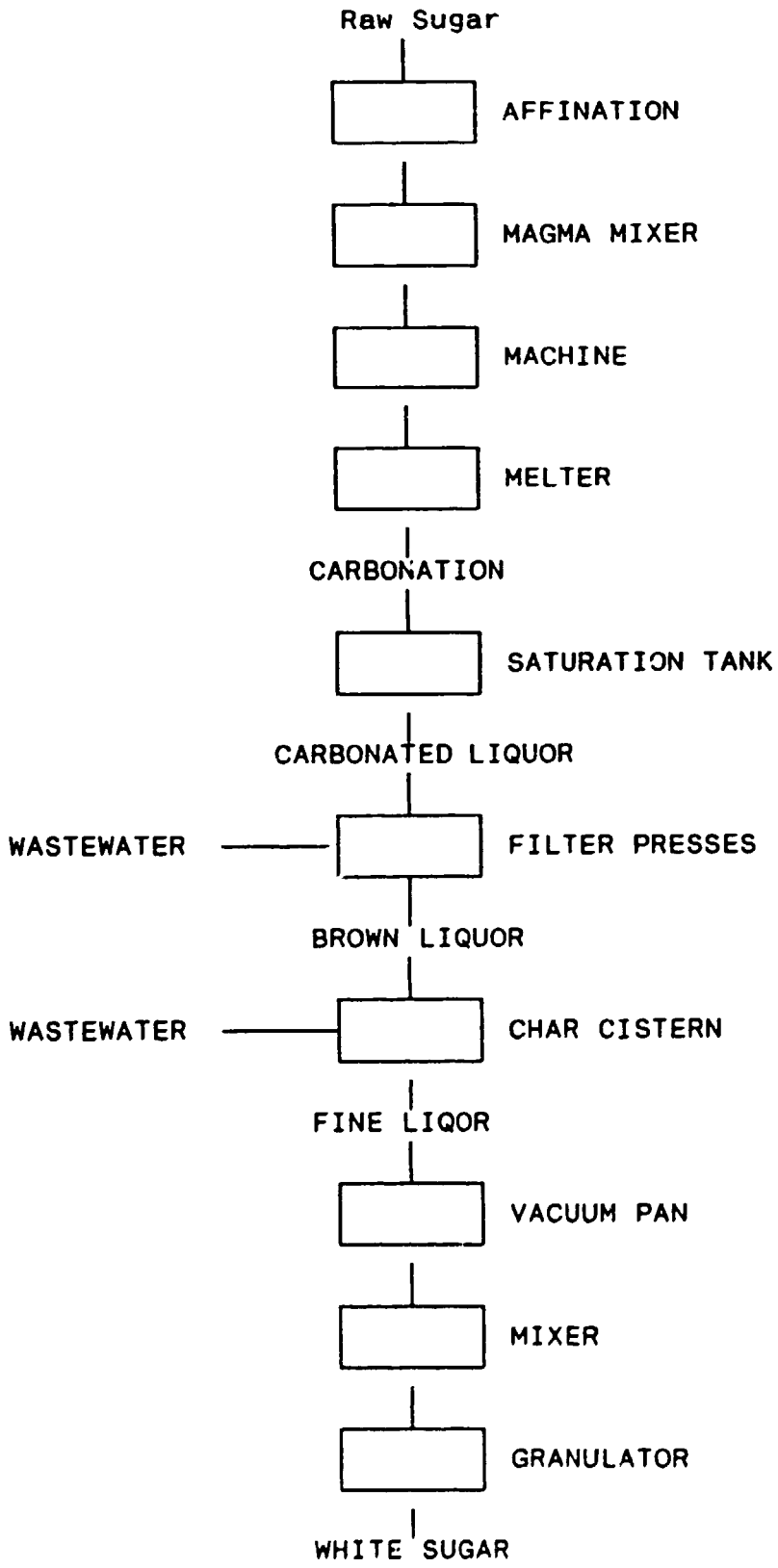
Environment Impact

In the absence of sufficient dilution in the sewers, the high COD values can lead to organic overloading in sewage treatment plants. The environmental consequences of such a situation are apparent.

Status of Treatment Technology

At Ndola Sugar Refinery the wastewaters are not pretreated in any way, they are discharged directly into a public sewer. This is totally undesirable in view of the fact that these wastewaters exceed their consent by far.

Figure 4.6: Simplified Process Flow Diagram - Ndola Sugar Refinery



Analytical Facilities

Only pH and Total Dissolved Solids and a few other parameters can be analysed at the laboratory at this plant.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 General

In the case of Zambia, lack of knowledge about the physical environment and its characteristics, lack of means and experience at the institutional and organisation level of government have all taken their toll in paralying policy, legislative, administrative and technical initatives in pollution control, management of natural resources and environmental planning. Both 'public' and 'industrial' awareness of the environment are unacceptably low.

Environmental strategies have not always been compatible with the overall planning approach by government. An environmental input should be injected at the highest planning level and governmnet must provide the leadership in environmental matters. This is particularly urgent in the case of industrial wastewater management as the following sections will show.

5.2 Legal and Administrative Framework

Industrial wastewaters are virtually unmanaged despite the existence of some legislation to regulate the generation and disposal of wastewaters. This is partly due to the fashionable practice of grafting foreign laws and standards onto unsuitable local vehicles. Legislation, in whatever form, must be followed by the setting up of the appropriate administrative mechanisms and the provision of commensurate resources, otherwise it can not be expected to take effect. Such a state of affairs gives false security.

Institutions involved in environmental management must be streamlined and strenthened and their research and operation capacity enhanced. Given the plethora of agencies that might claim some say in the environment, the simplest tendency has been towards inertia. A statutory body such as an environmental council must be set up to coordinate environment planning, management of natural resources and pollution control. And there should be explicit reference to industrial wastewaters as a menacing environmental pollution problem.

The Department of Water Affairs could, through the Water Development Board, be made more effective if it were strengthened and reorganised as previously envisaged in the Third National Development Plan (TNDP) with regard to the formation of national and regional water authorities. These could then unsurp some of the powers of the overburdened district councils particularly with regard to the regulation of the disposal of industrial wastewaters into water courses or water bodies. This department already has a hydrological network and the basic prerequisite staff background. The overlap in functions regarding the control of the disposal of wastewaters into streams or water bodies is unsatisfactory and leads only to inertia. If these changes are made, district councils would then be subject to monitoring by the Department of Water Affairs more so since

district councils are major polluters by reason of their sewage treatment plant discharges.

5.3 Industrial Technology

The industrial technology used in most of the plants visited is casual and wasteful. It has not dawned on the Zambia industrialist that wastes are simply residual resources. General decisions and industrial plant designs are made without any regard for the environment whatsoever. The government should make the approval of plans for new industries, however small, a prerequisite to issuing manufacturing licences. The submission of environmental impact statements should also become mandatory. The Zambian industrialist has to be made aware that the control of the quality and quantity of industrial wastewaters need not necessary entail the construction of a treatment plant. The industrialist may gain by instituting in-house pollution control measures such as separation or recovery of wastes.

5.4 Characteristics of Wastewaters

Neither the regulatory agencies nor the industries themselves regularly monitor the characteristics of wastewaters. This is a very unsatisfactory and irresponsible situation on the part of both industry and government. Most of the wastewaters sampled exceed consents by far in one way or another and it is scandalous that most of these industries are neither being advised nor made to pay for discharging the kind of wastes that may actually upset the public sewage treatment plants and cause general environmental hazards.

5.5 Environmental Impact

In a country where fish is a major source of protein and many people use water directly from streams for domestic purposes, the protection of recipient water courses or water bodies assumes not only health and economic but moral dimensions as well.

It is also important to realise that even where water is treated before use, there is no guarantee that the methods of treatment used remove the whole of foreign matter. This is all the more important for a developing country such as Zambia where most water treatment plants can not be said to be functioning properly. It is for these reasons that the environmental impact of unmanaged industrial wastewaters can not be overemphasised.

5.6 Status of Treatment Technology

In most of the industries visited, there is no pretreatment technology worth of note. Where pretreatment facilities exist, they are not operating under conditions for which they were designed and the equipment is not always well suited to the conditions in which it is being operated.

Lack of maintenance, the vast unplanned for increases in the load of effluent and various operational problems have left the few pretreatment units in very bad states.

The total lack of knowledge of the characteristics of wastewaters by industry does not augur well for the management of these same wastes. The problem has been compounded by the bad state of the economy which means that most industries are operating for below capacity. Consequently priorities do not favour the management of wastes.

The issue of requiring industries to pretreat their wastes should be approached cautiously in view of the fact that the Zambian industry is characterised by monopolies. The cost of pretreatment may actually be blindly passed on to consumers. Zambian industry, therefore, needs a lot of advice and guidance in this respect.

The pretreatment technolody to be adopted, wherever warranted, must be tailored to each industry. It must remove at least most of the gross setteable solids, grease, toxic chemicals and provide a means for balancing hydraulic andd organic loads. The available dilution in recipient sewers and streams should be ascertained.

Such methods of pollution control as good housekeeping, closer process control, process chemical substitution and internal reduction of waste loads should be considered. It need not always be a question of constructing a pretreatment plant.

5.7 Analytical Facilities

The only analytical facilities worth of note in respect of analysing wastewaters are those at the National Council for Scientific Research and the University of Zambia. The Department of Water Affairs and the district councils, their roles notwithstanding, do not have laboratory analytical facilities that can make them fully carry out their assigned roles. One district council visited did not even have a pH meter.

It is therefore recommended that the provision of laboratory analytical facilities for government regulatory agencies be treated as a matter of urgency. It is unrealistic to expect these agencies to perform their functions satisfactorily in the absence of basic commensurate resources.

The regulatory agencies' analytical facilities should then be made available, at a fee, to industries that can not afford to have their own facilities. The district councils are in a better position to administer this service.

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Appendix I: Characteristics of Industrial Wastewaters

Table A4.1.1 : Zambia Breweries

Parameter	Value (mg/l except for pH)	Maximum Permissible Value (Zambia)
pH	10.2	6-10
BOD	1200	1200
COD	2720	1800
Suspended solids (SS)	7188	1200
Total dissolved solids (TDS)	4960	-
Sulphate	60	500
Chloride	28	1000

Table A4.1.2 : National Breweries (Lusaka)

Parameter	Value (mg/l except for pH)	Maximum Permissible Value (Zambia)
pH	4.8	6-10
BOD	256.7	1200
COD	845	1800
Suspended solids (SS)	166	1200
Total dissolved solids (TDS)	760	-
Sulphate	2.5	500
Chloride	128	1000

Table A4.1.3 : National Breweries (Kafue)*

Parameter	Value (mg/l except for pH)	Maximum Permissible Value (Zambia)
pH	7.6	6-9
BOD	320	50
COD	503	60-90
Suspended solids (SS)	84	50
Total dissolved solids (TDS)	722	-
Sulphate	26	as low as possible
Chloride	16	<800

* Discharges into river

Table A4.2.1 : Kafue Textiles of Zambia

Parameter	Value (mg/l except for pH)		Maximum Permissible Value (Zambia)
	Raw	Final Effluent	
pH	8.3	9.1	6-10
BOD	362	1600	1200
COD	5260	4900	1800
Suspended solids (SS)	554	2248	1200
Total dissolved solids (TDS)	2278	198	-
Sulphate	76	58	500

Table A4.2.2 : Ndola Weaving Textiles

Parameter	Value (mg/l except for pH)	Maximum Permissible Value (Zambia)
pH	8.6	6-10
BOD	4167.5	1200
Suspended solids (SS)	44	1200
Total dissolved solids (TDS)	1064	-
Sulphate	35	500
Chloride	31	1000

Table A4.3.1 : Zambia Cold storage corporation (Lusaka)

Parameter	Value (mg/l except for pH)	Maximum Permissible Value (Zambia)
pH	7.5	6-10
BOD	1820	1200
COD	2710	1800
Suspended solids (SS)	930	1200
Total dissolved solids (TDS)	412	-
Chloride	107	1000

Table A4.3.2 : Zambia Pork Products (Lusaka)

Parameter	Value (mg/l except for pH)	Maximum Permissible Value (Zambia)
pH	7.6	6-10
BOD	2000	1200
COD	3200	1800
Suspended solids (SS)	584	1200
Total dissolved solids (TDS)	174	-
Chloride	974	1000

Table A4.4 : Bata Tannery

Parameter	Value (mg/l except for pH)		Maximum Permissible Value (Zambia)
	Raw	Final Effluent	
pH	12.5	12.1	6-10
BOD	4008	1300	1200
COD	4700	2360	1800
Suspended solids (SS)	30028	5718	1200
Total dissolved solids (TDS)	18538	21206	-
Sulphate	4300	2600	500
Sulphide	60	19	1
Chloride	10058	16906	1000
Chromium	86	11	5

Table A4.5 : Cooper Zambia

Parameter	Value (mg/l except for pH)	Maximum Permissible Value (Zambia)
BOD	60.25	1200
COD	776	1800

Table A4.3.2 : Ndola Sugar Refinery

Parameter	Value (mg/l except for pH)	Maximum Permissible Value (Zambia)
pH	7.3	6-10
BOD	1100.7	1200
COD	16400	1800
Suspended solids (SS)	58	1200
Total dissolved solids (TDS)	1160	-

Appendix II. Fertiliser Sub-sector

The only fertiliser plant in Zambia is Nitrogen Chemicals of Zambia (NCZ). The plant is currently operating at 50 % due to various operational and other reasons. The plant is at present unable to fulfil the demand for fertiliser.

Industrial technology

The industrial technology is conventional western technology. The major products are Ammonia, Nitric Acid, Ammonium Nitrate, Ammonium sulphate, Sulphuric Acid, NPK fertiliser. Refer to figure AI for the process flow diagram for the plant.

Characteristics of Wastewaters

Inorganic substances constitute the major pollution problem in fertiliser wasterwaters. Some organic pollutants are found but are mostly the result of contamination of waste streams by oils and lubricants, not the production process. Thermal pollution is also a major problem. Ammoia and nitrate ions; phosphates, flourides, chromats, salts, heavy matels and potassium are some of the inorganic pollutants. There is no

recycling of wastes at Nitrogen chemicals of Zambia. The volume of industrial wastewater discharged is about 350 m3/hr. Refer to Table AII for the characteristics.

Environmental impact

Toxicity to fish and other aquatic life, danger resulting from the entry of the inorganic polluntants into public water and eutrophication of receiving waters are some of the environmental impacts. The latter has already exhibited itself at the plants visited.

Status of Treatment Technology

It is true that fertiliser wastewaters almost always require chemical pretreatment before discharge. But at the only plant in the country, the only pretreatment provided is neutralisation. The neutralisation ponds probably also provide some sedimentation but this is felt to be totally inadequate.Coal slurry from gasifiers is settled in ponds and then pumped to lagoons. Lack of funds was cited as the impediment in providing adequate pretreatment facilities more so since the plant never operated at full capacity.

Analytical Facilities

The fertiliser plant has some facilities for analysing wastewaters and reasonably regular analyses are carried out. Incidentally the plant also has a full-time Environmental Hygiene Superintendent.

Table AII: Characteristics of Fertiliser Plant Wastewaters
Nitrogen Chemicals of Zambia (NCZ)

(A) Coal Slurry from Gasifiers

Parameters	Quantity
Water	78632 kg/hr
Suspended Solids	3878 kg/hr
pH	7-8
Dry material analysis	
Carbon 51.4 % and ash 47.2 %	

(b) Effuents From Fertiliser Plants

At full production, about 1200 m3/d of trade effluents are discharged to the council sewer. The composition of the effluent varies greatly.

Parameter	Value (mg/l except for pH)	Maximum Permissible Value (Zambia)
pH	8.48	6-10
Total Ammonium as NH	413	60
Nitrates	988	354
BOD	54	1200
Suspended solids (SS)	204	1200
Sulphates	83	500

(c) Effluent from sulphuric Acid Plant

Liquid effluent from this plant is neutralised and then pumped to the calcine lagoon. The total flow rate is about 105 m3/hr.

Composition of Calcine Slurry

Description	Quantity
Water	104918 kg/hr
Solute	240 kg/hr
Solids	600 kg/hr
pH	7-9

Dry Calcine Analysis :

Iron	51 %
Sulphate	6.4 %
Cao	4.5 %
Mgo	1.5 %

Trace Metals :	Copper	9900 mg/hr
	Zinc	842 mg/hr
	Lead	107 mg/hr
	Arsenic	79 mg/hr
	Selenium	40 mg/hr

Appendix III: Local Administrative Act (Act 15 of 1980)
The Local Administration (Trade Effluent) Regulations,1985.
Ist Schedule (Regulation 4)

Table of Standards for Trade and other Effluents (Extracts)

Col.1 Substance	Col.2 Trade effluent into public sewer	col.3 Sewage and other effluent
Physical		
Temperature	60 C	40 C at entry
Odour and Taste	Must not cause nuisance	Must not cause any deterioration in taste or odour as compared to natural state.
Total Suspended Solids	1200 mg/l (avoid blockage of sewer, affect free flow)	50 mg/l (no formation of sludge or scum in receiving water)
Salinity / Residue	7500 mg/l (must no affect treatment)	3000mg/l (must not adversely affect surface water)
B. Chemical		
pH	6 - 10	6 - 9
DO	-	Not less than 5mg/l
COD (Dichromat)	1800 mg/l	60-90 mg/l

BOD	1200 mg/l	50 mg/l (according to circumstances relating to self cleansing capacity of water courses)
Nitrate (NO_3)	80 mg/l	water courses < 50 mg/l. Lakes < 50 mg/l
Organic Nitrogen	300 mg/l	5.0 mg/l (mean)
Ammonia and Ammomium (Total) NH_3 as N/L	50 mg/l	10 mg/l
Cyanides	0.5 mg/l	0.1 mg/l
Phosphorous (Total) PO_4 as P/L	45 mg/l	1 mg/l in case of lakes
Sulphates	500 mg/l	as low as possible
Sulphide	1.0 mg/l	0.1 mg/l
Chlorides	1000 mg/l	<800 mg/l
Flourides	<30 mg/l	10 mg/l
C. <u>Metals</u>		
Al compounds	<20 mg/l	<10 mg/l
Antimony	0.5 mg/l	0.5 mg/l
Boron	<50 mg/l	<10 mg/l
Cadmium compounds	1.5 mg/l	0.5 mg/l
Cr^{6+}	5.0 mg/l	0.1 mg/l
Co	0.5 mg/l	0.5 mg/l
Cu	3.0 mg/l	1.0 mg/l
Fe	15 mg/l	<2 mg/l
Pb	1.5 mg/l	1.5 mg/l
Zn	25 mg/l	10 mg/l

D. Organics

Total hydrocarbons	20 mg/l	10 mg/l
Oils	100 mg/l	1-2 mg/l
Phenols	5 mg/l	0.2 mg/l
Fats	none reqd.	20 mg/l
Detergents	10 mg/l	2.0 mg/l
Pesticides	1.0 mg/l	0.5 mg/l
E. Radioactive Materials	No discharge accepted	Not permitted

- The above are just some of the parameters quoted in the Statutory Instrument.
- Column 2 refers to discharge into public sewers
- Column 3 refers to discharge from sewage works or any other discharge not provided elsewhere.

2nd Schedule

Charges for the Disposal of Trade Effluents

Formula:

$$C = V + (X/W + Y/20 + Z/7)B + (Q/R)S$$

Where,

C = Charge in Ngwee per 1000 litres for disposal of trade effluent
V = Volume charge in Ngwee per 1000 litres for conveyance, reception and preliminary treatment of sewage received
X = COD in mg/l of trade effluent
Y = Concentration of total toxic metals in trade effluent (mg/l)
Z = Concentration in mg/l of Cyanogen compounds as CN^-
W = COD of settled sewage (mg/l)
B = Cost in Ngwee per 1000 litres of biological purification of settled sewage
Q = Suspended solids in mg/l of trade effluent
R = Suspended solids in mg/l of average sewage treated at works

S = cost of sludge disposal expressed in Ngwee per 1000 litres of average sewage

Notes

(i) Cost in Ngwee/ 1000 litres for U,B,S to be determined by council at beginning of financial year and to be based on annual costs ascertained for the purpose of rate levy for sewers and sewage disposal

(ii) X,Y,Z,Q : means of results from analysis taken during previous financial year

(iii) Factors 20 and 7 in relation to Y and Z arise from limits of toxic materials which may be discharged under conditions of consent.

Appendix IV : Pollutants and their Environmental Im· cts

1. Biochemical Oxygen Demand (BOD)

BOD is a measure of the dissolved oxygen in a water needed to decompose organic materials therein. Adequate oxygen is a principle requirement in the maintenance of aquatic. BOD then, is a measure of organic pollution.

2. Chemical Oxygen Demand (COD)

This is a test based on the premise that all organic compounds, with few exceptions, can be oxidised to carbon dioxide and water by the action of strong oxidising agents.It serves a purpose similar to that of BOD.

3. Suspended Solids

These are characterised by the non-uniform distribution of a solid in liquid without the solids being dissolved in the dispersion medium. To a certian extent suspended solids give an idea of the clogging characteristics.

4. Total Dissolved Solids

This refers to a uniform distribution of a solid either organic or inorganic in a liquid. Soluble organics cause the depletion of dissolved oxygen. The presence of dissolved solids in industrial wastewaters may limit the subsequent uses of streams intc which they are discharged.

5. Temperature

The temperature of water is a very important parameter because of its effect on aquatic life, the chemical reactions and reaction rates, and the suitability of the water for beneficial uses.

6. pH

The concetration range suitable for the existence of most biological life is quite narrow and critical.

7. Chlorides

Highly saline water is known to cause problems of corrosion, of taste and in the quality of water necessary for industrial and agricultural use.

8. Sulphates

Sulphates in wastewaters may get reduced to sulphides and hydrogen sulphide by bacteria under anaerobic conditions. the hydrogen sulphide then gets oxidised to sulphuric acid which is very corrosive to sewer pipes.

9. Sulphides

The toxicity of sulphides is inherent in their ability to lower the dissolved oxygen concentration in water particularly at lower pH values. They are known to affect all forms of aquatic life. The possible evolution of hydrogen sulphide gas particularly in sewers is another concern.

10. Nitrogen and Phosphorous

The presence of nitrogen and phosphorous in water leads to the uncontrolled growth of algae and other plant life (eutrophication). The result is usually a total destruction of fish life and general lowering water quality with respect to aesthetic and recreational use.

11. Chrome

The toxic effect of chromium is dependent on the type of species exposed, the temperature and pH of the wastewater and the valence of chromium. Chrome in the hexavalent form is reported to have a toxic effect on aquatic life, especially fish food organisms and other forms of aquatic life. It is also known to inihibit growth of algae. Trivalent chrome which is common in tannery dischagres is believed to be less toxic

12. Other Toxic Compounds

Because of toxicity, certain cations are of great importance in the treatment and disposal of wastewaters. Copper, Silver, lead, Chromium, Arsenic and Boron are toxic in varying degrees to microorganisms and therefore must be taken into consideration in the design of biological treatment plants.