An Investigation into the Water Management and Effluent Treatment in the Processing of

(i) pulp and paper (ii) Metals (iii) fermentation products and (iv) Pharmaceutical products.

By the
Pollution Research Group
Department of Chemical Engineering
University of Natal

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Report to the

WATER RESEARCH COMMISSION

for the project

An investigation into the water management and effluent treatment in the processing of (i) Pulp and Paper, (ii) Metals, (iii) Fermentation Products and (iv) Pharmaceutical products.

PART III

Investigations into water management and effluent treatment in the Fermentation Industry.

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Prepared for the

WATER RESEARCH COMMISSION

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CONTENTS

	Page
ACKNOWLEDGEMENTS	1
1. INTRODUCTION	2
1.1 General	2
1.2 Water Research Commission	2
1.2.1 Formation and aims	2
1.2.2 Funds for research	3
1.2.3 Task areas of water research and development work	3
1.2.4 Water supplies in South Africa	4
1.2.5 Discharge of effluent into the environment	5
1.2.6 Sponsoring of research	5
1.2.7 Some industrial research which has been sponsored by the WRC	6
1.3 Project Guidelines	7
2. WATER AND EFFLUENT TREATMENT REGULATIONS AND DISPOSAL METHODS	8
2.1 The Water Act	8
2.1.1 The use of water	8
2.1.2 The purification of effluents and disposal to the environment	9
2.1.3 Acceptance of effluents by local authorities	12
2.1.4 Proposed ammendments to the requirements for industrial effluents	13
2.2 Local Authority Regulations for Discharge into Sewers	14
2.3 Future Trends	15

2.4 Methods for Disposal of Industrial Effluents 16

2.5 The Fermentation Industries 17

3. LITERATURE REVIEW 17

3.1 General 17

3.2 Sorghum Beer 17

3.3 Barley Beer 22

3.4 Distillery Wastes 36

3.4.1 Molasses and other distillery wastes 36
3.4.2 Wine distillery wastes 39

3.5 Yeast 42

3.6 Summary 45

4. REPORT 46

4.1 Collection of Information 46

4.2 Yeast (Other than Food Yeast) 47

4.3 Wine Distilleries 49

4.3.1 Conclusion 50

4.4 Molasses Distillery 50

4.5 Conclusions 53

4.6 Sorghum Beer 60

REFERENCES 71

FIGURES

Figure 3.1	Schematic of Brewing Process	22
Figure 3.2	Major Effluent from Brewery Effluent	33
Figure 4.1	Typical Process Flow Schemes - Possible Sources of Loss of Materials	69

TABLES

Table 2.1	Permissible Criteria - Discharge to Rivers	11
Table 3.1	Overall Plant Raw Waste Characteristics	24
Table 3.2	Raw Waste Contributions from In-Plant Sources	25
Table 3.3	Polluting Substances from Different Parts of a Brewery	26
Table 3.4	Origin of Wastewater at Pripps Bromma	27
Table 3.5	Water Balance for an 80 000 kl/week Brewery	31
Table 3.6	COD Effluent Levels During the Production Process	34
Table 3.7	Purification of Industrial Effluents by Means of Anearobic Digestion	41
Table 4.1	Yeast Factories	48
Table 4.2	Molassess Distilleries	51
Table 4.3	South African Breweries Limited. Beer Division. Location of Beer Production, Water Intake and Effluent Produced for Various Breweries.	55
Table 4.4	Water-Effluent Balance for a Large (3 million kl/a) Brewery	56
Table 4.5	Water, Effluent, Beer Ratios and Chemical Analyses (Average values from Surveys)	57
Table 4.6	South African Breweries Limited Southern Associated Malsters (Pty) Limited	59
Table 4.7	Sorghum Beer Breweries - Replies to Questionnaire.	62

APPENDICES

Appendix 3.1	Administration Boards, Development Corporations and Breweries ; Address List	75
Appendix 4.1	Yeast	80
Appendix 4.2	Wine Distilleries	83
Appendix 4.3	Molasses Fermentation/Distilleries	86
Appendix 4.4	Barley Breweries	89
Appendix 4.5	Sorghum Beer Industry	93
Appendix 4.5 (i)	Questionnaire (additional to 3.5, sent to some Sorghum Beer Breweries)	95
Appendix 4.6	List of Industries approached.	98
Appendix 4.7	A more Detailed Examination of a Particular Site	108
Appendix 5	Methods of Effluent Treatment	134

ABSTRACT

A survey on water management and effluent treatment/control in the Fermentation Industry has been carried out.

A brief statement on the establishment of, and the aims of, the Water Research Commission is given together with a summary of the important water and effluent regulations.

In the survey, the Fermentation Industry is taken as the sector which includes

Barley beer breweries,
Sorghum beer breweries,
Molasses based distilleries,
Wine based distilleries and
Yeast processing industries.

A short review of the literature, specific to the above areas, is included in the report but this has not revealed any really novel methods of dealing with the highly polluting effluents from the fermentation industries considered.

Information on the local fermentation industry was collected from questionnaires and during visits to different factories.

The Sorghum Beer industry consists of a large number of breweries which vary in size and which produced over one million litres of sorghum beer in 1981. At a water usage of between 2 - 4 litres per litre of beer, there is not a high effluent volume, particularly since this is proportioned between a large number of breweries (34) spread over the country. There is no central control on effluent matters since the 34 breweries are "allocated" to 19 Administration Boards or Development Corporations. An example of the examination of one brewery is given in the report.

The Barley Beer Industry in South Africa is 'controlled' by the South African Breweries Limited. The breweries produce approximately 600 000 kl of beer per annum with a water consumption of about 6 million kilolitres. The total waste volumes from these breweries is larger than for sorghum beer. There are, however, only nine barley beer breweries in the Republic of South Africa all under the same control and advantage of consistent policy towards effluent and effluent control is obvious.

There are only a few yeast factories in the country and the CSIR has undertaken studies over many years on the anaerobic biological digestion of the wastes from such factories. Approximately 70% of the COD is removed by anaerobic digestion but the residual COD is largely intractable.

Distillery wastes from wine fermentation are produced by wine co-operatives e.g. KWV. Work has also been carried out by the CSIR on the effluent from these wine based distilleries, and here again, the anaerobic biological process has been investigated and recommended.

Distillery wastes from molasses manufacture are produced at present from only three factories. The production of "Dried Distillers Solubles", a base for animal feeds, appears to be a satisfactory method for dealing with the highly polluting liquid from ethanol fermentation of molasses while market conditions are satisfactory.

With the advances, which have been made in the various membrane processes, it would seem that consideration should be given to investigations on the applicability of membrane processes for the treatment of effluents from the manufacture of yeast and from the distilleries based on wine and molasses fermentation.

CONCLUSIONS

1. Sorghum Beer

There are over 30 breweries and all except two discharge effluent to municipal sewers since the effluent is readily biodegradable. Effluent volumes per brewery are relatively low, from say 10 000 kl/a to 150 000 kl/a. Investigations on disposal as such appear to be necessary only where the biological load contributes an undesirable load on the sewage wastes concerned or where economics of the process is affected by the disposal charge.

No advanced treatment methods are recommended.

2. Yeast Manufacture and Wine Distilleries

Organisations involved in yeast manufacture or wine distilling appeared reluctant to take part in this survey because of previous surveys and because of the extensive testing over many years by CSIR using an anaerobic biological process.

It is considered however that investigations using the modern advanced technologies such as membrane separation processes should be undertaken to determine applicability to different effluent streams.

3. Molasses Distilleries

Disposal of distillery wastes by evaporation/drying is a technically feasible process but the process is economic only if the product can be marketed. Management was willing to discuss problems and eager to seek solutions to the effluent disposal. In this area, also, because of the advances in membrane separation processes, consideration should be given to determining the applicability of such processes to different effluent streams.

4) Barley Beer

In this industry, management clearly considers water management to be high on the list of priorities. The industry has a central Research and Development Section and this section studies water recovery and effluent volume reduction techniques. No additional investigations are necessary.

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(i) Pulp and Paper
(ii) Metals
(iii) Fermentation Products
(iv) Pharmaceutical Products"

from the Water Research Commission to the Department of Chemical Engineering, University of Natal.

The assistance of the various Plant Managers, and Government and Local Authorities in supplying the data needed is greatly appreciated.

1. INTRODUCTION

1.1 General

The Pollution Research Group, Department of Chemical Engineering, University of Natal, Durban, was appointed by the Water Research Commission in 1982 to undertake investigations into water management and effluent treatment in the Fermentation Industry. The objectives of the project were to collate the existing knowledge on water and effluent problems of this industry and to formulate, on a coordinated basis, the scope for improved effluent treatment, water management and the disposal of effluent.

1.2 Water Research Commission

1.2.1 Formation and aims

A Commission of Enquiry into Water Matters was appointed by the State President in 1966. The Commission's report, R P 34/1970, is a comprehensive document covering water provision and utilisation and many specific aspects including for example, reuse of water and reclamation of effluents for reuse.

When submitted to Parliament, the then Minister of Water Affairs stressed the necessity for the efficient generation of new knowledge and its application in the develpment and utilisation of water resources and that it was of national importance that a statutory body with the necessary powers and funds be established to promote and expedite the country's water research purposefully.

The Water Research Act (Act. No. 34 of 1971) was then passed and the Water Research Commission (WRC) was established (see Water Research Commission Report, September 1971 to March 1973).

The aims of the Commission in accordance with Section 2(3) of the Water Research Act are :-

'to co-ordinate, to promote, to encourage or cause to be undertaken, ... research in respect of :-

(a) the occurrence, preservation, conservation, utilization, control, supply, distribution, purification, pollution or reclamation of water supplies and water ;

(b) the use of water for -
(i) agricultural purposes,
(ii) industrial purposes; or
(iii) urban purposes.

1.2.2 Funds for research

In order to achieve the general objectives of the Water Research Commission and to fulfil its functions, provision was made for the establishment of a Water Research Fund which consists of :-

(i) Moneys appropriated by Parliament for the benefit of the Fund

(ii) Rates and charges levied in terms of the Water Research Act (this includes levy charges on water supplied or made available for use for agricultural purposes, urban purposes, industrial purposes or any other purposes.

(iii) Donations, bequests or contributions which the Commission may receive from any other sources.

1.2.3 Task areas of water research and development work

The main task areas of water research are given in the 1971/73 Report of the WRC. Some of the areas of direct concern to industry include :-

(i) Municipal, mining and industrial utilization
a) Internal reuse of water in industry and mining
b) Increased industrial production per unit of water

c) Purification of effluents
d) Water Management - industry and mining
e) Industrial processes : modification and development.

(ii) Pollution
a) Industrial effluents
b) Quality criteria for effluents
c) Parameters of pollution
d) Mineralization problems
e) Utilization of polluted effluents
f) Effects on living organisms
g) Measurement and evaluation of specific pollutants
h) Control systems
i) Solid wastes.

(iii) Water Reclamation
a) Process development
b) Quality criteria
c) Quality evaluation

(iv) Desalination
a) Mineralised effluents.

1.2.4 Water supplies in South Africa

In the WRC Report for 1976 it is shown that a study of the Republic's water balance reveals that water demands are escalating at such a rate that there will be little disparity between the country's water credits and debits by the year 2 000. However it is envisaged that the application of certain measures will increase the assured yield of, and decrease the demand for, water in South Africa so that there will be an estimated water credit of 10,7 milliard m^3 per annum by the turn of the century.

Of the proposed measures for decreasing water demand, the most important is undoubtedly planned water reclamation and reuse since it will yield an estimated 7,2 milliard m^3 per annum. Water reclamation, furthermore, provides the key to prevention of water pollution and the protection of the utilisation value of water.

1.2.5 Discharge of effluent into the environment

In the 1975 WRC Report it is emphasised that treatment and disposal of industrial effluents and their proper management is of cardinal importance to control pollution effectively and to conserve water in the Republic. It is also important for local authorities in that the acceptance of industrial effluents into their sewage systems often causes problems in sewers and at treatment works. This could seriously prejudice the ability of even well designed works to comply with the general standards (section 2.) for effluents and also the possible reuse of water (see section 1.2.4).

1.2.6 Sponsoring of research

In order to execute its coordinating function (see section 1.2.1), the Commission has effected the establishment of Coordinating Research and Development Committees (CR&D committees) and Study Groups for specific problem areas with representation from all interested organizations. These Study Groups and CR&D committees advise the Commission on the evaluation of research proposals, keep the Commission informed of research being done elsewhere, and expose shortcomings in the relevant fields of research which should receive attention.

It is well known that certain industries produce effluents which are difficult to manage and to purify in order to meet the quality requirements of the Water Act (see section 2.). Further there are certain chemical substances that may over the long or short term adversely affect human health and that these may reach the water cycle from the manufacturing process (e.g. in the manufacturing of insecticides and pharmaceutical products).

The Commission deems it to be of national importance to assist the industries in developing techniques to improve the quality of their effluents and simultaneously to encourage internal reuse of water. This is done on a coordinated basis of collaboration whereby the industry itself contributes facilities and manpower.

However industry covers many diverse activities and any research work which is sponsored by the Commission must be for the benefit of the whole of a particular type of industry and not for any particular member of that industry. Hence it is desirable for the Commission to liaise with the various National Associations which exist in connection with particular types of industry.

This is a basic principle of the operation of the Commission (WRC report 1977) since individual problems can be, and should be, dealt with by consulting engineers or specialists, but when problems are of national importance and are experienced by all members of a particular group of industries then there is justification for Commission assistance.

1.2.7 Some industrial research which has been sponsored by the WRC

The Commission has for several years been sponsoring research in connection with water management and effluent treatment in industry in order to assist industry and protect the quality of our water resources.

Examples include :-

(i) research on a number of projects in the textile industry such as wool scouring effluent treatment, sizing and desizing effluent treatment, cotton/synthetic fibre and wool/synthetic fibre dyehouse effluent treatment and reuse.

(ii) research on the purification and reuse of effluents from the hides and skin curing, fellmongery and tanning industries.

(iii) the optimization and evaluation of full scale treatment of spent wine residue.

(iv) the removal of metal ions from dilute solutions in an electrolytic precipitator.

(v) an investigation into water and effluent management problems in the fishing industry and

(vi) an investigation into water and effluent management problems in the fruit and vegetable processing industry.

1.3 Project Guidelines

The following guidelines were given for this study :-

(i) to survey water usage, chemical usage and effluent production by the Fermentation Industry in South Africa.

(ii) to study the processing techniques and to establish the quantity and quality of process streams, to determine the scope for the recovery of water and by-products and possible methods of effluent treatment.

(iii) to consider methods for the reduction of water intake, internal water recycling and in-house water and effluent management.

(iv) to assess the impact of advanced wastewater management techniques including closed loop recycle systems.

(v) to recommend research and development priorities for this industry.

(vi) to formulate a research plan for consideration by a Coordinating Research and Development Committee for the Fermentation Industry.

2. WATER AND EFFLUENT TREATMENT REGULATIONS AND DISPOSAL METHODS

2.1 The Water Act

2.1.1 The use of water

The Water Act No. 54 of 1956 (as ammended from time to time) is concerned with the control, conservation and use of water.

The use of water for industrial purposes and the control of effluents resulting from industrial processes is governed by this Act.

Section 12(1) of the Act requires that :-

(a) any person starting a factory which uses water, including sea water, must inform the Department of Environment Affairs of his proposed effluent treatment processs and the results he hopes to achieve, and

(b) if he proposes to use on average more than 250 m^3 of public water per day or more than 300 m^3 on any one day, a permit is required.

There are five possible sources of supply which are treated differently by the law and these are described simply as follows :-

(i) A private source of supply such as a borehole or spring arising on the owners property. No further legal action is required once the owner has informed the Director General of his intentions except for disposal of effluents.

(ii) A municipal supply. The Department requires proof that the municipality in question is willing and able to supply before it will recommend a Section 12(5) permit.

(iii) A supply from a public stream not in a control area proclaimed under Section 59 of the Act.
The owner, after obtaining his permit for industrial use, requires Water Court Authority under Section 11 of the Water Act to abstract such water.

(iv) A supply from a public stream in an area proclaimed under Section 59 of the Water Act. The owner requires a permit in terms of either Section 56(3) of the Act or in terms of Section 62 of the Act. This permit is often issued concurrently with the permit needed under Section 12(5).

(v) In the case of use by an industry of purified sewage effluent the supplier requires a permit under Section 22 of the Act.

2.1.2 <u>The purification of effluents and disposal to the environment</u>

Section 21 of the Water Act relates to the purification and disposal of industrial water and effluents. Important aspects are :-

(i) the purification of any wastewater or effluent or waste produced by or resulting from the use of water for industrial purposes shall form an integral part of the process.

(ii) a person using water, for industrial purposes, shall purify it to a predetermined standard which the Minister shall lay down after consultation with the Bureau of Standards.

(iii) Section 21(2) lays down that water, including sea water, used for industrial purposes and purified to the required standard must be returned to the stream of origin or the sea, (with certain exceptions).

To date three standards have been laid down and published in Government Gazette No. 553 of 1962 (with ammendments). These are :-

(i) the special standard for any wastewater or effluent produced by or resulting from the use of water for industrial purposes in catchment areas draining to river or portions of rivers described in Schedule 1.

(ii) the special standard for phosphate in industrial wastewater or effluent. The wastewater or effluent produced by or resulting from the use of water for industrial purposes and which drains into any portion of a river mentioned in Schedule 2 or any tributary of such river .... shall not contain soluble ortho-phosphate (as P) in higher concentration than 1,0 mg/l.

(iii) the general standard for any wastewater or effluent produced by or resulting from the use of water for industrial purposes in all areas of the Republic of South Africa other than in catchment areas draining into rivers or portions of rivers described in the schedule.

These standards are summarised in Table 2.1.

TABLE 2.1 : Permissible Criteria - Discharge to Rivers

Item	General Standard	Special Standard
Colour, odour, taste	Nil	Nil
pH	5,5 to 9,5	5,5 to 7,5
Dissolved oxygen	75%	75%
Typical faecal E Coli	Nil	Nil
Temperature	35 °C	25 °C
Chemical Oxygen Demand (COD)	75 mg/l	30 mg/l
Oxygen absorbed (OA)	10 mg/l	5 mg/l
Suspended solids (SS)	25 mg/l	10 mg/l
Total dissolved solids (TDS)	500 mg/l above intake	15% above intake
Sodium (Na)	90 mg/l above intake	50 mg/l above intake
Soap, oil, grease	2,5 mg/l	Nil
Residual chlorine	0,1 mg/l	Nil
Free and saline ammonia (N)	10 mg/l	1,0 mg/l
Nitrate (N)	Not specified	1,5 mg/l
Arsenic (As)	0,5 mg/l	0,1 mg/l
Boron (B)	1,0 mg/l	0,5 mg/l
Hexavalent chromium (as Cr)	0,05 mg/l	-
Total chromium (Cr)	0,5 mg/l	0,05 mg/l
Copper (Cu)	1,0 mg/l	0,02 mg/l
Phenolic compounds	0,1 mg/l	0,01 mg/l
Lead (Pb)	1,0 mg/l	0,1 mg/l
Phosphate (P)	Not specified	1,0 mg/l
Iron (Fe)	Not specified	0,3 mg/l
Manganese (Mn)	Not specified	0,1 mg/l
Cyanide (CN)	0,5 mg/l	0,5 mg/l
Sulphides (as S)	1,0 mg/l	0,05 mg/l
Fluoride (F)	1,0 mg/l	1,0 mg/l
Zinc (Zn)	5,0 mg/l	0,3 mg/l

NOTE : The "Special standard for phosphate in Industrial Wastewater of Effluent" limits the soluble ortho-phosphate (as P) to 1,0 mg/l for wastewater or effluent draining into rivers specified in Schedule 2.

Special standard

"The wastewater or effluent shall contain no other constituents in concentrations which are poisonous or injurious to trout or other fish or other forms of aquatic life".

General Standard

"The wastewater or effluent shall not contain any other constituents in concentrations which are poisonous or injurious to humans, animals, fish other than trout, or other aquatic life or deleterious to agricultural use".

However a permit can be granted exempting compliance with such standards where it would be impracticable for an industry to purify its effluent to the prescribed standard (21(5)). (This section includes conditions for discharge into the sea).

Such a permit is however subject to revision, modification or cancellation.

2.1.3 Acceptance of effluents by local authorities

Section 21(3) defines the rights and duties of a local authority in regard to receipt and disposal of effluents arising from the use of water within its area of jurisdiction. If the municipality of local authority is prepared to accept, treat and dispose of effluent not complying with the standards laid down in Government Notice R 553 of 1962 from industries within its boundaries, such industries do not require a disposal permit (21.5). However, it then becomes the responsibility of the local authority to conform with the requirements of the Act.

2.1.4 Proposed Ammendments to the Requirements for Industrial Effluents

The South African Bureau of Standards has circulated draft recommendations to the Minister of Environment Affairs for ammending the regional standards for industrial effluents as published in Government Notice R 553 on 5 April 1962 and Notice No R 124 on 1 August 1980.

The following ammendments and additions are proposed :-

(i) General Standards

Item 2.8.1 (increase in total dissolved solids must be less than 500 mg/l) is deleted and the increase in conductivity must be less than 75 mS/cm.

Item 2.8.2 total dissolved solids is replaced by mineral salts.

A new item, --- no industry shall discharge effluent having a conductivity of more than 300 mS/cm.

Item 2.12 : the limit for lead is decreased from 1 mg/l to 0,1 mg/l

Manganese	to	0,4 mg/l
Cadmium	to	0,05 mg/l
Mercury	to	0,02 mg/l
Selenium	to	0,05 mg/l

Total heavy metals (excluding zinc) 1,0 mg/l.

(ii) Special Standard

Items 1.8.1 and 1.8.2 have the words total dissolved solids replaced by mineral contents.

A new item 1.8.3, --- no industry shall discharge effluent having a conductivity of more than 300 mS/cm.

2.2 Local Authority Regulations for Discharge into Sewers

Regulations governing the discharge of effluents into municipal sewers are governed by the by-laws of the local authority concerned.

Such regulations often prohibit the discharge of effluent into sewers if the effluent :-

(a) contains any matter in such concentrations as will produce in the final treated effluent at any sewage works or sea outfall discharge point any offensive of otherwise undesirable taste, colour or odour or any foam ;

(b) may prejudice the reuse of treated sewage effluent for industrial or similar purposes or adversely affect any of the processes whereby sewage is treated to purify such effluent for reuse ;

(c) contains any substance or thing of whatsoever nature which is not amenable to treatment to a satisfactory degree at a sewage treatment works or which causes or is likely to cause a breakdown or inhibition of the processes in use at such works.

In addition the local authority may require, for example,

(a) the trade effluent to be subjected to preliminary treatment to reduce or eliminate certain components.

(b) the installation of equalising tanks etc. as may be necessary to control the rate and time of discharge.

The fees payable for the acceptance and treatment of effluent vary with the local authority concerned. The rate charged in cents per kilolitre for the Durban authority, for example, is :-

$$\text{Rate in cents per kilolitre} = x + y\frac{A}{30} + z\frac{B}{9}$$

where 'A' is the permanganate value being the oxygen absorbed, as expressed in parts per million.

'B' is the volume in millilitre of settleable matter in one litre of trade effluent.

'x' is the cost to the authority, per kilolitre, of the conveyance through the reticulation.

'y' is the cost per kilolitre of treatment in the wastewater treatment works of an effluent having a permanganate value of 30 ppm.

'z' is the cost per kilolitre of the treatment of an effluent having a settleable solids value of 9 ml/l.

2.3 Future Trends

In his paper on 'Current Trends in South Africa Regarding Effluent Discharges and Legislation', Zunckle (1981) has stressed that standards have their shortcomings and it is essential that :-

(a) they be subject to constant review ;

(b) they be tailored to meet the needs of a particular catchment ;

(c) they be tailored to anticipate future reuse needs.

In the longer term the Directorate intends launching an investigation into the applicability of the German 'Water Levy Act' to South African conditions. In terms of this scheme, dischargers pay a levy to the State depending on the number of 'harmful units' present in their annual discharge. The progressively increasing levy provides an economic incentive to improve the quality of the effluents.

2.4 Methods for Disposal of Industrial Effluents

It is evident that without limited water resources there is need to safeguard water quality and to recycle water. The discharge therefore of industrial effluents, particularly those that are saline and those containing high organic loads, potentially toxic compounds or intractable organics is becoming increasingly questionable because of the impact on the water utilization cycle.

The disposal of industrial effluents can be managed by three main methods :-

(i) direct discharge to sewer, provided that potentially toxic compounds or intractable organics are not present, and provided that the content of organics is not so high as to overload the treatment works.

(ii) partial treatment prior to discharge to sewers and extensive treatment for river or sea discharge to remove undesirable pollutants and

(iii) industry based recycle of effluents for reuse as process water either on an end-of-line or closed loop recycle basis.

The management of industrial effluents can, in some cases, be carried out advantageously by route (iii). This ensures that no undesirable pollutants are discharged into the water environment.

2.5 The Fermentation Industries

The fermentation industries in general have high organic and suspended solid loadings and difficulties in disposal arise. These difficulties could be more serious for industries situated away from the sea.

In this study the Fermentation Industry is taken as the sector which includes :-

Barley beer,
Sorghum beer,
Molasses based distilleries,
Wine based distilleries and
Yeast processing industries.

3. LITERATURE REVIEW

3.1 General

Lurie (1980) has given a survey of the Fermentation Industry in South Africa. At that time an approximate annual volume of the order of R600 million was estimated of which the production of alcoholic beverages (barley beer, sorghum beer and wine) accounts for the greater proportion.

3.2 Sorghum Beer

The raw materials and the brewing proces involved in the production of sorghum beer has been reviewed by Novellie (1968).

Sorghum beer is made by a process involving two fermentations - a lactic acid as well as an alcoholic fermentation. The method of brewing is still essentially as described by Novellie :-

"The lactic acid fermentation or souring is carried out by boiling a mixture of sorghum malt and water at 18 - 50°C for 8 - 16 hours until the requisite degree of acidity has been reached ... The soured malt mixture is pumped over to the cooker and diluted with almost two volumes of water. The adjunct is almost invariably brewers grits (corn grits) but a little sorghum meal is still used in a few breweries. Souring takes place naturally with the organism Lactobacillus present in the malt.

The thick sour porridge obtained by cooking is cooled to mash temperature (60°C). In some breweries a small amount of malt is added at about 75 - 80°C and the thinning that results speeds cooling. When 60°C is reached the coversion malt is added and the temperature held for 1½ - 2 hours. The mash is now much thinner and noticably sweet but still contains much starch. It is further cooled to about 30°C and pitched with a top fermenting yeast (Saccharomyces cerevisiae) ... The pitched mass is then transferred to strainers which remove the coarser particles ... From the strainer the waste goes to the fermenting tanks for a short high temperature fermentation ..."

The separated solids, which have a fairly high protein content are sold as animal feed.

The industry is unique in that it is one of the only large, modern industries founded on an African tribal art (Sorghum Beer Production Advances, South African Wine & Beverage p. 32, 1981). Secondly, the Industry (i.e. wet-based) lies entirely in the hands of the statutory bodies (Administration Boards) and Homeland Development Corporation and not in those of private enterprise.

Recently a Sorghum Beer Industry Development Committee was formed under the jurisdiction of the Department of Cooperation and Development. This group will attempt a more coordinated approach to development in the Industry.

There are currently over thirty breweries, many of which are expanding or being modernised and improved. A list of the Boards, Corporations and Breweries (supplied by the Sorghum Beer Unit) is given in Appendix 3.1.

The growth of the Industry appears to be significant. Kruger (1982) describes the operations at the Tlokwe Brewery operated by the Western Transvaal Administration Board at Potchefstroom. This is a new brewery geared to increase its production as and when required. Currently about 10 000 kl/month is brewed but at full capacity, expected in about 8 years, the output will be about 18 000 kl/month.

(The Liquor Survey, Supplement to Financial Mail, March 26, 1982 gives further general details regarding the Industry).

According to the Sorghum Beer Unit (CSIR), annual production to the second quarter of 1981 was 902 600 kl for breweries under the Administration Board and 194 200 kl for self-governing independent Black States, a total of 1 096 800 kl.

The Sorghum Beer Unit of the Council for Scientific and Industrial Research is supported by a levy on the sales price of sorghum beer. The Unit undertakes research on many aspects of the industry. In addition, the Unit assists brewers in establishing breweries and in attaining optimum producitivity.

During the manufacture of the sorghum beer product, effluent is produced from various stages but little work appears to have been done on the treatment of this effluent. A typical process flow scheme is given in Section 3.6.

In 1966 Henzen and Funke visited a few breweries with the specific purpose of identifying problems and to establish the possible lines of approach as regards the effluent treatment and disposal. Since then many changes have been made in the control of the breweries, modernisation has been carried out but nevertheless certain aspects which they mention in their report remain important, e.g. 'the application of waste prevention measures are by far the most powerful tool in the hands of the operator to reduce the pollutional load of the final effluents'.

'In the manufacturing process water is not only used as the bulk ingredient of beer but also in a multiplicity of other ways, all of which progressively tend to change the quality of the water. The major changes occur in the process where water is used as the dispersion and transportation medium for the removal of incidental spillages of raw materials, by products and beers from floors and equipment and the conveyance of the partly exhausted materials to sewers'.

The variation in oxygen absorbed (in 4 hours from acid N/80 $KMnO_4$ at 27°C in ppm) varied greatly at the breweries examined. Figures varying from 235 to 11 000 are given.

In 1977 Gomes reported on a survey of the Sorghum Beer Industry.

The water needs of the industry are described :

(1) Water used in the manufacturing process to prepare the sour and the fermentable mash. Some of this water can be lost due to :

   (a) Evaporation at the lactic acid generators, cookers and converter.
   (b) Spillages of sour, mash and beer during transfer and packing.
   (c) Spillages of beer during the fermentation phase.
   (d) Foaming during tanker filling operations.
   (e) Retention of water in the spent grits.

(2) Water for steam production.

(3) Water for cooling purposes.

(4) Water for cleaning equipment and buildings.

All equipment, floors and walls must be frequently washed with solutions of detergents and disinfectants and rinsed with clean water. The contribution of these cleaning and sterilizing operations to the total water consumption is important.

It is in this area that special attention is being given by the breweries.

(5) Water for domestic purposes.

(6) Specific use of water - i.e. the quantity of water required to produce a fixed volume of beer.

It was accepted that water is efficiently used if the value falls within 2 - 4 litres/litre of beer.

The effluent produced by the Industry is also described : the final effluent is a mixture of

(a) Water

(b) Spilled raw materials (malt, grits, etc.)

(c) Spilled intermediate and final products (sour, mash, beer)

(d) Detergents and disinfectants

(e) Boiled blow-down water and it is characterised by :

- (i) A high suspended solids (500 - 2 000 mg/l).
- (ii) A low pH (3, 5 - 6)
- (iii) A high COD 400 - 11 000 mg/l
- (iv) A high content of dissolved solids 700 to 3 000 mg/l
- (v) A high O.A. (700 - 11 000 mg/l)

In most of the breweries the effluent is discharged directly into the local sewage system, sometimes after passage through a settling tank.

3.3 Barley-Beer

A schematic of a brewing process as given by Zielinski and McWhorter (1977) is shown below. Raw waste chemical oxygen demand (COD) was shown to range from 2 000 mg/l to 5 000 mg/l with a mean of 3 400 mg/l. The BOD concentration was shown to be in the range from 1 000 mg/l to 4 000 mg/l with a mean of 2 200 mg/l.

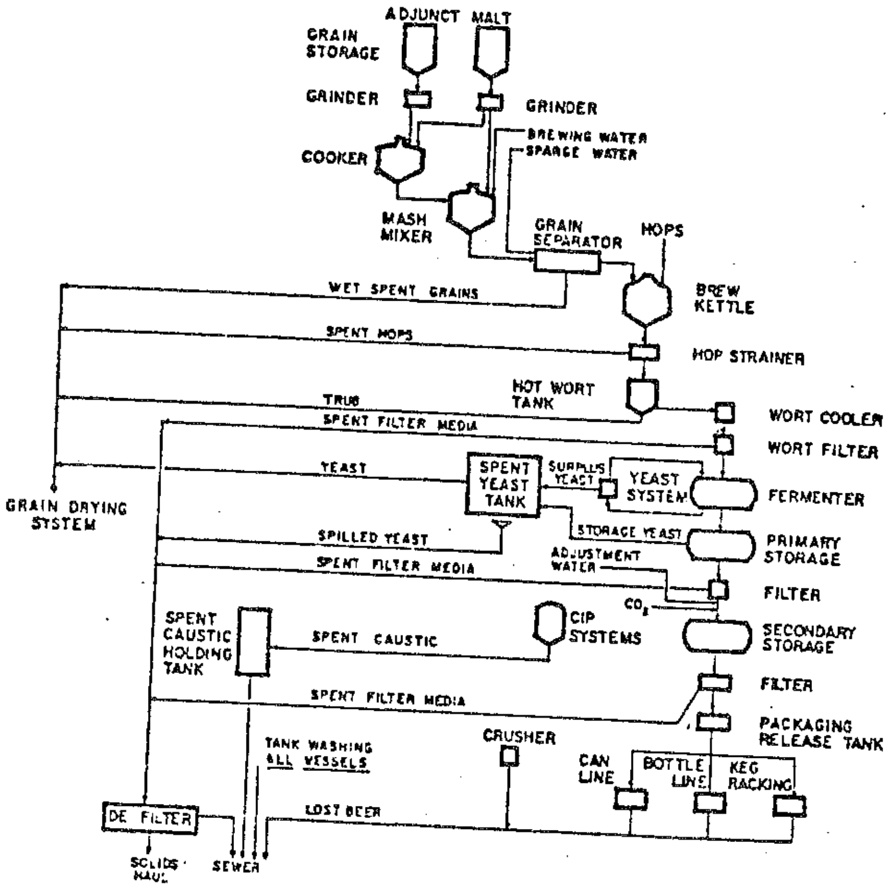


Figure 3.1 : Schematic of Brewing Process

According to EPA Technology Transfer Capsule Report No. 6 the Brewing Industry in the United States is comprised of 185 facilities producing malt beverages. Half of these are large facilities with individual water consumption rates exceeding 20 million gallons each year (75 700 kl). About 60 billion gallons of the water used annually in these major facilities are discharged as wastewater.

The mean raw waste loading levels for the large brewing facilities are 1 622 mg/l BOD and 772 mg/l suspended solids. These concentrations of oxygen demanding organic materials and suspended solids in the wastewater, at the quantities discharged, are sufficiently high to potentially cause oxygen depletion and sedimentation build-up in streams unless adequate treatment is provided. Therefore treatment must be provided at either the brewery facility or at the municipal waste treatment plant prior to discharge to a stream.

The Adolph Coors Company, produces all of its malt beverages in one facility at Golden Colorado. The Golden facility is a large single brewery producing in excess of 10,5 million barrels of beer per year. The pollution control efforts since 1951 of this company are described and reflected in Tables 3.1 and 3.2. The improvement not only in water discharged but in waste BOD was significant compared to the brewing industry mean.

The Joint Development Committee of the Allied Brewery Traders Association, London sent out a questionnaire to all breweries about effluent treatment. The replies to the questionnaire indicated that many breweries have considerable effluent problems, but no easily defineable pattern emerged from the replies (1973).

In 'Brewing and the Environment', Bidwell (1975) has descrbied how a brewery manager might set out to minimise the cost of waste disposal. Throughout the article it has been stressed that the waste disposal situation will vary considerably from brewery to brewery, but it has been indicated how in principle disposal costs can be minimised by a planned approach to the problem.

In his article on "Pollution Problems in Brewing", Meyer also points out that the brewing comprises a large number of batch operations, which means that the wastewater from a brewery varies widely in quality and quantity according to the time of the day and the day of the week. The tables below specify in somewhat more detail the polluting substances for various stages of the process.

TABLE 3.1 : Overall Plant Raw Waste Characteristics

Parameter	Coors raw waste loads[1]	Brewing industry mean raw waste loads[2]
Raw waste volume	108,5 gal/bbl[3] beer	257 gal/bbl beer
Raw waste BOD	0,751 b/bbl beer (825 mg/l)	3,051 b/bbl beer (1 622 mg/l)
Raw waste suspended solids	0,261 b/bbl beer (280 mg/l)	1,241 b/bbl beer (772 mg/l)

NOTES :
1. Based on average at Coors for month of June 1973.
2. Industrial Waste Survey of the Malt Liquor Industry SIC No. 2082 prepared for the Environmental Protection Agency, August 1971, by Associated Water and Air Resources Engineers, Inc.
3. One barrel contains 31 gallons.

TABLE 3.2 : Raw Waste Contributions from In-plant Sources

Source of raw waste	Coors raw waste loads[1] (gal/bbl beer)	Brewery Industry Mean raw waste loads[2] (gal/bbl beer)
Cooling water	3,1	43,5
House cleaning	15,5	21,8
Aging	24,8	12,4
Filtration	6,2	21,8
Fermentation	6,2	9,3
Brewing	9,3	37,3
Malting	40,3	-
Other	3,1	111,6
Total	108,5	257,7

Notes : 1. Based on average at Coors for month of June 1973.

2. Industrial Waste Survey of the Malt Liquor Industry SIC. No. 2082 prepared for the Environmental Protection Agency, August 1971, by Associated Water and Air Resources Engineers, Inc.

TABLE 3.3 : Polluting Substances from Different Parts of a Brewery

Source	Polluting substances
Mashing	Cellulose, sugars, amino acids, detergents
Straining	Spent grains, sugars, amino acids, detergents
Wort boiling	Hops, wort, detergent
Hop strainer	Spent hops, wort, detergent
Hot wort tank	Trub, wort, detergent
Fermentation	Yeast, trub, beer, detergent
Lagering	Yeast sedimentated protein, beer, detergent
Beer filtration	Kieslguhr, yeast, protein, beer, detergent
Bottling	Beer, glass, caps, detergent
Bottle washing	Beer, extract, glass, labels, glue oil
Machines	Degreasing agents, detergent, caustic

On the basis of the table it may be said that brewery waste primarily contains alcohol, various sugars and polypeptides, and suspended solids. Concentration of these substances is often high and easily broken down biologically when put through a sewage treatment plant. In his article, Meyer presents a case study of the Pripps Bromma Brewery (Stockholm). It is of interest to note that 45,5% of all wastewater originates from manual hosing from various hose points primarily located in the bottle washing machine hall and bottling hall. Some wastewater from the brew house also comes from manual cleaning (see table below). It is in these areas that measures are to be taken to reduce water consumption. A simple way is to fit all hoses with self-sealing nozzles.

TABLE 3.4 : Origin of Wastewater at Pripps & Pomma

Source	Wastewater volume %	
Brewhouse	16	
Brights	5,7	
CIP	15,0	
Bottle washing machines	14,7	
Manual washing		
Cold water	29,0	45,5
Hot water	16,5	
Losses of products	1,3	
Laboratories and offices	1,8	

In the case of this brewery 5,1 kl water is required to manufacture 1 kl beer. Of these 5,1 kl, 4,0 kl go into the waste pipe and the rest leave the brewery as product and steam.

A number of articles have appeared in the literature because in common with other industrialists, producers of potable alcohol have been facing increasing problems, in both technical and economic terms in meeting environmental standards.

Among others, the problem of disposing of wastewaters in an effective manner is particularly difficult at landward production sites. Campbell (1977) discusses this aspect in his article on "Wastewater Treatment in Brewing and Distilling".

Untreated brewery waste has been in the past discharged to local authority sewers usually at reasonable cost. Hence, the more realistic charging schemes now being introduced by the Regional Water Authorities (UK) together with the expansion and centralisation of brewing operations, are combining to bring on site treatment into consideration more frequently.

In his paper he discusses the treatment both of distillery and brewery effluents in view of the similarities in wastewater derivation and characteristics. Principles of operation and treatment plant design are covered in the paper and examples of malfunction are quoted to illustrate difficulties which may arise if attention to detail is insufficient at plant design stage.

Van Biljon (1981) in a paper on 'Industrial Effluent Policies and Problems and the Local Authority', has indicated, however, that small biological treatment units are expensive to construct and to operate. Further, in the case of strong trade wastes, dilution by sewage is helpful in treatment and at times the presence of nutrient in the sewage is of benefit to the treatment of trade waste.

All pretreatment increases the cost of effluent disposal. However, many industries have been shown that by good housekeeping, waste recovery and water reuse expenditure can be decreased.

In his article on 'Recycling of Some Brewery Wastes to the Brew House' Lewis (1976) suggests that recycling wastes to the brew house is a realistic possibility and one that is worth evaluation before other more direct methods of waste treatment are used. However, the tests conducted have been very limited.

In the Republic of South Africa the brewing industry is "controlled" by the South African Breweries Limited. In his paper presented at the I.W.P.C. Conference, Pretoria, in 1980, Hoffman described not only the brewing process, the influence of water composition on brewing and methods of treatment for process and service water, but also discussed water reclamation and effluent treatment.

In most of the breweries the waste materials such as yeast, trub, spent grits and diatomaceous earth (used in the beer filters) are collected and removed before discharging the effluents to the sewer. It is alleged that the cost of additional pretreatment on the brewery site and the aesthetic aspects thereof favour discharge of untreated effluent into municipal sewers at fairly high treatment costs. The combined treatment of brewery waste and domestic waste usually presents no problems as the domestic waste can provide the nutrients required for the treatment of nutrient deficient brewery wastewater. However, it is acknowledged that it may become economically feasible to provide for some form of pretreatment to reduce the organic load when large volumes of effluent are discharged.

Hoffman indicates that the breweries (9 established in the Republic with the remainder (4) in black states and neighbouring countries) consume approximately 6 million kl of water in the production of 600 000 kl beer per annum and that the capacities of most of the breweries are to be expanded.

The quantity of effluent is obviously significant. The wastewater from steeping (in the preparation of malt) contains dirt, suspended matter and dissolved substances from the grain and has a high organic load. Spent grains are partially dewatered and sold as cattle fodder and the yeast depositing in the fermentors is recovered as a by-product. The main liquid wastes, however, are from bottle washing and from overflow of pasteurisers. Large quantities of water are used in washing processes which results in considerable volumes of wastewater.

By reclaiming and recycling the bottle washer and pasteurised water substantial volumes of water can be conserved. Hoffman refers to water reclamation systems in operation at two large breweries for bottle wash waters and/or pasteuriser waters.

Automatic in-place cleaning systems are a standard feature in existing and new installations. The quantities of water consumption and effluent purchased for various sections of a hypothetical brewery are given by Hoffman in good detail as shown below. It is seen that more than 80% of water intake can be discharged as effluent, but this can be reduced by introducing water reclamation and recycling.

It is stressed that the composition of brewery effluents is extremely variable and is dependent on factors such as type of plant equipment in use, etc. Effluent BOD values ranging from over 1 300 to over 2 000 mg/l are quoted.

T. Sasahara (1982) in his paper on Treatment of Brewery Effluent, Part I, reports on water consumption and effluent discharge per production unit. Water consumption and effluent discharge per production unit are critical factors in process design and operation control of treatment facilities. In view of extremely variable values reported in the literature he examined 12 breweries belonging to Kiran Breweries Co. Limited. He derived a value of 10,5 m^3 water per kl beer. Effluent volumes per production unit of beer were 7,3 m^3/kl.

TABLE 3.5 : Water Balance for an 80 000 hl/week brewery

Production Department	Water Consumption		Effluent Produced	
	m^3 water/hl finished beer	Total Quantity m^3/h*	m^3 water/hl finished beer	Total Quanti m^3/h*
Brewhouse				
Brewing water	0,170	83,7	-	-
Wort copper	-	-	0,010	5,2
Condensate rinse water & waste	0,080	39,4	0,090	46,5
Total	0,250	123,1	0,100	51,7
Ferment & Cellars				
Rinse water & waste	0,122	109,2	0,112	105,9
Bottling				
Bottle washing	0,070	68,2	0,070	68,2
Bottle pasteurising	0,106	103,4	0,106	103,4
Rinse water & waste	0,030	29,3	0,030	29,3
Total	0,206	200,9	0,206	200,9
Ancillary Departments				
Filtration & bright Beer	0,130	109,2	0,156	104,8
Engine room ; Boiler house	0,044	37,1	0,005	3,7
Amenities	0,058	48,8	0,072	48,3
Total	0,232	195,1	0,233	156,8
Total	0,800	628,3	0,651	515,3

* Actual volumes, calculated according to production hours worked in various departments

The effluent was approximately 70% of the water. The value varied greatly in different breweries but its monthly variation in any given brewery was small. It will be seen that these values differ somewhat from those quoted by the previous author.

In Part II of the papers on 'Treatment of Brewery Effluent', Sasahara <u>et al</u> deal with the characteristics of the original effluent from twelve breweries (Kiran Brewery Co. Ltd., Tokyo), the nutrient ratio and the equalising effect of a balancing tank on hourly variation in the COD of effluent. Nutrient ratio was found to be satisfactory.

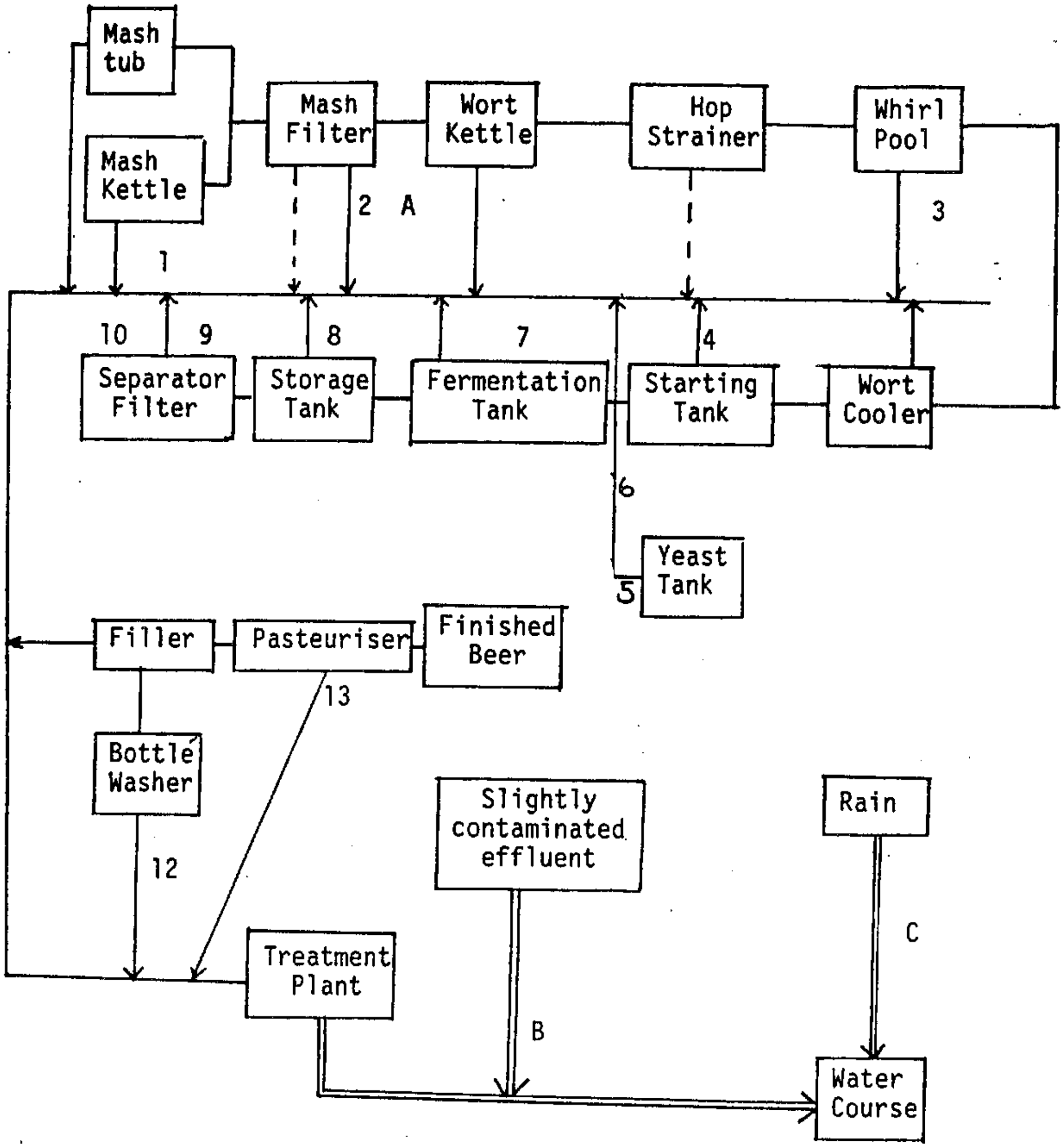
The main sources of COD in total brewery effluent are a few percent loss of raw waste from the brewing process and fermented waste and beer throughout the entire brewing and packaging process. These losses make the COD of the total brewery effluent 1 400 mg/l, in the case of 95% yield and 5% losses, if the yield be increased to 96% by reducing the loss percentage the concentration of COD in the total brewery effluent will decrease 20%. The brewing and packaging processes contribute considerably to the overall polluting strength of the effluent. Therefore, the processing losses must be reduced by improving the processing yield to reduce the COD load discharged in the effluent, and solid materials such as spent grain, spent hops and pulped lable debris must be removed as completely as possible at each step in the process.

The major effluent from brewery operation is shown by Sasahara <u>et al</u> in the Figure 3.2.

In general, a lot of stress has been laid on biological treatment/pretreatment but reference has also been made to such aspects as :

(a) Ensuring water is not unnecessarily wasted, recycling in plant as well as reducing polluting materials from the brewery by removal for solid disposal or use (e.g. spent grits, hops, yeast, diatomaceous earth, etc.). (refer also to Mahmud, 1980 and Hoffman, 1980).

FIGURE 3.2. : MAJOR EFFLUENT FROM BREWERY OPERATION



KEY

A : Contaminated Stream

B : Slightly Contaminated Stream

C : Rain Stream

1-13: Sampling Point

⟶: Major Effluent

--➔: Suspended Solids

(b) Recovery of yeast and enthyl alcohol from the fermenting and larger cellar. This was discussed by Wysocki as early as 1973 in his article on 'Treatment of Brewery Fermentation Effluents. Economics of Recovery Process for Yeast, Alcohol and Water'.

COD effluent levels (corresponding to the sample numbers in the diagram are given in the Table below :

TABLE 3.6 : COD Effluent Levels During the Production Process

No of sampling points	Brewing Process	COD (mg/l) in Effluent
	Brewing Section	
1	Washing of kettle and tube	3 000 - 6 000
2	Washing of filter cloth	5 000 - 8 000
3	Washing of sediment tank	40 000 - 200 000
4	Washing of starting tank	30 000 - 50 000
5	Washing of yeast	10 000 - 50 000
6	Treatment of waste yeast	30 000 - 100 000
7	Washing of Fermentor	4 000 - 12 000
8	Washing of storage tank	3 000 - 60 000
9	Washing of primary filter	200 - 500
10	Washing of secondary filter	3 000 - 4 000
	Bottling section	
11	Prewashing of returnable bottles	5 000 - 10 000
12	Washing of bottles inside and outside	10 - 50
13	Pasteuriser	10 - 50

(c) High alkalinity of bottle shop wastewater and waste from CIP systems. Here Lom (1977) refers to the application of CO_2 as the neutralising medium.

In regard to alcohol recovery (see Wysocki, 1975) the use of modern membrane technology may prove to be useful.

3.4 Distillery Wastes

3.4.1 Molasses and other Distillery Wastes

Sheenan and Greenfield (1980), have presented a comprehensive review of the methods for handling distillery wastewater. Distillery wastewater (stillage, slops, vinasse, or dunder) constitutes a high volume high strength acidic waste that presents significant disposal or treatment problems. The article reviews the problem of stillage production and the various disposal techniques which have been experimented with or put into practice over the past forty years.

The authors have considered the problem under the following headings :-

1) Ethanol fermentation

2) Nature of the problem

3) Utilisation of stillage

   a) Recycle
   b) Direct load application
   c) Evaporation, combustion
   d) Biomass and biochemicals production
   e) Food supplement

4) Physical-chemical treatment of stillage

5) Biological treatment of stillage

   a) Anaerobic digestion
   b) Anaerobic filtration
   c) Anaerobic lagoons
   d) Activated sludge
   e) Trickling filters

f) Rotating biological contactors
g) Stillage treatment and Municipal wastes
h) Miscellaneous techniques.

Mollases distillery wastewater which is typically more difficult to treat than others is characterised by a high biodegradable, dissolved solids content (of which up to 50% may be present as reducing sugars), high ash content, high temperature and low pH. The waste stream typically possesses high concentrations of potassium, calcium, chloride and sulphate ions and a BOD_5 of around 35 000 mgl^{-1}.

In regard to 3(d) Biomass production, and 3(e) Food supplement, Lurie (1980) has reported that the total effluent from two South African distilleries (National Chemical Products (Natal) and National Chemical Products (Transvaal)), is converted to 'Dried Molasses Distillers Soluble' which is the base for an animal feed.

Boruff, as early as 1947, in his article on 'Recovery of Fermentation Residues as Feeds' indicated that stillage from the alcohol fermentation of molasses, was concentrated to 50 - 60% solids in multiple effect evaporators and used as molasses substitute in cattle feeds or dried and used in mixed feeds. Similarly, most of the butanol-acetone stillage was also being evaporated and sold as vitamin supplement in mixed feeds.

In the case of a third South African distillers (Natal Cane By-Products Ltd.), the vinasse (slop) after removal of alcohol by distillation is utilized in part as a raw material for the manufacture of fodder yeast. This material is produced by continuous fermentation followed by centrifugal separation and drying. The organism Torulopsis utilis in addition to being able to metabolise hexose sugars can also utilise pentose sugars and other components (glycerol and fatty acids) present in vinasse. The fodder yeast is mainly sold for animal nutrition, although some goes into human foods.

It is of interest to note that in India, where sugar cane is one of the major crops, there are a large number of distilleries converting molasses to alcohol. Sharma et al (1973) however indicate that at the time of their studies there had been no successful attempt made to reduce the pollution load of the spent water from the distilleries, which was allowed to flow into nearby rivulets and streams. In their studies, Sharma et al showed that it was possible to adapt a yeast culture (Saccharomyces cerevisiae) to 100% distillery waste without nutrient addition. Total sugar and BOD reductions at 60% and 57,5% respectively were obtained under optimum sets of conditions.

According to Sheenan and Greenfield (1980), physical-chemical treatment of stillage has met with little success. Reference is, however, made to the use of reverse osmosis on distillery wastewater. With the advances in this area of effluent treatment such separation may be worth re-examination particularly for cane molasses distillery wastewaters. Where the avenues of stillage utilisation and by-product recovery are closed, Sheenan and Greenfield suggest that biological treatment of stillage offers the only real means of disposal. Additionally, the liquor remaining after by-product recovery is not generally suitable for discharge to a receiving water body and requires further treatment - biological treatment is often the most effective.

The characteristics of distillery wastewater vary considerably according to the fermentation feedstock (and to location) and the variability in reported treatment processes and their success or otherwise stems in part from this fact. In the evaluation and reporting of any treatment procedure Sheenan and Greenfield have stressed that detail must be given to the nature and concentration of the waste species.

In their article 'Stillage - A Resource Disguised as a Nuisance' Ribeiro and Branco (1981) discuss highlights of the technology, economics and market penetration matters and opportunities, in the recovery and utilisation of stillage and its products in Brazil. The capital layout necessary for implementation of most of the stillage recovery alternatives is bigger than that required for the implementation of the corresponding by-product distillery (i.e. molasses distillery) and can reach values which represent two thirds of the investment in independent distilleries (i.e. cane juice distilleries) of the same rated capacity. The economic profitability of future stillage processing units wil be a function of the prices attained by the recovered products and a market for such products.

The Centro de Technologia Promon, Brazil, has undertaken a multiclient study on the evaluation of processes for stillage recovery as a distillery by-product.

3.4.2 Wine Distillery Wastes

Wine distillery waste or spent wine, is the residue left after ethyl alcohol or brandy has been distilled from fermented grape juice. It contains residual organic acids, soluble proteins and carbohydrates, as well as various inorganic compounds, which are the normal constituents of grape juice. The average COD of spent wine distillery effluent is given as 23,5 g/l (Stander et al, 1968). Spent wine should therefore respond to anaerobic digestion. The National Institute for Water Research (CSIR) has investigated and reported on the full scale purification of wine distillery wastes by the anaerobic process (1968). Two separate plants were used for the full-scale investigations. The first was sited at the Paarl Sewage Purification Works and the other was the regular sewage sludge digester of the Stellenbosch Sewage Purification works. Major attention was devoted to development and use of the Paarl disgester for spent wine digestion since independent treatment was the primary objective of the project.

The effluent arising from the anaerobic digestion of spent wine contains residual organic matter, the COD of the effluent being of the order of 300 - 400 mg/l. In most instances, such an effluent may be discharged into a municipal sewer.

In his paper on 'Anaerobic Treatment of Soluble Organic Wastes' Ross (1981) has reviewed the research carried out by the National Institute of Water Research over the past 20 years in the field of anaerobic digestion of specific concentrated organic wastes including effluents from wine distillation and compressed yeast manufacture.

Full scale plants (with a capacity of 1 000 m^3) were constructed in the early sixties and are still being operated by normal sewage works personnel. The average degree of purification obtained is reflected below for three wastes :-

TABLE 3.7 : Purification of Industrial Effluents by Means of Anaerobic Digestion

Analysis as per Standard Methods		Wine Distiller Wastes			Maize-Starch Wastes			Compressed Yeast Waste		
		Raw feed	Clarigester Effluent	% Red.	Raw feed	Clarigester Effluent	% Red.	Raw feed	Clarigester Effluent	% Red.
pH value		4,5	7,5	-	4,5	7,1	-	4,9	7,3	-
Total solids	g/l	12,5	3,5	72,0	8,2	2,4	71	23,1	13,5	42,8
Chemical oxygen demand	mg/l	22 000	500	97,3	10 000	700	93	22 000	6 700	69,5
Permanganate value	mg/l	4 700	180	96,2	1 600	130	92	7 900	2 400	69,6
Organic N	mg/l	350	3	99,1	500	30	94	390	220	41,6
Ammonia N	mg/l	10	200	-	50	400	-	30	120	-
Orthophosphate as PO_4	mg/l	250	150	-	150	80	-	65	80	-
Volumetric load rate kg $COD.m^{-3}.d^{-1}$		3,2 at 33°C			2,5 at 24°C			4,0 at 35°C		
Capacity of digester alone	m^3	654			624			6,3		
Hydraulic retention time,	d	7,5			3,3			8,0		

The production of spent wine was of the order of 320 Ml in 1979 ; this contributes a significant pollution load on the environment. It will be seen from the table that by anaerobic treatment 97% reduction of an initial COD load of 22 000 mg/l can be achieved.

Current research being carried out by NIWR is aimed at optimizing the efficiency of the full-scale plants.

3.5 Yeast

In his paper given in 1977 South African Yeast and Fermentation Techniques Symposium, Howell gives a brief and essentially non-technical view of the Yeast Industry in Southern Africa.

He states that "having grown, separated, filtered and compressed or dried the product, the manufacturer is then faced with probably the biggest problem of all, namely the disposal of the effluent generated during the process. Extremely high COD and BOD values make the cost of disposal of such an effluent down the municipal sewers very high and in some cases the municipal sewage treatment works are simply unable to cope with the loading from this source. Most overseas factories are ideally situated with outfalls to the sea or large rivers, although to alleviate the pollution problem, some plants have installed evaporation equipment to concentrate the effluent to about 60% solids for disposal by sale as 'condensed molasses solubles'..... The economic disposal of yeast factory effluents by an environmentally acceptable procedure remains a major problem of the industry on a world wide scale".

Lurie (1980) has indicated that three factories at Industria, Bellville and Durban, producing compressed bakers yeast have an off-take of approximately 20 000 tons/annum in 1 kg pats into the baking industry. These three factories, in addition, sell a considerably smaller quantity of compressed yeast in 20 g. cubes for home baking and brewing purposes. It is estimated that the sales value of wet compressed yeast is of the order of R12 million.

Active dried yeast for home baking and brewing and active dried sorghum beer yeast for supply to the sorghum beer industry is produced at Industria and Welkom while at Bellville, production includes active dried wine yeast.

Fodder yeast however is produced by only one factory in Natal. It is produced by continuous fermentation followed by centrifugal separation and drying using slops from ethyl alcohol fermentation of cane molasses plus added molasses as substate. The organism used is Torulopsis utilis. The fodder yeast is mainly sold for animal nutrition although some goes into human foods.

In South Africa, sugar cane molasses is generally used as raw material for manufacturing of yeast. The effluent resulting therefrom is, however, relatively more polluted than that from beet sugar molasses, such as is commonly used in Europe. The problem of disposal of effluent is thus aggravated. The National Institute of Water Research (Stander et al, 1971) undertook a coordinated research programme with certain yeast companies. The report by Stander et al (1971) is entitled, 'Treatment and Disposal of Yeast Wastes'.

Surveys of individual factories indicated that waste liquor from the first separation of yeast cake was by far the most potent (70 000 COD or 23 000 OA mg/l). This relativley small volume of effluent (20 - 30% of the total effluent flow) carried about 65% of the total organic load. Separate treatment and/or disposal of this faction coupled with balancing of the other effluents and wash waters would obviously result in substantial reduction of the average organic strength of the factory discharge.

The investigation indicated that about 70% of the COD of yeast wastes could be removed by anaerobic digestion. The residual COD was largely intractable and will not constitute an equivalent BOD load. (See also Table 3.7 in Section 3.4.2).

Koehler, R. (1974) also gives details of the use of continuous contact-type anaerobic decomposition units for partial purification of effluents from molasses fermentation (yeast and alcohol production plants). Advantages claimed for the system include high efficiency, low space requirements, low energy requirements, minimum sludge formation, absence of objectionable smells and formation of large quantities of gas which may be used as a fuel.

Boruff (1947) describes undiluted waste from yeast plants using molasses as a substrate as containing from 1 - 3% total solids (75% organic load) and possessing a 5-day BOD of 7 000 - 14 000 ppm depending on the materials and concentrations used in developing the yeast.

The waste is too low in solids content and food or feed value to justify recovery. An anaerobic disposal method is described.

Interest in anaerobic digestion continues and recent studies on the determination of the kinetic parameters are described by Hansford (1982). The operating method described was tested during the course of experimental investigation on the anaerobic digestion of a yeast factory effluent.

There have however also been non-biological studies and Rembowski _et al_, (1974) have carried out investigations on the application of reverse osmosis for treatment and utilization of wastes from the Yeast Industry.

They state that it was found possible to concentrate yeast waste five times with simultaneous considerable lowering of filtrate BOD_5. Such a filtrate can be reused in the yeast production process. The concentrated wastes on the other hand, after additional evaporation can further be used in the production of feed stuff.

3.6 Summary

This survey on fermentation is restricted to the following areas only :-

1) Sorghum beer
2) Barley beer
3) Distillery wastes - from molasses and wine fermentation
4) Yeast.

The Sorghum Beer Industry consists of a large number of breweries which vary in size and which gave a total output of over one million kl in 1981. At a water usage of between 2 - 4 litres/litre of beer there is not a high effluent volume, particularly since this is proportioned between a large number of breweries spread over the country. High quality research and technical advice on processing is available to the breweries through the Sorghum Beer Unit, CSIR.

The Barley Beer Industry in South Africa is "controlled" by the South African Breweries Limited. The breweries produce approximately 600 000 kl of beer per annum with a water consumption of about 6 million kl. The total waste volumes from these breweries is larger than that for sorghum beer. There are, however, only nine breweries in the Republic all under the same control and the advantage of consistent policy towards effluent and effluent control is obvious.

Distillery wastes from molasses manufacture are produced at present from only three factories. The production of 'Dried Distillers Solubles', a base for animal feeds, appears to be a satisfactory method for dealing with the highly polluting liquid from ethanol fermentation of molasses while market conditions are satisfactory.

Distillery wastes from wine fermentation are produced by the wine co-operatives e.g. KWV. NIWR (CSIR) has carried out research on these wastes and shown that they can be treated effectively by anaerobic digestion.

Yeast (other than Fodder yeast - see Section 3.4.1) is made by only four factories. Research undertaken by NIWR (CSIR) has shown that 70% of the COD of the yeast waste could be removed by anaerobic digestion. (The residual COD was largely intractable).

The literature has not revealed any really novel methods of dealing with the highly polluting effluents from the fermentation industries considered. There does appear to be a need to examine the treatment of effluents by other biological or evaporation techniques. Membrane separation processes are progresssing rapidly and treatment by such processes needs to be considered.

4. REPORT

4.1 Collection of Information

Names and addresses of various organisations/firms concerned with fermentation and distilling were obtained from sources such as :-

Techo Economics Division, CSIR, Pretoria
The Department of Statistics, Pretoria
National Trade Index of South Africa 1981.

The areas of interest were :-

(i) Yeast manufacture
(ii) Wine distilleries
(iii) Molasses distilleries
(iv) Barley beer manufacture
(v) Sorghum beer manufacture.

In order to have some indication of overseas practices, letters were written to :-

United States Breweries Association Inc.
Distilled Spirits Council of the United States
The Brewing Research Foundation, U.K.
Effluent Guidelines Division, Office of Water and Hazardous Materials, U.S. Environmental Protection Agency.

The information received was incorporated in Section 3.

Questionnaires were drawn up and sent out under cover of a letter to the manufacturers/organisations shown above (i) - (v). See also Appendices 4.1 - 4.5.

4.2 Yeast (Other than Food Yeast)

4.2.1 Five yeast manufacturing companies were approached. Two of the companies felt that they had been active in the field of water management and effluent treatment for many years together with authorities such as CSIR and that another survey would not be of any real benefit. It appears that both concerns dispose of their effluent to municipal sewers satisfactorily.

One concern did not reply and the response to the questionnaire by the remaining two is given in Table 4.1.

TABLE 4.1 : Yeast Factories

Factory No.	1	2
Ave. number of employees	60	85
Volume of water intake	228 000 kl/a	127 750 kl/a
Average rate consumption	625 kl/d	350 Kl/d
Maximum rate consumption	744 kl/d	400 kl/d
Total volume of effluent	-	124 100 kl/a
Discharge of effluent :	'weak' to sewer (not measured) 'strong' by tanker to sewage works for sea disposal (91 462 kl/a)	weak to sewer strong by tanker to evoporation pond (150 kl/d)
Analysis :		
'Weak' OA	400 mg/l (spot sample)	600 mg/l
'Strong' OA	12 000 mg/l (spot sample	13 000 mg/l
Comments	Disposal costs estimated at R30 000/annum for 'weak' and over R130 000 for 'strong' (mainly transport costs).	University in area is undertaking ivestigations on 'strong' effluent, using a novel fixed bed anaerobic treatment process. Disposal costs at present 'weak' R74 000 'strong' R84 000

4.2.2 Only one factory was visited (No. 1). The process involves the use of molasses as the substate for yeast growth (<u>Saccharomyces cerevisiae</u>). The yeast from the fermentors is separated from the liquor by centrifugation. A counter-current wash system is used. The cream is stored cold and filtered on a rotary vacuum drum to about 30% solids. Fermentors are washed out and a caustic soda solution used for cleaning. The charge is circulated but not recovered.

There is a system of drains which allows for separation of 'strong' wastes from 'clean' floor washings.

The 'clean floor' washings are drained to a central sump and discharged to sewer. The 'strong' waste is stored in a special sump and pumped to a tanker, which removes the material to the sewage works for sea disposal.

The site is very crowded and there is little room available for additional plant.

4.2.3 Conclusions

Work done by the CSIR on pre-treatment of strong yeast wastes by anaerobic digestion should not be overlooked and the ongoing research at a University for Factory No. 2 should be encouraged.

In any factory, however, attention to detail in regard to 'house keeping' and use, reuse/recycle of water will assist in some volume reduction.

Problem areas

1) Disposal of molasses waste after fermentation.
2) Cleaning liquors.

4.3 Wine Distilleries

In answer to the correspondence on wine distilleries, KWV indicated, "In the case of the Wine Industry, in general, and the KWV, in particular, we had however completed a project a few years ago which was carried out for many years by the Water Research Unit of the CSIR under guidance of the Water Research Commission in close cooperation with the KWV and technical people from various other Wine firms..... the Water Research Commission will have more and better co-ordinated information about Water Management and Effluent Treatment in the Wine Industry than ourselves. In view of this it may not be necessary or worthwhile for us to go through this type of survey again.

4.3.1 Conclusion

In view of the above the continuing work being done by the CSIR on the anaerobic treatment of wine distillery wastes, it does not appear reasonable to pursue this matter further.

4.4 Molasses Distillery

4.4.1 There are only three molasses distilleries in the country, one of which also produces a food yeast. The returns submitted are shown in Table 4.2.

TABLE 4.2 : Molasses Distilleries

Factory No.	1	2	3
Ave. number of employees	1 000	620	375
Volume of water intake (kl/a)	1 214 000	360 000	865 000
Average rate (kl/d)	3 326	1 000	2 370
Maximum rate (kl/d)	3 800	1 000	2 600
Recycle :	Steam condensate to boiler feed Evaporator distillate recycled to ethyl fermentation	Steam condensate to boiler feed Evaporator distillate recycled to ethyl fermentation	Distillery residue used as substate for torula yeast production
Consumptive use (kl/d) approx. (cooling water, make-up, etc.)	2 000	590	815
Total effluent volume (kl/a)	492 000	146 000	627 800
Average analysis : OA mg/l	880 (without boiler effluent)	1 800 - 2 000	20 000
COD mg/l	-	-	55 000
Treatment before discharge :	Effluent passes into buffer tanks before discharge Note : It is endeavoured to recover all solids from fermentation via evaporator & spray dryers	pH adjustment with lime ; cooling Note : It is endeavoured to recover all solids from fermenation via evaporators & spray driers	Cooled, settled centrifuged before pumping to outfall
Discharge point	Municipal sewer	Municipal sewer	Municipal Sea outfall via own pipe-lines.

General Comment

Besides alcohol other products are produced at three factories.

Factory (1) can meet the standards required by the local authority under normal operating conditions.

At Factory (2) it is claimed that OA is the major factor that accounts for over 75% of the effluent costs. The major OA contribution is from the handling of the slop after alcohol removal. The cost of effluent disposal is of the order of R120 000 p.a.

At factory (3), the high OA is unacceptable into sewage works and effluent is discharged to sea outfall after pH and solids control.

4.4.2 Visits to Factories to Supplement Information on Questionnaire

Two factories were visited (Factories 2 and 3). The general impression gained was that the factories were well run and that management was willing to discuss the problems of effluent control/discharge.

A considerable amount of detail is available on water usage and attention is being paid to good housekeeping and reuse/recycling of water.

In factory 3, the high OA of the effluent is being re-examined from the point of view of evaporation and drying of the effluent or the manufacture of condensed molasses solubles but this is very much dependent on the market.

4.4.3 General

Two of the factories have adopted the same procedure for the treatment of distillery wastes (evaporation/drying). One uses the distillery waste (dunder) to manufacture yeast. This process still leaves an effluent with a very high OA. The effluent is at present disposed of satisfactorily to sea outfall. The factory however has a number of schemes for treatment and reuse but they are dependent on market viability and other factors such as microbiological contamination.

4.4.4 Conclusions

The need for research and development on effluents in Factory (3) is not clear until a decision is taken on the recovery of by-products from the effluent. Factory (2), which has a reasonably low load would still be interested in reducing this further before discharge.

4.5 Barley Beer Manufacture

4.5.1 The South African Breweries Limited control operations of all barley-beer breweries in South Africa. Management considers water management to be high on their list of priorities during the next decade.

They have a central Research and Development Section and have carried out in depth studies at various breweries. They are currently investigating water recovery and effluent volume reduction techniques. A firm of consulting engineers have been engaged to undertake a study on water management.

It is considered that when a decision is taken in water/effluent management strategy for the larger breweries (pretreatment recycling, by-products enhancement and disposal) high techology applications (reverse osmosis, electrodialysis) will have to be evaluated on a pilot scale.

4.5.2 Reply to Questionnaire

The amounts of water intake, production of beer and waste produced is given in Table No. 4.3.

It will be seen that the approximate ratio of beer to water intake is 8,3, but this varies from an expected value of 7,2 to 10. Values quoted in the literature are variable but there is a trend to go to lower ratios.

Water reclamation is practiced in the Isando and Alrode Breweries. It is claimed that 75% of the packaging hall water is reclaimed.

Consumptive use of water is approximately 12% of total intake in the product and steam losses etc. account for 8%.

The volume of water to and from various sections for a large 300 000 kl/annum brewery is given in detail in Table 4.4.

From this table it will be seen that the BOD percentage of the total/brew is of the order of 38% for the Cellars and Filtration Section and about 48% for the Packing Hall Area. The corresponding effluent volumes are approximately 23% and 42% per brew.

Average values for water, effluent, beer ratios and chemical analysis for two breweries are given in Table 4.5.

Discharge of final effluent is in all cases to municipal sewers, and this is apparently acceptable to local authorities.

SOUTH AFRICAN BREWERIES LTD

TABLE 4.3 : Location of ; beer production ; water intake and effluent produced for various breweries

Region	Northern Transvaal and Orange Free State			Southern Transvaal		
Brewery	Rosslyn (new brewery under construction)	United Breweries	Bloemfontein	Isando	Alrode	Chamdor
Location	Galgher St. Rosslyn	Garankuwa Bophuthatswana	208 Kert St. Bloemfontein	Isando Rd. Isando	Johnsons St. Alrode	3 Fransen St. Chamdor Krugersdorp
Beer output (kl/a)	300 000	48 750	13 500	202 500	240 000	150 000
Water supply	RWB	RWB	Bloemf. Mun : Maselspoort & Welbedacht	RWB	RWB	RWB
Total water intake (kl/a)	2 400 000	500 000	135 000	1 600 000	2 000 000	1 350 000
Ave. consumption, kl/d	8 500	1 800	480	5 700	7 000	4 800
Total volume of effluent (kl/a)	1 920 000	400 000	180 000	960 000	1 200 000	1 080 000
Solids wastes						
Spent grains	Will be sold dry	Sold wet	Sold wet	Sold dry	Sold wet	Sold wet
Spent yeast	Will be sold wet			Sold wet	Sold wet	Sold wet
Spent Kieselguhr	Dispose by means of tanker	← Discharged into effluent →				
Water pretreatment	Process water : ozonation Service water : chlorination	No pretreatment	No pretreatment	Brewing water : GAC treatment	Brewing water : GAC treatment	Process water : lime softening, ozonation. Service water : chlorination

TABLE 4.3 : Location of ; beer production ; water intake and effluent produced for various breweries (cont)

Region	Natal			Western Province		Eastern Province	Total
Brewery	Prospecton	Umbilo	Fountain Park	Ohlssons Cape Breweries Newlands	Ohlssons Cape Breweries Butterworth	Port Elizabeth	
Location	25 Jeffels Rd. Prospecton	49 Fennis-rowles Rd. Durban	41 Jeffels Rd. Prospecton	Main Rd. Newlands	Tainton Rd. Ibeka, Butterworth	335 Main St. Port Elizabeth	
Beer output (kl/a)	56 250	22 500	22 500	56 250	7 875	37 500	Approx. 1,2 x 10^6
Water supply	Durban Municipality : Nagel, Midmar, Albert Falls Dams			Newlands, Spring, Kommetjie, Spring, One borehole Municipal supply : various sources	Butterworth Municipality Gcuwa River	P.E. Municipality Churchill and Lurie dams	
Total water intake (kl/a)	750 000	450 000	225 000	500 000	80 000	375 000	Approx. 10 x 10^6
Ave. consumption, kl/d	2 700	1 600	800	1 800	280	1 300	
Total volume of effluent (kl/a)	600 000	360 000	180 000	400 000	64 000	300 000	Approx. 7,6 x 10^6
Solids wastes Spent grains	Sold wet	Sold wet	Sold wet	Sold wet	Sold wet	Sold wet	Approx. dry tonnages produced/a 44 000
Spent yeast	Sold wet	Sold wet	Sold wet	Sold dry	Discharged into effluent	Sold wet	4 800
Spent Kieselguhr	← Discharged into effluent →						3 000
Water pretreatment	Brewing water : GAC treatment	No pretreatment		No pretreatment	Ion exchange ; dealkalisation ; GAC	Brewing water GAC treatment	

TABLE 4.5 : Water, Effluent, Beer Ratios and Chemical Analyses (Average Values from Surveys)

Parameter	Brewery Department					
	Brewhouse	Fermenting cellars	Filtration cellars	Packaging hall	Engineering services	Final Effluent
Water : beer ratio	2,66	0,33	0,09	2,15	1,93	7,16
Effluent : water ratio	0,51	1,00	1,00	0,90*	0,59	0,68
kg OA/kl beer - bottled	4,72	1,04	0,19	1,38	0,07	7,40
pH	7,5	7,5	7,0	10,0	7,6	7 - 9
Settleable solids cm^3/dm^3	20	15	4	1	1	2 - 10
Suspended solids cm^3/dm^3	1 500	1 300	1 200	200	150 - 500	600 - 700
Oxygen absorbed mg/dm^3	800	700	300 - 1 800	110	30	300 - 450
COD, mg/dm^3	7 000	6 000	4 000 - 15 000	1 000	250	2 500 - 2 800
BOD, mg/dm^3	4 000	3 400	2 000 - 7 000	600	80	1 500 - 1 700
TDS, mg/dm^3	-	-	-	-	-	1 000 - 1 800
BOD : N : P ratio	-	-	-	-	-	100 : 3,6 : 1,9

* Without reclamation this would be nearer 1.

4.5.2.1 Future

In regard to the future, there is some worry regarding the deterioration of the quality of the water supply on the Rand (see Table 4.3 for present treatment). The Group is currently investigating water recovery and effluent volume reduction techniques. When a decision is made on water/effluent strategy for the larger breweries (pretreatment, recycling, by-products enhancement and disposal) high technology applications such as reverse osmosis, electrodialysis will have to be evaluated.

4.5.3 Only two maltsters are operated and water and effluent data and effluent analyses are given in Table 4.6. The effluent from these operations is accepted by the respective municipalities.

4.5.4 A familiarisation visit was paid to the Prospecton Brewery and this was followed by a visit to the Central Laboratory of the South African Breweries Ltd. at Isando for discussions with Dr. J.P. Murray (Director Brewing Research and Development) and Mr. J.R.H. Hoffman (Water Technologist). Mr Abbot of Binnie and Partners International was also at the discussion for some of the time.

Management is well motivated and aware of problems associated with water management and effluent treatment in the brewing industry and they have already retained a firm of consulting engineers to investigate excess water usage and recommend :

(i) Methods for lowering water usage.
(ii) Effluent treatment at new breweries.

TABLE 4.6

South African Breweries Ltd
Southern Associated Maltsters (Pty) Ltd

Water and Effluent Data

Maltings		Alrode	Caledon
Water supply :		RWB	Caledon Municipality The Waterskloof Dam
Water usage	(kl/d)	323 800	305 440
Ave flow	(kl/d)	300	300
Peak flow	(kl/d)	1 000	1 000
Malt production	(tonnes/a)	48 000	46 000 (first phase)
Total effluent	(kl/a)	292 000	275 000
Effluent preatreatment		None	Holding tank, aeration

Alrode Maltings Effluent Analysis. (values in mg/dm^3)

Sample	First steep	Second steep	Bed wash	Final Composite
Permanganate value	680	222	62	320
COD	3 880	1 744	624	2 083
BOD	3 700	1 615	460	1 925
Suspended solids	105	66	285	152
Dissolved solids	2 521	970	482	1 323
Total nitrogen (N)	1,6	0,04	0,01	0,55
Total phosphate (PO_4)	4,2	0,1	0,05	2,0
pH	5,7	6,2	6,7	6,2

Solid wastes : malt sprouts, malt dust, etc. sold as cattle feed.

General aspects during discussion covered such aspects as :-

(i) Removal of solids such as spent grains, yeast etc. effectively to avoid gross contamination of effluent.

(ii) Effluent disposal to sewer is the normal route as brewery effluent is so readily biodegradable. However charges are relatively high and are expected to increase. With decrease in water : beer ratio effluent COD may be expected to increase. With this in mind the expansions envisaged, it may be expected that advanced effluent treatment methods involving both by-product recovery and water reuse will become standard practice.

(iii) No major alterations to processing methods are foreseen for the present.

4.5.5 It appears from the above that at present there is no need for a research programme on water use/reuse or effluent treatment/pretreatment but at a later stage the investigations into certain aspects of the application of high technology techniques in the large breweries may become necessary.

4.6 Sorghum Beer

4.6.1 The various Administration Boards and Development Corporations controlling sorghum breweries were approached. (The letter incorporating the questionnaire is given in Appendix 4.5. This was followed in some cases by the Questionnaire in Appendix 4.5 (i)). This list of Boards and Corporations is given in Appendix 4.6. The number of breweries linked to each Board and Corporation is also shown.

4.6.2 Visits to Breweries

The breweries Nos. 20 and 21 were visited to gain a general impression of operations, layout, etc. At both breweries information was freely given.

Brewery No. 20 is a large brewery with many facilities such as in place cleaning, etc., whereas Brewery No. 21 is much smaller.

The larger brewery is obviously more concerned regarding water usage and it is planned by management to give lectures to staff on "good housekeeping" and water management. It is at present looking into energy saving and at methods of manufacture to effect steam saving, cooling water saving, hot water generation for starting brews, hot washing etc.

At both breweries there is concern regarding the high effluent disposal charges. 'Strong' and 'weak' effluents are not separated but collected in holding tanks for pH adjustment. Solids are removed as far as possible on screens, but the fine (almost colloidal) solids in the effluent are a problem.

This preliminary visit assisted in the interpretation of the returns submitted by the various breweries.

4.6.3 Replies to Questionnaire

An examination of the returns submitted by the various breweries, Table 4.7 indicates two large volume producers with others ranging in output from 4 000 to just over 7 000 kl/annum.

Nearly all dispose of their effluent via municipal sewers. Since OA and COD would be, say, 200 - 400 mg/l and 1 700 - 4 000 mg/l respectively, effluent charges could be high. For example, from Brewery No. 10 the charge is of the order of R58 000 per annum.

Brewery No	Number of Employees	Output kℓ/a	Water Intake		Average/d kℓ	Maximum/d kℓ	Effluent Volume kℓ/a	Ratio water intake to beer produced	Analysis of Effluent	Discharge	Comments
			Source	Volume kℓ/a							
1	150	24 000	Municipality	57 000	190	230	30 000	2,38		Sewer	No waste problem
2	148	30 000	Municipality	108 680	-	-	67 920	3,62		Sewer Pretreatment: Vibrator to remove solids from brewery effluent; pH adjustment of total effluent	
3	197	30 420	Municipality	231 600	680	950	171 400	7,61		Sewer Pretreatment: chloride of lime in settling tank	Production flow & programming chart shows re-use of condensate from drier and mash heat exchanger
4	170	40 600		164 800	-	-	13 000	4,06		Sewer	
5	122	48 000 (Total cap. 72 000)		153 720			Variable	3,20	OA 80-800mg/ℓ COD 1740-3360 Susp.Solids 500-3000g/ℓ Set.Solids 10-175 mg/ℓ	Sewer	Possible research programme with local Univ. in preliminary treatment of effluent by biological farming
6	79	14 000		42 000			28 000	3,00		Sewer	
7	92	25 000		67 500			23 500	2,70		Sewer	
8	44	16 000		43 200			15 000	2,70		Sewer	May be necessary to reduce total solids and COD before discharge

TABLE 4.7 : SORGHUM BEER BREWERIES REPLIES TO QUESTIONNAIRE (CONTINUED)

Brewery No	Number of Employees	Output kℓ/a	Water Intake		Average/d kℓ	Maximum/d kℓ	Effluent Volume kℓ/a	Ratio water intake to beer produced	Analysis of Effluent	Dishcarge	Comments
			Source	Volume kℓ/a							
10	34	10 200		29 600			17 700	2,90		Sewer	Effluent charges based on analysis of random sample. This applies to Breweries Nos. 11, 12, 13 and 14 also.
11	53	9 500	Municipality	36 000			21 600	3,79		Sewer	
12	7	5 900		15 600			12 000	2,64		Sewer	
13	58	14 500		44 616			-	3,08		Sewer	
14	25	8 600		28 500			17 100	3,31		Sewer	
15	60	10 000		24 000			Not metered	2,40		Sewer	
16	170	41 760		111 400			51 200	2,67		Sewer	
17	45	11 230		-			-	-		Sewer (no pretreatment)	
18	60	26 000	Municipality	62 970	172	437	33 980	2,42	-	Sewer (no Pretreatment)	Steam & cooling tower losses: 57 000 kℓ/a. % of intake: Product 37 Steam cooling 9 Effluent 54 Use/reuse : water reused in heat exchangers is used in preheated water in product. Steam condensate is used in boilers

Brewery No.	Number of Employees	Output kℓ/a	Water Intake		Average/d kℓ	Maximum/d kℓ	Effluent Volume kℓ/a	Ratio water intake to beer product	Analysis of Effluent	Discharge	Comments
			Source	Volume kℓ/a							
19	60	21 000	Municipality	58 330	160	292	28 500	2,78		Sewer (no pretreatment)	Steam cooling water losses 9030 kℓ/a Use/reuse : Water used in heat exchanger is used as pre-heated water in product. Steam condensate is reused in boilers, cooling tower water is recycled
20	438	180 750	Municipality	560 760			149 490	3,10	pH 6,5 Susp.Solids 5-150 mℓ/ℓ OA 200 mg/ℓ	Sewer Pretreatment: pH adjustment with NaOH. Solids removed by DSM screen.	Use/reuse: Water used in heat exchangers is used in product. Spent grain - sold. Solids from effluent screening removed by contractor. Effluent charges per annum: R85 000
21	150	44 000	Municipality	164 350	450		107 360	3,74	Tot.solids 4500mg/ℓ Dis-solids 2000mg/ℓ Susp. " 2500mg/ℓ (Spot sample taken by investigator: COD 3570 OA 420-550 Tot.solids 3700mg/ℓ)	Sewer (pre-treatment, solids removal on vibrating screen. pH correction with lime)	Effluent charges over R22 000 per annum

TABLE 4.7 : SORGHUM BEER BREWERIES REPLIES TO QUESTIONNAIRE (CONTINUED)

Brewery No.	Number of Employees	Output kℓ/a	Water Intake		Average/d kℓ/a	Maximum/d kℓ	Effluent Volume kℓ/a	Ratio water intake to beer product	Analysis of Effluent	Discharge	Comment
			Source	Volume kℓ/a							
28	52	12 000	Municipality	30 000	60	80	12 000	2,5		Sewer (pre-treatment, solids over hydrosieve)	No problems foreseen
29	36	8 500	Municipality	25 000	68,5	111,5	14 800	2,9	Standards to be met: pH 6-9 COD 5000 mg/ℓ TSS 2000 mg/ℓ	Sewer (pre-treatment, pH not solids removal	No problems foreseen - sludge and solids sold

TABLE 4.7 : SORGHUM BEER BREWERIES REPLIES TO QUESTIONNAIRE (CONTINUED)

Brewery No.	Number of Employees	Output kℓ/a	Water Intake		Average/d kℓ	Maximum/d kℓ	Effluent Volume kℓ/a	Ratio water intake to beer product	Analysis of Effluent	Discharge	Comments
			Source	Volume kℓ/a							
22	120	28 090	Municipality	84 270			56 184	3,00		Dams	
23	270	59 510	Municipality	207 600	610	1215	Not measured	3,48		Dams	
24	180	112 460		275 180			Not measured	2,45		Sewer	Volume of effl. is calculated according to intake
25	292	72 400	Municipality	297 000	813	1032	110 200	4,1	Av. OA = 230 mg/ℓ	Sewer (no pretreatment)	Water for cooling water & steam generation recycled. Ratio of effluent volume:beer produced should improve with better housekeeping
26	46	14 112	Municipality	24 000	65	90	9 800	1,7	Av. OA = 106 mg/ℓ	Sewer (no pretreatment)	Water for cooling water and steam generation recycled. Ratio of effluent volume:beer produced should improve with better housekeeping
27	36	9 513	Municipality	41 000	112	150	27 000	4,3	Av. OA = 131 mg/ℓ	Sewer (no pretreatment)	Water for cooling water and steam gneration recycled. Ratio of effl. vol:beer produced should improve with better housekeeping

The breweries vary in design, age, floor space and in the ratio of bulk to packaged beer produced. All these factors will affect the water usage. Other factors are batch size, availability of in place cleaning and "good housekeeping". Nevertheless in some cases the ratio (water intake : beer production) appears anomalous.

A number of practices are in use to reduce water usage, and improve energy savings, e.g. use of heat exchanger water as preheated water in the product, return of steam condensate to boiler feed, and, of course, recycling of cooling water ; use of final rinses in the cleaning cycle for cleaning of floors.

In addition, aspects such as the following were raised :

(i) pH control (difficulties in maintaining correct level).
(ii) Method of deriving levy for effluent treatment based on analysis of random samples.
(iii) Need for better effluent treatment system to assist in reducing municipal charges.
(iv) Better systems for removal of fines from effluent.
(v) Examination by plant management into energy savings, methods of manufacture, etc to obtain steam saving, cooling water saving, hot water generation for starting brews and hot washing.
(vi) Age of plant and associated problems.
(vii) Need for preliminary treatment before discharge to sewer.
(viii) The high carbohydrate nitrogen ratio in a brewery effluent may cause problems in activated sludge plants if brewery effluent forms a large portion of the influent to a sewage works.

In general, however, there were few comments regarding water supply and waste problems (now or anticipated in the future) or comments on the overall aspects of water development and research.

4.6.4 Design

The Sorghum Beer Unit at the CSIR, has been advising on the design of breweries and over the last ten years the design has made it possible to flush rinsing waters from the cooler to the conversion unit to the strainer and then into the fermentor (see Figure 4.1).

Such a sequence of operations not only saves water but also should reduce effluent arising and restrict them to the fermentor area and the packaging area.

Breweries at Dundee, Port Elizabeth, Bloemfontein, Potchefstroom and Witbank were designed for this system, which can also be practiced at the breweries at Langlaagte and Congella.

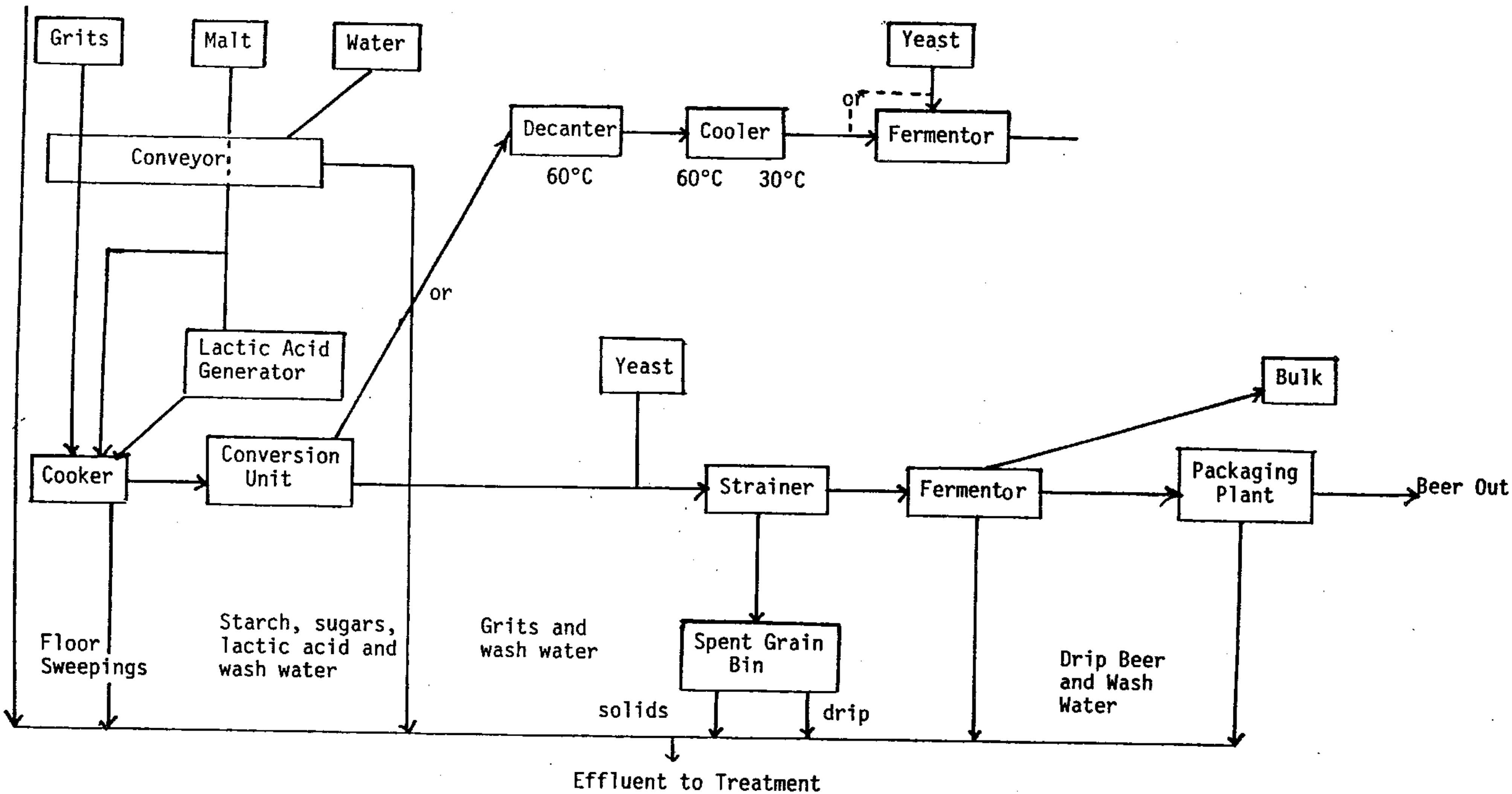
4.6.5 Process Flow

Typical process flow schemes are given in Figure 4.1. The brew formula however may differ within a brewery and from brewery to brewery. This should not, however, affect effluent aspects significantly.

Individual variation in process, design, layout and plant practices will determine the extent of use/recycle/reclamation practiced.

In breweries, in particular those with facilities for rinsing from cooler to fermentor, any investigations for effluent improvement accepting normal "good housekeeping" practices, will probably be required in the Fermentor and Packaging Areas.

TYPICAL PROCESS FLOW SCHEMES - POSSIBLE SOURCES OF LOSS OF MATERIALS



4.6.6 Conclusion

The breweries have access to the Sorghum Beer Unit of the CSIR for advice on many aspects of the Industry. In the operations field, wastewater aspects arise naturally and specific aspects of disposal may be referred to the National Institute of Water Research.

All except two breweries discharge to municipal sewers since the effluent is readily biodegradable. Effluent volumes per brewery are relatively low, from, say, 10 000 kl/annum to 150 000 kl/annum.

In-plant aspects are covered largely by the Sorghum Beer Unit. Thus, investigations on disposal as such appear to be necessary only where the biological load contributes an undesirable load on the sewage wastes concerned, or where the economics of the process is affected by disposal charges.

The question of fine solids in the effluent is a matter of concern in a number of breweries, on the other hand others seem to have solved the problem satisfactorily (see Brewery No. 9).

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APPENDIX 2.1

List of Administration Boards, Development Corporations and Breweries

Address List

The Chief Director
Western Cape Administration Board
Private Bag X7
GOODWOOD
7460 Tel : 021 - 98 7987

The Mfuleni Brewery is situated at Somerset West (Tel : 024 - 4 3121)

The Chief Director
Eastern Cape Administration Board
P.O. Box 14025
SIDWELL
6061 Tel : 041 - 4 0071

This is the Port Elizabeth Brewery (Tel : 041 - 61 1511)

The Chief Director
Northern Cape Administration Board
Private Bag X5005
KIMBERELY
8300 Tel : 0531 - 3 2711

They have two breweries, one at Kimberely (Tel : 0521 - 3 2711) and one at Vryburg (Tel : 01451 - 3901)

The Chief Director
Southern Orange Free State
Administration Board
P.O. Box 2313
BLOEMFONTEIN
9300 Tel : 051 - 7 0601

They have two breweries, at at Bloemfontein (Tel : 051 - 8 9891) and one at Welkom (Tel : 017 - 51302)

The Chief Director
Orange Vaal Administration Board
Private Bax X029
VANDERBIJLPARK
1900
Tel : 016 - 31 2900

They have two breweries, the Sebokeng Brewery situated at Vanderbijlpark (Tel : 016 - 31 2900) and the Kroonstad Brewery (Tel : 01411 - 2 6652)

The Chief Director
Port Natal Administration Board
Private Bag X54310
DURBAN
4000
Tel : 031 - 29 1131

This is the Congella Brewery (Tel : 031 - 25 5311)

The Chief Director
Drakensburg Administration Board
P.O. Box 1724
PIETERMARITZBURG
3200
Tel : 0331 - 5 6201

The have one brewery at Dundee (Tel : 0341 - 2 1688) and one at Ladysmith (Tel : 0361 - 2965)

The Chief Director
West Rand Administration Board
P.O. Box 5382
JOHANNESBURG
2000
Tel : 011 - 21 4911

They have the following breweries :

Langlaagte (001 - 839 2211/8)
Roodepoort (011 - 766 2000)
Randfontein (001 - 693 4440)

The Chief Director
East Rand Administration Board
P.O. Box 57
GERMISTON
1400 Tel : 011 - 825 3235

They have five breweries :

Alberton (011 - 864 1673)
Daveyton (011 - 735 1820)
Nigel (011 - 739 3531)
Springs (011 - 813 3902)
Wattville (011 - 54 3036)

The Chief Director
Highveld Administration Board
P.O. Box 20
WITBANK
1035 Tel : 01351 - 2251

They have a brewery at Witbank (Tel : 01351 - 2523) and a brewery at Standerton (Tel : 01331 - 2237).

The Chief Director
Eastern Transvaal Administration Board
P.O. Box 888
Nelspruit
1200 Tel : 01311 - 2204

They have only one brewery at Nelspruit (Tel : 01311 - 5226)

The Chief Director
Northern Transvaal Administration Board
P.O. Box 829
PIETERSBURG
0700

They have only one brewery at Pietersburg (01521 - 6851)

The Chief Director
Central Transvaal Administration Board
Private Bag X449
PRETORIA
0001 Tel : 012 - 28 5180

This is the Kwaggakop Brewery (Tel : 012 - 79 7134)

The Chief Director

Western Transvaal Administration Board
Private Bag X1213
POTCHEFSTROOM
2520 Tel : 01481 - 2 5011

They have only one brewery at Potchefstroom (Tel : 0148 - 2 5311)

The General Manager
Kwazulu Development Corporation Limited
P.O. Box 2801
DURBAN
4000 Tel : 031 - 92 2242

They have three breweries, one at Pietermaritzburg (Tel : 0331 - 8 1296) one at Ngwelizane (Empangeni) (Tel : 0351 - 9 4347) one at Madadeni (Newcastle) (Tel : 0343 - 2 5647)

The General Manager
Ciskei National Development Corporation
Private Bag X463
KING WILLIAMSTOWN
5600 Tel : 0433 - 22500

The Mdantsane brewery (Tel : 043242 - 219) is close to East London.

The General Manager
Venda Development Corp Ltd.
P.O. Box 9
SIBASA
0970 Tel 015582 - 150

The brewery is at Sibasa

The General Manager
Shangaan-Tsonga Development Corp Ltd.
Private Bag X401
LETABA Tel : 01523 - 4231/5

The brewery is at Nkowakowa close to Tzaneen (Tel : 01523 - 4525)

The General Manager
Transkei Breweries
P.O. Box 80
BUTTERWORTH
Transkei

The General Manager
Bophuthatswana National Development Corp Ltd.
P.O. Box 16180
PRETORIA NORTH
0116

(These breweries operate independently)

(There are two breweries).

UNIVERSITY OF NATAL
KING GEORGE V AVENUE • DURBAN, NATAL 4001
TELEPHONE: 253411 TELEGRAMS: "UNIVERSITY"

Department of Chemical Engineering

In reply please quote:

Dear Sir,

SURVEY ON WATER MANAGEMENT AND EFFLUENT TREATMENT IN THE FERMENTATION INDUSTRY

The Pollution Research Group of the University of Natal, Durban, plans to undertake a survey/investigation into water management and effluent treatment in the fermentation industry on a National basis.

The survey/investigation will be done for the Water Research Commission in close cooperation with industry to identify pollution problems and areas where improvements can be made.

We would like to include your yeast factory in this survey and are writing to you to ask for your cooperation in the survey.

In other surveys/investigations of this nature (e.g. in the Textile and Wool Washing industries) we have found it useful to be able to make contact with an individual, for example, a process engineer of a particular factory with whom we can have discussions, arrange visits etc. and obtain detailed information on water and effluent aspects of his factory. We would very much like to follow a similar pattern with your organisation. Would you be kind enough to advise us who we could contact for this purpose?

Meanwhile we are attaching hereto a copy of a questionnaire which should enable us to make a start on the collection of some of the data before we go into greater detail (where necessary) with your nominated contact. It would be appreciated therefore if you could arrange for the questionnaire to be completed and returned to us.

Please be assured that this information will be treated as confidential. It is hoped that the survey will supply us with information which will enable the Water Research Commission to assess the needs for future research and development on water management and effluent control in the fermentation industry. It is quite important to realise that this planning would cover the period of the next 5-10 years (or longer) and thus it is essential that the views of industry on the need of a research and development effort be fully expressed.

Yours sincerely,

F. G. NEYTZELL-DE WILDE
RESEARCH PROFESSOR
POLLUTION RESEARCH GROUP

QUESTIONNAIRE : WATER MANAGEMENT AND EFFLUENT TREATMENT SURVEY

(Information supplied is solely for use by the Water Research Commission to assess the needs for future research in industry and will not be disclosed to other parties.)

1. NAME OF INDUSTRY:

2. ADDRESS/LOCATION OF FACTORY:

3. TYPES OF GOODS MANUFACTURED:

4. AVERAGE NUMBER OF EMPLOYEES:

5. WATER SUPPLY:

a) Water Permit (full particulars) if any :

b) (i) Source of water (please list all sources) :
(ii) Is water from various sources pretreated at factory?

c) (i) Total volume of water intake from each source (kilolitres per annum

(ii) Total volume all sources (kilolitres/annum) :

d) Rate of consumption per day :
average :
maximum :

e) Seasonal fluctuations in consumption :

6. QUALITY, USE AND REUSE OF WATER

a) Quality required at intake :

b) Any particular requirements at any stage of manufacture?:

c) Is water recycled at any stage? (please specify operation) :

(i) without pretreatment :
(ii) with pretreatment :

d) Consumptive use of water :

(i) in product
(ii) other e.g. steam losses :

7. INDUSTRIAL WASTE FROM FACTORY

a) (i) Total volume of effluent (kilolitres/annum) :
(ii) Percentage of volume from various uses :

b) Average analysis :

c) Is pretreatment undertaken before discharge? :

7. INDUSTRIAL WASTE FROM FACTORY:(continued)

d) Discharge point(s) (e.g. to municipal sewers etc.)

e) Standards required by any authority and difficulties in complying with these :

(i) State authority :

(ii) Local authority :

(iii) Other :

f) Sludge/solid wastes - (i) quantity :

(ii) method of disposal :

8. SPECIFIC:

Product :

Output : (i) Yeast

(ii) Other :

9. Please supply a simple line diagram which will clarify the water inputs and effluents (liquid/solid) :

10. FUTURE:

With regard to your type of industry, please give a long range view of any water supply and waste problem which you consider may develop in your field within the next 10-15 years.

11. GENERAL

Any comments which you consider would be of assistance in the overall aspect of water development and research in your field of operation :

UNIVERSITY OF NATAL
KING GEORGE V AVENUE • DURBAN, NATAL 4001
TELEPHONE: 253411 TELEGRAMS: "UNIVERSITY"

Department of Chemical Engineering

In reply please quote:

Dear Sir,

NATIONAL SURVEY ON WATER MANAGEMENT AND EFFLUENT TREATMENT IN THE FERMENTATION INDUSTRY

The Pollution Research Group of the University of Natal, Durban, plans to undertake a survey/investigation into water management and effluent treatment in the fermentation industry on a National basis.

The survey/investigation will be done for the Water Research Commission in close cooperation with industry to identify pollution problems and areas where improvements can be made.

We would like to include wine distilleries in this survey and are thus writing to you to ask for your cooperation in the survey.

In other surveys/investigations of this nature, (e.g. in the Textile and Wool Washing Industries) we have found it useful to be able to make contact with an individual, for example, a process engineer of a particular factory/operation with whom we can have discussions, arrange visits etc. and obtain detailed information on water and effluent aspects and his factory/operation where necessary. We would very much like to follow a similar pattern with your distilling operation. Would you be kind enough to advise us who we could contact in your operation(s).

Meanwhile we are attaching hereto a questionnaire which we would like you to complete and return to us. This should enable us to make a start on the collection of some of the data before we go into greater detail with your nominated contact.

Please be assured that the information will be treated as confidential and will not be published in any manner which would make it possible to identify any particular distillery and will be cleared by your nominated contact anyway.

The information which we are collecting will be used by the Water Research Commission for plans for future research.

We look forward to your reply and thank you in anticipation for your cooperation.

Yours sincerely,

F. G. NEYTZELL-DE WILDE
RESEARCH PROFESSOR
POLLUTION RESEARCH GROUP

CONFIDENTIAL

QUESTIONNAIRE : WATER MANAGEMENT AND EFFLUENT TREATMENT SURVEY

(Information supplied is solely for use by the Water Research Commission to assess the needs for future research in industry and will not be disclosed to other parties)

1. NAME OF INDUSTRY :
2. ADDRESS/LOCATION OF FACTORY:
3. TYPE OF GOODS MANUFACTURED :
4. AVERAGE NUMBER OF EMPLOYEES :
5. WATER SUPPLY:
   a) Water Permit (full particulars) if any :
   b) Sources of water (please list all sources) :
   c) Total volume of water intake from each source (kilolitres/annum):
   d) Rate of consumption per day :
      average :
      maximum :
   e) Seasonal fluctuations in consumption :
6. QUALITY, USE AND REUSE OF WATER :
   a) Quality required at intake :
   b) Any particular requirements at any stage of manufacture :
   c) Is water recycled at any stage :
      (i) without pretreatment :
      (ii) with pretreatment :
   d) Consumptive use of water :
      (i) In product :
      (ii) Other, e.g. steam losses :
7. INDUSTRIAL WASTE FROM FACTORY
   a) Total volume of effluent (kilolitres/annum) :
   b) Average analysis :
   c) Is pretreatment undertaken before discharge : (Please give details of control/pretreatment)
   d) Discharge point :
   e) Standards required by an authority and difficulties in complying with these :
      (i) State authority :
      (ii) Local authority :
      (iii) Other :

7. INDUSTRIAL WASTE FROM FACTORY (continued)

f) Sludge and/or solid wastes (i) quantity :

(ii) method of disposal :

8. SPECIFIC :

Product

Output : (i) (kilolitres/annum)

(ii) other

9. GENERAL:

Any comments which you consider would be of assistance in the overall aspects of water development and research in your field of operation.

UNIVERSITY OF NATAL
KING GEORGE V AVENUE • DURBAN, NATAL 4001
TELEPHONE: 253411 TELEGRAMS: "UNIVERSITY"

Department of Chemical Engineering

In reply please quote:

Dear Sir,

NATIONAL SURVEY ON WATER MANAGEMENT AND EFFLUENT TREATMENT IN THE FERMENTATION INDUSTRY

The Pollution Research Group of the University of Natal, Durban, plans to undertake a survey/investigation into water management and effluent control in the fermentation industry on a National basis.

The survey/investigation will be done for the Water Research Commission in close cooperation with industry to identify pollution problems and areas where improvements can be made.

We would like to include your fermentation and distillery operations in this survey and are thus writing to you to ask for your cooperation in the survey.

In other surveys/investigations of this nature (e.g. in the Textile and Wool Washing Industries) we have found it useful to be able to make contact with an individual, for example, a process engineer of a particular factory with whom we can have discussions, arrange visits, etc. and obtain detailed information on water and effluent aspects of his factory. We would very much like to follow a similar pattern with your organisation. Would you be kind enough to advise us who we could contact for this purpose?

Meanwhile we are attaching hereto a copy of a questionnaire which should enable us to make a start on the collection of some of the data before we go into greater detail (where necessary) with your nominated contact. It would be appreciated therefore if you could arrange for the questionnaire to be completed and returned to us.

Please be assured that the information will be treated as confidential; it will be used by the Water Research Commission to assess the needs for future research work in industry.

I look forward to your reply and thank you in anticipation for your cooperation.

Yours sincerely,

F. G. NEYTZELL-DE WILDE
RESEARCH PROFESSOR
POLLUTION RESEARCH GROUP

QUESTIONNAIRE : WATER MANAGEMENT AND EFFLUENT TREATMENT SURVEY

(Information supplied is solely for use by the Water Research Commission to assess the needs for future research in industry and will not be disclosed to other parties.)

1. NAME OF INDUSTRY :

2. ADDRESS/LOCATION OF FACTORY :

3. TYPE OF GOODS MANUFACTURED :

4. AVERAGE NUMBER OF EMPLOYEES :

5. WATER SUPPLY :

   a) Water Permit (full particulars) if any :

   b) Sources of water (please list all sources) :

   c) Total volume of water intake from each source (kilolitres per annum):

   d) Rate of consumption per day :
      average :
      maximum :

   e) Seasonal fluctuations in consumption:

6. QUALITY, USE AND REUSE OF WATER :

   a) Quality required at intake :

   b) Any particular requirements at any stage of manufacture :

   c) I water recycled at any stage :

      (i) without pretreatment :
      (ii) with pretreatment :

   d) Consumptive use of water :

      (i) In product :
      (ii) Other, e.g. steam losses :

7. INDUSTRIAL WASTE FROM FACTORY :

   a) Total volume of effluent (kilolitres/annum) :

   b) Average analysis :

   c) Is pretreatment undertaken before discharge :
      (Please give details of control/pretreatment)

7. INDUSTRIAL WASTE FROM FACTORY : (Continued)

d) Discharge point :

e) Standards required by any authority and difficulties in complying with these :

(i) State authority :

(ii) Local authority :

(iii) Other

f) Sludge/solid wastes - (i) quantity :

(ii) method of disposal :

8. SPECIFIC:

Product

Output (i) Distillery products

(ii) Other

9. GENERAL:

Any comments which you consider would be of assistance in the overall aspect of water development and research in your field of operation:

APPENDIX 4.4 : BARLEY BREWERIES

UNIVERSITY OF NATAL
KING GEORGE V AVENUE • DURBAN, NATAL 4001
TELEPHONE: 253411 TELEGRAMS: "UNIVERSITY"

Department of Chemical Engineering

In reply please quote:

The General Manager,
Beer Division,
The S.A. Breweries Ltd.,
P.O. Box 1099,
JOHANNESBURG,
2000

25th March 1982

Dear Sir,

SURVEY ON WATER MANAGEMENT AND EFFLUENT TREATMENT IN THE FERMENTATION INDUSTRY

The Pollution Research Group of the University of Natal, Durban, plans to undertake a survey/investigation into water management and effluent treatment in the fermentation industry on a National basis.

The survey/investigation will be done for the Water Research Commisssion in close cooperation with industry to identify pollution problems and areas where improvements can be made.

We would like to include your breweries and malsters (separately from sorghum beer breweries) in this survey and are thus writing to you to ask for your cooperation in the survey.

In other surveys/investigations of this nature (e.g. in the Textile and Wool Washing industries) we have found it useful to be able to make contact with an individual, for example, a process engineer of a particular factory/operation with whom we can have discussions, arrange visits etc. and obtain detailed information on water and effluent aspects of his factory/operation where necessary. We would very much like to follow a similar pattern with your breweries. Would you be kind enough to advise us who we could contact in the various breweries?

We are attaching hereto a questionnaire which should enable us to make a start on the collection of some of the data before we go into greater detail with your nominated contacts. It would be appreciated therefore if you could arrange for the questionnaire to be completed for each of your breweries, and returned to us. (Six extra copies of the questionnaire are enclosed for your convenience).

Please be assured that this information will be treated as confidential and will not be published in any manner which would make it possible to identify an individual brewery and will be cleared by your nominated contact anyway.

The information which we are collecting will be used by the Water Research Commission for plans for future research.

We look forward to your reply and thank you in anticipation for your cooperation.

Yours sincerely,

F. G. NEYTZELL-DE WILDE
RESEARCH PROFESSOR
POLLUTION RESEARCH GROUP

CONFIDENTIAL

QUESTIONNAIRE : WATER MANAGEMENT AND EFFLUENT TREATMENT SURVEY

(Information supplied is solely for use by the Water Research Commission to assess the needs for future research in industry and will not be disclosed to other parties.)

1. NAME OF INDUSTRY:

2. ADDRESS/LOCATION OF FACTORY:

3. TYPES OF GOODS MANUFACTURED :

4. AVERAGE NUMBER OF EMPLOYEES :

5. WATER SUPPLY :

a) Water Permit (full particulars) if any :

b) (i) Sources of water (please list all sources) :
(ii) Is water from various sources pretreated at factory:

c) Total volume of water intake from each source (kilolitres per annum) :

d) Rate of consumption per day :
average :
maximum :

e) Seasonal fluctuations in consumption :

6. QUALITY, USE AND REUSE OF WATER :

a) Quality required at intake :

b) Any particular requirements at any stage of manufacture ?:

c) Is water recycled at any stage ? (Please specify operation):

(i) without pretreatment :
(ii) with pretreatment :

d) Consumptive use of water :

(i) in product :
(ii) other, e.g. steam losses :

7. INDUSTRIAL WASTE FROM FACTORY

a) (i) Total volume of effluent (kilolitres/annum):
(ii) Percentage of volume from various uses :
(iii) Ratio of volume of effluent discharged to volume of beer made :

b) Average analysis

c) Is pretreatment undertaken before discharge?:
(Please give details of control/pretreatment)

QUESTIONNAIRE : WATER MANAGEMENT AND EFFLUENT TREATMENT SURVEY (Continued)

7. INDUSTRIAL WASTE FROM FACTORY : (Continued)

d) Discharge point(s) (e.g. to municipal sewers etc) :

e) Standards required by any authority and difficulties in complying with these :

(i) State authority :

(ii) Local authority :

(iii) Other

f) Sludge/solid wastes - (i) quantity :

(ii) method of disposal :

8. SPECIFIC :

Product :

Output, (i) beer (kilolitres/annum)

(ii) other :

9. Please supply a simple line diagram which will clarify the water inputs and effluents (liquid/solid) :

10. FUTURE

With regard to your type of industry, please give a long range view of any water supply and waste problem which you consider may develop in your field within the next 10-15 years.

11. GENERAL

Any comments which you consider would be of assistance in the overall aspect of water development and research in your field of operation :

APPENDIX 4.5 : SORGHUM BEER INDUSTRY

UNIVERSITY OF NATAL
KING GEORGE V AVENUE • DURBAN, NATAL 4001
TELEPHONE: 253411 TELEGRAMS: "UNIVERSITY"

Department of Chemical Engineering

In reply please quote:

18th February 1982

Dear Sir,

SURVEY ON WATER MANAGEMENT AND EFFLUENT TREATMENT

The Pollution Research Group of the University of Natal, Durban, plans to undertake a survey investigation into water management and effluent treatment in the fermentation industry on a country wide basis.

The survey/investigation will be done for Water Research Commission in close cooperation with the industry to identify pollution problems and areas where improvements can be made. Research and development programmes will then be initiated on a priority basis to find effective solutions to the pollution problems.

We would like to include the sorghum-beer industry and are writing to you and other Corporations in this regard.

In other surveys/investigations of this nature (e.g. in the Textile and Wool-washing industries) we have found it useful to be able to make contact with an individual, for example, a process engineer, of a particular factory or undertaking with whome we can have discussions, arrange visits, etc and obtain detailed information on water and effluent aspects of his factory/undertaking.

We would very much like to follow the same pattern with the Sorghum-beer industry. Would you be kind enough to advise us who we could contact in the breweries under your control.

In the meanwhile could you please also supply us with the following information on each of the breweries under your control to enable us to make a start on the collection of some basic data.

(a) The number of breweries controlled by your Corporation and their location.

(b) The number of employees per brewery.

(c) The output in kilolitres per annum per brewery.

(d) The volume of water intake per brewery per annum.

(e) The volume of effluent dishcarged per brewery per annum.

(f) Discharge points of effluents.

If there are any problems regarding the discharge of effluents either now or anticipated in the future, we would be very glad to have your comments.

We look forward to your reply and thank you in anticipation for your cooperation.

Yours faithfully,

F. G. NEYTZELL-DE WILDE
RESEARCH PROFESSOR
POLLUTION RESEARCH GROUP

CONFIDENTIAL

QUESTIONNAIRE : WATER MANAGEMENT AND EFFLUENT TREATMENT SURVEY

(Information supplied is solely for use by the Water Research Commission to assess the needs for future research in industry and will not be disclosed to other parties.)

1. NAME OF INDUSTRY :

2. ADDRESS/LOCATION OF FACTORY :

3. AVERAGE NUMBER OF EMPLOYEES :

4. WATER SUPPLY :

(a) Water Permit (full particulars) if any :

(b) (i) Source of water (please list all sources) :

(ii) Is water from various sources pretreated at factory? If so, how?

(c) (i) Total volume of water intake from each source (kilolitres/ annum) :

(ii) Total volume from all sources (kilolitres/annum) :

(d) Rate of consumption per day :

average :

maximum :

(e) Seasonal fluctuations in consumption :

5. QUALITY, USE AND REUSE OF WATER :

(a) Quality required at intake :

(b) Any particular requirements at any stage of manufacture ? :

(c) Is water recycled at any stage? (Please specify operation) :

(i) Without pretreatment

(ii) With pretreatment

(d) Consumptive use of water :

(i) In product :

(ii) Other, e.g. steam losses :

6. INDUSTRIAL WASTE FROM FACTORY :

(a) (i) Total volume of effluent (kilolitres/annum) :

(ii) Percentage of volume from various uses :

(iii) Ratio of volume of effluent discharged to volume of beer made :

QUESTIONNAIRE : WATER MANAGEMENT AND EFFLUENT TREATMENT SURVEY (Continued)

6. INDUSTRIAL WASTE FROM FACTORY (Continued) :

(b) Average analysis of various effluent streams.

(c) Is pretreatment undertaken before discharge? (Please give details of control/pretreatment) :

(d) Final discharge (e.g. to sewer or river/stream) :

(e) What standards are required by any authority and what difficulties are there in complying with these ?

(i) State authority :

(ii) Local authority :

(iii) Other :

(f) Sludge/solid wastes :

(i) Quantity and source :

(ii) Method of disposal :

7. SPECIFIC

Product output,

(i) Beer (kℓ/annum)

(ii) Other

(iii) Ratio water input to product output :

8. Please supply a simple line diagram which will clarify the water inputs and effluents (liquid, solid) :

QUESTIONNAIRE : WATER MANAGEMENT AND EFFLUENT TREATMENT SURVEY (Continued)

9. FUTURE :

With regard to your type of industry, please give a long range view of any water supply and waste problems which you consider may develop in your field within the next 10-15 years.

10. GENERAL

Any comments which you consider would be of assistance in the overall aspect of water development and research in your field of operation :

APPENDIX 4.6

List of Industries Approached

Questionnaires were sent to the following :-

(i) Yeast

Anchor Yeast (Pty) Ltd.
P.O. Box 14
EPPINDUST
7475

Anchor Yeast (Pty) Ltd.
P.O. Box 43143
INDUSTRIA
2042

Free State Yeast (Pty) Ltd.
P.O. Box 727
WELKOM
9460

NCP Yeast (Durban)
P.O. Box 1659
DURBAN
4000

Union Yeast Products Limited
P.O. Box 43200
INDUSTRIA
2042

(Natal Cane By-products Limited included under distilleries)

(ii) Wine Distilleries

Distillers Corporation Ltd
P.O. Box 184
STELLENBOSCH
7600

Gilbeys Distillers and Vintners (Pty) Ltd
P.O. Box 137
STELLENBOSCH
7600

(NOTE : Redistillation of neutral alcohol only)

KWV
P.O. Box 528
SUIDER PAARL
7624

Stellenbosch Farmer's Winery
P.O. Box 46
STELLENBOSCH
7600

Union Wine Limited
P.O. Box 246
WELLINGTON
7655

(NOTE : Do not distill)

(iii) Molasses Distilleries

National Chemical Products (Natal)
P.O. Box 2204
DURBAN
2000

National Chemical Products (Transvaal)
P.O. Box 344
GERMISTON
1400

Natal Cane By-Products Ltd.
P.O. Box 31003
MEREBANK
4059

(iv) Barley-Beer Manufacture

The South African Breweries Limited
Beer Division
P.O. Box 1783
JOHANNESBURG
2000

(v) Sorghum Beer Manufacture

Western Cape Administration Board
Eastern Cape Administration Board
Northern Cape Administration Board
Southern Orange Free State Administration Board
Orange Vaal Administration Board
Port Natal Administration Board
Drakensburg Administration Board
West Rand Administration Board
East Rand Administration Board
Highveld Administration Board
Eastern Transvaal Administration Board
Northern Transvaal Administration Board
Central Transvaal Administration Board
Western Transvaal Administration Board
Bophuthatswana National Development Corporation Ltd.
Kwazulu Development Corporation Ltd.
Ciskeian National Development Corporation Ltd.

Transkei Breweries
Vendaland Development Corporation
Shangaan-Tsonga Development Corporation.

APPENDIX 4.7

A More Detailed Examination of a Particular Site

1. Brewery No. 20 was selected for more detailed examination of the wastewater arisings.

1.2 Plant Layout

Figures A1 and A2 show the layout of the plant. The water reticulation is given in Figure A1 and the effluent system is shown on Figure A2. Transfer lines from brew house to screeners, to balance tanks, to heat exchangers, to cellars and to packaging are not shown. Approximate volumes of the various lines are however given below. Transfer from lactic generators to brew vessels is effected via flexible hoses. Transfer from brew vessels to screeners is done by connecting the brew vessel to the stainless steel transfer lines via a flexible hose. Transfer from screeners to intermediate storage (balance tanks) in the cellars is via stainless steel transfer lines. Transfer from intermediate storage to heat exchangers is via stainless steel transfer lines. Transfer from heat exchangers to cellar lines is via flexible hoses to vats. Similarly transfer from cellar vats to packaging is via stainless steel transfer lines connected to the respective vat by flexible hose.

Brew house stainless steel transfer lines (including one hose length) ..	530 l
Transfer lines from brew house pump to screeners ..	1 460 l
Transfer lines from screeners to balance tanks in cellars ..	330 l
Transfer lines from balance tank to heat exchangers ..	100 l
Transfer lines from heat exchangers to cellar lines ..	450 l
Transfer lines from cellars to packaging (including hose) ..	560 l
Total	3 430 l

1.3 Main Process Raw Materials

Sorghum corn, sorghum malt and maize grits are received in rail trucks and pneumatically conveyed to storage silos. The corn and malt are ground before transporting to the brew house. All these materials are automatically weighed and transferred pneumatically to the brew house.

If the system is well maintained and any spillages swept up, the operation of the system should not contribute any load to the wastewater.

1.4 Brew House

There are forty cookers (15 000 l capacity) in the brew house. Two (Nos 29 and 30) are used as lactic acid generators for the special beer. In addition, there are six lactic generators (7 500 l capacity) of which three are used for special beer and three for the standard beer.

Effluents high in organic load arise from spillages from hoses used in the transfer of lactic acid liquor and also from the transfer of cooker contents to screeners. The loss from the latter operation should be relatively small because the brew is followed by a small amount of rinse water.

Blockages at the bottom outlet of the lactic generators occur from time to time and considerable spillage may occur during attempts to unblock the lines. Improved stirring may assist in preventing the blockages.

Clean effluent arises from the draining of coils in cookers before applying steam to the coils for heating of brews. Similarly condensate from the heating cycle is allowed to go to drain. All this water could be recovered. The floors of the brew house are frequently hosed down to transfer spillages to drains. The washing with large diameter hoses does not appear efficient and an excessive amount of water appears to be used. Hoses with automatic shut-off nozzles would assist in reducing careless usage.

1.5 Cellars

There are sixty vats of 1 500 l capacity in four rows. The vessels are cooled to 25°C by water from a chilling plant.

High organic load effluent arises from spillages from hoses during uncoupling of hoses after transfer between tanks, to bulk tankers and to packaging. The spillage is washed down with clean mains water from large bore hoses. A considerable amount of water could be saved by efficient hosing-down using hoses fitted with automatic shut-off nozzles.

All other effluent arises from the washing out of the vats. This is done by an in-place cleaning (CIP) and only the first rinse is discharged to drain. The length of the cleaning cycles (and hence the volume of the rinse) can be controlled for each row to tanks.

On average 30 - 40 tanks are rinsed each day. To determine the load on the effluent system a test was carried out on the washing out of three different brews.

The CIP system was operated so that the first rinse could be diverted to a special tank where the total volume of the rinse could be measured and a representative sample of the rinse taken. In all tests the tanks were well drained before the cleaning cycle was started.

The volumes of the first rinses were found to be :-

Brew 'A' (single tank)	1 180 l
Brew 'A' (two tanks)	2 100 l (approx. 1 050 l per tank)
Brew 'B' (a mix of A and C) (single tank)	1 525 l
Brew 'C' (single tank)	1 075 l

Product B (a bulk product) is generally more 'mature' than products intended for carton filling. The total volume of this rinse was high in volume and in solids.

The analysis of the first rinse samples from the CIP system is given below in Table A1.

TABLE A1 : Analysis of First Rinse CIP System

		Brew A single tank	Brew A two tanks	Brew B single tank	Brew C single tank
pH		12,02	11,69	6,47	9,15
Conductivity	mS/cm	9,45	4,43	1,83	1,82
Settleable solids	ml/l	2,3	5	935	150
Total solids	g/l	5,9	3,4	17,5	8,2
Total dissolved solids	g/l	5,8	3,2	6,8	5,8
Suspended solids	g/l	0,1	0,2	10,7	2,4
COD	g/l	1,1	1,1	37,4	8,3
OA	mg/l	134	93	2 782	444
Na	mg/l	1 590	920	426	680
TC	g/l	1,0	0,6	11,0	3,3

Variations in the organic loading of the rinse could arise from a number of factors : type or brew, age of beer, effectiveness of draining of contents before washing, time (and volume) of cycles of CIP systems etc.

If the total carbon (TC) in beer is taken as 3 800 mg/l (see section 1.12) then based on the above tests, brews of type A could constitute the equivalent of only 16 - 30 litres of beer to the effluent per wash. Brews of the type B however, would constitute the equivalent of as much as 440 litres of beer to the effluent and brews of type C about 90 litres/wash.

It is considered that a detailed examination of the system to determine the variation in load over the whole range of products should be undertaken to pin-point the high load areas.

1.6 Decanters (or Screeners) and Spent Grain Hopper

Loss of product (beer) in the grain could be reduced by detailed attention to the screening procedure. Moisture values on the reject solids in four tests varied between 69,1% to 74,9%. Tests should be conducted on the total loss in this area and the need to reduce moisture values on the spent grain. Spillage from the spent grain hopper is hosed down into the effluent drain. The contribution to the load on the effluent system could be reduced if this spent grain was swept up and disposed of with the rest of the spent grain in the contractor's removal truck.

1.7 Tanker Filling and Washing

The tanker filling/washing bay has a CIP system available but the system was not used during the survey. On average 15 tankers are rinsed per day. This is done manually but the methods used do not appear to be thorough and no load estimate was made.

1.8 Distribution

Effluent in this area arises from floor washing of beer spillages during stacking and loading of crates. Good housekeeping methods could do much in this area.

1.9 Returned Beer

Disposal of returned beer should be carefully examined. Where blending into product is not possible consideration should be given to separate disposal e.g. into the municipal sea disposal point. Where this is not possible then greater care should be taken to blend the waste into the effluent system to avoid short period high peak loads.

1.10 Packaging

In the packaging area, cartons are filled on 7 Nimco machines and occasionally on 4 old API machines.

Minibulk containers are filled two at a time on one automatic weighing machine and one at a time on one manual platform scale.

Bottles are filled on a modern bottle packaging machine.

The carton filling machines appear to require a higher standard of servicing. Effluent arises from beer spillages, 'filling' in the absence of cartons under filling nozzles and a continuous flow of water to sweep away spillages.

The minibulk filling points give rise to losses particularly by frothing.

No estimate of beer wastage was made because of the extreme variability of losses in the packaging machines.

Other losses arise from :-

(i) rinsing of packing machines when changing from one brew to another

(ii) rinsing out machines at the end of packing operation (water, caustic soda and sterilant)

(iii) washing out of header tanks (water, caustic soda)

(iv) washing of mini-bulk containers and crates
(v) bottling machine, lines and vats.

A detailed examination of procedures in the area including good housekeeping practices could prove rewarding.

1.11 Effluent Drains and Final Effluent Treatment

The layout of the effluent drains is given in Figure A2. Because of the physical layout, variable flow and variable load and lack of flow measurement, satisfactory samples cannot be taken to estimate the pollution load from individual sections.

The final effluent treatment section consists of a receiving sump of about 115 m^3 effective volume. Effluent from this sump is pumped to the overflow weirs of two concave wedge wire type screens (500 micron) to remove solids. The screened liquid flows through a measuring weir into another sump from which it flows to the municipal sewer.

The pumping of the effluent from the lower sump is controlled by level probes and during pumping the bottom sump is swirled by a bypass stream.

Caustic soda is fed into the bottom sump for pH control but the pH probe is after the measuring weir. The system does not offer satisfactory pH control.

Performance of the wedge wire screens is dependent on the opening between wedge bar and the velocity of the material flowing across the curved surface. The latter is fixed by the overflow weir ; the size of openings between the bars was found to lie between 500 - 600 microns. The screens appear to be in good condition, however, under flow from the screen shows an extremely variable value for settleable solids. The value, however, is related to the pollution load (and thereby also to the starch content).

Clear supernatant liquor obtained after prolonged settling (or centrifugation) of the effluent under flow gives only a slight positive iodine test for starch. The settled material shows a very marked starch reaction with iodine.

Further tests will have to be conducted to determine the relation between settleable solids and other values such as oxygen absorbed, total carbon or starch before any major change is made to the existing screen system e.g. installation of finer screens.

1.12 Quality and Quantity of Effluent

Tests were conducted to determine the variability of volume and pollution load of the wastewater.

In one test, samples were taken each time the sump pumps switched on. The samples were taken from the wastewater entering the bottom sump (balancing tank) and from the wastewater being discharge to the municipal sewer.

The variation in volume is shown in Figure A3. The results of tests for oxygen absorbed (mg/l) are shown in Figures A3, A4 and for total carbon (TC) in Figure A5.

It will be seen that the volume of wastewater discharged to sewer is very variable over 24 hours. The pollution load (oxygen absorbed and/or total carbon) follow the volume discharged pattern.

A total volume of approximately 600 kl was discharged over 24 hours, with a pumping time of about 10 hours.

In a second test the variability of volumes discharged was determined from the difference between integrated flows measured on the hour each hour. The results are shown in Figure A6, together with total carbon values for samples taken from effluent flowing in to the balance tank. There is a considerable variation of volume over the period. A total of about 600 kl was discharged over 24 hours ; the pumping time was about 9,2 hours. The extremely high value for total carbon shown on the 3 a.m. sample was clearly due to a beer load into the effluent at this time. The total solids and COD were also very high and the settleable solids test could not be carried out.

Analytical results for the above two tests are given in Tables A2, A3, A4 and A5.

The balancing tank volume (total available approx. 115 m^3) is clearly not large enough to smooth out the large variation of the incoming effluent.

Since liquors from the brew house and screeners and beer from the rest of the works are the only real contributors to the organic pollution load, it was decided to analyse a number of products and intermediates for total carbon. The analysis for total organic carbon or total carbon in the absence of any significant amount of inorganic carbon offers an easy, rapid method for the measurement of organic matter in a sample. The method measures the total organic carbon content of the sample by a combustion method which is rapid and generally accurate and reproducible.

The average value for the total carbon content of pitched and unpitched brews was found to be approximately 37 000 mg/l.

If a value of 1 000 mg/l total carbon is taken as an average value for the effluent, the total carbon per day would be equivalent to 600 000 g per 600 m^3 effluent. This in turn is equivalent to over 16 000 l beer per day. Obviously a large proportion of this arises from the necessary washing out of vessels and lines to maintain aseptic conditions. However the quantity (and value, about R4 000/d) justifies an investigation to determine where savings can be made.

TABLE A2

ANALYTICAL RESULTS FOR WASTE WATER INTO SEWER TEST 1

TIME	FLOW L/S	INTEG M	PH	COND MS/CM	SET S ML	TS G/L	TDS G/L	SUS S G/L	TC MG/L	TC FIL MG/L	OA MG/L	OA FIL MG/L	COD G/L	COD FIL G/L	NH4 PPM
10.43	15.00	558422	7.11	2.40	195	5.72	3.31	2.41	2050	1404	736	533	6.59	3.40	650
11.24	15.00	558444	6.67	1.20	55	3.47	2.37	1.09	1575	1240	617	421	5.63	3.45	263
12.12	15.00	558472	6.61	0.86	150	4.50	3.62	0.87	2010	1725	657	452	6.30	4.51	219
12.54	15.00	558493	6.30	1.00	270	5.35	4.42	0.93	2350	2250	846	640	8.26	6.17	250
14.17	15.00	558546	7.67	1.00	10	3.97	3.08	0.86	1925	1725	866	630	7.26	4.83	275
15.00	15.00	558563	6.95	0.98	50	4.52	3.57	0.95	1830	1875	700	560	6.67	4.77	213
15.39	15.00	558580	6.35	1.37	165	5.07	2.56	2.21	1865	1600	942	612	7.85	4.12	375
16.25	15.00	558599	6.26	0.96	70	3.27	2.05	1.23	1225	1175	581	400	4.89	2.99	263
17.12	15.00	558615	6.13	0.90			1.69			990		346		2.31	250
18.00	15.00	558636	7.19	1.13	9	2.71	2.23	0.48	1014	1010	309	233	3.04	2.16	366
19.55	16.00	558659	9.56	1.03	6	2.26	1.91	0.35	814	840	231	163	5.00	1.73	269
19.50	17.00	558679	7.30	0.97	5	2.20	1.84	0.36	760	760	221	179	2.33	1.75	256
20.45	17.00	[illegible]	6.17	1.25	7	4.64	2.74	1.90	1420	1200	359	273	3.42	2.61	344
21.50	17.00	558734	9.87	2.19	12	3.75	3.13	0.57	1400	1150	330	276	3.05	2.31	575
22.22	17.00	558753	10.25	2.50	14	3.73	3.14	2.70	1160	996	301	226	3.05	1.96	650
0.53	17.00	558764	10.50	1.72	6	2.55	1.72	0.86	890	816	231	173	2.20	2.09	425
1.45	17.00	558782	10.42	0.98	11	2.39	1.33	1.07	770	800	211	166	2.41	1.26	274
3.03	17.00	[illegible]	10.03	1.42	7	2.34	2.74	[illegible]	1475	1225	233	234	5.49	1.63	330
3.55	[illegible]	[illegible]	9.72	1.50	43	4.53	1.47	3.05	2500	1900	517	419	6.83	4.40	320
5.50	15.00	[illegible]	6.42	2.13	[illegible]	[illegible]	[illegible]	1.50	1975	1750	549	472	7.40	4.74	419

TABLE A3

ANALYTICAL RESULTS FOR WASTE WATER INTO BALANCING TANK TEST 1

TIME	FLOW L/S	INTEG M	PH	COND MS/CM	SET S ML	TS G/L	TDS G/L	SUS S G/L	TC MG/L	TC FIL MG/L	OA MG/L	OA FIL MG/L	COD G/L	COD FIL G/L	NA PPM
10.43	15.00	558422	11.30	1.02	6	1.64	1.25	0.39	660	495	163	141	2.20	1.37	190
[illegible].24	15.00	558444	7.52	0.45	2	1.60	1.00	0.60	660	527	185	140	2.26	1.24	100
[illegible].12	15.00	558472	7.35	1.21	5	2.47	1.84	0.62	830	765	224	175	2.70	1.63	340
12.54	15.00	558493	10.24	1.56	2	2.16	1.92	0.25	650	610	167	140	1.80	1.21	410
[illegible].17	15.00	558546	5.35	0.91	670	10.41	8.19	2.22	5300	4350	1601	1370	10.52	12.05	170
15.00	15.00	558563	11.23	1.00	11	1.75	1.37	0.38	660	585	189	156	2.20	1.47	180
[illegible].39	15.00	558580	6.81	.60	5	1.18	.89	0.29	427	375	127	95	2.00	0.87	161
[illegible].25	15.00	558599	6.00	0.43	17	1.71	1.20	0.51	640	610	233	184	2.41	1.54	100
17.12	15.00	558615	8.23	0.60	4	2.26	1.92	0.34	900	900	229	198	2.93	2.04	143
[illegible].00	15.00	558636	5.19	0.33	87	2.54	2.05	0.50	900	980	320	266	3.30	2.54	73
18.55	16.00	558659	7.30	1.73	9	2.76	2.23	0.53	815	815	221	136	2.50	1.47	443
[illegible].50	17.00	558679	6.84	1.71	10	3.48	3.02	0.46	1240	1280	302	269	3.85	2.97	450
20.45	17.00	558598	10.53	2.70	2	2.63	2.57	0.06	690	650	133	76	1.34	0.89	663
[illegible].50	17.00	558724	9.50	0.3[illegible]	4	1.42	0.80	0.62	440	[illegible]	92	47	1.26	0.92	70
[illegible]	17.00	558753	11.24	1.36	7	1.29	1.20	0.19	420	3[illegible]2	62	4[illegible]	0.96	0.65	275
[illegible].5[illegible]	17.00	558764	10.19	1.07	4	1.74	1.50	0.45	540	515	[illegible]	65	1.64	1.54	265
[illegible].45	17.00	558780	11.15	0.64	13	1.65	0.75	0.91	220	300	90	10	1.22	0.65	120
[illegible].03	17.00	[illegible]	8.95	0.51	16	4.23	3.27	1.01	2400	1900	590	545	6.92	5.45	[illegible]
[illegible].55	16.5[illegible]	[illegible]	[illegible]	2.[illegible]4	9	3.54	2.49	0.55	1060	[illegible]	2[illegible]	226	3.57	2.97	523
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	14	5.3[illegible]	2.1[illegible]	1.26	1490	1150	320	245	4.32	3.37	105

TABLE A4

ANALYTICAL RESULTS FOR WASTE WATER INTO BALANCING TANK TEST 2

TIME	FLOW L/S	INTEG M	PH	COND MS/CM	SET S ML	TS G/L	TDS G/L	SUS S G/L	TC MG/L	TC FIL MG/L	OA MG/L	OA FIL MG/L	COD G/L	COD FIL G/L	NA PPM
9.00	17.50	543620	10.30	1.25	57	2.42	1.94	0.48	564				2.48		245
10.00	0.00	543644	8.10	2.05	5	3.33	2.66	0.67	1200		232		3.76		330
11.00	17.50	543663	6.70	0.75	95	5.16	2.73	2.43	1310				8.37		195
12.00	18.00	543691	11.47	2.20	3	2.56	2.45	0.11	800				1.99		470
13.00	18.00	543730	4.10	0.55	35	2.88	1.29	1.59	700		564		3.98		130
14.00	17.50	543773	10,28	2.05	19	5.45	4.54	0.91	2250		730		6.31		512
15.00	17.50	543809	9.60	1.50	123	5.69	4.07	1.62	1825		700		7.09		400
16.00	17.50	453856	10.60	0.97	7	3.89	3.24	0.64	1290		480		4.89		255
17.00	17.50	543886	11.30	1.65	6	3.05	2.41	0.64	964		416		3.45		300
18.00	17.50	543906	11.40	2.08	6	3.18	2.82	0.36	704		176		2.18		540
19.00	17.50	543934	11.00	1.15	3	2.55	2.12	0.43	830		320		2.80		240
20.00	17.50	543962	11.10	1.00	6	2.63	2.29	0.35	950		260		3.20		195
21.00	17.50	543975	12.20	9.80	3	11.66	10.93	0.73	3650				9.49		2000
22.00	17.50	544006	10.00	1.22	61	4.24	3.69	0.56	1585		[illegible]		4.89		310
23.00	17.50	544016	9.50	0.65	250	2.62	2.32	0.30	1850				2.27		250
24.00	17.50	544035	10.40	3.30	15	3.75	3.35	0.40	990				1.34		800
1.00	17.50	544051	11.40	1.80	15	2.61	2.27	0.34	935		[illegible]		2.02		375
2.00	17.50	[illegible]	11.00	0.70	65	3.45	2.62	0.83	1225		500		3.12		130
3.00	17.50	544082	4.70	1.12		28.37	16.05	12.55	5000				40.78		200
4.00	17.50	[illegible]	11.10	1.15	3	3.53	3.22	0.30	1300		[illegible]		4.84		150
5.00	17.50	[illegible]	11.70	10.10	1	9.58	5.43	0.15	1460		224		1.10		3475
6.00	17.50	544137	9.20	0.44	75	3.65	3.02	0.57	1440		220		3.40		285
7.00	17.50	544159	11.50	2.20	5	6.02	5.76	0.25	650		170		3.76		600
8.00	17.50	544195	11.20	1.32	4	2.62	2.38	0.24	850				1.84		410

TABLE A5

ANALYTICAL RESULTS FOR WASTE WATER INTO SEWER TEST 2

ME	FLOW L/S	INTEG M	PH	COND MS/CM	SET S ML	TS G/L	TDS G/L	SUS S G/L	TC MG/L	TC FIL MG/L	OA MG/L	OA FIL MG/L	COD G/L	COD FIL G/L	NA PPM
.00	17.50	543620	8.10	1.20	17	3.76	2.75	1.03	1200		570		5.04		250
10.00	0.00	543644	7.94	1.50	20	3.93	3.16	0.77	1200		504		5.14		365
.00	17.50	543663	8.50	1.05	5	3.43	3.03	0.40	1140		436		4.40		275
2.00	16.00	543691	6.90	0.70	9	3.24	2.28	0.96	970		495		4.01		250
.00	16.00	543738	6.00	0.64	65	4.76	2.97	1.79	1330		974		6.03		220
.00	0.00	543773	6.10	0.56	162	4.93	3.24	1.69	1725		940		6.67		140
5.00	16.00	543809	6.10	0.60	320	6.60	4.35	2.24	2250				10.57		170
.00	19.00	543856	6.20	0.87	49	3.00	2.32	0.64	1030				4.33		245
7.00	0.00	543886	9.00	0.77	46	2.60	2.05	0.55	1060		380		3.34		210
.00	0.00	543906	11.10	2.75	42	5.02	4.35	0.64	1150		900		5.27		635
.00	16.00	543934	10.40	1.12	-3	2.61	2.20	0.32	570		454		2.99		275
.00	0.00	543962	10.10	1.05	2	3.91	2.45	1.46	640		48[illegible]		2.85		275
.00	0.20	5439[illegible]	10.00	0.80	62	2.85	2.41	0.44	1075		360		2.55		205
.00	15.20	5440[illegible]	11.00	1.35	10	3.01	2.45	0.55	1250		452		3.19		290
.00	0.00	544016	10.90	1.20	2	2.22	2.45	0.34	1250		460		2.70		255
.00	0.0[illegible]	544035	10.20	0.75	50	2.57	2.69	0.19	1010		450		3.12		190
.00	0.80	544051	9.50	1.15	6	3.64	3.00	0.65	1075		440		3.49		320
.00	0.00	5440[illegible]	10.40	1.45	3	3.05	2.65	0.40	1120		520		3.10		250
.00	0.20	5440[illegible]	11.50	1.30	23	3.16	2.94	0.22	1210				3.69		310
.00	[illegible]	5441[illegible]	9.45	0.90	5[illegible]	7.23	6.13	1.05	3125		760		10.23		245
.00	13.00	544[illegible]	10.90	2.05	62	5.33	4.84	0.49	1950		720		4.50		390
.00	0.00	5441[illegible]	10.[illegible]	2.40	1	3.23	3.15	0.05	360		284		1.63		700
.00	0.00	544159	10.32	1.40	3	2.93	2.70	0.23	1090				2.77		335
.00	0.00	544[illegible]	9.40	1.10	65	3.23	2.99	0.22	1060				3.12		275

The beer/brew losses to effluent arise from

a) transfer spillages e.g. spillages from hoses and transfer lines when uncoupling (this applies to brew house, screeners, cellars and packaging and tanker filling areas).
b) washing out of lines between product changes and at end of shifts before thorough draining of lines.
c) washing out of tanks in the Cellar Section on the CIP system and in the Packaging Section. Losses will be high if vessels are not drained effectively before washing out.
d) poor operation of packaging machines.
e) rough handling in the conveying of and stacking/off loading/loading of crates in Packaging section and Distribution section.
f) washing out of tankers.

In addition, packed beer returned to the brewery is bled into the effluent system. In October 1982, the quantity amounted to about 17 000 l over the month. This is a relatively small quantity compared to the calculated daily loss.

Some of these losses could be overcome by design changes (direct coupling of stainless steel lines making it possible to flush lines from cooker to strainer to fermenter) and others can be reduced by attention to operating methods.

It is considered that detailed accounting of production and transfer from section to section should be carried out from time to time to determine losses and encourage efficient operation.

1.13 Water Consumption

The water reticulation system is outlined in Figure A1. It was not possible to arrive at figures for the usage of water in the various sections since there were no meters installed. The situation is now being rectified and when the full set of recommended meters is installed it will be possible to measure all incoming water and recovered hot water and recovered condensate (See Figure A1). A critical survey of water in the various sections will then indicate where water wastage areas are, whether water usage can be reduced without affecting product output/quality.

Immediately, however, a reduction in consumption could be achieved by fitting all water hoses with automatic shut-off valves.

1.14 Effluent Costs

The cost of effluent at the particular site is related to volume, the oxygen absorbed value (mg/l) and the settleable solids value (ml/l) as shown in Figure A7.

At a discharge of 600 m^3/day, an OA value (average) of 400 mg/l and settleable solids (average) of 30 ml/l, the charge would be R92 800 p.a. The equivalent incoming water (600 m^3) charge would be R61 300, a total of R154 100.

Obviously volume and settleable solids are both significant contributors to the cost and both are factors which can be controlled by physical methods. For example, reducing volume to 400 m^3/d and settleable solids to 15 ml/l without reducing the OA total load which then becomes 600 mg/l, the effluent charge will reduce to R60 700 p.a. and the total charge to R101 580 a saving of R52 520 p.a.

If in addition, the OA value is reduced to 200 mg/l the effluent charge is reduced to R41 500 and the total charge to R82 380 a saving of R71 720 p.a.

2. RECOMMENDATIONS AND CONCLUSIONS

2.1 Throughout the brewery 20 mm I.D. hoses are used for washing down floors etc.

Cleaning can often be accomplished successfully by using less water at high pressure in sprays or jets.

To limit flow it is recommended that automatic shut-off valves be fitted to all hoses.

Wherever possible recovered water should be used in preference to fresh water intake and wastage to drain of this water should be avoided.

2.2 There appears to be occasional blockage of the outlet to some of the lactic acid generators. In attempts to unblock the outlets considerable spillage occurs. Agitation of these vessels should be improved to prevent settling of solids in the outlets.

2.3 Clean effluent which arises from condensate and draining of coils in the brew house should be recovered.

2.4 The pollution load arising from the in-place cleaning (CIP) system in the Cellars will vary with such factors as effectiveness of transfer of contents, type of brew, age of brew, etc. This should be examined in greater detail to identify the main factor giving high pollution loads.

2.5 Spent grain spilled onto the floor at the loading bay should be swept up rather than hosed down the effluent system.

2.6 Considerable spillage appears to arise in the tanker filling area. The tanker CIP system was not in operation during the survey. Supervision by plant management would undoubtedly improve operations in this area.

2.7 The disposal of returned beer needs to be thoroughly investigated. The principle of separation of strong effluents from weak effluents could be applied if arrangements could be made with the municipal authorities for direct disposal to the sea outfall. The economics will have to be carefully examined however.

2.8 The whole of the Packaging and Distribution Sections would benefit from a major exercise to improve good housekeeping and quality of operation of packaging machines etc.

2.9 At the effluent treatment plant, control of pH is ineffective and an unnecessary addition of caustic soda is occuring.

2.10 The wedge wire screens (500 microns) appear to be in good condition. However, the finely dispersed starch present in the effluent is not removed. Investigations should be carried out to confirm the high settleable solids values with starch content of the effluent. If there is a positive correlation then centrifugation should be considered if it can be shown to be cost effective (both settleable solids and some OA should be removed).

Trials should also be carried on on finer screens to remove more of the heavier non-starch particles which pass the present screens (small test screens are available on loan from some manufacturers).

2.11 The total carbon value of the effluent can be related to equivalent beer loss. Although the equivalent beer loss as a percentage of output may not be high (just over 3% in the sample given in the test) the money value equivalent over the year is large enough to justify an investigation to determine where savings can be made.

2.12 It was not possible to measure volumes of water into individual sections during the survey. The position is being rectified by installation of water meters as shown in Figure A1. When all the meters are installed, a critical survey of water usages in various sections should be undertaken to indicate where wastages occur and whether the water requirements can be reduced without adversely affecting the quality of production.

2.13 Recovered water is at present stored in a series of tanks for redistribution to the Cellar, Distribution and Packaging Sections. Since the water is hot on collection, consideration should be given to conserving the heat by lagging of the storage vessels.

2.14 The effluent is essentially one containing organic materials arising from the use of sorghum corn, sorghum malt and maize grits in the brewing of beer. The effluent is readily biodegradable and after simple pretreatment involving equalisation, pH adjustment, and settleable solids removal, the effluent is dealt with satisfactorily by disposal to the municipal sewer. No advanced treatment methods are recommended.

However to reduce costs the following should be attempted

1) reduce the volume of the wastes - by conserving water, waste is saved.
2) reduce the absolute organic load - any effort to find means of reducing the total mass of polluting matter in the wastewater will result in savings.

FIGURE A1
PROCESS WATER

1	Mains water
2*	Brew house (No. 1 meter)
3*	Condensate and make-up to boilers
4*	Chilling plant cooling water
5* + 6*	Heat exchangers
7*	Cellars
8*	CIP in Cellars (meter No. 1)
9*	Packaging
10*	Packaging
11*	Waste grain hopper
12a*	Hot water to Cellars
12*	Hot water from Cellars
13*	Hot water to Packaging
14	Cooling Tower No. 1
15	Cooling Tower No. 2
16	Boiler Water make-up (water storage)
17	Boiler make-up (Boiler house)
18*	Additional feed (packing)
19*	Brew house (No. 2 meter)
20*	CIP No. 2 meter
21*	Tanker Bay
22*	Tanker CIP

--------- recovered water

________ fresh water

* meters required/being installed.

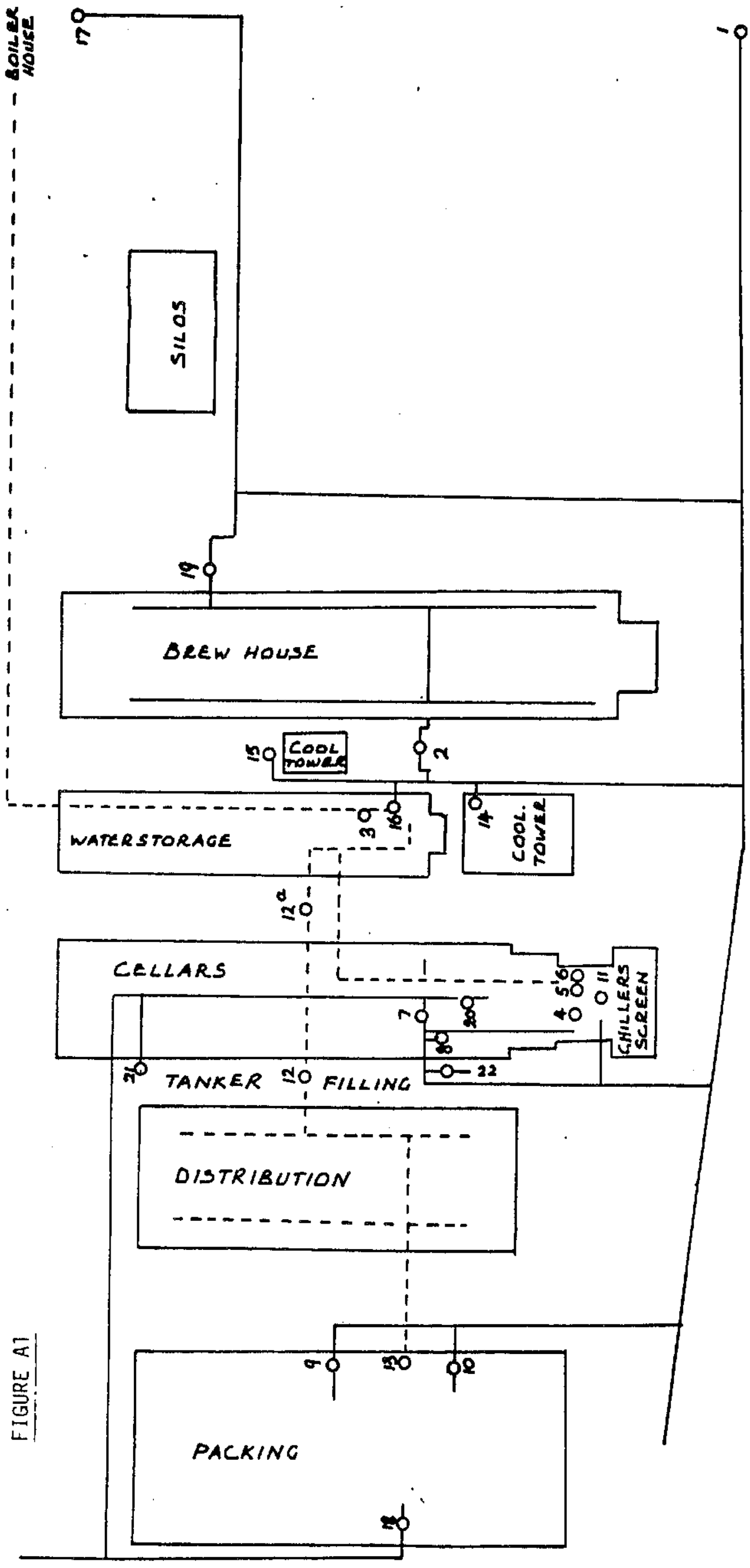

BOILER HOUSE
17
1
SILOS
19
BREW HOUSE
15
COOL TOWER
2
3
16
14
COOL. TOWER
WATERSTORAGE
12a
CELLARS
5
6
11
4
7
20
8
CHILLERS SCREEN
22
21
TANKER
12
FILLING
DISTRIBUTION
9
13
10
PACKING
18

FIGURE A1

FIGURE A2

WASTEWATER DRAINS

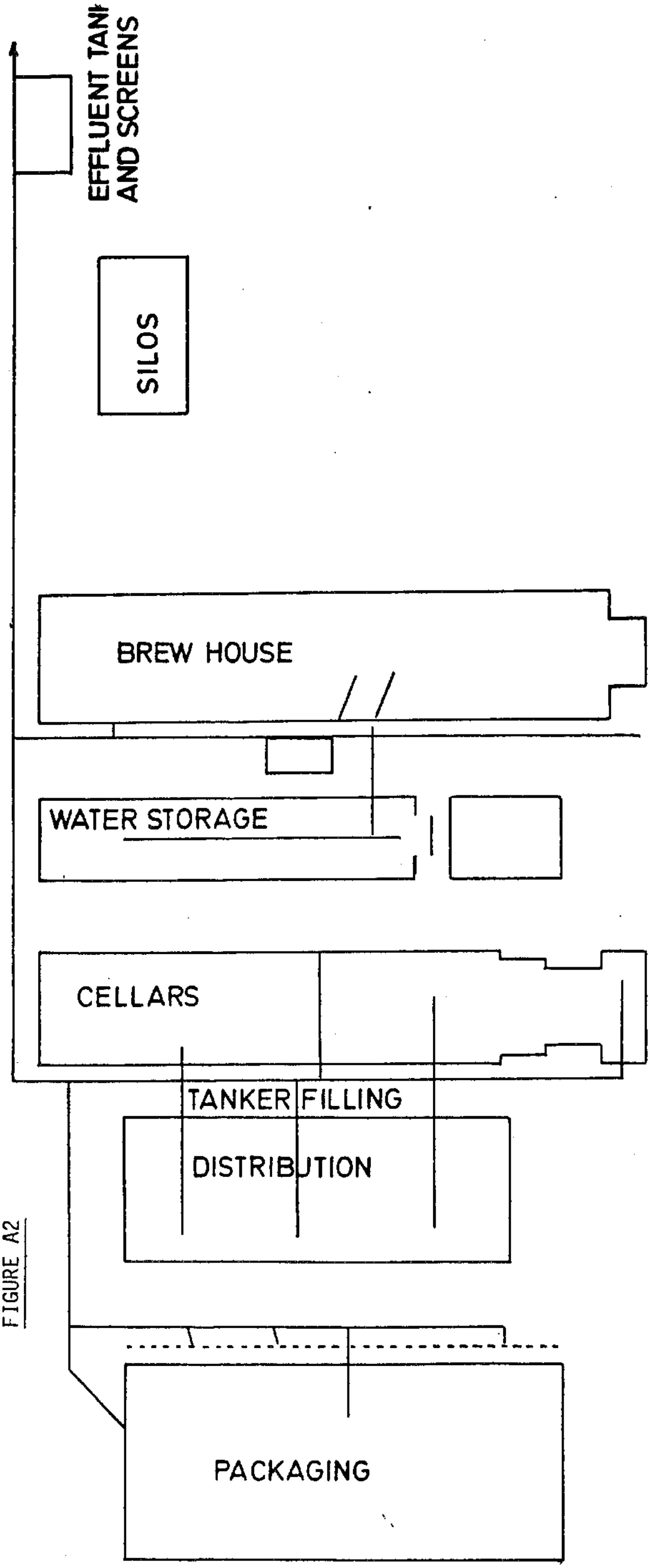

EFFLUENT TANK
AND SCREENS
SILOS
BREW HOUSE
WATER STORAGE
CELLARS
TANKER FILLING
DISTRIBUTION
PACKAGING

FIGURE A2

FIGURE A3

EFFLUENT VOLUME
AND
OXYGEN ABSORBED (mg/l)
OF
EFFLUENT TO SEWER

TEST 1

unfiltered sample
filtered sample

FIGURE A3

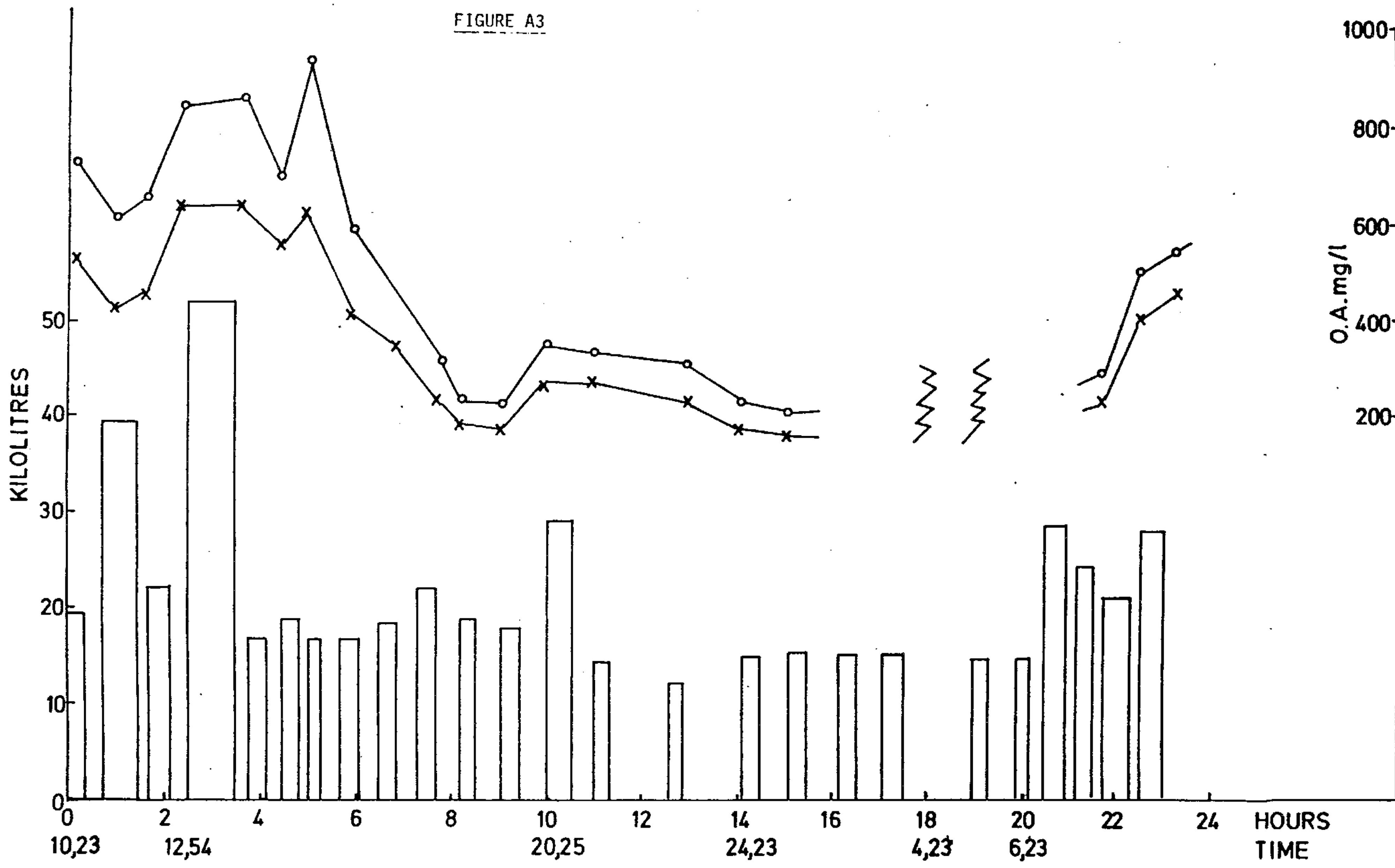

1000
800
600
400
200
O.A.mg/l
KILOLITRES
50
40
30
20
10
0
0
2
4
6
8
10
12
14
16
18
20
22
24
HOURS
TIME
10,23
12,54
20,25
24,23
4,23
6,23

FIGURE A4

OXYGEN ABSORBED (mg/l) OF EFFLUENT TO BALANCING SUMP

TEST 1

o—o—o unfiltered sample

x—x—x filtered sample

FIGURE A4

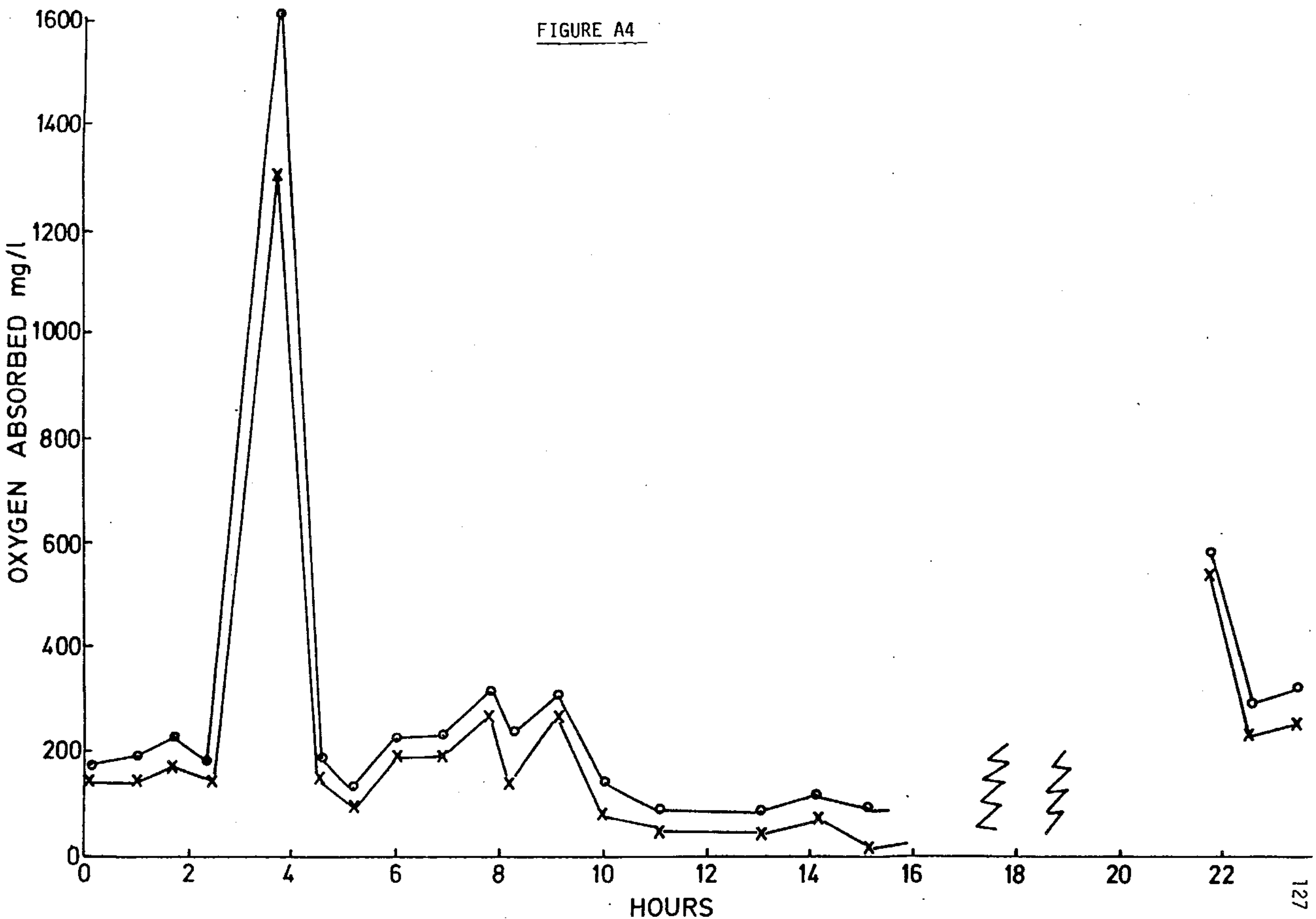

OXYGEN ABSORBED mg/l
1600
1400
1200
1000
800
600
400
200
0
2
4
6
8
10
12
14
16
18
20
22
HOURS

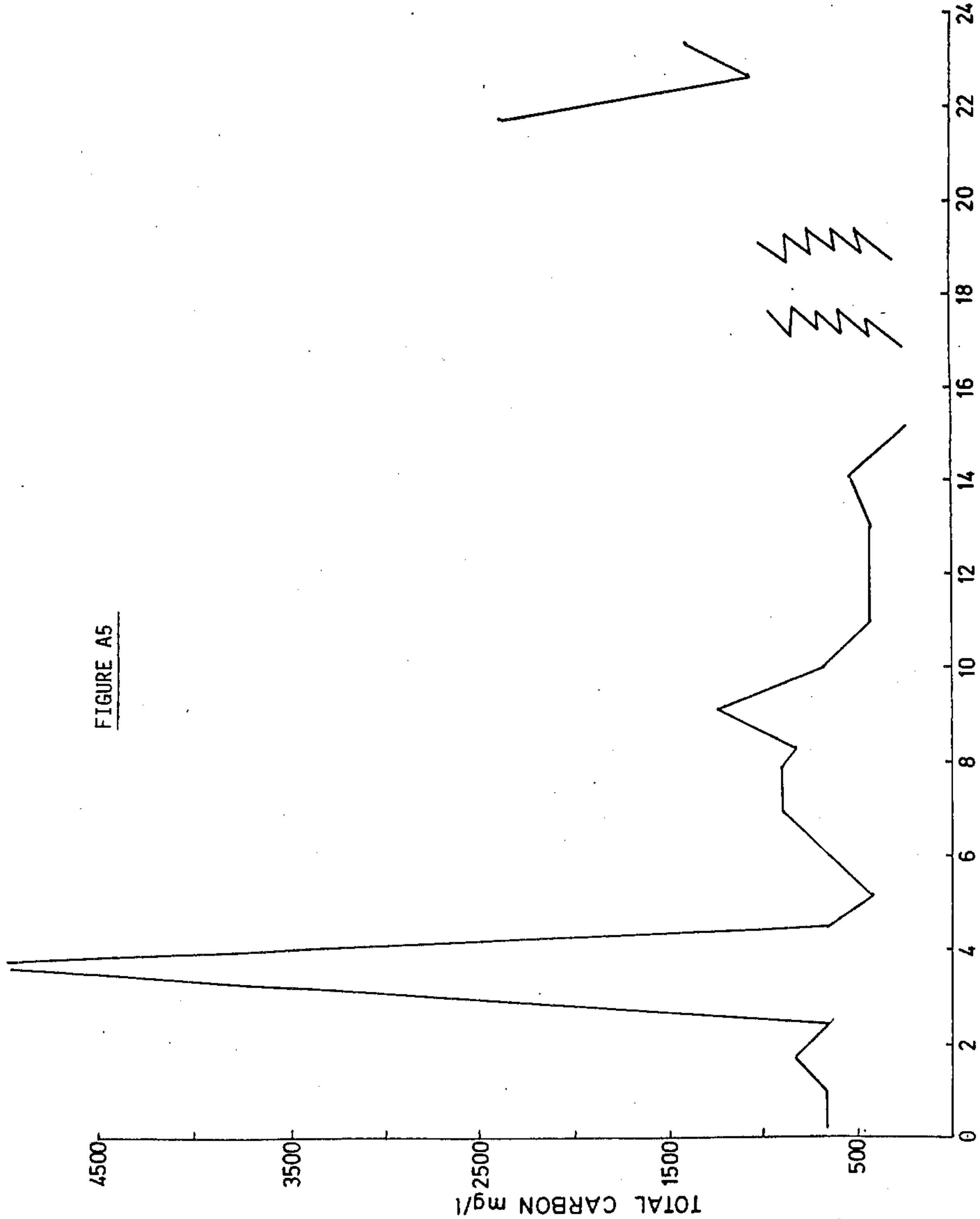
FIGURE A5

EFFLUENT TO BALANCING TANK

TOTAL CARBON (mg/l)

UNFILTERED SAMPLE

TEST 1



4500
3500
2500
1500
500
TOTAL CARBON mg/l
0
2
4
6
8
10
12
14
16
18
20
22
24
HOURS

FIGURE A5

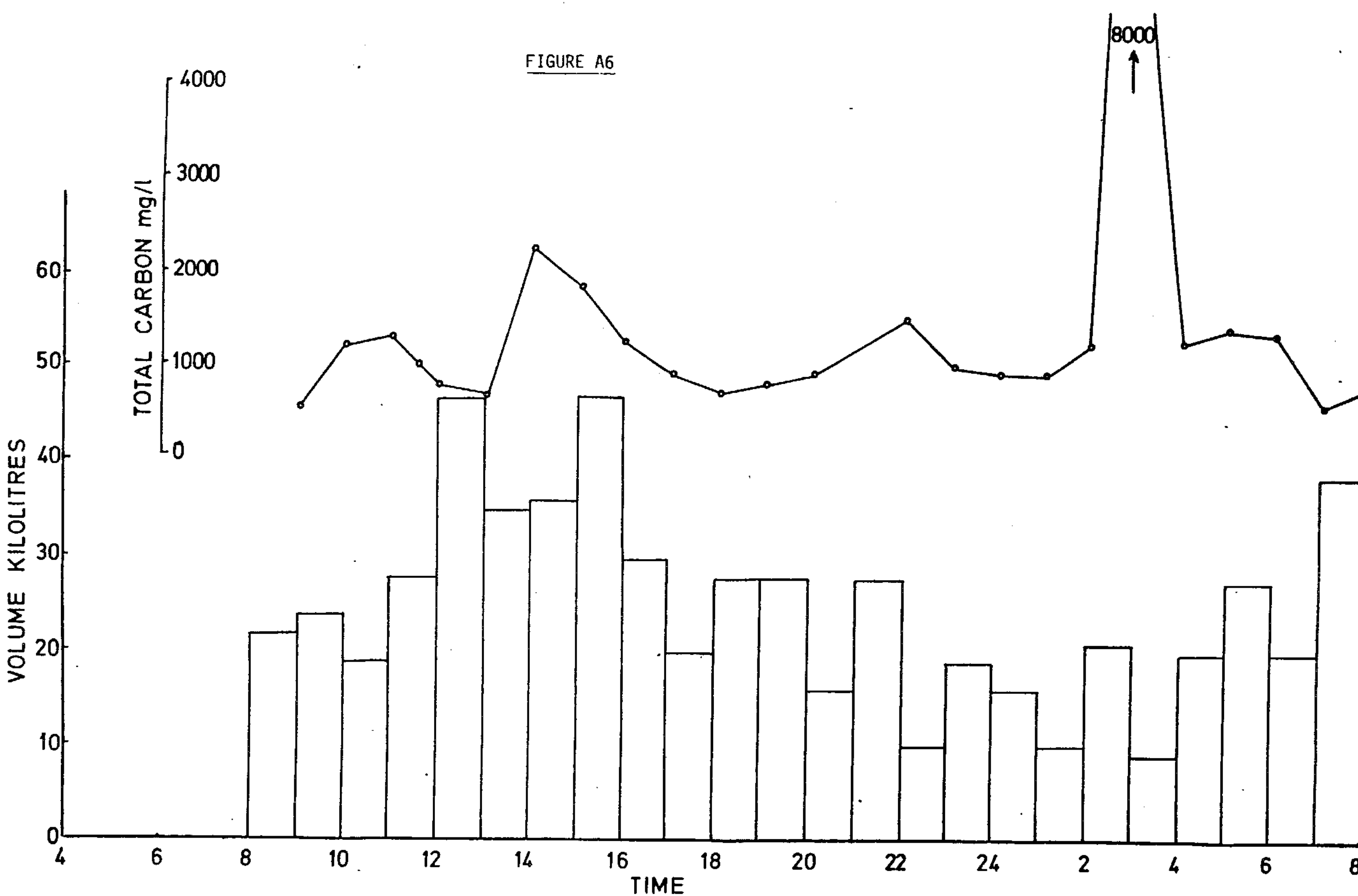
FIGURE A6

EFFLUENT VOLUMES OVER 24 HOURS

AND TOTAL CARBON (mg/l)

TEST 2.

FIGURE A6

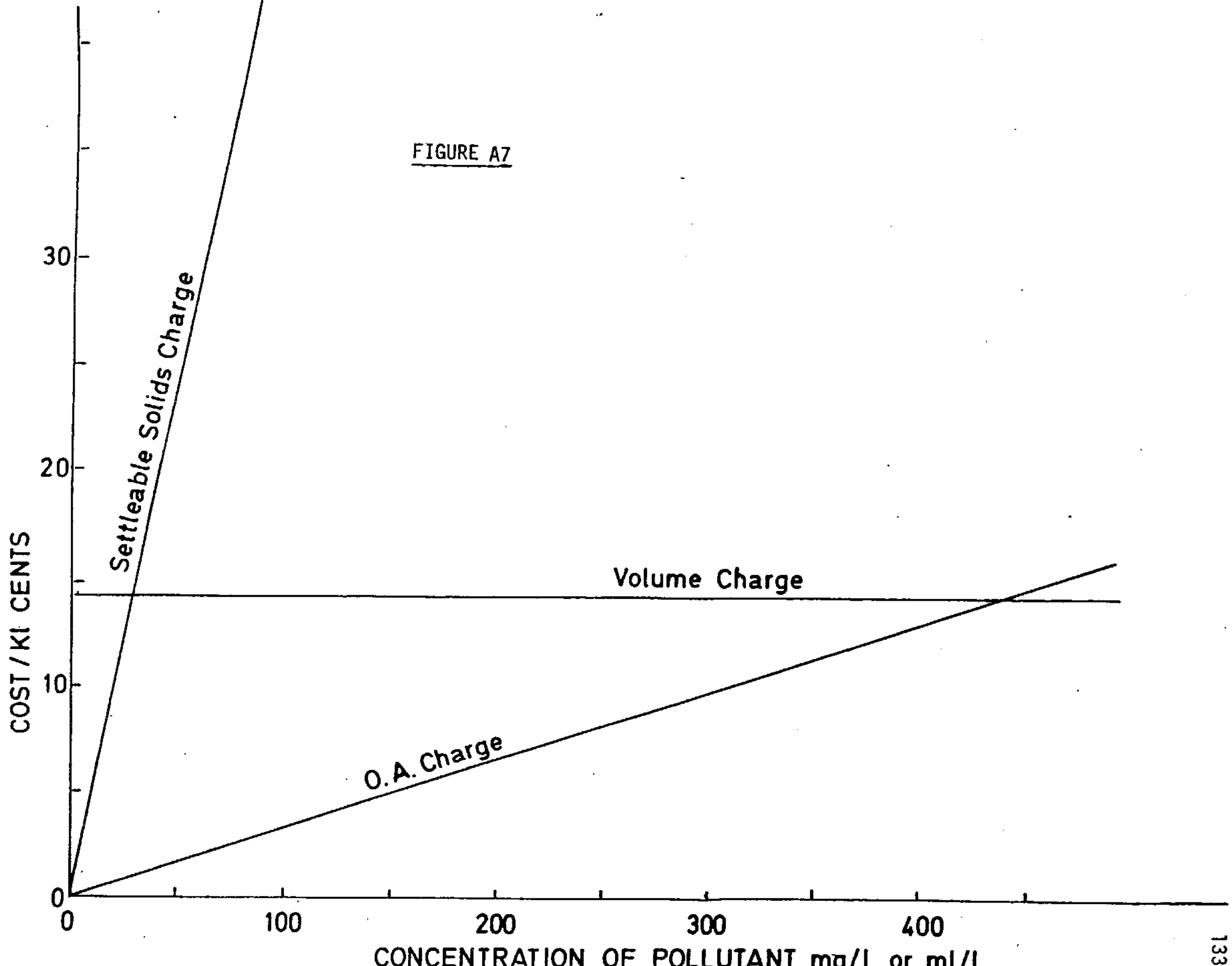


TOTAL CARBON mg/l
4000
3000
2000
1000
0
8000
VOLUME KILOLITRES
60
50
40
30
20
10
0
4
6
8
10
12
14
16
18
20
22
24
2
4
6
8
TIME

FIGURE A7

EFFLUENT CHARGES

FIGURE A7


Settleable Solids Charge
Volume Charge
O.A. Charge
COST / Kl CENTS
0
10
20
30
0
100
200
300
400
CONCENTRATION OF POLLUTANT mg/l or ml/l

APPENDIX 5

METHODS OF EFFLUENT TREATMENT

1. INTRODUCTION

The treatment of wastewater involves the removal of undesirable materials by one process or combination of processes which can be physical, chemical or biological in nature. Treatment methods are generally sub-divided into the following categories :-

(i) Preliminary treatment e.g. screening, neutralisation, settling.
(ii) Primary treatment e.g. chemical-flocculation, sedimentation, flotation.
(iii) Biological secondary treatment e.g. aerobic and anaerobic biological treatment processes.
(iv) Tertiary treatment e.g. disinfection, solids removal, dissolved solids and organics removal.

2. PRELIMINARY TREATMENT

2.1 Screening

2.1.1 Screening is used to remove fairly large suspended or settleable solids and has a useful function in preventing pump blockage. Sometimes, screening may be used to recover a useful solid by-product e.g. fermentation biomass.

2.1.2 The types of commonly used screens are :-

(i) vibrating screen (e.g. Sweco type)
(ii) rotating drum screen
(iii) Static wedge-wire screen
(iv) rectangular travelling screen

2.1.3 The effective separation of solids depends principally on the physical properties of the particles including size, density and concentration, and on the capability of the equipment for their separation.

2.1.4 Coarse screens have openings of 6 mm or more ; fine screens less than 6 mm ; and screens in the range 20 - 70 m are often termed microscreens or microstrainers.

2.1.5 Most suspended solids have fairly large organic pollution parameters and hence their removal prior to sewer discharge is advantageous in terms of reducing both organic and settleable solids discharge costs.

2.2 Neutralisation

2.2.1 Neutralisation of effluents prior to sewer discharge may be necessary to comply with municipal by-laws.

2.2.2 If both acid and alkaline wastewaters are generated in the factory, then balancing is often an effective technique. This allows self-neutralisation to occur and hence minimise pH correction dosage. Balancing is also useful for smoothing out both hydraulic loads and high strength wastewaters. This may be advantageous in allowing more accurate effluent samples to be taken and used to effect a 24 h/d discharge for an 8 or 16 h/d processing facility.

2.2.3 Normally neutralisation can be effected using an automatic pH controller and a fully mixed flow through a reactor of sufficient residence time. For more difficult situations, a two-stage neutralisation process is often preferred.

2.2.4 For the neutralisation of acidic wastewaters, sodium hydroxide, sodium carbonate and calcium hydroxide are used. Calcium hydroxide is often preferred on economic grounds.

2.2.5 For the neutralisation of alkaline wastewaters, hydrochloric acid, sulphuric acid or stack gas carbon dioxide are used.

3. PRIMARY TREATMENT

3.1 Sedimentation (Clarification)

3.1.1 Primary sedimenation is used for the separation of settleable solids by gravity using a long residence time. In rectangular settling tanks the solids are mechanically transported along the bottom of the tank by a scraper mechanism and pumped as a sludge underflow. Often scum removal devices are incorporated on sedimentation tanks.

3.1.2 Coagulation chemicals such as alum or ferric chloride may be used to accelerate or enhance the settleable solids removal.

3.2 Flotation

3.2.1 Flotation is also used as a separation method for suspended solids and uses gaseous bubbles which adhere to particles and cause them to float to the surface.

3.2.2 The advantages of flotation over sedimentation are the much shorter residence time (allowing smaller units) ; removal of non-settleable solids, including in some cases, colloidal material ; the higher the floated solids concentration than settled solids sludge. However, flotation systems have higher operating and maintenance costs and the effluent quality produced is often inferior to that achieved by sedimentation.

3.2.3 Flotation types are dispersed air, dissolved air and electroflotation.

3.3 Chemical Coagulation

3.3.1 Coagulation is used prior to sedimentation or flotation to accelerate and enhance suspended solids removal. Chemical coagulants assist in neutralisation of the electrical charges on small particles and agglomerate them to produce flocculant material.

3.3.2 Alum (aluminium sulphate), ferrous sulphate and ferric chloride are the common coagulants and these react with hydroxyl ions to form at around neutral pH, insoluble hydrous oxides. Polyelectrolytes (long chain charged polymers) are often used to augment the effect of the chemical coagulants.

3.3.3 Coagulation and flocculation is achieved by the use of flash mixing and a 10 - 30 minute flocculation zone prior to sedimentation.

4. BIOLOGICAL TREATMENT

Secondary treatment is used to remove non-settleable biodegradable organic material. The fraction of organic material that is biodegradable depends on the nature and loading of the effluent.

4.1 Aerobic Biological Treatment

4.1.1 Microorganisms are used to oxidise organic material to carbon dioxide and they themselves increase in population. Thus following removal of organics from wastewaters, the microorganisms have to be removed, normally by sedimentation.

4.1.2 Biological systems require soluble nutrients to ensure cell growth. For aerobic systems a BOD/nitrogen/phosphorous ratio of about 100:5:1 is generally adequate. This is an important aspect when considering biological treatment of an industrial effluent. The presence of toxic chemicals or breakdown products may seriously impair the efficiency of biological treatment systems.

4.1.3 Various types of aerobic biological treatment systems are available and include biofilters ; activated sludge - conventional, high rate, extended aeration, pure oxygen and nitrification type ; aerated lagoons ; and biological fluidised bed (BFB). In the BFB process the bacteria are grown on suspended particles. The liquid to be treated is passed up through a bed of fine medium at a velocity sufficient to cause fluidisation of the medium. Once fluidised, the medium provides a very large specific surface for biological growth. The very high biomass concentrations achieved in BFB compared to activated sludge plants lead to a much higher rate of reaction per unit volume. One disadvantage of intensifying the volumetic rate of treatment is that the rate of dissolved oxygen supply to the reactor must also be increased beyond the point at which air can be used economically and commercial grade oxygen must be used (Cooper, 1981).

4.2 Anaerobic Biological Treatment

4.2.1 Anaerobic digestion is used for the treatment of high strength effluents as a pretreatment prior to sewer discharge or aerobic biological treatment. It may also be used to treat secondary biological sludges.

4.2.2 The main anaerobic processes are high rate digestion and anaerobic pond treatment. The advantage of the former is the production of methane gas as a by-product. Pond treatment often leads to odour problems.

4.2.3 A BOD/N/P ratio of 100:2:0,5 is generally adequate.

The cost of anaerobic digestion of strong wastes is less than that of equivalent aerobic processes. The latter again are more economic at COD concentrations below 4 000 mg/l. As a rough guide (Cillie, et al, 1969), below COD concentrations of

4 000 mg/l aerobic methods should receive priority, between 4 000 and 50 000 mg/l COD anaerobic digestion would be preferrable and above this value evaporation with possible solids recovery should receive serious consideration.

5. TERTIARY TREATMENTS

Tertiary treatment is used for upgrading effluents to meet General or Special Standards for receiving waters or in cases where water recycle is envisaged.

5.1 Chemical Flocculation

Coagulation, flocculation and sedimentation is used to remove suspended solids and non-biodegradable organics from secondary treated effluents.

5.2 Filtration

5.2.1 In tertiary treatment applications, filtration is used as a polishing step to remove suspended solids from a variety of effluent types. It is also used for the dewater of sludges.

5.2.2 Many types of filtration equipment are available from simple gravity sand filters to complex multi-media, automatic backwash filters.

5.3 Activated Carbon

5.3.1 Activated carbon is used to removed refractory organics and residual COD.

5.3.2 Thermal regeneration is the common method of renewing active sites and the losses involved are an important aspect of this treatment method.

5.3.3 Not all organic compounds are removed by activated carbon and pilot-tests on particular effluents are often necessary.

5.4 Disinfection

Prior to final discharge to receiving streams, purified effluents may need disinfection. This is carried out with chlorine or ozone. Some trace organics removal may be obtained during chemical disinfection.

5.5 Ion Exchange

5.5.1 Although primarily used for softening, ion exchange is being used as an effluent treatment unit operation for the removal of ions and as an adsorbent.

5.5.2 Several new types of ion exchange resins have been introduced in the last decade and are used for specific applications in many industries e.g. removal of colour from pulp mill effluents, desalination of food pickling brines and the removal of nitrates and phosphates from municipal wastewaters.

5.6 Membrane Separation

5.6.1 Ultrafiltration, reverse osmosis and electrodialysis are being used increasingly for industrial treatment. Many application areas have been tested exhaustively and new areas are being developed.

5.6.2 In many cases, effluent may be reused as process water after membrane separation and hence these unit operations have enormous potential for use on selected streams for reuse applications.

5.7 Thermal Separation

5.7.1 Thermal processes are used either for the recovery of water from wastewater or for the recovery or concentration of the wastes themselves.

5.7.2 Although very energy intensive, they may be used to produce very high dissolved solids concentration (20 - 40%). They are also capable of handling a wide variety of mixed wastewaters.

5.7.3 Various types are available : multieffect boiling, multistage flash and vapour compression.

5.8 Chemical Oxidation Processes

5.8.1 Wet oxidation is used for the destruction of organic matter by oxidisng with air at high temperatures. It is particularly useful for toxic and non-biodegradable materials.

5.8.2 Catalytic ozonation is also being used in application areas similar to wet oxidation.

5.9 General

The technical guide K9 CSIR, Pretoria, 1969. (A guide to water conservation and water reclamation in industry) gives, in greater detail, various methods to restore the reuse value of process effluents in industry generally.