NATSURV 1

WATER AND WASTE-WATER MANAGEMENT IN THE MALT BREWING INDUSTRY

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Prepared for the

WATER RESEARCH COMMISSION

By

BINNIE & PARTNERS

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DISCLAIMER

FOREWORD

The need for guidelines to reduce water intake and waste-water disposal by industry is of national concern in view of South Africa's water scarcity.

To establish norms for water intake and waste-water disposal, the Water Research Commission (WRC) in collaboration with the Department of Water Affairs (DWA) contracted Binnie & Partners, a firm of consulting engineers, to undertake a National Industrial Water and Waste-Water Survey (NATSURV) of all classes of industry. The results obtained in the survey of the brewing industry form the basis of this Guide on **Water and Waste-Water Management in the Brewing Industry.**

It is expected that this Guide will be of value to the industry itself and to other interested parties such as municipalities, legislators, researchers and consultants in the water and effluent fields.

ACKNOWLEDGEMENTS

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We would also like to thank The South African Breweries Limited for their cooperation and assistance.

LIST OF TABLES

GLOSSARY

BRIGHT BEER	- Beer after maturation and the final filtration stage when remaining traces of yeast and proteins are removed.
CHASING	- The use of water (or other medium) to transfer process liquids.
COPPER KETTLE	- The vessel in which sweet wort is boiled.
DRIP BEER	- Beer which is spilt during the filling process.
FERMENTATION VESSEL	- Vessel in which fermentation occurs.
GREEN BEER	- Beer which has not undergone maturation.
HOPS	- A natural material added to sweet wort to impart bitterness and flavour. They may be whole hops or in powder, pellet or extract form.
KIESELGUHR	- Filtration medium used to remove traces of yeast and proteins from beer after maturation.
LAUTER TUN	- The vessel in which spent grains are removed from the sweet wort.
LUCILITE	- Alternative filtration medium to kieselguhr.
MALT	- A cereal grain, usually barley, which has been germinated for a limited period and then dried.
MASH TUN	- The vessel in which sugars are enzymically extracted from malt on the addition of water to produce sweet wort.
MASHING	- The process carried out in the mash tun.
PLATO SCALE	- A scale based on pure sucrose solutions used to describe sugar content.
SPARGE	- The spraying of grains in the lauter tun with water in order to extract the maximum amount of useful material from the grain.
SPECIFIC EFFLUENT VOLUME	- The effluent volume for a particular period divided by the product volume for the same period.
SPECIFIC POLLUTION LOAD	- The mass of given pollutant for a particular period divided by the product volume for the same period.

SPECIFIC WATER INTAKE - The water intake for a particular period divided by the product volume for the same period.

STORAGE VESSEL - Vessel in which beer is stored during maturation.

TRUB - Proteinaceous material precipitated both when wort is boiled in a kettle and when it is subsequently cooled (also known as hot break and cold break).

WHIRLPOOL - The vessel in which hot trub is separated from the wort centrifugally.

WORT - The liquid resulting from the mashing process. It is a mixture of partially degraded starch, sugars, enzymes, proteins and water.

ABBREVIATIONS

BOD - Biochemical Oxygen Demand.

CIP - Cleaning in Place.

COD - Chemical Oxygen Demand.

FV - Fermentation Vessel.

OA - Oxygen Absorbed.

SEV - Specific Effluent Volume.

SPL - Specific Pollution Load.

SS - Suspended Solids.

SV - Storage Vessel.

SWI - Specific Water Intake.

TDS - Total Dissolved Solids.

TOC - Total Organic Carbon.

1 INTRODUCTION

Malt beer brewing presently accounts for an approximate yearly water consumption of 8,7 million m^3. Annual beer production has been increasing steadily with current output at about 1,2 million m^3/yr. In the medium term the market is expected to expand further and several breweries will undergo expansion in response to this trend. In addition a new brewery is to be built in Pietersburg.

At present there are eight malt breweries in South Africa, located regionally as follows:

Northern Transvaal	- one brewery;
Central and Southern Transvaal	- three breweries;
Orange Free State	- one brewery;
Natal	- one brewery;
Western Cape	- one brewery;
Eastern Cape	- one brewery.

There is also an extensive network of packaging and distribution points throughout the country.

Breweries are also responsible for discharging a considerable volume of effluent which results from their processes. This is generally 65 to 70% of the water intake volume which amounts to 5,9 million m^3 of effluent. The effluent generated from brewery processes will contain several of the following pollutants: maltose, dextrose, wort, truh, spent grains, yeast, filter slurry (kieselguhr and lucilite), green beer and bright beer. This effluent will then have a high organic pollution load and a relatively high solid pollution load. Municipal treatment works have to deal with the majority of this polluted effluent.

The malt brewing industry in South Africa is therefore a significant one, both from a water intake and effluent point of view. The information used in this Guide has been collected from breweries throughout South Africa. Some basic information for each brewery is summarised in Section 3.

For the purpose of this Guide, it was decided to concentrate on the four breweries in the Transvaal and detailed surveys were carried out in each one.

2. PROCESS RESUME[1]

2.1 Definition

Beer is an alcoholic and carbonated beverage which involves in its production:

(a) extracting malted barley perhaps mixed with other materials (usually maize, maltose or dextrose) with water;

(b) boiling this extract with hops for flavour;

(c) cooling the extract and fermenting it with yeast.

This fermented beverage is then clarified and dispensed in an effervescent condition.

2.2 The major steps in beer production

2.2.1 Malting

Malting is usually not carried out on a brewery site but is an integral part of the brewing industry and as such is worthy of some attention in this Guide. Malt is derived from a cereal grain, usually barley, which has germinated for a limited period and has then been dried. It is rich in carbohydrate, degraded proteins, various B vitamins and inorganic material. It also contains an abundance of enzymes which are useful in the process of degrading starch into sugar.

Dark beers are derived from malt which has been dried or kilned under more severe conditions. The malt is known as chocolate malt because of its dark-brown colour.

The malting process involves three main stages:

(a) steeping the grain in water;

(b) germinating the grain;

(c) drying and airing.

Typically, 5 m^3 of water is used to produce one ton of malted barley. About 3,4 m^3 of effluent is generated per ton of malted barley, mainly as a result of steep water discharge. The effluent would typically have the following analysis:

Suspended Solids	250 mg/l
Chemical Oxygen Demand	3 000 mg/l
Total Carbon	1 300 mg/l
pH	5,5
Conductivity	100 mS/m

2.2.2 Milling and mashing

Malted barley is ground so that the husk is left intact while the rest becomes a very coarse powder, rich in starch and enzymes. This milling process can be done either wet or dry and for new breweries it is recommended that dry milling be employed because mill steep liquor makes a significant contribution to the brewery's total pollution load.

The enzymes contained in the coarse powder are capable of quickly degrading the starch to sugars on contact with water. This process is called mashing and is carried out in a mash tun. The product is called sweet wort and is a mixture of partially degraded starch, sugars, enzymes, proteins and water. The wort is then separated from the spent grains in a lauter tun. In the lauter tun the grains are sprayed or sparged with water in order to extract the maximum amount of useful material. The washings are monitored for sucrose content (Plato scale) and when the runnings from the lauter tun reach approximately 1° Plato the sparging is stopped. The spent grains are collected for off-site disposal, usually as animal feed, and the last runnings from the lauter tun are normally discharged to drain. Sometimes spent grains also find their way into the final effluent usually as a result of careless on-site handling and washing of spillages into drains. Sweet wort recovery could reduce the volume of the last runnings discharge.

2.2.3 Boiling with hops

The sweet wort from mashing is boiled in a copper kettle in order to:

(a) arrest further enzyme action;

(b) precipitate proteinaceous material (hot trub);

(c) sterilize the wort;

(d) hasten certain chemical changes.

Often excess water is freely evaporated but boiling under pressure is also feasible and is practised in some breweries.

The boiling process is normally associated with the addition of:

(a) hops or hop extracts for flavour;

(b) sugars or syrups;

(c) coagulants (of proteins or tannins).

Hot trub and other insoluble material is then removed in a whirlpool tank.

Spent hops, hot trub and other solid proteinaceous materials can be disposed of with spent grains to produce an enriched animal feed but are often discharged to drain. All breweries should be encouraged to provide sufficient storage capacity to contain trub and spent hops and then dispose of them with the spent grains as they can contribute up to 20% of the total daily organic pollution load in brewery effluent.

2.2.4 Wort cooling and fermentation

Clear hopped wort is cooled in order to prepare it for fermentation. Further precipitation of proteins and tannin occurs which is known as cold trub or fine break. During the cooling, aeration or even oxygenation takes place in preparation for the fermentation stage.

Fermentation begins with the addition of yeast and can continue for 2 to 16 days. Normally the yeast is added in one vessel (the fermentation vessel) and when the fermentation process has reached completion, the yeast is drawn off. The green beer is then transferred to another vessel (the storage or maturation vessel). This transfer process involves "chasing" the green beer from one vessel to the other with water. Inevitably the last runnings from this transfer process is heavily polluted and great care should be taken to minimise the volume which has to be discharged to drain.

Following the maturation period, yeast and/or yeast extracts known as tank bottoms, are removed by settling and sold. Again, care should be taken to avoid spillages.

Finings (fish collagens) are added to the beer after maturation to promote flocculation of any remaining yeast or proteins and the mixture is filtered through a filtration unit (such as a plate-and-frame filter) coated with a filter slurry of kieselguhr and/or lucilite. The result is a clear or bright beer. Spent filter slurry is highly polluting and a particular problem for municipalities because it settles very easily and tends to block sewers and pipes. Specially designed brewery equipment is required in order to prevent discharge of spent filter slurry and this should be incorporated into any new breweries.

If high gravity brewing has been practised it is usual to blend with sterile deaerated water to normal gravity after fermentation. Such high gravity brewing gives rise to substantial savings in the energy needed for wort boiling and cooling and in the size of vessels required to hold worts and beers.

Other additions at this stage include stabilizers to promote longer shelf life and foam improvers to retain a stable, white foam when the beer is poured.

2.2.5 Packaging and pasteurizing

Bright beer is stored and then filled into containers. In the process of filling, a small volume of beer (drip beer) is spilt. This should also be collected and can be reprocessed but often it is allowed to go to drain.

Bottle washing of returned bottles requires a considerable volume of water and greater use of non-returnable containers would reduce brewery water consumption.

Pasteurization also requires large volumes of water and balancing of pasteurizer water systems is essential to prevent wastage. Pasteurizer water recycle should be incorporated in new breweries as it can achieve major reductions in water intake.

Effluent from these stages is generally high volume and low strength in nature (due to dilution). The main pollutants are drip beer from fillers (as mentioned above), beer from pasteurizer breakages and beer residues in returned bottles.

Packaged beer is then placed in warehouses to await transportation to customers.

3 SUMMARY OF SURVEY RESULTS

3.1 Water intake

The results in this Section are best summarised in tabular form:

TABLE 1 - Typical SWI's for breweries in South Africa

Brewery	Average Beer Production/month (m^3)	Average Water Intake/month (m^3)	Specific Water Intake (SWI)
A	17 100	102 500	6,0
B	9 000	79 100	8,8
C	18 200	129 000	7,1
D	14 000	77 000	5,5
E	2 000	13 700	6,8
F	16 000	100 800	6,3
G	8 300	61 700	7,4
H	5 200	34 700	6,7

Points to note in relation to this Table are:

(a) Beer is normally brewed at high gravity (30% higher than normal) and afterwards blended to normal gravity, so to calculate average beer production, the average of beer brewed (normal gravity) and beer packaged has been used in this Guide;

(b) Production characteristics have to be investigated when considering data such as this because breweries which process large volumes of the same brand of beer will generally be more water efficient and produce lower pollution loads than those which produce a large variety of brands.

3.2 Breakdown of water use

For the purposes of this Guide the main water using areas of the brewery are:

(a) brewhouse;

(b) cellars;

(c) packaging area;

(d) utilities (including engine room, boiler house, cooling and amenities).

Water use attributed to these areas includes all water used there. It includes the water used in the product, vessel washing, general washing and cleaning in place (CIP) which are of considerable importance both in terms of water intake and effluent produced.

Taking a typical SWI of 6,65 and dividing it between the basic areas of the brewery, the following has been obtained:

- . Brewhouse : SWI 1,75 m^3/m^3.
- . Cellars : SWI 1,15 m^3/m^3.
- . Packaging : SWI 1,50 m^3/m^3.
- . Utilities : SWI 2,25 m^3/m^3.

(a) Brewhouse : For breweries which have high SWI's the brewhouse can account for the higher figure. In South Africa the variation in SWI for the brewhouse was 1,4 to 3 m^3/m^3. This can be compared with figures obtained by Pöhlmann (1980)[2] in West Germany for the same area. In this study the variation was found to be 1,8 to 4,2 m^3/m^3 of marketable beer.

(b) Cellars : This area, which includes filtration, had an SWI variation of 1,0 to 1,5 m^3/m^3. Pöhlmann gave a variation of 0,8 to 1,7 m^3/m^3 of marketable beer for this area. [2]

(c) Packaging : This area, which includes pasteurization, can also be responsible for high overall SWI's. The variation in South Africa was 1,3 to 1,8 m^3/m^3 which again compares favourably with Pöhlmann's findings [2] which were 0,9 to 1,9 m^3/m^3 of marketable beer for the same area.

(d) Utilities : This covers engine room, boilers, cooling and general amenities and also shows wide variation, especially boilers which can have SWI's between 0,7 to 1,9 m^3/m^3. For combined utilities Pöhlmann found a variation of 1,25 to 3,3 m^3/m^3 of marketable beer. [2]

As this area includes general amenities such as office, truck fleet, canteen and ablution blocks, it is probable that considerable savings could be achieved here simply through reduction in water wastage.

3.3 Effluent

It is much more difficult to generalise about brewery effluents than for water intakes because of the large variation in management practices which can significantly affect effluent quality and quantity. However, typical final effluent pollution loads are given in Table 2.

Between 65 and 70% of incoming water to a brewery leaves as effluent. It should also be remembered that brewery effluent can vary enormously from one minute to the next. After intensive sampling of brewery effluent it has been established that approximately 100 samples would need to be taken over a 24-hour period to obtain a composite sample representative of that 24-hour period. Great care should therefore be taken with sampling procedures.

TABLE 2 - Typical final effluent loads

Total effluent volume m^3/month	OA (settled) kg/month	TOC (soluble) kg/month	COD (total) kg/month	SS kg/month	TDS kg/month
100 000	26 000	63 500	296 000	130 000	175 000

Previously brewery effluent was thought to contain a certain amount of intractable organic material but experience with modern treatment technology would suggest that given a reasonable residence time, up to 90% COD removal can be achieved.

3.4 Breakdown of pollution load

In a similar way to that employed in Section 3.2, the Specific Pollution Load (SPL) of brewery effluent based on various parameters, can be assessed in the four key areas of a brewery.

Parameters chosen in this Guide are Suspended Solids (SS), Total Dissolved Solids (TDS) and Chemical Oxygen Demand (COD). Other organic parameters such as Oxygen Absorbed (OA) or Total Organic Carbon (TOC) could be used instead of COD. An attempt has been made to derive a ratio between these three organic parameters from chemical anlayses of brewery effluents (see Section 3.5).

An attempt has also been made to determine the Specific Effluent Volume (SEV) for each of the key brewery areas. Variation in SEV and SPL is shown in Table 3.

A representative SEV is 4,5 m^3/m^3. Although results for breweries A and B show the same values for SPL based on COD, there are special reasons related to production patterns which explain why they are higher than expected. Brewery F implements effluent pretreatment. For this reason the SPL based on COD for brewery C, (10,4 kg COD/m^3), has been chosen as more representative and accordingly has been used to show the breakdown of SPL for a brewery. The SPL based on SS is more consistent and 2,9 kg SS/m^3 has been used. An SPL based on TDS of 7,9 kg TDS/m^3 has been found.

The breakdown of SPL in a typical brewery is shown for COD, SS and TDS in Table 4.

TABLE 3 – Typical specific pollution loads

Brewery	Average Beer Produced/month (m^3)	Average Effluent Produced/month (m^3)	SEV (m^3/m^3)	SPL		
				$\frac{kg\ COD}{m^3}$	$\frac{kg\ SS}{m^3}$	$\frac{kg\ TDS}{m^3}$
A	17 100	70 500	4,1	20,0	4,0	5,6
B	9 000	40 000	4,4	20,0	2,9	9,9
C	18 200	93 000	5,1	10,4	2,9	8,3
D	14 000	nm *	nm	nm	nm	nm
E	2 000	nm	nm	nm	nm	nm
F	16 000	43 500	2,7	0,7	nm	nm
G	8 300	51 700	6,2	9,4	nm	nm
H	5 200	25 300	4,9	10,7	1,6	nm

* nm = not measured

TABLE 4 – Breakdown of SPL within a typical brewery

Area	SEV (m^3/m^3)	Effluent Quality – SPL		
		kg COD/m^3	kg SS/m^3	kg TDS/m^3
Brewhouse	0,5	3,7	0,7	0,5
Cellers	1,15	3,1	2,1	0,5
Packaging	1,5	3,5	negl.*	0,2
Utilities	1,35	0,1	0,1	6,7
Totals	4,5	10,4	2,9	7,9

* negl. = negligible.

SPL based on COD has been reported for breweries in West Germany by researchers Seyfried (1980) [3], Gehm and Bregman (1976)[4] and Seyfried and Rosenwinkel (1981)[5] as shown in Table 5. All these reported SPL's were based on BOD_5 and have been converted to COD using the ratio between the two established in Section 3.5 of this Guide.

3.5 Effluent parameter ratios

From the large number of chemical analyses of brewery effluent collected as data for this Guide, ratios between the main organic pollution parameters were derived.

TABLE 5 - Comparative SPL's for South Africa and West Germany

	South Africa	Seyfried	Gehm & Bregman	Seyfried & Rosenwinkel
Specific Pollution Load (kg COD/m^3)	10,4	12,0	23,6	10,6

These are calculated as:

1 OA : 2,6 TOC : 5,6 BOD_5 : 11,2 COD.

As no BOD_5 analyses were carried out we have derived a ratio of BOD_5 to OA from brewery effluent data reported by Briggs et al[1]. This gave a ratio of BOD_5 to OA of 5,6.

These ratios have been used several times in this Guide to convert data only available in terms of other organic parameters to COD, which has been used as standard throughout the Guide. Of particular interest is the ratio of COD to TOC and OA to TOC. COD/TOC = 4,3 and OA/TOC = 0,4. As TOC may be the parameter used to determine organic pollution loads in the future, these ratios could be of interest to researchers and legislators alike. The ratio of COD to BOD_5 was found to be COD/BOD_5 = 2,0.

3.6 Solid wastes

Breweries produce large quantities of solid wastes as shown in Table 6.

In a number of breweries, several of these solid wastes are present in the final brewery effluent though it is possible through correct design and management to dispose of all of them in other ways off-site.

TABLE 6 - Typical solid wastes for a brewery producing 17 000 m^3/month

Solid Waste	Quantity
Spent grains (80% m/m moisture)	20 t/100 m^3 brewed
Surplus yeast (90% m/m moisture)	3 m^3/100 m^3 brewed
Kieselguhr (70% m/m moisture)	0,6 m^3/100 m^3 packaged
Ash	1,7 t/100 m^3 packaged
Malt and maize dust	250 kg/100 m^3 brewed
General (incl. cardboard, plastic, glass and tyres)	180 t/month

They are also in some cases valuable by-products which could be sold by the brewery. Two examples are:

(a) Spent grains, spent hops and trub which represent a valuable source of protein for animal feed and would generate some additional revenue from sales. The spent grain yields typically 125 to 130 kg wet for every 100 kg of malt and its composition is 28% protein, 8% fat and 41% nitrogen-free substances;

(b) Surplus yeast which can also be resold as animal feed. On a dry solids basis, the yeast contains 50 to 60% proteins, 15 to 35% carbohydrates and 2 to 12% fat making it another valuable source of protein for animal feed.

4 CONCLUSIONS AND RECOMMENDATIONS[6]

4.1 Water intake

Breweries in South Africa have a range of SWI of between 5,5 and 8,8 m^3/m^3 with a typical SWI of 6,65 m^3/m^3. Considerable advances have been made within the industry itself in recent years in achieving these figures. In 1983, a typical SWI was 9,2 m^3/m^3 and the range was 7,8 to 10,3 m^3/m^3 (ref.7).

However, the water resources in South Africa are scarce and every effort should be made to reduce water intake further. In West Germany SWI's as low as 4,85 m^3/m^3 have been reported and theoretically an SWI of less than 4,0 is achievable, assuming pasteurizer water recycle is employed.

With these facts in mind, target SWI's could be set at 6 m^3/m^3 for existing breweries and 5 m^3/m^3 for any new breweries. Improved water efficiency can be achieved in two basic ways:

(a) improving water management;

(b) introducing new technology where possible - particularly in new breweries.

Methods of reducing water intake are listed below:

(a) Dry milling of malted barley;

(b) Greater use of non-returnable containers - bottle washing requires 0,50 l per bottle;

(c) Installation and control of water meters at all sections of the operation;

(d) Improved staff training to increase awareness of water-saving methods;

(e) Greater use of high-pressure, low volume equipment for cleaning. Consumption is likely to be only 25 to 50% of that used in a low pressure system;

(f) Greater use of CIP installations for pipes and tanks;

(g) Greater water recovery in CIP operations, particularly by ensuring that recovered water vessels are sized properly - no overflows;

(h) Reclamation of bottle washer rinse water;

(i) Pasteurizer water recycle;

(j) Use of compressed air for cleaning where possible, e.g. to clean the mashing filter.

It should be noted that any reduction in water intake is likely to increase effluent concentrations. It is therefore important that reduction in water intake should be implemented simultaneously with measures aimed at reducing the pollution load in the brewing effluent.

4.2 Effluent

The quality and quantity of brewery effluent can vary enormously according to the design of the brewery and the management practices implemented. Accordingly, it is much more difficult to set targets for SPL than for SWI but the survey results have shown that an SPL of 10 kg COD/m^3 beer would be reasonable for existing breweries and 7,5 kg COD/m^3 beer for any new breweries.

A number of sources of high-organic effluent are listed in Table 7.

TABLE 7 - Main sources of high-organic effluent in a brewery

Effluent Source	kg COD/m^3 Brewed
Trub from hot wort receiver	3,2
Last runnings - FV/SV transfer	2,7
Lauter tun last runnings	2,5
Cleaning fermentation vessels	1,4
Spent filter slurry	1,4

It is clear that just the load from the effluent sources in Table 7 could exceed the target set of 10 kg COD/m^3 of beer though they are peak values and not averages. However, several of them can very easily be eliminated from the effluent by appropriate management strategy as they are relatively low volumes.

Methods of reducing pollution loads in brewery effluents are listed below:

(a) Dry milling of malted barley;

(b) Sweet wort recovery;

(c) Recovery of spent grains, spent hops and trub for resale as animal feed;

(d) Minimize fermentation vessel/storage vessel transfer last runnings;

(e) Prevent kieselguhr from entering effluent drains by installing gravity settling or by removing it as a semi-dry cake from plate-and-frame filters;

(f) Recovery of yeast for sale as animal feed;

(g) Recovery of drip beer from fillers (approximately 3 ml per bottle);

(h) Use of waterproof labels and reduction in the amount of glue;

(i) Use of spent grains as an absorbent. The spent grains could be centrifuged to reduce their moisture content and the dewatered grains could then be contacted with strong effluent and having absorbed as much organic material as possible, be sold in the wet state as animal feed.

4.3 Effluent treatment[8]

4.3.1 Balancing of effluent

Balancing is the storage and mixing of effluent over a chosen period to smooth out the volumetric discharge rate and the pollutant strength. It is particularly important when dealing with brewery effluent due to the extreme fluctuations which are experienced in effluent volume and strength as a result of the brewing process.

It is recommended that all breweries in South Africa should balance their effluent, whether as a first step towards pretreatment or even if the effluent is discharged to a municipal treatment works, as a balanced brewery effluent is much easier to treat in both cases. Care should be taken in the sizing of a balancing facility because holding brewery effluent for longer than a few hours may result in highly anaerobic conditions and considerable odour problems.

4.3.2 Solids removal

Prior to balancing or discharge, brewery effluent should undergo solids removal. This can be done effectively by the use ot screens. Fine screens are available in rotary, vibrating and static versions and static wedgewire screens have proved effective in removal of spent grains from brewery effluent. They must, however, be cleaned regularly to maintain efficient operation.

4.3.3 pH Control

The control of pH within certain limits is necessary irrespective of whether the effluent is discharged into the municipal system or pretreated on-site. Municipal limits are generally from pH 6 to pH 10-11. For biological treatment the optimum pH lies between 6,5 and 7,5.

4.3.4 Anaerobic treatment

A high-rate anaerobic system is now available in South Africa and has already been successfully installed at one brewery. This high-rate system is said to be capable of treating high-strength wastes in equipment requiring low retention times at lower overall costs.

There are more than 35 full-scale plants of this type operating worldwide. With digester volumes generally between 1 500 m^3 and 4 000 m^3, these systems are designed to treat daily COD loads ranging from 5 000 to 50 000 kg. Volumetric loading capacities in excess of 10 kg COD/m^3 have been achieved and COD removal is 80 to 90% in most cases.

As well as brewing effluents, waste water from alcohol distilleries, bakers yeast manufacturers, grain starch manufacturers and the sugar and potato industries have been successfully treated using this technology.

4.3.5 By-product recovery from brewery effluent

Pretreatment of high-strength brewery waste by collection, fermentation, ethyl alcohol stripping and solids removal has proven to be an effective method of plant chemical oxygen demand (COD) and suspended solids (SS) reduction. Organic removal is about 80% and SS removal is 98%.

The system has been demonstrated to be shock loading stable, it produces a valuable by-product (ethyl alcohol) and it can stop/restart without problems.

Collection equipment for the treatment system can be installed in all areas of the brewery which have high-strength waste streams. These can include:

(a) lauter tun drains, hop and trub solids;

(b) surplus yeast;

(c) fermentation vessel rinsings;

(d) drip beer from fillers;

(e) returned packaged beer/unsaleable dump beer.

4.4 Internal control and record keeping for the brewing industry

It is believed that data to monitor SWI and SPL in the brewing industry could be updated relatively simply. Breweries would be required to submit monthly:

(a) beer brewed (normal gravity);

(b) beer packaged;

(c) water intake;

(d) average COD, TDS and SS concentrations of the effluent;

(Every brewery should sample their effluent regularly and should analyse monthly 24-hour composite samples. As mentioned earlier in the Guide, the variability of brewery effluent would suggest that these 24-hour composite samples should be made up of samples taken every 5 to 10 minutes, meaning that an automatic sampler would be required.

Efforts should also be made by breweries to measure the volume of effluent which they are discharging).

(e) details of any major changes in the brewery plant.

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