Natsurv 7:

Water and Wastewater Management in the Red Meat Abattoir Industry

(Edition 2)

Jerrard Müller

WATER RESEARCH COMMISSION

TT 701/16

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Report to the
Water Research Commission

by

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in association with the Red Meat Abattoir Association

WRC Report No. TT 701/16

January 2017

Obtainable from

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The publication of this report emanates from a directed project entitled *Revision of Natsurv 7: Water and Wastewater Management in the Red Meat Abattoir Industry* (WRC Project No. K5/2385).

This is a revised and updated version of Natsurv 7 that was published in the Natsurv-series in 1987 as WRC Report TT 41/89.

ISBN 978-1-4312-0868-5

Printed in the Republic of South Africa

EXECUTIVE SUMMARY

Internationally, red meat abattoirs are known to be high volume water consumers. Similarly, they are also serious polluters of wastewater.

The increasing demand of increasing number of domestic water consumers, and the limited supply in a water scarce South Africa focuses the attention on high volume industrial consumers to assist in reducing water consumption.

Red meat abattoirs process the following animals:

- Cattle
- Sheep
- Pigs
- Ostriches

During the 1988 Natsurv 7 survey period, there were 25 registered abattoirs throughout South Africa, out of which the ten large metropolitan abattoirs (owned by Abakor) processed approximately 50% of the national red meat requirements. In these large abattoirs, weighted process water consumption ranged between 0.7 kl and 1.2 kl per slaughter unit (SU), whilst in smaller abattoirs consumption figures of as high as 4.64 kl per SU was recorded.

The deregulation of the South African meat industry in the 1980s brought about the demise of Abakor, and most of the large abattoirs closed down. The markets opened up and smaller abattoirs proliferated, taking over the role of the large abattoirs. Management staff of smaller abattoirs is quite often not seriously concerned with water consumption and wastewater quality, as they focus on the quality of meat, which is their core business.

Abattoirs in the category of 2-20 slaughter units now (2015) represent 45% of the slaughter capacity in South Africa. Water consumed per SU increases inversely to the abattoir slaughter capacity. Average consumption for large abattoirs is 0.91 kl/SU, increasing to 2.04 kl/SU (124%), for small abattoirs.

Wastewater qualities similarly have average COD values of 1217 mg/l for large abattoirs and values as high as 5025 mg/l in small abattoirs.

Abattoir management can greatly influence the volumes of water consumed as well as the quality of wastewater produced in red meat abattoirs.

Reducing water consumption and improving wastewater quality can have major impacts on the financial viability of red meat abattoirs.

To assist abattoirs in reducing water consumption and improving wastewater quality, thereby reducing production costs, a best practice guide has been provided. Finally, a detailed action plan has been supplied.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

COD	Chemical oxygen demand
CU	Cattle unit
FOG	Fats, oils, and greases
OA	Oxygen absorbed
RMAA	Red Meat Abattoir Association
RO	Reverse osmosis
SEV	Specific wastewater volume
SPL	Specific pollution load
SS	Suspended solids
SU	Slaughter unit
SWI	Specific water intake
TDS	Total dissolved solids
TKN	Total Kjeldahl nitrogen
UF	Ultrafiltration
WRCU	Water-related cattle unit

GLOSSARY OF TERMS

CHEMICAL OXYGEN DEMAND (COD)	The COD test is used to indirectly measure the concentration of organic compounds in water. Most applications of COD determine the amount of organic material in surface water or wastewater, making COD a useful measure of water quality, expressed in milligrams per litre (mg/), which indicates the mass of oxygen required to oxidise the chemical solutes and solids per litre of water.
LAIRAGES	Stock-holding pens where animals are held pre-slaughter at an abattoir.
OFFAL	The organs of a slaughtered animal, usually divided into: • Red Offal o heart o liver o kidneys o ox tongues • Rough Offal o Stomach o Intestines o other organs
PRE-BREAKER	Item of plant in which large pieces of condemned carcasses are broken down to smaller sized pieces, suitable for further processing, such as sterilising and rendering.
RENDERING	Cooking and sterilising of animal waste products, which are not fit for human consumption (i.e. “condemned”), as well as evaporation of moisture in order to produce a proteinaceous meal. Melted fat is normally recovered for further utilisation, such as tallow production.
SLAUGHTER UNIT (SU)	The number of non-bovine species considered equivalent to one bovine animal for abattoir purposes.
SPECIFIC POLLUTANT LOAD (SPL)	The pollutant mass load for a period (in terms of any parameter, e.g. COD, TKN) arising from an industrial unit process divided by the number of SU used in production during the same period.
SPECIFIC WASTEWATER VOLUME (SEV)	The wastewater volume generated in a particular period divided by the number of slaughter units processed during the same period.
SPECIFIC WATER INTAKE (SWI)	The water intake for a particular period divided by the number of SU during the same period.
SPECIFIC WATER USE (SWU)	The water used in an industrial unit process divided by the number of SU processed.
STICKING	The slitting of an animal’s throat after stunning, allowing the carcass to bleed.
STUNNING	Mechanical, electrical or other means of rendering an animal unconscious before slaughtering, in an approved and humane manner.

SUSPENDED SOLIDS (SS)	Small solid particles which remain in suspension and are not dissolved in water. Suspended solids are important, as pollutants and pathogens are carried on the surface of particles. The smaller the particle size, the greater the total surface area per unit mass of particle, and so the higher the pollutant load that is likely to be carried.
TOTAL DISSOLVED SOLIDS (TDS)	A measure of the combined content of all inorganic and organic substances dissolved in water. Generally, the operational definition is that the solids must be small enough to survive filtration through a filter with pores of two micrometre (nominal size, or smaller).
TOTAL KJELDAHL NITROGEN (TKN)	The sum of organic nitrogen, ammonia (NH_3), and ammonium (NH_4^+) in the chemical analysis of water and wastewater.
WATER INTAKE	All water entering premises from municipal and/or other sources such as boreholes, rivers, etc.

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1 INTRODUCTION

Red meat abattoirs typically process the following animals:

- Cattle
- Sheep
- Pigs
- Ostriches

As the South African meat industry was being deregulated in the late 1980s to early 1990s, red meat abattoir owners realised they would require an industry representative body. The Red Meat Abattoir Association (RMAA) was commissioned in February 1991 to act as a representative forum for abattoir owners in South Africa. The majority of red meat abattoirs are affiliated with the RMAA.

The abattoir industry is responsible for the conversion of livestock to edible meat. This process remains critical to ensure a safe and wholesome product to consumers. The Meat Safety Act, 2000 (Act no. 40 of 2000) addresses measures to promote the safety of meat and animal products and to establish and maintain essential national standards in respect of abattoirs.

Up to the early 1990s, Abakor was the largest single role player in the industry, slaughtering approximately 50% of the national requirements in their ten large abattoirs, with the remaining 50% being processed through 275 smaller abattoirs.

The demise of Abakor brought about opportunities for the change of ownership, expansion of privately owned abattoirs and building of new abattoirs. Owners could suddenly increase their slaughter throughput. They could afford to upgrade their abattoirs and implement new slaughter techniques and slaughter procedures. This has had significant effects on the water consumption and wastewater production of red meat abattoirs.

While Abakor had strict control measures in place to minimise water consumption, wastewater production, and pollution, according to the 1988 Natsurv results, the water consumption in large abattoirs was considerably lower per slaughter unit (SU) than the consumption in small abattoirs. In larger abattoirs, systems were in place to effectively monitor and control water usage, while in smaller abattoirs, water consumption was not being monitored or controlled.

When the number of large abattoirs reduced, and the number of small abattoirs increased to cope with red meat demand, the overall industry usage patterns changed dramatically. The 1988 Natsurv 7 survey is therefore outdated.

In the 1988 survey, 84 % of the water intake was deemed to have been discharged as wastewater. During the 2015 survey, it became apparent that the average figure seems to be slightly lower, in the region of 82%.

Wastewater quality from red meat abattoirs could be broadly summarised as follows:

- pH 5.7 to 8.4
- COD 730 to 8 900 mg/l
- suspended solids 1 700 to 3 048 mg/l
- TDS 595 to 2805;
- Total Kjeldahl Nitrogen 1.0 to 24.0 mg/l

Abattoirs require potable water for processing of carcasses and other related products for human consumption.

Solid waste emanating from abattoirs are categorised as:

- Dewatered solids:
    - Hair
    - Stomach content (fibres)
        - Disposal means include removal by farmers for various types of animal feed, compost supplementation, or
        - Disposal to landfill (if permitted) with chlorine and lime pre-treatment, trenching and covering.

- Fat and oil skimmings
    - Could be utilized for further processing, or landfilled (if permitted) with chlorine lime pre-treatment, trenching and covering.

- Blood solids
    - Normally converted into blood meal. However, at small abattoirs blood disposal present severe problems, with blood being, inter alia, sprayed on land as fertilizer. Unfortunately this action also attracts vermin, birds and other animals such as jackal, which could distribute diseases contracted from condemned carcasses. Blood was also found to be dumped into trenches, and covered over.

- Hides
    - Utilised in tanneries for processing of leather

- Other waste, including animal trimmings, feet, heads and condemned carcasses
    - Utilised in pet food manufacture

- Hooves
    - Utilised for gelatine manufacture

2 PRODUCTION PROCESSES

2.1 Overview

The red meat abattoir industry is internationally renowned to be a high water consumer, with intense wastewater pollution.

South Africa is facing severe water shortages in 2015 – according to the Department of Agriculture, Fisheries and Forestry (2012), availability of fresh water is 1 700 kl per capita, the expected availability in 2025 will have reduced by 41% to 1 000 kl per capita, which is being exacerbated by the deteriorating water infrastructure, resulting in huge fresh water losses during the distribution process.

Red meat abattoirs are divided into categories determined by the maximum (design) capacity of the abattoir.

In the 2014/15 study it became apparent that newly built abattoirs, and abattoirs where alterations have been done, had undergone significant design changes, and determination or categorisation of wastewater quality had to envelop the new design layouts.

Water supply networks have been installed in ring systems for optimised water supply and water pressure purposes, or they have been installed under-floor and underground to facilitate the installation of smaller diameter (and less expensive) piping networks. A single supply pipe would therefore have branches at various positions into different processing areas, making it impossible to determine water consumption for individual slaughter areas.

In the older abattoirs, additions, alterations and modifications have rendered the existing metering systems inaccurate.

The quantity of water used in red meat abattoirs is linked to the number of animals slaughtered. For ease of use, a comparative measure was developed which enabled the simultaneous monitoring of the three species which are generally processed in these abattoirs. The term “water related cattle unit” (WRCU) was introduced in the 1988 survey, but this terminology was never accepted by the industry. The industry-developed term is “slaughter units” (SU), with the ratio between species as indicated below.

Table 1. Abattoir Slaughter Units

Category	Number per Slaughter Unit
Cattle	1
Sheep / goats	6
Pigs	2

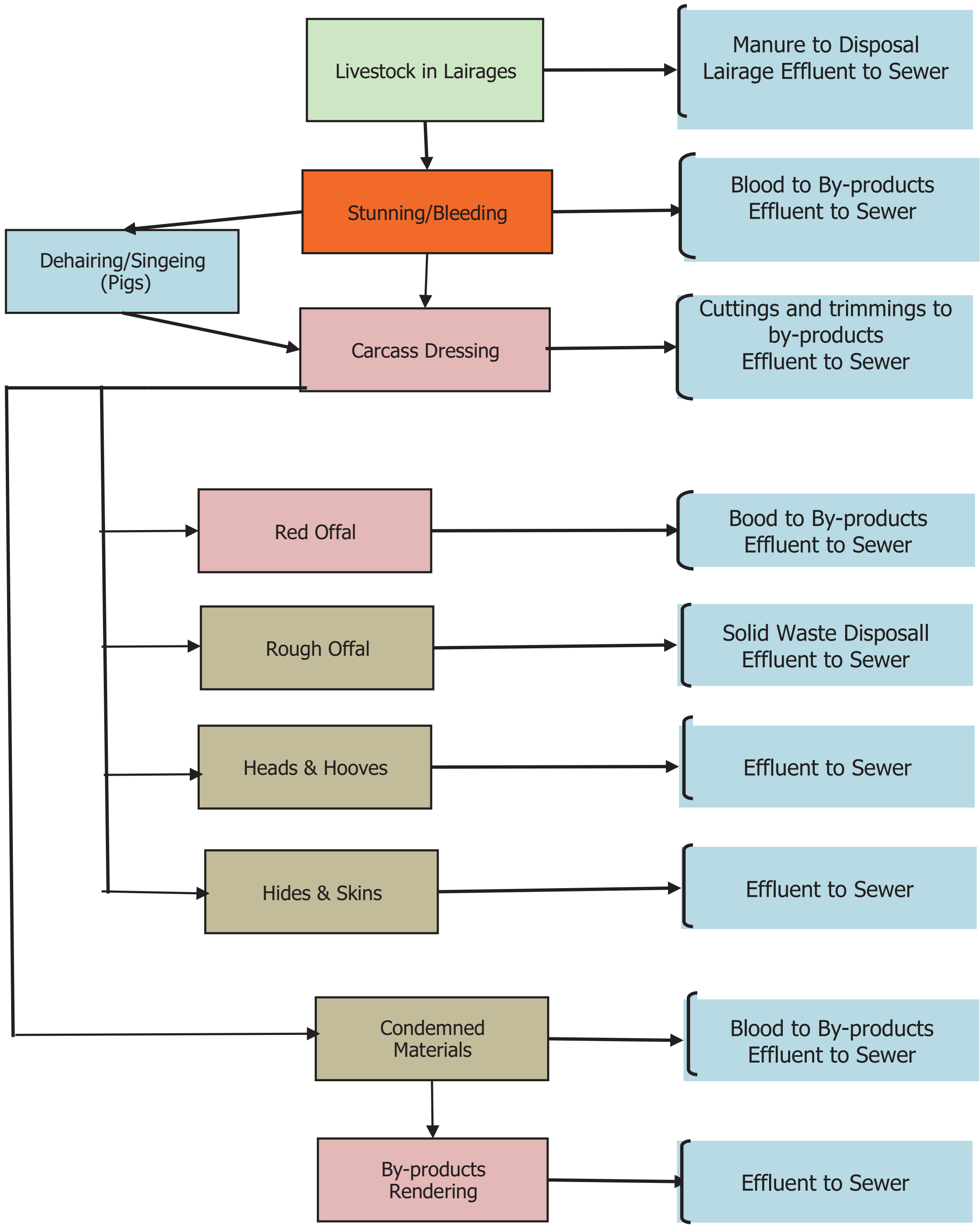


Figure 1. Water and waste related flow chart

2.2 Abattoir size distribution

In the 1988 Natsurv 7 survey, red meat abattoirs were divided in five capacity categories, grades "A" (largest) to "E" (smallest) based on daily slaughter capacity.

The main large abattoirs have mostly been closed down, and the total number of abattoirs has increased dramatically (by 52%):

- 285 officially registered abattoirs in 1998
- 432 abattoirs in 2014 according to RMAA records.

The emphasis has changed to a larger number of smaller abattoirs, which are now divided into five categories, as listed below:

Table 2. Abattoir size distribution

1998					2014			
Class	**Capacity (SU)**	**No.**	**% of Total No.**		**Class**	**Capacity (SU)**	**No.**	**% of Total No.**
A	>100	28	10%		**Large**	>100	78	18%
B	51-99	16	6%		**Medium**	51-100	17	4%
C	21-50	34	12%		**Small**	21 50	36	8%
D	6-15	56	20%		**Smallest**	2-20	216	50%
E	1-5	151	53%		**Rural**	1-2	69	16%
					Undetermined		16	4%
Total		285	100%		**Total**		434	100%

In all nine South African provinces, the "smallest" category of abattoirs has proliferated, and 49.8% of the total slaughter capacity is based in these small size abattoirs.

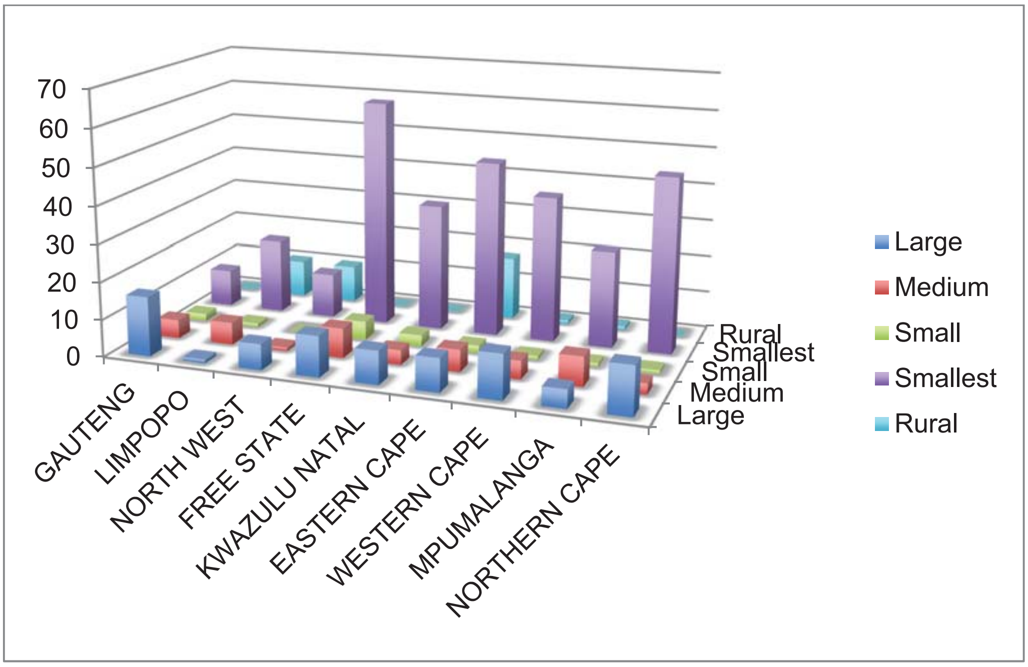


Figure 2. Capacity of Red Meat Abattoirs per Province

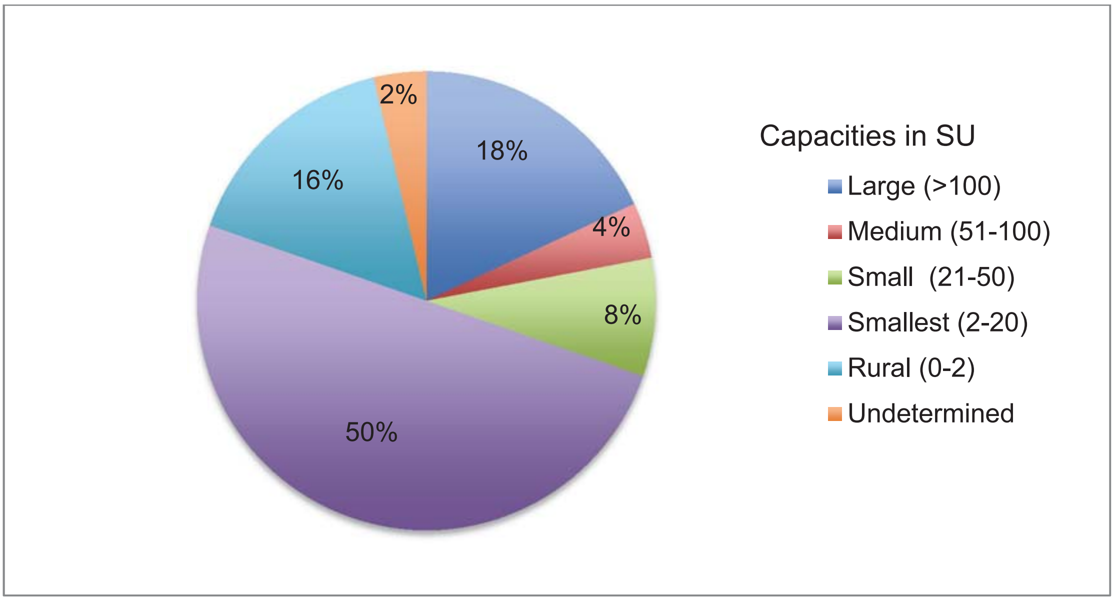


Figure 3. National size distribution of red meat abattoirs

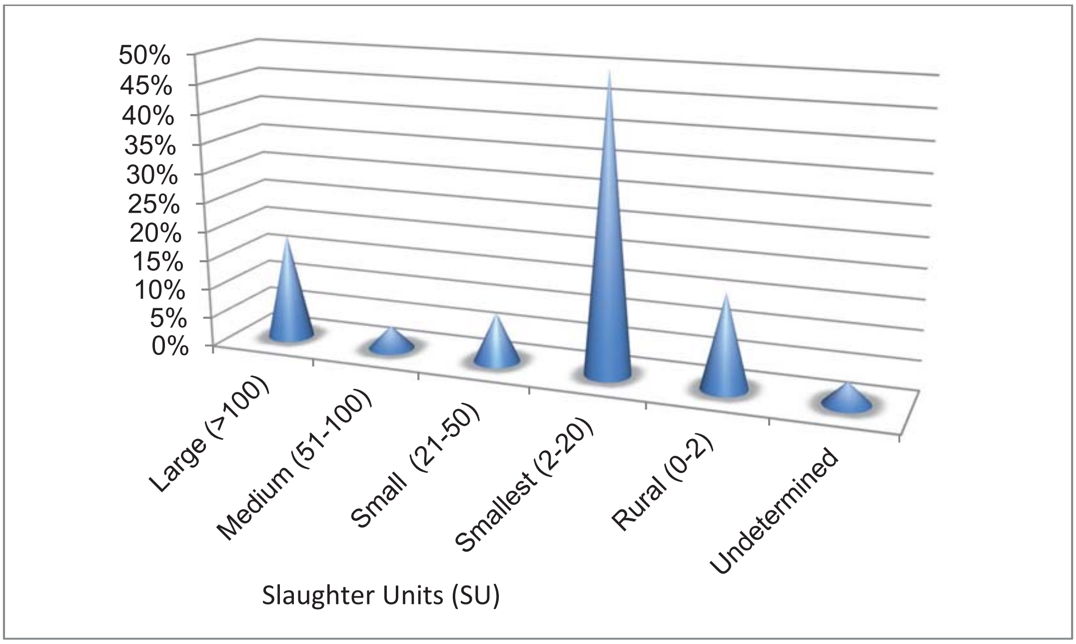


Figure 4. Percentage of capacity in different sizes of abattoir

2.3 Abattoir processes

The slaughtering process may be considered as a series of chronological batch operations, which are generally similar for cattle/calves/horses, sheep/goats, and pigs. However, the three main species are, due to specific requirements, preferably processed in separate areas, when handled in one particular abattoir.

2.3.1 Lairages (stock-pens)

Holding pens/areas where animals are kept separately by specie, and anti-mortem inspections are conducted to identify possible diseases. Holding times generally vary from a few hours to a day or two.

The lairage structure generally consists of a graded concrete floor sloping towards floor drainage outlets. Lairages are generally covered with a roof structure to provide shade and prevent contaminated storm water entering the wastewater drainage system.

Drinking troughs are provided, but animals are normally not fed unless they spend more than 48 hours in the lairages to minimise the volume of paunch content to be disposed of after slaughtering.

Lairages are normally cleaned at least once per day by initial dry-cleaning, followed by a cold water wash down. In larger abattoirs, the wastewater would be channelled over screens for the removal of solid waste particles, before the liquid part being treated further or discharged to the municipal sewer.

2.3.2 Stunning

At larger abattoirs, each specie is processed separately, while in smaller abattoirs, the same facilities are used on a rotational basis for different species.

Animals are normally rendered unconscious by one of various methods, such as electrical shock or a stunning pistol before slitting of the throat – for normal slaughter as well as for Halaal ritual slaughter.

In kosher slaughtering, stunning is not practised – the throats of live animals are slit by a Rabbi.

2.3.3 Sticking / bleeding

This term is used for slitting the throat, normally over bleeding troughs, where blood is collected and then transferred into a receptacle for further processing.

Coldwater wash-down is done periodically during the slaughter process.

Blood should be contained and not allowed to enter the wastewater drainage system, as this has a high pollution effect on the quality of the liquid wastewater.

Hot water at temperatures of approximately 82˚C is supplied to small basins, for purposes of sterilising equipment and knives.

2.3.4 Hoof and head removal

This process is performed manually by cutting heads and hooves from the carcass. Heads and feet are normally transferred to an area for further processing or rendering by means of conveyors, chutes or small pans or bins. These items are spray-washed en-route and the processing area is periodically hosed down.

The wastewater drains to sewer.

2.3.5 Hide removal

Removal of hides and skins is often performed by means of mechanical "hide pullers" in larger abattoirs, or manually in smaller abattoirs. These are trimmed by removing fats, etc. and then transported to tanneries for further processing.

Pollution of wastewater occurs when fat particles are dislodged, and washed down to sewer.

2.3.6 Carcass wash-down

After removal of hides, the carcasses are washed down with high-pressure cold water jets, which are either done manually or by means of automated spray booths.

Blood and pieces of fat are the main wastewater contaminants.

2.3.7 Dearing

Dearing of pig carcasses is accomplished by submergence in a scalding tank containing hot water above 80˚ C (maintained by steam heating coils, live steam or a continuous flow of hot water) after which the carcass enters a detailing machine, where rotating rubber strips or “fingers” flay off most of the hair or bristles. The last process of hair removal is carried out by manual scraping and finally singeing (burning by means of an open flame).

Water from the scalding tank is discharged continuously throughout the process shift, and also at the end of each slaughter period.

The bristles are sometimes recovered or otherwise discharged to sewer. This wastewater normally has a very high COD.

2.3.8 Evisceration

Removal of the viscera is carried out by mechanically cleaving or splitting the carcass and allowing the stomach, intestines and internal organs to fall onto a pan, which could be handled manually, or could be connected to a conveyor, being kept clean by water sprays.

Accidental damage to viscera results in spillage of contaminants such as paunch contents onto the process floor, creating wastewater contamination.

2.3.9 Hygiene inspection

After evisceration, the head and feet conveyor, the carcass conveyor and the viscera conveyor are synchronised to pass an inspection point where all the component parts of a single animal are inspected simultaneously to determine the suitability of the carcass for human consumption.

If the animal is condemned at this point, all parts are transferred to a condemned room for subsequent rendering in a by-products plant (if provided) or incinerated (if not provided), or disposed of by other means.

Water utilised for the cleaning process in the condemned room, is discharged directly to sewer, and not to any wastewater pre-treatment plant, due to the possibility of cross-infection or cross-contamination.

Carcasses which are approved for human consumption then proceeds further on the dressing line for splitting, while the viscera are sorted and conveyed to the various separated offal processing areas.

2.3.10 Red offal

Red offal (hearts, lungs, kidneys and livers) requires only some cold water washing to remove blood, etc. before storage, resulting in a small amount of wastewater being discharged to sewer.

2.3.11 Rough offal

This process comprises the opening up of paunches and intestines for dry removal of paunch content, where after washing by means of cold water sprays takes place, to clean the offal to required standards for human consumption.

Water usage is higher than in any other abattoir operation. The paunches and intestines contain large quantities of suspended solids and the organic strength of paunch contents and associated wash waters is very high. Wastewater from the rough offal processing area is usually screened prior to discharge to sewer.

2.3.12 Carcass splitting

This process normally consists of mechanically splitting the carcass down the backbone, to facilitate ease of handling (sheep carcases are not split).

Trimming is carried out manually to remove pieces of fat or meat before manually washing the carcass with high-pressure cold water jets.

Wastewater is contaminated by pieces of meat and fat and saw-cuttings derived from the carcass splitting process.

NOTE: At the end of each process shift, large quantities of hot and cold water are utilised in the slaughter processing areas for cleaning and sterilisation purposes.

2.3.13 Cold storage

In the larger abattoirs, cold storage has to be provided. Carcasses must be stored at temperatures between 0°C and 5°C. Maintaining the required temperatures in cold rooms involves the use of large chilling systems. Some abattoirs use evaporative cooling systems, where large quantities of water are evaporated to achieve the desired cooling effect. Cooling coils inside chiller rooms experience a build-up of ice on the chiller coils, these are defrosted periodically, and the defrosted water finds its way to the wastewater stream.

Small volumes of water are used in the cold rooms for cleaning purposes.

2.3.14 By-products processing

By-products processing includes the transforming of condemned meat, blood and carcass trimmings into usable by-products.

Where economically viable, the most attractive route is rendering to produce marketable by-products such as carcass meal blood meal and tallow. The large capital layout for rendering plants however restricts their installation to the very large abattoirs, which then can also handle products from neighbouring smaller abattoirs.

Water is used for steam generation (for the cookers), plant cleaning, sterilisation and vapour condensation for odour control.

Wastewater is generated as condensates and floor washings.

2.3.15 Deboning or meat packing

Abattoirs have started doing their own value adding in the food chain, and are doing further processing to supply meat in consumer demanded cuts.

As this is not considered part of the slaughter process, this element was excluded from the study.

3 LEGISLATION AND REGULATIONS

Various acts control the operation of abattoirs, of which the most applicable are:

- **Meat Safety Act 2000, Act no. 40 of 2000**: Control of abattoirs and abattoir processes.

  To provide for measures to promote meat safety and the safety of animal products; to establish and maintain essential national standards in respect of abattoirs; to regulate the importation and exportation of meat; to establish meat safety schemes; and to provide for matters connected therewith.

  The provisions of this act is overseen by the National Executive Officer of the Department of Agriculture, Forestry and Fisheries.

- **Animal Diseases Act, 1984, Act no 35 of 1984**. Controlled by the Department of Agriculture, Forestry and Fisheries.

- **Animals Protection Act, Act no. 71 of 1962. H**andling of animals presented for slaughter.

- **Environment Conservation Act, Act no 73 of 1989** introduces legal obligations on the generator of waste, and is controlled by the Dept. of Environmental Affairs.

  Off-site disposal: As regards waste being removed from an abattoir, Section 20(9) requires disposal to "appropriately permitted" facilities. Abattoir operators must accordingly confirm that the receiving site is appropriately permitted (or exempted) in terms of section 20(1) of ECA, and further that the waste is in fact received at the site and disposed of in accordance with the prescribed disposal method .

- **National Water Act 1998, Act. No. 36 of 1998.** The management of abattoir waste is regulated through NEMA, (NWA) the Meat Safety Act and sections 24a and 24b of the Constitution of South Africa, 1996.

- **Meat Safety Act 1992, Act no 40 of 2000** Improvement of safe meat processing and abattoir hygiene management at abattoirs was addressed by provisions made for *essential national standards* in Act No. 40 of 2000. International trends in food safety control strategies leaned towards co-regulation during the 1990s. This approach resulted in the regulation of food safety systems to be implemented and managed by private operators. In South Africa, Section 11(1)(e) of the Meat Safety Act, Act 40 of 2000 made provisions for the regulation of the Hygiene Management System (HMS) and Hygiene Assessment System (HAS) that was one of eleven *essential national standards* applicable to abattoirs.

- **Red Meat Regulations No. 1072 of 2004.** Hygiene Management System requirements were regulated for red meat abattoirs according to the Red Meat Regulations, benchmarking similar approaches to those used in the United Kingdom (UK), the Hygiene Assessment System audit checklist was adapted. Together, these two systems are central in the management and demonstration of meat safety during handling and processing at South African abattoirs.

The two main operative laws, normally used by the Department of Water Affairs and Fisheries, are briefly referred to (Guideline Manual for the Management of Abattoirs and Other Waste of Animal Origin – Gauteng Department of Agriculture and Rural Development, 2009).

- Definition of waste in terms of the **National Water Act 1998, Act no. 36 of 1998**:

"Waste" includes any solid material or material that is suspended, dissolved or transported in water (including sediment) and which is spilled or deposited on land or into a water resource in such volume, composition or manner as to cause, or to be reasonably likely to cause, the water source to be polluted.

- Definition of waste in terms of the **Environment Conservation Act 1989, Act no. 73 of 1989**:

  "Waste" means any matter, whether gaseous, liquid or solid or any combination thereof, which is from time to time designated by the Minister by notice in the Gazette as any undesirable or superfluous by-product, emission, residue or remainder of any process or activity.

- Technical definition of Abattoir Waste:

  Abattoir waste can be defined as waste or wastewater from an abattoir which could consist of pollutants such as animal faeces, blood, fat, animal trimmings, paunch content and urine.

  Abattoir waste could therefore be regulated through either the Environment Conservation Act, 1989 (protection of the total environment, i.e. water, air, soil, humans, flora and fauna), or the National Water Act, 1998 (predominantly protection of the water regime).

  Water quality protection in terms of the National Water Act could be achieved via water use licenses (section 21 (f) for discharges – excepting sewage reticulation and 21 (g) for disposal on land), directives in terms of:

  - *section 19 for preventing and remedying pollution*
  - *section 20 to control emergency incidence involving the spilling of a harmful substance that could detrimentally affect a water resource.*

  Relevant procedural approaches for the preceding exist in documentation cited as "Water use authorisation process".

  The protection of water quality including the environment, against the effects of abattoir waste disposed of onto land could also be achieved through section 20 (prescribing the need for a disposal site permit from the Minister of Water Affairs to establish and/or operate a disposal site) of the Environment Conservation Act. Standards and protocols for the deployment of Section 20 permitting exist in the form of the Minimum Requirement Trilogy (second edition 1998).

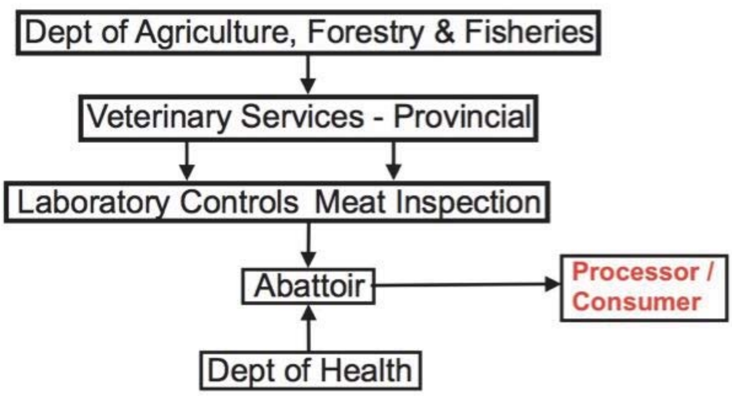


Figure 5. Regulatory Control System

4 WATER USE AND WASTEWATER MANAGEMENT

4.1 Water use

The Red Meat Abattoir Industry consumed an estimated 5.8 million m^3 in 1989 (Department Of Agriculture And Rural Development, Gauteng Provincial Government)[1] of water annually, extrapolated to 2014 value of 8.8 million m^3, of which approximately 82% (7.2 million m^3) is discharged as wastewater.

The water consumed per SU increases inversely to the abattoir slaughter capacity – small abattoirs processing between 20 and 50 SU per day uses much more water than their larger counterparts. This is due to the fact that larger abattoirs are more cost-conscious, and manage their expenditures better.

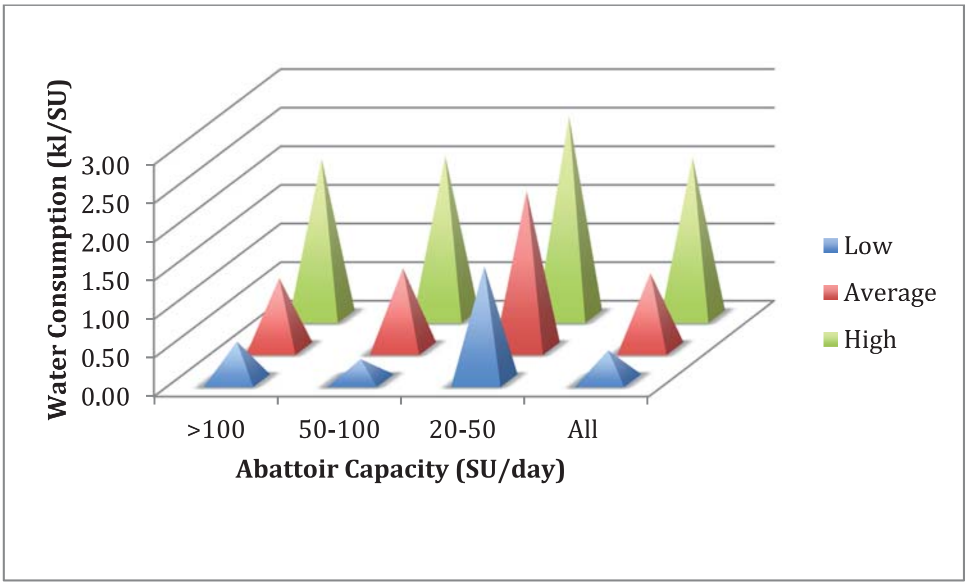


Figure 6. Range of Water Consumption in Red Meat Abattoirs

Table 3. Water Consumption in Red Meat abattoirs

Abattoir Capacity	Water Consumption (kl/SU)		
	Maximum	**Average**	**Minimum**
>100	0.50	0.91	2.05
50-100	0.28	1.04	2.08
20-50	1.48	2.04	2.60

In a single abattoir, water consumption varies greatly between the different processing areas. The largest water-consumers are the stunning/bleeding, main process and rough offal preparation areas.

Water is utilised for the following purposes in the abattoir areas:

- Lairages (stock-pens):
  - Livestock drinking
  - Wash-down of the livestock holding pens

- Stunning and Bleeding:
  - Wash-down of blood spillages
  - Continuous cleaning of area
  - Sterilisation of equipment

- Carcass Process Area (main slaughter area):
  - Carcass wash-down
  - Sterilisation of equipment such as mechanical flaying knives, manual slaughter knives, evisceration pans, etc.
  - Continuous cleaning of process floor

- Pig Scalding Area:
  - Scalding Tank or Scalding Cabinet – continuous flow of water for scalding purposes
  - Sterilisation of equipment

- Red Offal Processing:
  - Wash-down of red offal such as livers, hearts, lungs, etc.
  - Sterilisation of equipment such as manual knives, offal holding pans, etc.

- Rough Offal Processing:
  - Cleansing of paunches, intestines, etc.
  - Sterilisation of equipment such as manual knives, offal holding pans, etc.

- Heads & Hooves area:
  - Wash-down of heads and hooves, as required
  - Sterilisation of equipment such as knives, offal holding pans, etc.

- Hides and Skins:
  - Wash-down of floors as and when required
  - Sterilisation of equipment such as manual knives

- Condemned Area:
  - Wash-down of carcases
  - Sterilisation of equipment
  - Sterilisation of area

- By-products Rendering:
  - Rendering of condemned products
  - Sterilisation of equipment
  - Sterilisation of area

4.2 Wastewater generation

Approximately 82%, or 7.2 million m^3 of fresh water consumed, is discharged as wastewater, containing a high organic loading (COD), varying in range from approximately 730 mg/l to 9930 mg/l.

Areas where wastewater is generated are:

4.2.1 Lairages (holding stock-pens)

Animals excrete organic matter during their holding period before slaughter. Livestock are normally held overnight before slaughter, with the effect that volumes of excreta are high.

Pens should be dry-cleaned (manure removed by mechanical means such as scraping and then swept by broom) before wash-down. However, it was very often found that wash-down hoses are utilised as “wet brooms”, transporting solid wastewater by means of water, and thus creating high wastewater contamination.

4.2.2 Stunning and bleeding areas

Due to careless bleeding operations of carcases, blood spillage occurs outside the bleeding trough, onto the process floor. This blood is then washed down to sewer as part of the continuous cleaning process and keeping the area hygienically clean.

In some instances it was observed that excess raw blood, which could not be contained in the receptacle, is washed down to sewer.

The COD of raw blood, is typically 400 000 mg/l (UK Environmental Agency), and congealed blood has a COD of typically 900 000 mg/l.

Blood is considered to be one of the biggest wastewater polluters in the red meat abattoir industry.

4.2.3 Carcass dressing (main slaughter floor)

During the carcass dressing operation, blood drippings cannot be contained and are discharged to the floor. This has a limited volume, but high COD.

Carcass cuttings such as pieces of fat, pieces of meat, and bone particles (due to the splitting operation of cattle carcases) are deposited on the floor. These should be dry-swept and removed to containers, but invariably, this is swept away by the “wet broom” operation.

When opening the intestinal area, intestines and internal organs are accidentally cut, causing the contents to land on the floor, and being washed down to sewer.

Carcases receive a final wash-down, causing excess contamination elements such as bone chips, pieces of fat and meat to be washed to sewer.

4.2.4 Rough offal

In the rough offal area, paunches and intestines are slit open or receive an internal rinse to remove paunch and gut content. These materials are present in large quantities, and are normally discharged into receptacles for further treatment. However, spillages invariably occur, and these are washed down to sewer.

Large quantities of water are used in this area and very high levels of contamination are experienced.

4.2.5 By-products rendering

Material, which is not fit for human consumption, such as blood, condemned carcases and condemned offal, is processed and sterilised in this area.

The process entails the breaking up of carcases and other condemned items into pieces of approximately 25 mm to 50 mm, before being placed into pressurised cookers, where sterilisation can be achieved. The cooked and sterilised carcass material also contains fat, which is removed from the carcass meal, and sold as an income-generating product.

Fat spillages and the cleaning of items used in the fat manufacturing process have very high contamination levels, resulting in high COD-values.

Similarly, blood is congealed and then placed into pressurised containers where sterilisation is achieved. Blood spillages contribute to extremely high COD-levels.

Carcases typically contain 80% moisture, with the sterilised end-product having moisture contents in the region of 8% to 12%. The moisture is evaporated off during the rendering process, resulting in huge quantities of highly saturated air. The moisture is malodorous, ranging from slightly annoying cooking odours to unbearable nauseating odours, creating serious levels of air pollution.

To abate these odours, the moisture-laden air is condensed. Smaller particles of meal are transported along with the moisture, and during the condensation process, this also ends up in the wastewater stream.

The result is highly contaminated, high COD wastewater streams, as summarised in Table 3 below.

4.3 Wastewater quality

The wastewater emanating from red meat abattoirs depends to a great extent on the size of the operation. Table 4 and Figure 7 show the range of COD concentrations found. Figure 8 displays the results of measuring COS, suspended solids (SS) and total dissolved solids (TDS) in large and small abattoirs.

Table 4. COD concentrations (mg/L) of abattoir wastewater

Abattoir Capacity	Lowest COD measured	Average COD	Highest COD measured
>100	731	1217	5859
50-100	761	2650	8942
20-50	1325	5025	9924

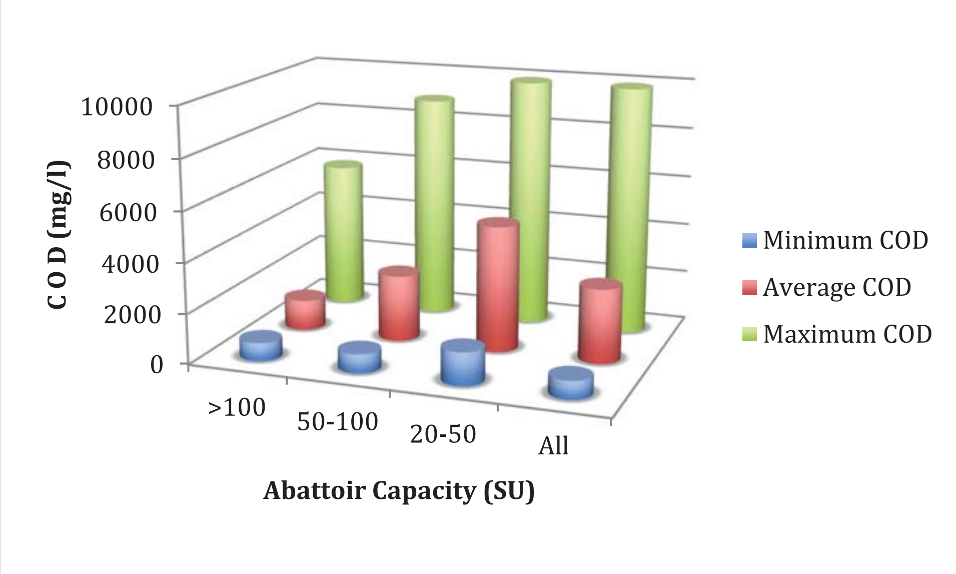


Figure 7. Abattoir wastewater COD concentrations

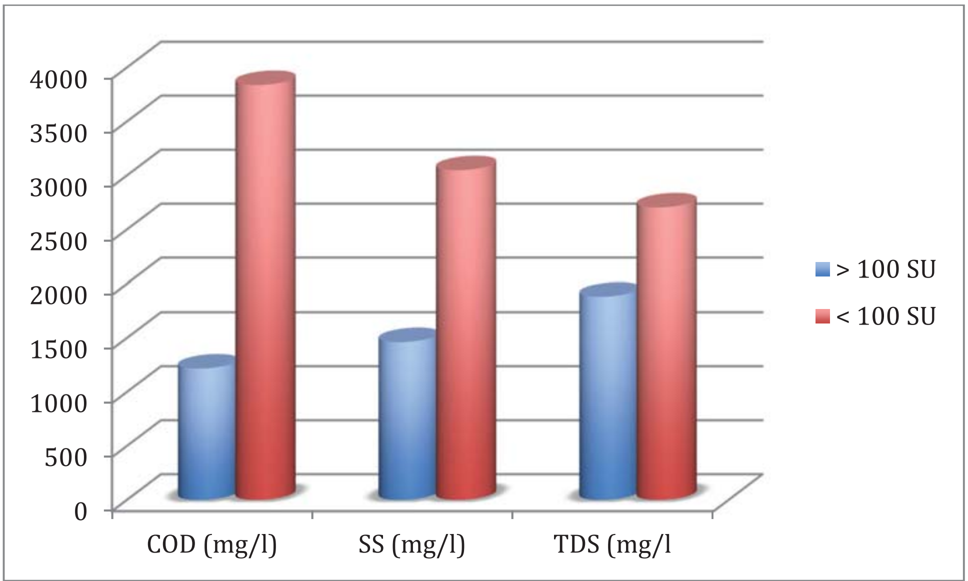
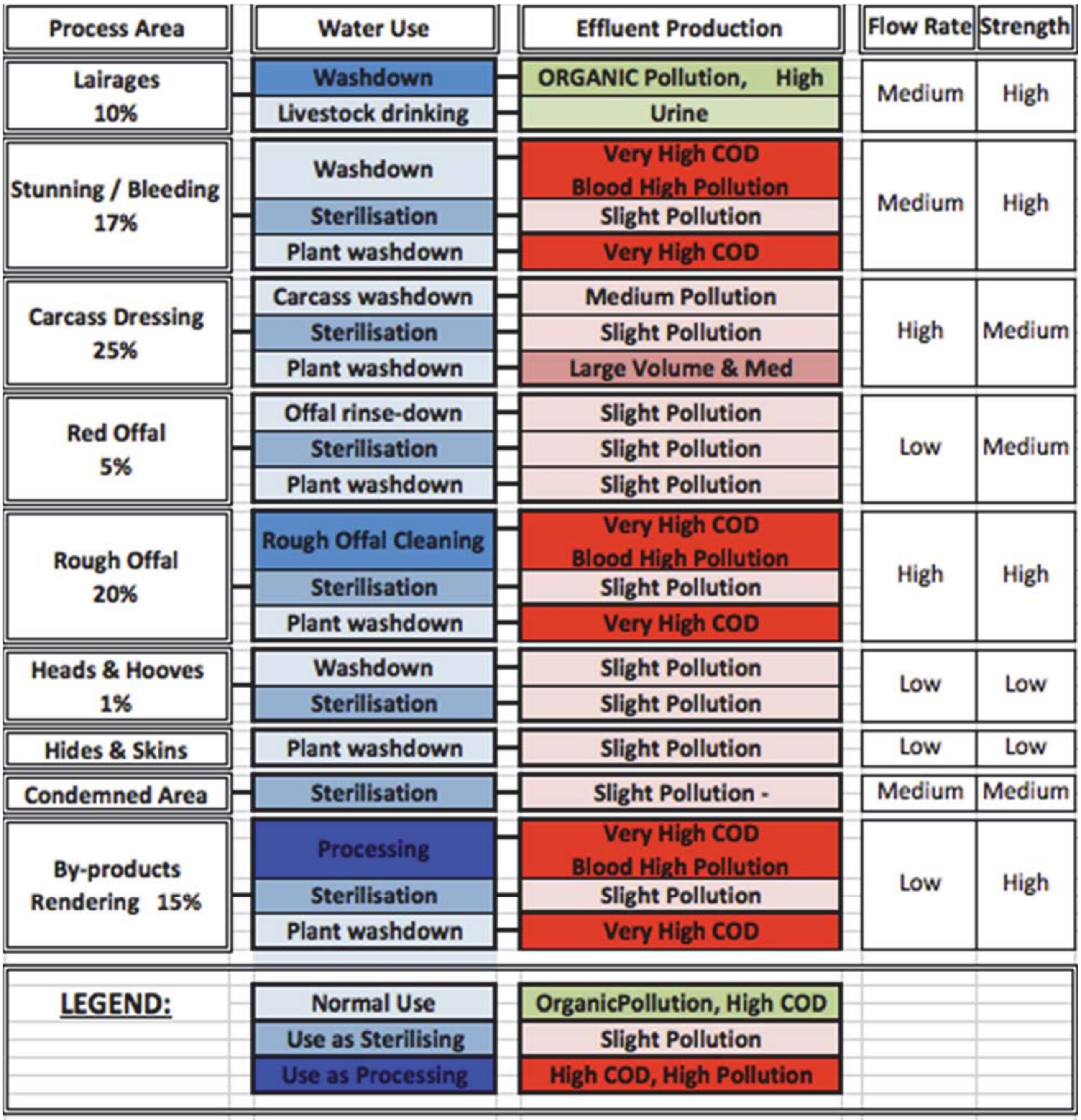


Figure 8. Wastewater quality of abattoirs

The sources of wastewaters of different characteristics can be found in Figure 9.



Process Area	Water Use	Effluent Production	Flow Rate	Strength
Lairages 10%	Washdown	ORGANIC Pollution, High	Medium	High
	Livestock drinking	Urine		
Stunning / Bleeding 17%	Washdown	Very High COD Blood High Pollution	Medium	High
	Sterilisation	Slight Pollution		
	Plant washdown	Very High COD		
Carcass Dressing 25%	Carcass washdown	Medium Pollution	High	Medium
	Sterilisation	Slight Pollution		
	Plant washdown	Large Volume & Med		
Red Offal 5%	Offal rinse-down	Slight Pollution	Low	Medium
	Sterilisation	Slight Pollution		
	Plant washdown	Slight Pollution		
Rough Offal 20%	Rough Offal Cleaning	Very High COD Blood High Pollution	High	High
	Sterilisation	Slight Pollution		
	Plant washdown	Very High COD		
Heads & Hooves 1%	Washdown	Slight Pollution	Low	Low
	Sterilisation	Slight Pollution		
Hides & Skins	Plant washdown	Slight Pollution	Low	Low
Condemned Area	Sterilisation	Slight Pollution -	Medium	Medium
By-products Rendering 15%	Processing	Very High COD Blood High Pollution	Low	High
	Sterilisation	Slight Pollution		
	Plant washdown	Very High COD		
LEGEND:	Normal Use	OrganicPollution, High COD		
	Use as Sterilising	Slight Pollution		
	Use as Processing	High COD, High Pollution		

Figure 9. Abattoir process flow, indicating water use and wastewater quality

5 ENERGY GENERATION

New technology, which has originated Austria and Germany is presently being introduced into abattoirs in South Africa by Bio4gas.

This consists of an anaerobic digestion system in which methane gas is generated, the methane gas is utilised to power a gas engine, which in turn drives an electrical generator.

Waste heat from the gas engine is utilised to pre-heat the hot water requirements of the abattoir.

The wastewater from this process reportedly results in achieving lower COD levels.

6 BEST PRACTICE IN WATER USE AND WASTEWATER MANAGEMENT

South Africa, being a water scarce country, has to reduce water consumption in all industries, but especially so in the industries which are classified as large water consumers.

Red meat abattoirs are renowned to be large volume water consumers and they therefore generate equally large volumes of wastewater. The wastewater contains high concentrations of waste products, high in chemical oxygen demand (COD) and suspended solids content. Typically, raw blood generates exceptionally high COD levels, while cleaning and carcass washing operations normally account for more than 80% of total water use and wastewater volume.

It is possible for red meat abattoirs to adopt a systematic approach to minimising water use and reduce their water and wastewater costs by 15-30%, and in smaller abattoirs by as much as 60%, at little or no cost to business.

This best practice analysis describes a range of cost-effective measures to assist companies in reducing costs while cleaning and washing effectively, without compromising hygiene standards. The ever-increasing cost of potable fresh water supply as well as wastewater treatment cost, increases the pressure on red meat abattoirs to reduce water consumption and wastewater generation.

Many abattoirs can significantly improve both process and cleaning operations. This manual assists in achieving volume and the associated cost savings by adopting systematic approaches to improving water use and wastewater generation.

The aim should be to minimize waste generation, and systems should be put in place to:

- Reduce water consumption
- Minimise quantities of waste generated
- Minimise spillages
- Remove solids before entering waste streams
- Institute dry-cleaning regimes prior to wash-down

Strategies should therefore be instituted to facilitate cleaner operational procedures, minimise and/or prevent waste generation, properly dispose of waste, recycle waste or institute waste beneficiation systems, which should include:

- Effective management of water utilisation and the accompanying generation of wastewater.
- Implementation of system improvements:
    - Livestock transportation and lairage arrangements
    - Process operations
    - Cleaning regime
    - Wastewater pre-treatment
- Water Conservation

Storm water contaminated by organic materials should be collected in storage reservoirs (dams) for re-use as irrigation supply.

Lairages, livestock receiving areas, wastewater treatment plants and all processing areas should be roofed over to minimize the volume of wastewater.

Clean storm water should be separated from contaminated water/wastewater.

High water pressure with adequately designed spray nozzles should be utilized, as water conservation measures.

Process areas should be permanently paved and adequately sloped to facilitate proper drainage to sewerage systems, and avoid contamination of storm water.

Red Meat Abattoirs can effect significant savings by managing their water use and wastewater generation.

- Both water and wastewater charges are significant expenditures in the operational costs of an abattoir;
- Most abattoirs consume vast quantities more water than is required, even taking into account the hygiene requirements;
- Uncomplicated measures may reduce volumes and the associated costs significantly;
- This best practice guide describes cost-effective measures to assist red meat abattoirs to utilise less water, and to clean and wash effectively without any compromise to hygiene standards.

Water and wastewater charges are significant expenditures to red meat abattoirs. Due to the scarcity of water in South Africa, these costs are increasing at an alarming rate.

Wastewater charges will be increasing still further as local authorities seek to recoup the massive investment required to upgrade their wastewater treatment plants to meet wastewater standards.

Red meat abattoirs utilise large quantities of water and generate large volumes of highly polluted wastewater with high chemical oxygen demand levels (COD) and suspended solids content. Cleaning and carcass washing operations typically utilise more than 80% of total water use and wastewater volume.

6.1 Minimisation of water use and wastewater generation

Water use in red meat abattoirs is intrinsically high because of the need to meet stringent hygiene requirements. Not disregarding hygiene requirements, many companies waste (and pay) for more water than is necessarily required.

Excessive usage can generally be attributed to:

- Lack of awareness of the volumes utilised and discharged.

- A wide margin of safety to ascertain minimum hygiene requirements being achieved – this is compounded by a lack of awareness of what can be achieved without compromising hygiene. Cleansing and carcass washing can be performed in more efficient, cost-effective and environmentally responsible ways. General hygiene requirements should be taken into consideration, i.e. regulations require potable water to be utilised in abattoir processing, and for slaughter equipment to be sterilised utilising water at 82°C. In this instance, high pressure low volume sprays can be utilised for general cleaning of lairage areas, they may not be used in meat processing areas where meat is present, due to the risk of atomised water droplets spreading contamination. The use of recycled wastewater is not permitted in process areas.

This best practice guide assists in:

- Assessing the actual cost of water and wastewater;

- Identifying ways to achieve savings without compromising hygiene – it is important to ascertain that all relevant meat hygiene standards will continuously be met.

Adopting systematic approaches in red meat abattoirs, minimising water consumption can considerably reduce the water and wastewater bills at little or no cost to business. By utilising appropriate equipment, further water and wastewater cost savings can easily be achieved.

Red meat abattoirs are guided in ways to use less water and thereby generating less wastewater. When utilized as a management tool, improved management of water, cleaning chemicals and wastewater will result.

This best practice management guide will assist in achieving the following

- Awareness of quantities of water consumed, wastewater generated and associated costs

- Advice in achieving the best results

- Advice in improving:

    - Transportation scheduling

    - Lairage arrangements

    - Process operations

    - Cleaning operations

    - Pre-treatment of wastewater

Waste reduction should start at source, as this is the most effective approach in the reduction of costs.

6.2 Identification of Water and Wastewater Quantities and Costs

6.2.1 Typical Benchmark Values for Water Use

a. Overall water use per animal

The volume of water utilized for the processing of one animal is dependent on a range of factors such as:

- Animal species
- Construction and layout of lairages
- Degree of mechanization of slaughtering process
- Physical size of the process areas
- Carcass dressing method and slaughtering technique

Abattoir process areas are constantly being washed down during the slaughter process, and are thoroughly cleaned and sterilized at the end of the process shift. Consequently, the size of the abattoir process area has a significant impact on the water consumption.

Although water consumption is influenced by the design layout and individual intricacies of each abattoir process area, benchmarks are provided for measuring and comparison of the individual abattoir consumption areas. Water consumption is normally expressed as kilolitre per slaughter unit, where one head of cattle equals one slaughter unit, two pigs equals one slaughter unit, and six sheep equals one slaughter unit.

b. Steps to be taken when water consumption exceeds the norm

Decrease of water consumption can be achieved through improved management and control of water use. However, it should be borne in mind that some sectors are beyond the control of the abattoir operator, such as a large floor area.

c. Specific water use by process

The next step in making an assessment is to effectively control water usage – consumption in process areas should be measured independently, and be compared to the benchmark figures supplied.

d. Relative use of hot and cold water

Slightly less than half of the water consumed is hot water (Figure 10). Due to the cost disparity between hot and cold water, consumption recordings should be separated as exemplified in Figure 11 or Table 5.

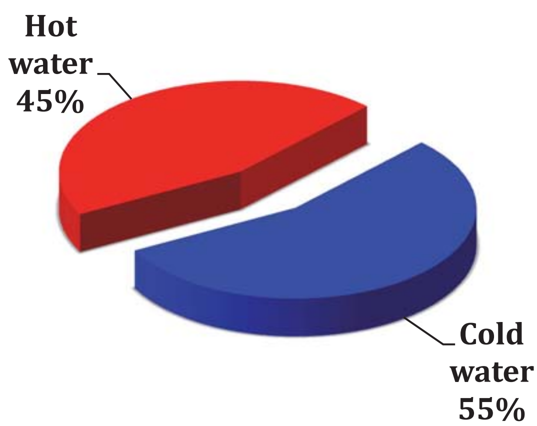


Figure 10. Typical breakdown of hot and cold water consumption

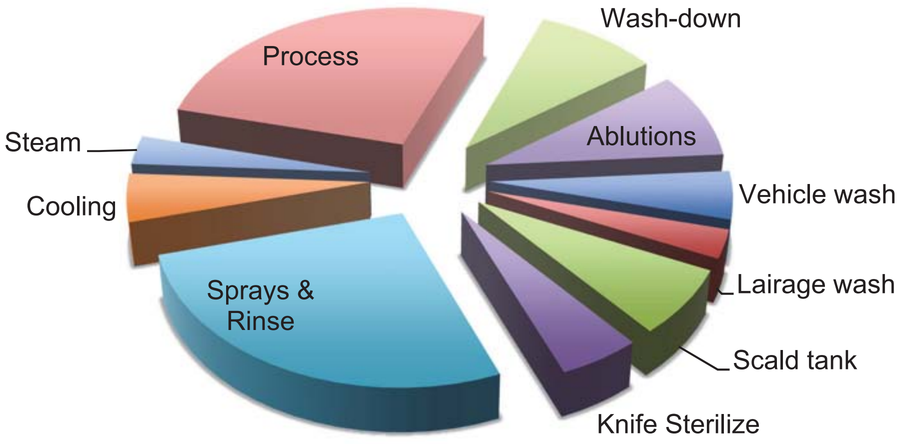


Figure 11. Water consumption per process area at typical abattoir

Table 5. Water consumption per process area

Vehicle wash	5%
Lairage wash	5%
Scald tank	6%
Knife Sterilization	5%
Spray & Rinse	26%
Cooling	5%
Steam	3%
Process	27%
Wash-down	9%
Ablutions	9%
	100%

The slaughter area utilizes approximately 60% of the total consumption (Table 5).

6.2.2 Quantifying water use to identify opportunities

An essential step towards reducing the use of water, detergents, and energy, is the determination of quantities utilised.

This allows:

- Identification of high use areas;
- Identification of areas where consumables are being wasted
- Comparison with target consumptions
- Focusing the attention on areas with the greatest possibility of facilitating savings
- Identifying potential opportunities for reduction of water use.

A simple estimate made as a 'one-off' exercise provides an excellent starting point, allowing identification of areas for achieving substantial savings through the introduction of simple good housekeeping measures.

For sustainability, regular regimes would have to be implemented to adopt a systematic approach to water use reduction. Good housekeeping measures would require the installation of individual water meters dedicated to monitor the consumption of these areas. Experience indicates the cost of installation of water meters to be recoverable in an extremely short period.

6.2.2.1 Initial Estimates

As a basic method of determining the water use of a particular process area, the time in which a container of known volume takes to fill up from an appropriate part of the process pipework can be measured – this method should not be utilised for continuous measuring purposes.

Manual estimates may be useful for rapid identification of leaks in water supply systems. As part of a best practice system, a leak detection and repair programme should be instituted.

Major causes of leaks normally include:

- Corroded supply piping and storage tanks
- Damaged pipe connections, flanges and fittings
- Worn-out valves and valve seats
- Defective float valves in water tanks or cisterns

Red meat abattoirs are likely to achieve significant savings by implementing measures identified through a measurement routine with dedicated water meters. A precise and overall view of total water consumption as well as consumption per process area could be obtained.

Once routine measurements have produced sufficient data, a database can be built up against which the day-to-day usage can be monitored:

- Construct a water balance to determine where water is being utilised;
- Identify water and cost saving opportunities.

6.2.2.2 Calculation of water and wastewater costs

The largest percentage of water utilised eventually ends up as wastewater, and red meat abattoirs produce large volumes of high-strength wastewater. Most of the larger red meat abattoirs effect some form of wastewater treatment prior to discharge to municipal sewer in order to reduce trade wastewater charges.

A number of large companies screen wastewater before being discharged to sewer, and some of the larger companies even treat their wastewater further using more sophisticated techniques.

6.2.2.3 Applying wastewater cost calculation formula

Knowledge of the method of calculation of trade wastewater charges is essential in determining what stage and what type of treatment will be cost-effective.
The main factors determining the strength of wastewater are its chemical oxygen demand (COD) and total suspended solids (TSS) content.

It is commonly believed that reducing water use alone will increase wastewater costs due to higher COD and TSS levels. However, even if reducing water use leads to an increase in cost per kilolitre of wastewater, it will be more than compensated for by lower volume costs. Obviously, the most effective way of making cost savings is when both wastewater strength and volume charges are reduced simultaneously.

6.3 Phased approach to improvement of operations

The following sections explain the importance of executing process items in the correct order, i.e. analyzing the operation and process and initially 'reduce at source' first, thereafter considering downstream measures and ultimately wastewater treatment.

A phased approach to instituting improvements:

- Improving of operational measures
- Scheduling of livestock arrivals
- Washing of vehicles – installation of metered truck-wash dispenser
- Reduction in lairage holding times
- Dry cleaning of lairages before wash-down
- Removal of manure in solid form
- Probable re-use of clear water for primary washing
- Improved collection of raw blood
- Pig scalding
- Carcass washing
- Dry cleaning of gut before washing
- Dry cleaning of meat scraps and solids from process floor
- Control of water use
- Appropriate use of cleaning chemicals
- Constantly maintaining and cleaning of screens for optimal performance
- Consider primary as well as secondary wastewater treatment

7 MEASURES TO REDUCE WATER USE AND WASTEWATER GENERATION

The below cost-saving opportunities can be divided into improvements to process and cleaning operations.

- Improved scheduling of transport arrangements
- Controlling lairage arrangements
- Minimizing of downstream clean-up requirements and reduction of water costs in process operations
- Minimisation of downstream wastewater treatment requirements and reduction of water costs in general cleaning operations
- Optimisation of the cleaning performance of screening equipment

7.1 Reduction at source

Upstream operations always have to be streamlined before considering any changes to the downstream treatment plant.

Small changes in operational procedures or process plant can significantly impact on the volume and/or strength of waste, thereby reducing or even eliminating the need for high cost changes to wastewater treatment systems.

Reduction of water volumes used and wastewater produced will, in the first place reduce operating costs and impact positively on financial results.

Reducing waste at source, rather than first contaminating water and then treating it at a later stage, is one of the simplest possible methods in achieving enormous savings.

7.2 Improvement of transport and lairage arrangements

The following subsections describes how red meat abattoirs can achieve significant water and wastewater savings by:

- Scheduling animal delivery to achieve continuous slaughtering operations
- Installation of metered water dispensers to limit the volume of water used for vehicle washing
- Collecting lairage manure as a solid waste
- Utilising water from other acceptable processes for primary washing of lairages
- Designing lairage areas for minimum manure build-up and reducing wash-down requirements.

7.3 Optimising delivery times

The number of cleaning regimes depends on how dirty an area becomes. Cleaning is also required during breaks in the slaughtering process. Production should be scheduled to minimise the number of breaks, and hence the number of cleaning exercises required during each shift. Adopting a JIT, or 'just-in-time' turnover system will reduce holding periods and allow continuous slaughtering operations. The benefits of optimising delivery times include:

- Reduction of manure build-up in the lairage areas and subsequently the need for wash-down;
- Reduced need for cleaning due to breaks in the slaughtering line.

7.4 Lairage wash-down and drainage

The manure in the lairages and the wash water has a high nutrient content.

Water from other process areas, such as:

- Chiller condensate from carcass refrigeration rooms,
- Cooling water and steam condensate

could be used for the primary wash-down of lairages. Lairages normally have solid concrete floors and, as a result, the manure that builds up during the day, dries against the walls and floors. Substantial amounts of wash-down water are then required for removal. To reduce the build-up of manure and the amount of wash-down water required, lairage pens should be constructed with slatted concrete floors laid to adequate falls, with a drainage system installed below the floor, draining into a slurry tank.

7.4.1 Improved scheduling increases abattoir efficiency

It was found that water consumption for overnight operations such as cleaning and services (e.g. boiler make-up and cooling tower make-up) approached a constant figure, and did not vary with throughput. Water consumption in the slaughtering area did vary during the day and peaked during breaks in slaughtering when cleaning operations were taking place for maintaining adequate meat hygiene standards. The slaughter areas had to be washed down during breaks to prevent build-up of congealed blood.

Phasing staff breaks and programming animal deliveries to arrive within a prearranged time schedule, will allow an abattoir to achieve continuous slaughtering operations, (thereby reducing water and wastewater volumes and labour costs).

7.5 Installation of metered water dispensers

All vehicles should be washed down after deliveries to red meat abattoirs. At most installations dedicated hosepipes are provided for this action. High-pressure low-volume sprays substantially reduce water consumption.

Most red meat abattoirs do not charge for vehicle wash water. However, a number of abattoirs have installed vehicle wash meters that dispense sufficient water to clean an average- sized vehicle. Because the meter system increases awareness of the amount of water used, drivers tend to use less water – leading to cost savings for the abattoir.

7.6 Improving process operations

Cleaning and carcass wash typically account for approximately 80% of total water use and wastewater volumes at red meat abattoirs. Blood spillages during slaughtering operations need to be washed down and is a major contributing cause of high wastewater strength.

It has been determined that blood has the highest COD of all wastewaters from abattoir operations. Liquid blood has a COD of about 400 000mg/l and congealed blood has a COD of about 900 g/l. If the blood from a single cattle carcass was discharged directly to sewer, the wastewater load would be equivalent to the total sewage produced by a small town of 50 people on an average day.

Owing to this high COD, washing of blood in trade wastewater results in extremely high trade wastewater charges. A large number of abattoirs are unaware of the true costs of discharging blood to the wastewater stream, and can make substantial cost savings from improvements in this area.

From the following subsections it is clear how red meat abattoirs can significantly reduce their water and wastewater costs by:

- Avoiding blood spillage and optimising blood collection;

- Efficient scalding- and water/waste management (pig abattoirs);
- Utilising dry cleaning of gut manure (cattle and sheep abattoirs);
- Ascertaining the effective control of wash water;
- Utilising directional spray nozzles for carcass wash-down;
- Continuous maintenance of nozzles used for processing.

7.6.1 Optimising blood collection

To reduce the COD and suspended solids content of wastewater, it is essential to prevent blood and meat from entering the wastewater stream.

It is always more cost-effective to collect blood for separate disposal.

- Efficient bleeding procedures and effective blood collection in a blood trough are essential. Blood troughs should be designed long enough to adequately provide for the collection of blood.
- The blood trough should be accessible to facilitate easy cleaning and squeegeeing before washing.
- Blood troughs should be fitted with dual outlets – one for blood collection and the other for wash-down water, being channeled to sewer. When not in use, the drain openings should be sealed with removable plugs.
- Before trough wash-down, blood should be sluiced with a few litres of cold water and a squeegee utilised to transfer the concentrated blood solution into the blood drain.

Due to increase in throughput and the consequent speeding up of process lines, the lengths of blood troughs become inadequate, and spillages of blood into sewer systems take place. The length of blood troughs should be extended.

7.6.2 Pig scalding

Traditionally, carcasses are immersed in scalding tanks filled with hot water at approximately 60°C. Alternatively, carcasses can also be showered in a cabinet utilising re-circulated hot water. Shower scalding uses large volumes of water and energy, and is not advocated.

For an abattoir processing about 100 pigs/hr, the dimensions of a scald tank are typically approximately 4 m x 1.7 m and 0.8 meter deep. Such a tank contains approximately 5 000 litre of water. Some larger abattoirs use a conveyor system to drag the carcass through a longer tank equipped with countercurrent water flow, filtration and recycling.

The installation of water limiting devices (i.e. ball valve) to automatically disconnect the water supply greatly reduces water consumption.

It was observed that pre-slaughter filling of scalding tanks are often executed by leaving the water supply on until it is switched off by cleaning staff, or even allowing it to run overnight and the excess water spilling over into the sewage system.

An efficient scalding process uses humidified air to transfer heat to the carcass surface through steam condensation. Heat and moisture is transferred to the scalding air by atomised hot water droplets in a circulating airflow. This process can maintain a constant temperature and 100% humidity under varying loads – presenting opportunities for good scalding.

The advantages of steam condensation compared to tank scalding include:

- Elimination of water in the sticking wound

- Eliminating water ingress into the lungs
- Low water consumption;
- Increased energy efficiency
- Limiting of over-scalding due to line stoppages
- Reduced start-up times

7.6.3 Viscera washing

7.6.3.1 Gut washing

Abattoirs clean the rough offal (i.e. paunches, gut, etc.) to a high standard for sale to the offal trade.

Paunches and gut are normally cut open on a process table, and water is utilized to push the manure over a screen system before being drained into a holding container. This method of operation produces wastewaters with a high COD content, as the contents of gut have a COD of over 100 000 mg/litre of which approximately 80% typically dissolves in the washing water.

Dry gut cleaning should be advocated as significant reductions in water and wastewater costs can be achieved. In this process, the paunches are opened without the use of water and the manure is removed in a dry format. Washing in a stream of water does the final cleaning.

A compressed air system is extremely effective in blowing dry paunch material to waste handling areas.

A compactor could be utilised to reduce the volume of the manure and thus enable easier handling.

7.6.3.2 Intestine washing

Small and large intestines of carcasses, which have been approved for human consumption, are usually squeezed and washed for use in casings.

In reducing water use and wastewater production, intestine washing should be executed in two stages, i.e. primary wash in a water container with continuous water filtration and recirculation, followed by a final rinse in clean potable water.

7.6.4 Wash water control

On automated and semi-automated slaughter lines, wash water is sprayed continuously onto carcasses even during line stoppages or where there are gaps between carcasses on the dressing conveyor.

Continuous water flows can be considerably reduced by the installation of sensing devices, which will only allow the spraying to take place when a carcass is detected or when the line is in operation.

7.6.4.1 Manual switching during start-up and shutdown

A less efficient alternative to automation, but involving no capital expenditure, is manual intervention where an operator is responsible for manually activating all rinses, scalds, and other washing equipment.

A sheep carcass renders approximately 27 m of casings, which are utilised for sausages. Pigs render approximately 19 m of rougher casings, which are edible. Cattle produce approximately 34 metres of tough, strong casings, which are also utilized for edible purposes.

7.6.5 Directional spray nozzles for carcass washing

In optimizing water consumption, the uses of spray nozzles for wash-down of carcasses are advocated. Washing down typically accounts for approximately 30% of water use at red meat abattoirs. In optimizing washing efficiency while reducing water consumption, the use of water spray nozzles to direct the water flow is an excellent tool.

Red meat abattoirs have been observed using showerhead arrangements or even crudely constructed pipes with drilled holes for carcass washing, leading to excessive water wastage. Excessive washing removes fluids and tissues from the product, flushing these into sewer systems. Considerable savings can be achieved by using more efficient flat spray nozzles, and with improved direction and angling of the sprays, the desired level of washing can be maintained using a lower water pressure.

Typically, a reduction in water use of 20% can be achieved by:

- Automatisation of water wash-down systems
- Installation of efficient directional nozzles for wash-down.
- Abattoirs who already have spray wash-down systems could, therefore, benefit from reviewing the latest spray technology. In selecting nozzles for wash-down operations, consideration should be given to:
    - Flow rate,
    - Pressure drop
    - Spray pattern
    - Spray impact
    - Droplet size

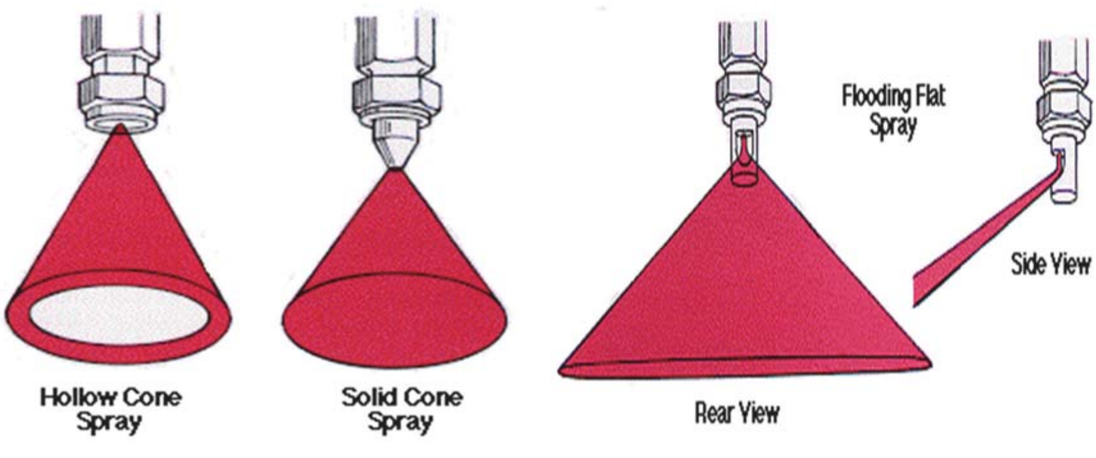


Figure 12. Spray Nozzle Type and Pattern

7.6.5.1 Nozzle maintenance

In areas where calcification of water systems is prevalent, it is good practice to have replacement nozzles available, enabling frequent descaling and maintaining the required efficiency.

In soft water areas, spray systems should be inspected periodically for worn spray nozzles. Worn nozzles can be expected to give inadequate washing performance and the water pressure will be reduced.

7.7 Improving cleaning operations

General advice on how to cut cleaning costs without compromising hygiene standards can be effected by:

- Calculating the actual costs of cleaning;
- Determining what the costs should be;
- Enhancing control and management of cleaning operations;
- Reducing consumption of cleaning chemicals and water;
- Minimising wastewater contamination;
- Instituting appropriate technology for cleaning processes.
- Cleaning and carcass wash-down typically accounts for more than 80% of an abattoir's total water use and wastewater volume.

The following subsections provide specific advice for red meat abattoirs on how to reduce water and wastewater costs associated with cleaning operations by:

- Interception and dry cleaning of meat cuttings;
- Utilisation of appropriate cleaning methods;
- Appropriate use of cleaning chemicals.

7.7.1 Collections and dry cleaning of meat scraps

As a general rule it is more cost effective to keep solid wastes out of water than allowing it to enter the waste stream and to try and remove them afterwards.

At many red meat abattoirs, it is common practice for staff during the cleaning operation to:

- Use water jet sprays as "liquid brooms" for sweeping of floors
- remove screens covering floor drains, thereby flushing solids directly down the drain in the belief that a subsequent screen or catch pit will entrap these.

However, the turbulence, pumping and mechanical screening which is encountered in the waste stream breaks down the solids, increasing the COD of the wastewater flow and releasing fats and particles. Wastewater treatment and disposal to sewer is and expensive method of operation. It is simpler and cheaper to implement good housekeeping practices such as the collection of solid waste and keeping these out of the wastewater stream in the first place, e.g.:

- Consider opportunities in the cutting and trimming areas to collect meat wastes before they enter the drains;
- Install trays to catch solids, meat scraps and other wastes emanating from the process;
- At all times ascertain mesh covers being in place to stop solid wastes from entering the sewer system;
- Train cleaning staff to empty drain traps into collection containers before implementing the cleaning regime.

Dry cleaning of any meat scraps that fall to the floor should be encouraged by:

- Sufficient waste containers, which are fit for the purpose
- Training personnel to utilise squeegees and other equipment for continuous collection of solids
- Explaining the consequences of using water hoses as wet brooms to flush solids into sewers;

- Making hose pipes less accessible for general use and abuse
- Waste bins should be emptied and cleaned at regular intervals to ensure hygiene standards are adhered to.
- To avoid excessive water consumption when hoses are used, trigger-action guns should be fitted to the hoses.

7.7.2 Use of appropriate cleaning methods

Low-pressure spray guns with flat spray nozzles ensure optimal water usage for wash- down operations.

Flat sprays should also be used for cleaning of conveyors or smaller items, such as wash stations for the cleaning of meat hooks passing through on a conveyor belt.
Clinically shaped nozzles should be utilised for larger items as they provide more thorough coverage with fewer nozzles.

To improve hygiene, by reducing the potential for airborne contamination in areas such as slaughtering, cutting and portioning, abattoirs should switch from high-pressure low volume spray guns to low-pressure spray guns. Such an adequately designed and operated spray system will not increase water consumption as much as might be expected.

Good practice with spray guns reduces water use
Reviewing the operation of existing spray guns and converting from large diameter hoses to small diameter hoses can considerably reduce water consumption.

7.7.3 Appropriate use of cleaning chemicals

A vast range of cleaning chemicals is available on the market of which some of formulated for use in specific, hard-to-clean, areas, whilst the others are for general use applications.

Advances in biological technology have also improved the formulation of biotechnical cleansing agents.

Biotechnological cleansing products, containing naturally occurring enzymes – can be utilised for cleaning of equipment, floors and walls, and lately for sterilization disinfection as well.

The use of specific cleaning chemicals is that being addressed in this guide, but note should be taken of the following:

- Only chemicals suitable for forward great cleansing should be used
- Consideration should be given to utilising the correct cleaning chemicals for every application. Utilising the correct product can reduce chemical costs and provide for more successful cleansing regimes.
- Product concentration is one of the most common misuses found in abattoirs. Staff into over-concentrate or under-dilute chemical cleansing agents, thinking that bitter end-results could be achieved. This is a fallacy and should be rectified by proper training of staff.
- Use of automatic chemical dosing systems is normally advantageous and should be considered.
- It has been experienced that higher concentration chemicals normally you provide more cost-effective results, on condition that staff do not over utilise the highly concentrated products. Lower concentration products normally contain chemical fillers and could be

less expensive upon initial purchase. However, additional packaging and transportation costs of larger volumes are hidden costs, which are not initially visible.

- Training of staff should be a prerequisite for personnel executing the cleaning and sterilizing duties – the cleansing agent suppliers, could normally supply this free of charge.
- Consideration should be given to purchasing cleansing agents from one supplier with the view to optimizing the use of cleansing materials and reduction of water consumption, whereby by significant cost savings could be achieved.

7.7.4 Ring mains water supply

A single hot water generating system is generally and more efficient than having a variety of individual water heating units. Hot water is then continuously recirculated, ascertaining that hot water is always instantly available at the correct temperature at any location in process areas.

Benefits of such a system includes:

- More efficient use of water as the hot water is always readily available at the discharge point
- Cleaning operations can be executed in shorter time periods
- Cleaning and hygiene standards can be improved

7.7.5 Screening of wastewater

The ultimate solution for reducing trade wastewater costs is reduction of the quantity of wastewater generated at source.

This also reduces the demand for on-site treatment and the associated reduction of wastewater charges. Only all avenues for the minimization of wastewater volumes as well as wastewater strengths have been exhausted, should wastewater pre-treatment be considered. It should be borne in mind that wastewater treatment is not the core business of an abattoir and this department will have its own source of problems.

The basic steps in the reduction of trade wastewater charges are screening to remove larger particles of solids. Appropriate operation and maintenance of screening systems is required defect the maximum reduction of wastewater and loads and therefore wastewater costs.

The most commonly utilized screening mechanisms are indicated below.

Static wedge screens are generally inexpensive to install and operate, but require more operational maintenance than other designs.

These screens have to be constantly monitored, cleaned and defatted to retain optimal performance.

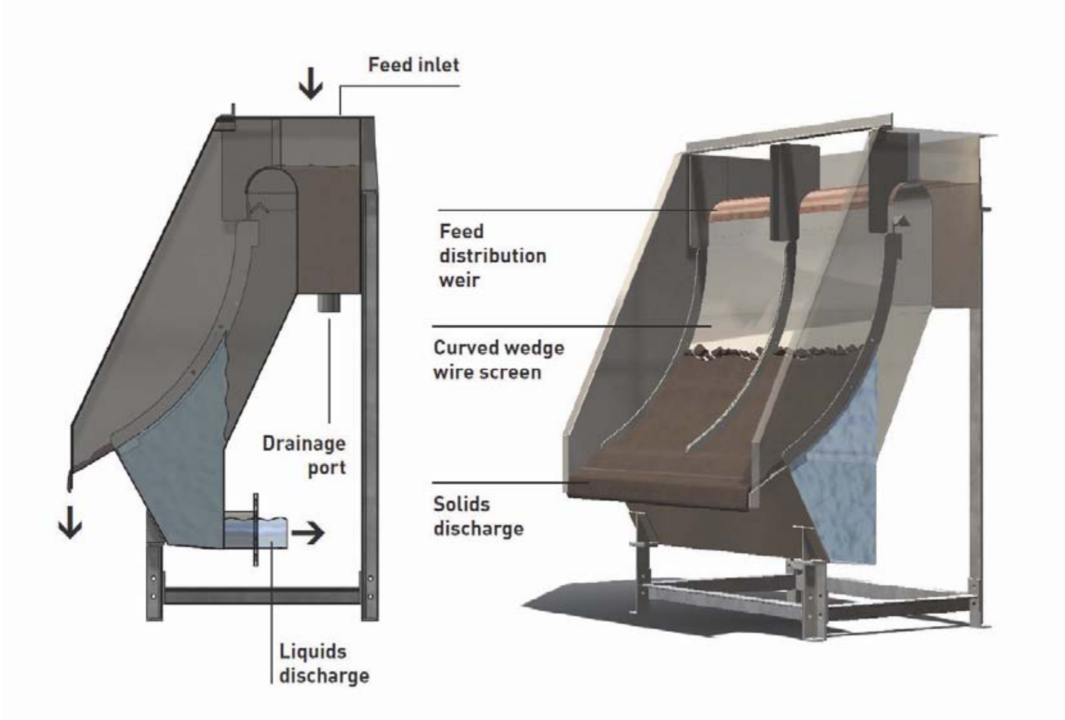


Figure 13. Typical static wedge screen

Rotary drum screens or much more expensive than static screens but are basically self-cleaning and require less operational and maintenance intervention.

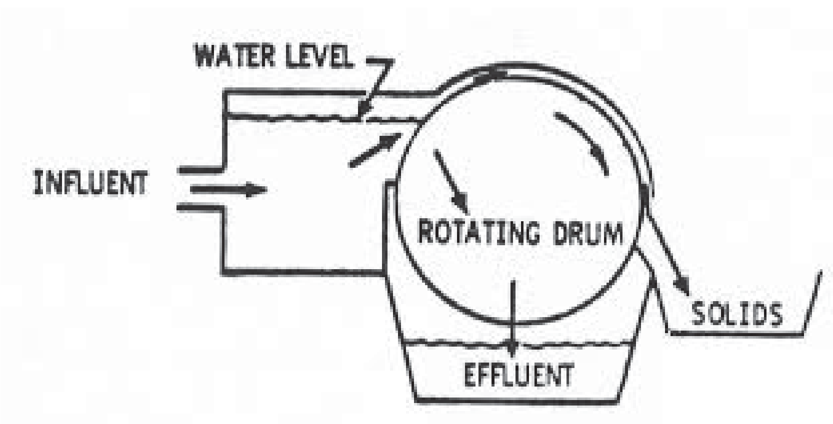


Figure 14. Typical rotary drum screen

Screening effects large savings in the cost of wastewater discharge, but these do not provide optimal results.

One of the more popular options of further treatment, is the Dissolved Air Flotation System, where wastewater is discharged into a container, micronized air bubbles are floated through the same container from the bottom upwards, and these micro-bubbles tend to attract solids and fats, floating them to the top, where it can be removed by scraping.

This is an extremely cost-effective, efficient and financially attractive method of treating abattoir wastewater.

It has been experienced that DAF equipment can reduce COD from ranges of more than 4000 mg/l to 500 mg/l, and suspended solids can typically be reduced from 1800 mg/l to below 100 mg/l.

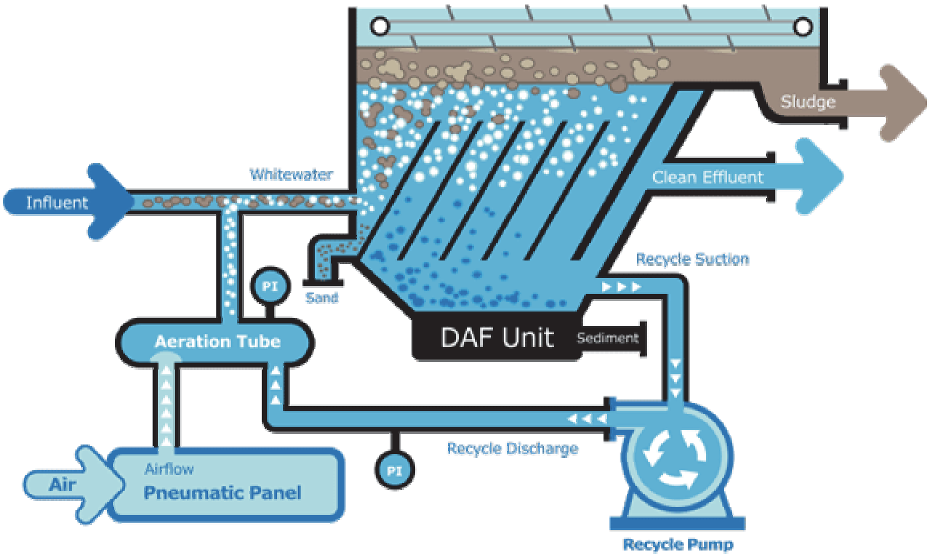


Figure 15. Typical dissolved air flotation (DAF) system

Wastewater charges constantly increasing, and large abattoirs find it cost-effective to install and operate additional wastewater treatment systems.

7.8 Action plan

The section serves to summarise the contents of this Best Method document

- Determine water and wastewater volumes used in production.
- Reduce water and wastewater volumes by:
  - Scheduling of livestock deliveries
  - Installation of metered truck washing facilities
  - Dry cleaning of lairages before wash down
  - Not using water spray as a “wet broom”
  - Retaining blood in bleeding receptacles
  - Effective nozzle spray systems
  - Efficient scalding methods for pigs
  - Centralised heating of what water and recirculating systems
  - Dry-cleaning of solid pieces from process areas
  - Collection of water which may be used for lairage wash-down
  - Measuring water consumption in abattoir process areas
  - Implementation of leak detection systems
- Reduce wastewater strength and COD by:
  - Dry cleaning of solid particles, (both in lairages and process areas) not being washed down to wastewater
  - Eliminating blood from entering wastewater systems
  - Elimination of cleansing materials with high COD levels
- Action
  - Improvement of transport and lairage arrangements – consider benefits of a JIT (just-in-time) livestock delivery system to reduce holding periods, ensure continuous slaughter.

- Institute high-pressure low volume (HPLV) hoses for final lairage wash-down.
- Institute a coin operated, pre-paid system water for vehicle washing.
- Always practice dry-cleaning of manure from lairages before wash-down.
- Investigate recent water and wastewater costs to determine water and wastewater cost.
- Compare volume of water used per animal to national standard. If consumption is higher, reduce through improved management and control.
- Install water meters to measure use of hot and cold water in each process area.
- Utilise data to calculate water costs per process area, identify target areas for potential improvement.
- Compare water consumption of equipment with expected use as specified by equipment manufacturer.
- Identify and implement no-cost and low-cost opportunities – always ensure hygiene standards are not denigrated.
- Implement leak detection and leak repair programmes.
- Investigate re-use of clear water (e.g. chiller water from carcass refrigeration rooms, cooling water and steam condensate) for primary washing of lairages.
- Improve process and cleaning operations
- Segregate blood from wastewater treatment streams where possible to minimise wastewater COD.
- Ensure bleeding times are over the blood trough are sufficient.
- Squeegee blood for pumping to blood tanker, before washing down blood trough.
- Ensure control of pig scald tank water level. Consider changing to other forms of scalding, such as steam scalding.
- Execute dry gut manure removal, for cleaning of cattle and sheep viscera.
- Preferably, use pneumatic gut blowing systems, rather than wet conveyancing.
- Institute controls to ensure that continuous washing operations are discontinued during process breaks.
- Install water-efficient directional nozzles for carcass washing, evisceration, wash-down and conveyor cleaning.
- Maintain nozzles appropriately for carcass washing, spray cooling and other uses.
- Ascertain that trays are in place to receive meat scraps rather than being deposited on the floor.
- Ensure fine mesh covers being in place to eliminate solid waste from entering the sewer system, and that these are removed consistently.
- Utilise squeegees for dry collection of blood and solids from processing areas.
- Provide waste bins within easy reach, and ensure continuous emptying.
- Start wash-down only after manual dry-cleaning has been completed.
- Install automatic shut-off valves and/or trigger action controls to hoses.
- Cooperate with the supplier of cleaning materials to optimise use of water and cleaning chemicals.
- Institute continuous cleaning of screening equipment to provide optimal performance of the equipment.
- Investigate the installation of wastewater pre-treatment systems to reduce contamination, such as COD-levels prior to discharge.

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APPENDICES: QUESTIONNAIRES

Abbreviated Questionnaire

NATSURV 7: Red Meat Abattoir Industry								
Abbreviated Questionnaire for Participating Abattoirs								
1	Name of abattoir							
2	Nearest town							
3	Contact Person							
4	Landline no.							
5	Mobile no.							
6	Email address							
7	Throughput	Cattle	Calves	Sheep	Goats	Pigs	Ostriches	Other
a	Design capacity / day							
b	Average / day (6 months)							
8	Only main water meter	Yes	No					
9	Water meters per area	Yes	No					
10	By-products plant	Yes	No					
12	Effluent treatment on site	Yes	No					

General Information Questionnaire

NAME OF COMPANY				
NAME OF HOLDING COMPANY				
NAME OF FACTORY				
STREET ADDRESS				
P O BOX ADDRESS				
CONTACT PERSON				
SERVICE AUTHORITY (Municipality)				
FACTORY OPERATION				
MONTH	NO. OF DAYS	NO. OF SHIFTS / DAY	DURATION OF SHIFT	NO. OF EMPLOYEES SITE/24H
JAN				
FEB				
MAR				
APR				
MAY				
JUN				
JUL				
AUG				
SEP				
OCT				
NOV				
DEC				

Slaughter Volume Questionnaire

PRODUCTION									
PRODUCTION PERIOD:		START		END		YEAR			
SLAUGHTER (NUMBER OF HEAD)								SPECIES	
	CATTLE	CALVES	SHEEP	GOATS	PIGS	OSTRICHES	OTHER*	TOTALS	
MONTH									
JAN									
FEB									
MAR									
APR									
MAY									
JUN									
JUL									
AUG									
SEP									
OCT									
NOV									
DEC									
TOTALS									
* PLEASE SPECIFY (EQUINES – HORSES, MULES, ETC.)									

Water Use Questionnaire

WATER USE												
SPECIES												
WATER USAGE CATEGORY	WATER USAGE (m^3 PER MONTH)											
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
PROCESS												
WASH-DOWN												
COOLING												
REFRIGERATION												
BOILERS												
ABLUTIONS												
LAUNDRY												
VEHICLE WASHING												
GARDENS												
OTHER (SPECIFY)												
TOTALS												

Water Balance Questionnaire

WATER INTAKE				
MONTH	TOTAL WATER INTAKE (m^3)			
JAN	MUNICIPAL	BOREHOLE	OTHER	TOTAL
FEB				
MAR				
APR				
MAY				
JUN				
JUL				
AUG				
SEP				
OCT				
NOV				
DEC				
TOTAL				

Wastewater Questionnaire

DISPOSAL ROUTE FOR ABATTOIR WASTE							
ESTIMATED ANNUAL WASTEWATER VOLUME (m^3)							
WASTEWATER ANALYSES (YEAR 20……..)							
PARAMETER		JAN	FEB	MAR	APR	MAY	ETC.
pH	min						
	max						
	mean						
Chemical oxygen demand (COD)	min						
	max						
	mean						
Total solids (TS)	min						
	max						
	mean						
Suspended solids (SS)	min						
	max						
	mean						
Total dissolved solids (TDS)	min						
	max						
	mean						
Phosphate (PO_4 as P) (PO_4-P)	min						
	max						
	mean						
Other (specify)	min						
	max						
	mean						
Other (specify)	min						
	max						
	mean						
Other (specify)	min						
	max						
	mean						
BREAKDOWN OF ANNUAL WASTEWATER VOLUME							
		JAN	FEB	MAR	APR	MAY	ETC.
FLOW (m^3 / MONTH)							
MIN (m^3 / MONTH)							
MAX (m^3 / MONTH)							
MEAN (m^3 / MONTH)							

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