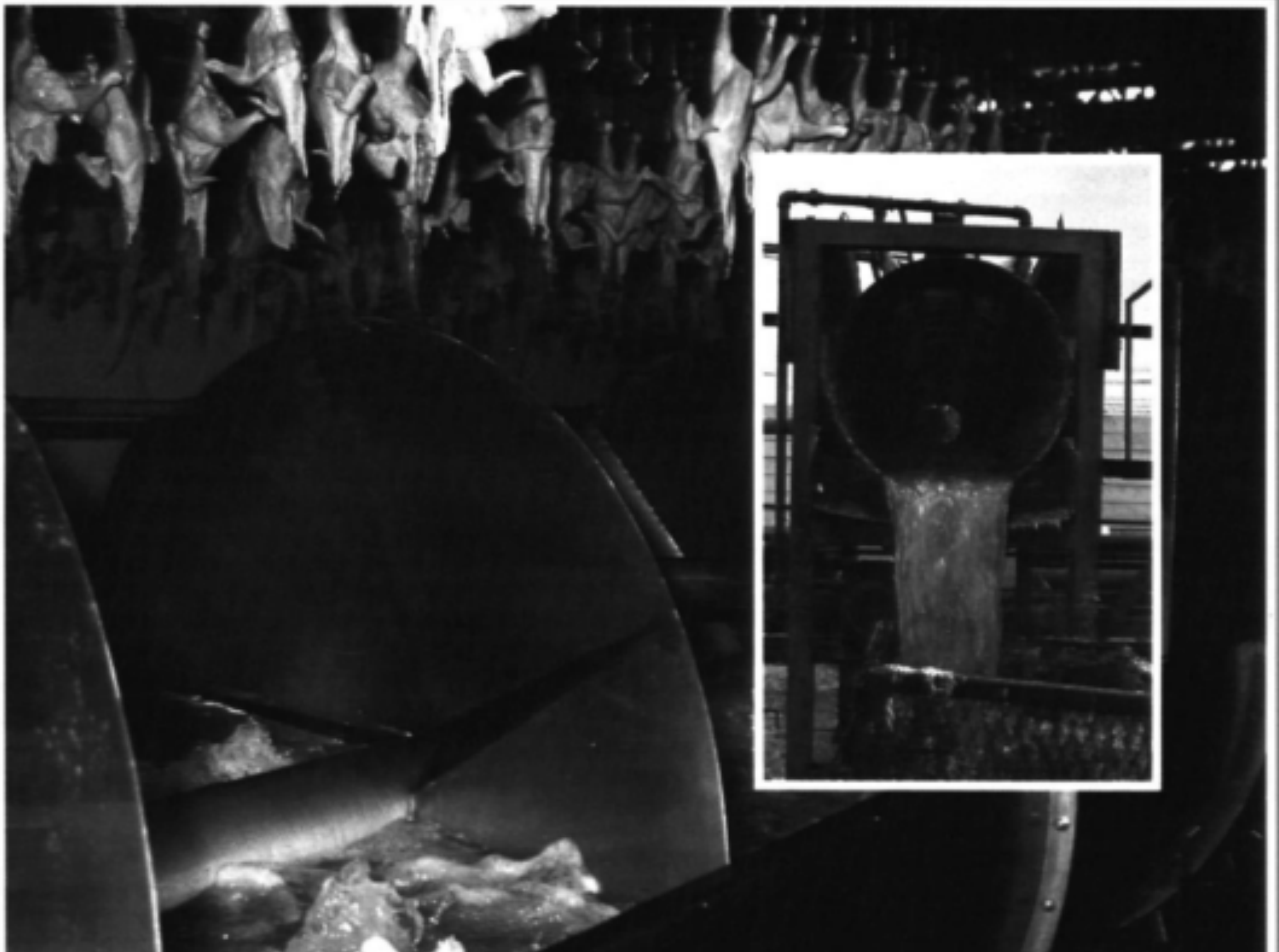
NATSURV 9

WATER AND WASTE-WATER MANAGEMENT IN THE POULTRY INDUSTRY



NATSURV 9

WATER AND WASTE-WATER MANAGEMENT

IN THE POULTRY INDUSTRY

PREPARED FOR THE
WATER RESEARCH COMMISSION

BY

STEFFEN, ROBERTSON AND KIRSTEN
CONSULTING ENGINEERS

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Steffen, Robertson and Kirsten Inc.
16th Floor
20 Anderson Street
JOHANNESBURG
2000

P O Box 8856
JOHANNESBURG
2000
Tel. (011) 492 1316

Available from:

Water Research Commission
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PRETORIA
0001
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FOREWORD

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

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 Steffen, Robertson and Kirsten, a firm of consulting engineers, to undertake the National Industrial Water and Waste-water Survey (NATSURV) of all classes of industry. The consultants identified 75 industrial groupings in South Africa, one of which is the poultry industry. The results obtained in the survey of the poultry industry form the basis of this guide on water and waste-water management in the poultry industry.

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

ACKNOWLEDGEMENTS

The preparation of this publication was guided by the following editorial committee:

Dr O O Hart	Water Research Commission
Mr J Cawson	Earlybird Farm Pty Ltd
Mr D F Sutton	Department of Water Affairs
Mr P Skivington	Steffen, Robertson and Kirsten

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ABBREVIATIONS

b	-	birds
COD	-	Chemical oxygen demand
FOG	-	Fats, oil, grease
OA	-	Oxygen absorbed
RO	-	Reverse osmosis
SEV	-	Specific effluent volume
SPL	-	Specific pollution load
SS	-	Suspended solids
SWI	-	Specific water intake
TDS	-	Total dissolved solids
TKN	-	Total Kjeldahl nitrogen
UF	-	Ultrafiltration

GLOSSARY

1 **Evisceration** - Removal of organs from a slaughtered bird.

2 **Rendering** - Cooking of animal wastes followed by drying in order to produce a proteinaceous meal. Melted fat may be recovered at the same time for tallow production.

3 **Scalding** - Immersion of birders in water at 50 - 55^{0}C in order to loosen feathers prior to defeathering.

4 **Specific effluent volume (SEV)** - The effluent volume generated in a particular period divided by the number of birds used in production during the same period.

5 **Specific pollution load (SPL)** - The pollutant mass load before secondary treatment for a particular period (in terms of any particular pollutant parameter, eg COD, FOG, TKN, etc) arising from an industrial unit process divided by the number of birds used in production during the same period.

6 **Specific water intake (SWI)** - The water intake for a particular period divided by the number of birds used in production during the same period.

7 **Stunning** - Electrical or other means of ensuring that a bird is made insensible in an approved humane manner before slaughtering.

SUMMARY

There are 140 poultry abattoirs in South Africa which slaughter some 330 million birds annually and use some 6 million m^3 of water. The weighted average SWI was found to be 17 l/bird for AP grades and 20 l/bird for other grades. The ranges of SWI figures found were 15 to 20 l/bird for AP grade abattoirs and 15 to 30 l/bird for other grades.

A target SWI of 15 l/bird is proposed for AP grades and 20 l/bird for other grades.

The weighted average SPL was found to be 29 g COD/bird and 7 g SS/bird for AP grade abattoirs and 64 g COD/bird and 14 g SS/bird for other abattoirs. Target SPL figures of 29 g COD/bird and 7 g SS/bird for AP grade abattoirs and 64 g COD/bird and 14 g SS/bird for other abattoirs are proposed.

1 INTRODUCTION

South Africa's poultry slaughtering requirements are carried out by approximately 140 abattoirs, of which about 100 can be considered as being of a commercial size. These provide approximately 40% of the nations's meat by mass with red meat providing the remaining 60%. The poultry industry is growing at a rate of 6-7% per annum and is assuming an increasingly important role in the South African abattoir industry.

The annual water consumption of the poultry industry is in the region of 6 million m^3. Approximately 90 % of this water is discharged as waste water. Waste water from a poultry abattoir will contain several of the following contaminants: blood, skin, fat, feathers, viscera and faeces. Each of these contributes to a high organic load as well as a considerable quantity of suspended matter.

The data presented in this guide have been collected from detailed surveys conducted at 15 separate abattoirs.

Poultry abattoirs are graded according to the maximum daily slaughter that their facilities allow. This grading system is indicated below:

Grade	Maximum Daily Slaughter Allowed (birds/d)
AP	Above 10 000
BP	10 000
CP	500
DP	200
EP	50

The total number of birds slaughtered commercially in South Africa in 1988 was approximately 330 million. Some 93% of this figure can be accounted for by the 19 AP grade abattoirs in the country.

2 PROCESS RÉSUMÉ

2.1 Reception Area

Live birds are normally delivered to an abattoir in crates. These crates are stored in a holding area until the birds are off-loaded onto a conveyor travelling to the slaughter area. The birds are hung by their feet on an overhead conveyor. As part of the overall hygiene requirements of a white meat abattoir the reception area must be kept clean and this is usually achieved by frequent wash-down. Contaminants in this area include dirt, feathers and droppings. In addition, large abattoirs have crate-washing facilities which represent another considerable water demand.

2.2 Slaughter Area

Birds are stunned by immersing the head and neck in an electrified water bath and the throats are slit manually. Most large abattoirs have blood collection facilities consisting of a trough into which blood flows from the birds as they pass along the process line. Blood spillage is a potential source of high organic pollution from this area.

2.3 Scalding and Defeathering

After bleeding the birds are immersed in a scalding tank containing water at 50 - 55°C in order to loosen the feathers. Scalding tanks are operated with a flow of hot water and a corresponding overflow from the tanks so that the scalding water quality and temperature are maintained. High organic and solid pollution loads arise from scalding tank overflows and considerable shock loads occur when scalding tanks are emptied.

Following the scalding operation, feathers are removed from the birds by defeathering machines, equipped with rotating rubber fingers so that the skin is not damaged. The feathers can be further processed to give a valuable by-product or collected for disposal as solid waste. They are usually collected in a flume and pumped over screens before further processing or dumping. The waste water following screening contains a considerable organic pollution load.

2.4 Evisceration

After defeathering, the bird's heads and feet are removed and the carcasses are sprayed with water (sometimes chlorinated). Carcasses are cut open and the viscera pulled out for inspection. Hygiene is vitally important at the evisceration stage in order to prevent microbiological contamination of the meat. Evisceration takes place in a separate room from slaughtering, scalding and defeathering. After passing inspection, the viscera are sorted into edible and inedible offal. Carcasses which do not pass this inspection stage are removed form the production line. Water used to transport inedible offal away from the evisceration area for screening is another potential source of high organic pollution loadings. It contains significant levels of blood, fat and grease, tissue and intestinal contents which screening only partially removes.

2.5 Chilling

Again for reasons of hygiene, and particularly to minimize microbiological contamination, the birds are chilled to less than 10^0C. This can be done by either cold air or chilled water.

Water chillers operate on a make-up and overflow system to maintain water quality and temperature. This overflow contains significant levels of organic pollution.

2.6 General Washing

Relatively large quantities of water are used in all of the process areas described for cleaning purposes. Vehicle washing also consumes a significant quantity of water as does water used for boot cleaning and ablutions.

2.7 By-product Processing

Blood, feathers, inedible offal and condemned carcasses can be further processed to produce valuable by-products. This is normally done by rendering. A number of larger abattoirs have their own rendering facilities on site. Washing out of rendering cookers is a source of organic pollution. The wash-water is discharged to drain and can contain a significant organic pollution load. Another source of waste-water from this area is the condenser used to condense malodorous vapours leaving the cookers.

3 SUMMARY OF SURVEY RESULTS

3.1 Specific Water Intake (SWI)

The SWI figures for 17 poultry abattoirs are listed in Table 3.1 below.

Table 3.1 Specific water intake (SWI) for poultry abattoirs

Abbatoir grade	Birds slaughtered (birds/day)	Water intake (m^3 /d)	SWI (l/bird)
AP	174 900	2 800	16
AP	122 450	1 620	13 *
AP	87 960	1 760	20
AP	45 650	780	17
AP	29 900	540	18
AP	27 820	420	15
AP	22 460	337	15
AP	20 370	380	19
BP	8 750	130	15
BP	4 900	98	20
BP	4 800	110	23
BP	4 600	117	25
CP	460	9	20
CP	440	10	23
CP	430	13	30
DP	170	4	24
DP	140	4	29

* Outlying result (not directly comparable with others)

It is proposed that for the purpose of this guide, AP grade abattoirs be considered separately from the other grades. AP grade abattoirs process much larger numbers of birds than the other grades and therefore utilize much greater volumes of water. The weighted average SWI for AP grade abattoirs was found to be 17 l/bird. The weighted average SWI for other grade abattoirs was found to be 20 l/bird. It can be seen that on average, large abattoirs are more water efficient than smaller ones but it is also interesting to look at the range of SWI found for the two groups. For A-grade abattoirs the range of SWI was found to be 15 to 20 l/bird while for other grades it was found to be 15 - 30 l/bird.

Small abattoirs often operate on a stop-start basis and do not have the personnel available for intensive water management practices. Also, as they are dealing with much smaller volumes of water, water management does not warrant the close attention given to it by larger abattoirs.

Utilization of abattoir capacity is also an important factor when considering water utilization. This is significant from the point of view of water management, because an abattoir operating at significantly below its design capacity will have its SWI pushed up by operations such as cleaning which must be carried out to the same extent regardless of the number of birds being processed. This is not that significant when considering smaller abattoirs which can often at times of low throughput close down completely which is something that larger abattoirs cannot so easily do.

Even within the AP grade there is a difference of over eight times the production throughput between the largest and the smallest abattoir examined in this study. Although water management principles are the same for all sizes of abattoir some measures may be more appropriate for very large abattoirs than for the smaller ones.

When considering abattoirs with very similar production throughput considerable differences in SWI have been found (see Table 3.1). This is true for all grades of abattoir but it is especially significant for AP grade abattoirs because of the much larger volumes of water involved. This is a clear indication that there is still considerable room for improvement in water management practices within the industry.

3.2 Breakdown of Water Use

Table 3.2 Water use for a typical large poultry abattoir

	Average percentage	Breakdown of SWI for an AP grade abattoir l/bird
Process		
- Hanging, stunning, bleeding	1	0,15
- Scalding	17	2,9
- Evisceration	33	5,6
- Spin-chilling	12	2,0
	63	10,65
Utilities		
- Boilers	1	0,15
- Cooling towers and refrigeration	7	1,2
	8	1,25
Wash-down		
- Floor & equipment washing	17	2,9
- Crate washing	2	0,3
- Truck washing	3	0,5
	22	3,7
By-products rendering	5	0,8
Domestic	2	0,4
	100	17

Overall the process accounts for 63% of the water intake, wash-down for 22%, utilities for 8%, by-products rendering for 5% and domestic for 2%. The biggest single user of water in a white meat abattoir is the viscera transport flume. Water used in defeathering is afterwards used to transport feathers and edible offal.

The breakdown of water use for a smaller abattoir could be very different as sophisticated means of viscera transport and spin-chilling for example, may not be employed. General wash-down would tend to be responsible for the largest use of water in smaller abattoirs.

3.3 Waste water

3.3.1 Specific parameters

Poultry abattoir waste water varies considerably in quality over a 24-hour period. Composite samples of screened, raw waste water from 15 abattoirs were collected and the results summarized in Table 3.3. The waste water will include cleaning agents as well as organic contaminants.

Table 3.3 - Waste-water quality data from poultry abattoirs

	Water intake	Waste water	% of water intake disc	Determinand			
				pH	COD mg/ℓ	SS mg/ℓ	TDS mg/ℓ
Range: AP grade	380 - 2800	340 - 2640	85 - 94	5,9-10,1	698-4744	106-1240	332-2040
Other grade	4 - 130	4 - 128	88 - 99	6,0- 8,8	1100-6780	141- 970	477-2170
Mean : AP grade	1002	902	90	7,2	1760	410	900
Other grade	55	52	94	7,7	3410	730	1250

Table 3.4 Specific pollution loads (SPL) and specific effluent volumes (SEV) for poultry abattoir

	Waste water (m^3/d)	Birds slaughtered (bird/d)	SPL			
			COD (g/bird)	SS (g/bird)	TDS (g/bird)	SEV (l/bird)
Range: AP grade	340 - 2640	20370-174900	11,6-38,1	1,8-10,4	4,4-19,2	7,7-16,4
Other grade	4 - 128	140- 8750	6,7-71,6	1,0-18,7	6,0-34,1	9,6-28,2
Mean : AP grade	902	58440	28,5*	6,9*	13,9*	15,4*
Other grade	52	2740	64,1*	13,6*	22,2*	19,0*
(weighted ave. *)						

From Tables 3.3 and 3.4 the following have been calculated:

Mean waste-water discharge
a) for AP-grade abattoirs = 902 m^3/d
b) for other grade abattoirs = 52 m^3/d

Mean number of birds slaughtered
a) for AP-grade abattoirs = 58440 birds/d
b) for other grade abattoirs = 2740 birds/d

Therefore the mean SEV for AP grade abattoirs is 15,4 l/bird and 19,0 l/bird for other grades.

The mean water intake is 1002 m^3/d for AP grade abattoirs and 55 m^3/d for other grade abattoirs.

This gives a mean percentage waste-water discharge of 90% for AP grade abattoirs and 94% for other grades. From the average pollutant concentrations calculated from Table 3.3, the following weighted average SPL figures have been calculated:

weighted average COD load	=	28,5 g/bird	for AP grade abattoirs
	=	64,1 g/bird	for other grade abattoirs
weighted average SS load	=	6,9 g/bird	for AP grade abattoirs
	=	13,6 g/bird	for other grade abattoirs
weighted average TDS load	=	13,9 g/bird	for AP grade abattoirs
	=	22,2 g/bird	for other grade abattoirs

These figures indicate that lower SPL are found at large abattoirs compared to smaller ones. In most cases large abattoirs have an ongoing waste-water management policy and have equipment installed to ensure efficient blood collection and viscera and feather transport. This material is then either rendered or removed from site as solid waste. For smaller abattoirs with less extensive facilities higher SPL's occur due to spillage of pollutants such as blood and their subsequent washing into the waste-water drainage system.

3.3.2 Breakdown of specific pollution load (SPL)

It has been found that in a white meat abattoir the most significant sources of organic pollution loads are the evisceration water used to transport inedible offal (after screening) and the wash-down water. The scalding tank overflow can also carry a considerable organic load.

It is estimated that the final waste-water COD load from a white meat abattoir can be apportioned as follows :

	Average percentage	**Breakdown of SPL for AP grade abattoirs**
Evisceration room	49%	14,0 g/bird
Wash-down	35%	10,0 g/bird
Scalding	10%	2,9 g/bird
Miscellaneous	6%	1,6 g/bird
	100%	28,5 g/bird

This breakdown is for large abattoirs utilizing water for feather and inedible offal transport and which have efficient blood collection facilities. In the absence of large-scale water use for offal transport and without efficient blood collection, the load would be distributed differently, with wash-down being responsible for the largest portion (up to 60% of the total organic load).

3.4 By-products and Solid Waste

Solid waste and by-products at a poultry abattoir include:

a) screened feathers, associated fat and other matter,

b) screened inedible offal, associated with grease and other matter,

c) condemned carcasses,

d) blood, and

e) dissolved air flotation sludge.

For abattoirs with access to rendering facilities, feathers, inedible offal and condemned carcasses are further processed as by-products. Otherwise these materials are regarded as solid waste and are transported to appropriate solid waste sites.

4 CONCLUSIONS AND RECOMMENDATIONS

4.1 Water Intake

It was found during this study that the range of SWI for white meat abattoirs was 15 to 20 l/bird for AP grade abattoirs and 15 - 30 l/bird for other grades. Targets of 15 l/bird for AP grade abattoirs and 20 l/bird for other grades are proposed.

4.2 Recommendations for Reducing Water Intake

The variations in SWI for white meat abattoirs indicate that considerable scope exists for improvement in water management practices. It is expected that many of the proposed methods of reducing water intake will be applicable to all sizes of abattoir but it is in the AP grade abattoirs where improved water management will cause the most significant reductions in the use of water by the poultry industry.

Methods of reducing water intake include -

(a) pressurizing water used for general washing and use of mixed water and compressed air streams to produce water sprays,

(b) fitting all hoses with self-closing nozzles to prevent wastage when not in use,

(c) using brooms to sweep up loose dirt and feathers in the reception area with wash-down taking place using a proportion of recycled water (this will also reduce the pollution load),

(d) providing effective solids traps in drains,

(e) water meters should be installed at all the key areas in the abattoir and management should monitor and act on the water meter figures,

(f) staff training should include an appreciation of the need for water conservation and management should consider incentive schemes linked to water conservation measures in the abattoir,

(g) dry transport of viscera from poultry carcasses,

(h) sprays should be linked to process line operation so that they switch off when the lines are stationery, and

(i) custom-built vehicle and crate-washing facilities.

It is apparent that, in the white meat abattoir industry, there are several opportunities for water reuse which are worthy of consideration. All of these measures would, of course, be subject to approval by the meat hygiene authorities. The suggested measures are:

(a) recycle of feather transport water after screening for reuse in the defeathering process or for offal removal, and

(b) reuse of treated water for floor and vehicle washing.

4.3 Waste water

It was found that waste-water quality in AP grade abattoirs was 29 g COD/bird and 7 g SS/bird. For other grade abattoirs the corresponding figures were 64 g COD/bird and 14 g SS/bird. Target figures corresponding to these industry weighted averages are proposed. By striving to achieve these targets, significant cost savings in waste-water treatment can be realized.

4.4 Recommendations for Reducing Pollution Loads at White Meat Abattoirs

The potential sources of waste water in a poultry abattoir are as follows:

(a) overflow water from the scalding tanks,
(b) feather transport water,
(c) viscera transport water,
(d) chiller overflow water, and
(e) general wash-down water and carcass spray water.

Blood, loose dirt and feathers can act as contaminants of waste-water flows. In most larger abattoirs many of these water flows are recycled and the volume of waste water and, to some extent, the pollution load are reduced. However, hygiene requirements dictate that water quality be maintained and the potential for water reuse is therefore limited. Chlorination of certain water streams should be investigated where feasible for reuse. Other systems for transport of offal (which are responsible for a large proportion of the waste water generated at white meat abattoirs) that do not require the use of water at all, are worthy of consideration, provided again that health requirements are satisfied.

Blood has the potential of increasing a plant's waste-water pollution load significantly and, as blood represents 6-8% of poultry body weight, it is obviously essential that the blood be collected with a minimum of spillage. In most poultry abattoirs efficient blood collection is in evidence, though from time to time, spillages do occur.

In smaller abattoirs the collection of blood often does not receive sufficient attention and COD levels of over 100 000 mg/l have been sampled leaving slaughter areas where poor or no blood collection facilities exist. One reason for this may be that in larger abattoirs, blood is seen as a potentially valuable by-product which can be further processed either on site or reasonably close to the abattoir, in a rendering or protein recovery plant. For smaller abattoirs where no further processing facilities are available, blood spillage is often seen as a nuisance and as such is discharged to drain rather than collected.

High waste-water pollution loads as a result of general wash-down are inevitable but greater use of dry methods such as sweeping and vacuuming with a water wash-down occurring only at the end of shifts, for example, would reduce the waste-water pollution load considerably.

5 WASTE-WATER TREATMENT

5.1 Preliminary Treatment

The use of vibratory and self-cleaning screens will reduce the solids loading of final waste water from an abattoir. The screened waste water will still have a high dissolved and colloidal organic content however, and efforts should be made to reduce this.

FOG removal facilities positioned upstream of any waste-water treatment facility will greatly improve the effectiveness of the subsequent treatment process. Balancing of abattoir waste water which has previously passed through screens and FOG removal facilities is recommended. It does, however require technical supervision and should be viewed as a resource recovery process. It is especially important to consider if further on-site treatment such as that described below is to be effective. Abattoir waste water fluctuates enormously in quality and quantity and balancing of this waste water for an appropriate period of time gives rise to a waste water of much more consistent quality than could otherwise be achieved. As well as benefiting any on-site treatment, there are obvious advantages for a municipal treatment works.

5.2 Dissolved Air Flotation

In this process the waste-water stream is pressurized and injected with compressed air to create supersaturated conditions. The supersaturated waste water is then allowed to reach equilibrium with atmospheric pressure. The sudden reduction in pressure causes the air to leave the solution as very fine bubbles which adhere to any oil, fat or other suspended solids in the waste water, carrying them to the surface. The layer of solid material which forms is then swept off the surface and can be recovered for rendering.

5.3 Membrane Processes

To render abattoir waste water suitable for recycle and selective reuse, further treatment is required. Considerable work has been carried out to determine the applicability of membrane separation, in particular ultrafiltration (UF) and reverse osmosis (RO), for this task.

A major consideration in these processes is membrane fouling which results in a reduced flow of liquid through the membrane. The rate of flow of liquid through the membrane is termed flux, and is measured in units of $1/m^2.h$ for a given driving pressure. Flux levels are monitored throughout operation and, when the flux falls to a predetermined level, a cleaning agent, (such as a hot alkali solution) is flushed through the system to restore the flux. Membranes are constructed in a number of materials including cellulose acetate, polyamides and polysulphonates. They can only be selected for a particular duty after pilot plant work has been conducted to identify which type is best suited and what cleaning agent should be used to restore flux.

5.4 Centralized Rendering Facilities

At many of the smaller abattoirs, especially those situated in rural areas, disposal of blood and other by-products such as feathers, trimmings and carcasses classified as unfit for human consumption, is problematic. At large abattoirs these by-products are sent for rendering in an adjacent rendering plant which may also receive by-products from smaller abattoirs situated close by. Often small abattoirs in rural areas have no alternative but to discharge blood and other by-products to the local waste-water treatment works. This obviously puts considerable strain on what is possibly a small works and results in high costs for both the abattoir and the municipality.

With the provision of a centralized rendering facility wherever geographically feasible, these problems would be largely obviated to the advantage of both abattoir and municipality. The abattoir would benefit financially as the blood and other by-products are of considerable value, in addition to saving on waste-water disposal costs.

5.5 Protein Recovery

As the major portion of the organic matter in abattoir waste waters is proteinaceous in nature, several methods of protein recovery have been developed -

(a) adjustment to low pH and protein precipitation with lignosulphonate or sodium hexametaphosphate,

(b) use of cellulose-based ion-exchange resin to recover protein,

(c) maximisation of biomass yield in activated sludge followed by protein recovery in the form of the generated biomass, and

(d) use of ultrafiltration to separate large-molecular-weight proteins from waste water.

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