Natsurv 9:

Water and Waste Water Management in the Poultry Industry

(Edition 2)

G Pocock & H Joubert

WATER RESEARCH COMMISSION

TT 730/17

NATSURV 9

WATER AND WASTE WATER MANAGEMENT IN THE POULTRY INDUSTRY

(Edition 2)

Report to the

Water Research Commission

by

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VitaOne8 (Pty) Ltd

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The publication of this report emanates from a project entitled: *Revision of Natsurv 9: Water and Wastewater Management in the Poultry Industry* (WRC Project No. K5/2505/3).

This is a revised and updated version of Natsurv 9 that was published in the Natsurv series in 1987 as WRC Report TT 43/89.

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EXECUTIVE SUMMARY

The aim of this project was to undertake a survey of the South African poultry industry to obtain an overview of operations, specific water use, specific effluent volume and the extent to which best practice are being implemented. This was achieved by reviewing appropriate literature, disseminating questionnaires, holding workshops, interviewing companies and undertaking site visits.

A previous survey of this industrial sector was conducted in 1989 by Steffen, Robertson and Kirsten Consulting Engineers (Steffen, Robertson & Kirsten, 1989). Since this time, the industry has undergone several significant changes such as new legislation, new markets, social attitudes and change in ownership as well as the use of updated technology. In addition, there is growing awareness of the need to optimise water and energy use and reduce the production of waste, and this should be reflected in the specific water consumption and effluent production. It was therefore considered an opportune time to review the water and waste water management practices of the poultry industry and identify the changes that have been made since the 1989 survey. The 1989 National Survey (Natsurv) for the poultry industry did not include information on egg producers, breeders/hatcheries or broilers. While the contribution of these sectors in terms of water use and waste water generation is relatively small when compared to abattoirs, they nonetheless are integral to the industry as a whole and were considered in this revision.

Surveys were developed for each industry sector and sent to registered abattoirs, egg producers, hatcheries and broilers by the South African Poultry Association (SAPA) on behalf of VitaOne8, which included approximately 200 egg producers and 16 large broiler producers with abattoirs. Smaller non-SAPA members were contacted directly. These surveys aimed to obtain an overview of production figures, water use and pretreatment, effluent generation and quality, as well as to identify the best practices implemented within the companies. The participants were given the option to indicate either a range in which their company falls for each category, or to specify an exact number or amount, and had the option to respond anonymously. All results are reported anonymously, and no indication of province is given to protect the identities of the participants.

It is unfortunate that many of the producers contacted were unwilling to participate in the study, particularly among the smaller producers. Participation from large producers was good, which has resulted in the findings being skewed in their favour. However, it was observed that, as expected, the larger producers are setting the benchmark in terms of industry best practice.

The 1989 Natsurv (Steffen, Robertson and Kirsten Consulting Engineers, 1989) reported that South Africa's poultry slaughtering requirements were carried out by approximately 140 abattoirs, of which 100 could be considered commercially sized. The total number of birds slaughtered in South Africa in 1988 was approximately 330 million. By 2015, this number had increased to 1004 million (SAPA, 2015a), approximately three times more than in 1989.

Of the eight AP grade abattoirs (those slaughtering >10 000 broilers/day) assessed in 1989, the highest reported specific water intake (SWI) (ℓ/bird) was 20, with an average of 17. For the AP abattoirs assessed with daily slaughter numbers ranging from 20 370 to 174 900, the water intake range was 380-2800 m^3/d, and the waste water discharge range was 340-2640 m^3/day (84-90%). For the four BP grade abattoirs (those slaughtering a maximum of 10 000 broilers/day), the highest reported SWI was 25, with an average of 20.75. On average, it was determined that large abattoirs were more water efficient and had a narrower range or SWI than smaller ones. For AP grade abattoirs, the range of SWI was found to be 14-20 ℓ/bird, while for other grades it was found to be 15-30 ℓ/bird.

Of the responding abattoirs in the current survey, 12 of the 15 are classified as high-throughput abattoirs (more than 2000 units/day) according to the new grading legislation contained in the Poultry Regulations R153 of 24 February 2006. Of these, 11 would have been classified as AP grade abattoirs according to the previous grading system. Of the high-throughput abattoirs, the water intake range was from 500-3800 m^3/day, with an average percentage waste water discharge of 70-90%. The SWI ranged from

9 ℓ/bird to 14 ℓ/bird. There has therefore been significant growth in the industry since the previous survey, as well as an improvement in terms of water use.

Updating *Natsurv 9: Water and Wastewater Management in the Poultry Industry* has been a challenging task due to the limited participation of the producers and the resultant lack of data. Those companies that did participate provided valuable information, but further data is required before trends and averages can be determined with any degree of accuracy.

On average, the poultry sector has grown by approximately three times (in terms of meat production) since the 1989 survey, while at the same time the average SWI for abattoirs has decreased from an average of 17 ℓ/bird to 12.8 ℓ/bird. This indicates that the sector is becoming more efficient in terms of water consumption.

The contribution of egg producers, hatcheries and broiler producers in terms of water use and waste water generation is relatively small when compared with abattoirs. The egg producers that provided information on their water use were all within the range of 3000-20 000 kl/year, with an overall average of 6375 kl/year. The SWI for egg producers was <5 ℓ/bird. Hatcheries were within the range of 28 200-151 585 kl/year, with an average annual consumption of 93 192 kl, and an average SWI of <1 ℓ/bird. Broiler producers were within the range of 5001-40 000 kl/year, with an average annual water consumption of 11 250 kl and an average SWI of 6 ℓ/bird.

The movement of producers, particularly larger abattoirs, towards best management practices indicates that the sector is committed to sustainable production.

ACKNOWLEDGEMENTS

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The project Reference Group is thanked for contributing their knowledge and insights to the project.

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ABBREVIATIONS

SAPA	South African Poultry Association
DAFF	Department of Agriculture, Forestry and Fisheries
MSA	Meat Safety Act
USDA	United States Department of Agriculture
USA	United States of America
IQF	Individually Quick Frozen
AFMA	Animal Feed Manufacturers Association
VAT	Value-added Tax
FOB	Free on Board
EU	European Union
AI	Avian Influenza
MDM	Mechanically Deboned Meat
UK	United Kingdom
Stats SA	Statistics South Africa
HPAI	Highly Pathogenic Avian Influenza
SMME	Small, Medium and Micro-sized Enterprise
NWA	National Water Act
IWRM	Integrated Water Resource Management
CMS	Catchment Management Strategy
CMA	Catchment Management Agency
DWS	Department of Water and Sanitation
DWA	Department of Water Affairs
DWAF	Department of Water Affairs and Forestry
NWRS	National Water Resource Strategy
COD	Chemical Oxygen Demand
Waste Act	National Environmental Management: Waste Act, 2008 (Act 59 of 2008)
NWMS	National Waste Management Strategy
HACCP	Hazard Analysis and Critical Control Point
SABS	South African Bureau of Standards
WSA	Water Services Authority
WSP	Water Services Provider
TSS	Total Suspended Solids
SWI	Specific Water Intake
BOD	Biological Oxygen Demand
DAF	Dissolved Air Floatation

SS	Suspended Solids
EC	Electrical Conductivity
TDS	Total Dissolved Solids
TKN	Total Kjeldahl Nitrogen
TP	Total Phosphorus
HFO	Heavy Fuel Oil
LPG	Liquefied Petroleum Gas
GDARD	Gauteng Department of Agriculture and Rural Development
GAP	Good Agricultural Practice
NEMA	National Environmental Management Act (Act 107 of 1998)
UASB	Up-flow Anaerobic Sludge Blanket Reactor
CHP	Combined Heat and Power
WPA	Water Pinch Analysis
ISO	International Organization for Standardization
WC/DM	Water Conservation/Demand Management
NMBM	Nelson Mandela Bay Metropolitan Municipality

1 INTRODUCTION

1.1 Poultry Industry Overview

The poultry industry is the largest agricultural sector in South Africa contributing 19.7% (15.5% from poultry meat and 4.2% from eggs) of agricultural income and 42.2% of animal products in 2014. The gross primary agricultural production values from poultry meat and eggs for 2014 were R33.810 billion and R9.195 billion, respectively (Figure 2). Approximately 76% of birds in the South African poultry industry are used for meat production, while the remaining 24% are used in the egg industry (SAPA, 2014d). The gross value of ostrich feathers and products was R410.6 million in 2014; this is 0.19% of agricultural production and 0.40% of total animal products (DAFF, 2014).

The day-old chick-supply industry supplies inputs to both the egg and broiler industries. Pure lines are imported at great-grandparent or grandparent level. Most imports are at grandparent level with some parent level imports. No commercial level day-old chicks or fertile eggs may be imported (SAPA, 2014d).

The South African Poultry Association (SAPA) conducted a poultry census in 2014. From the models used to determine the broiler and egg industry's potential production figures, it was derived that at the end of June 2014 there were an estimated 140 million chickens at any given time in South Africa. Actual census data as reported by participants indicated a total bird population of 132 480 358 in June 2014. The provincial distribution of chicken farms per type of farm as reported by participants is depicted in Table 1. The provincial totals are illustrated in Figure 1. North West housed the largest total number of birds at 21.7%, followed by the Western Cape at 20.5%. The Northern Cape province housed the lowest number of birds at 0.2%.

Table 1 Provincial distribution of chicken farms in South Africa (SAPA, 2014e)

	Broiler industry		Egg industry		Grand total	
	Broiler birds	**% of total broiler birds**	**Layer birds**	**% of total layer birds**	**Total birds**	**% of total birds**
Eastern Cape	7 038 453	6.4%	928 385	4.0%	7 966 838	6.0%
Free State	6 067 200	5.5%	3 567 327	15.4%	9 634 527	7.3%
Gauteng	7 979 772	7.3%	6 036 520	26.1%	14 016 292	10.6%
Kwazulu-Natal	14 599 240	13.4%	3 391 447	14.6%	17 990 687	13.6%
Limpopo	2 486 300	2.3%	1 713 603	7.4%	4 199 903	3.2%
Mpumalanga	21 429 738	19.6%	1 063 432	4.6%	22 493 170	17.0%
North West	26 366 010	24.1%	2 418 496	10.4%	28 784 506	21.7%
Western Cape	23 205 600	21.2%	3 978 561	17.2%	27 184 161	20.5%
Northern Cape	157 000	0.1%	53 274	0.2%	210 274	0.2%
Grand total	**109 329 313**	**100.0%**	**23 151 045**	**100.0%**	**132 480 358**	**100.0%**

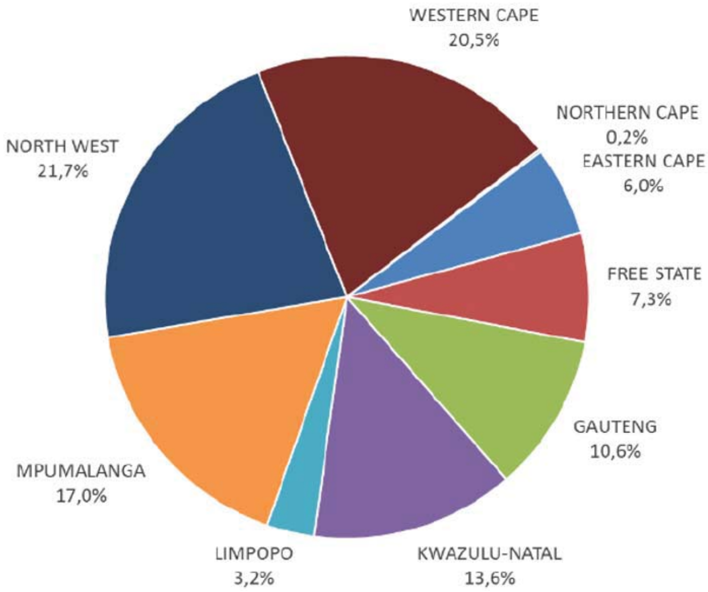


Figure 1 Provincial distribution of chickens in South Africa

According to SAPA (2015a), The Department of Agriculture, Forestry and Fisheries (DAFF) estimated the gross value of primary agricultural production from poultry meat for 2015 as R38.807 billion, while a gross value of R9.833 billion was recorded for eggs (Figure 2). Combined, the gross poultry farm income for 2015 was R48.640 billion, showing a yearly increase of 12.0%, up from 9.4% in 2014. According to DAFF estimates for 2014, total production of poultry meat, including spent hens from the broiler and layer sectors, was 1.697 million tons. The total production of shell eggs and eggs products was 0.436 million tons.

Together, broiler and egg producers represent the largest segment of South African agriculture at 20.9% of all agricultural production and 42.8% of all animal products in Rand value. The gross value of ostrich feathers and products was R516.6 million in 2015; this represents 0.5% of animal products and 0.2% of agricultural production.

The total gross value of animal products was R113.685 billion and the total gross value of agricultural products was R233.237 billion in 2015. Total animal products contributed 48.7% to the gross value of total agricultural products, with poultry meat contributing 16.6% and eggs 4.2%.

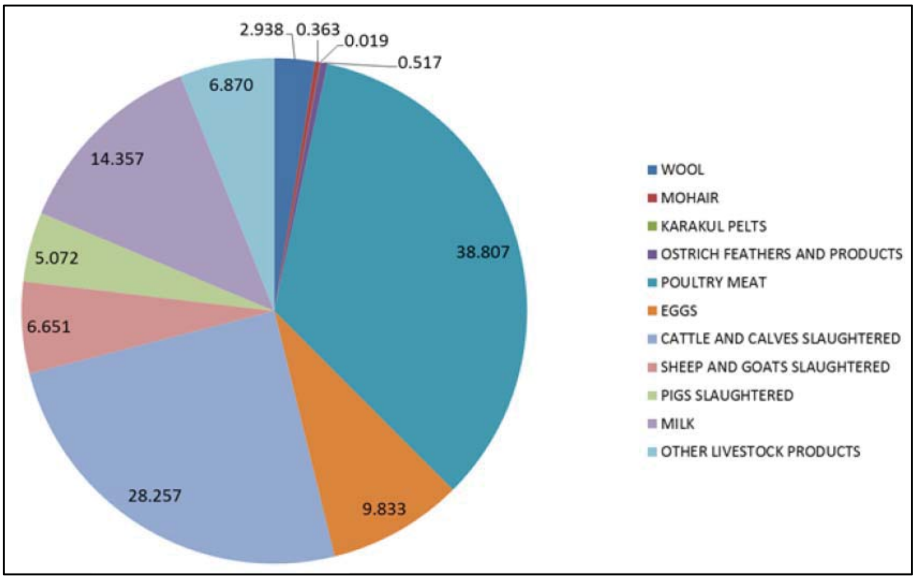


Figure 2 Gross value of South African animal products for 2015 (R billion) (SAPA, 2015a)

The poultry industry provides direct employment to over 56 218 people and indirect employment to about 108 000 people. Known poultry farmers include 275 producers and 231 contract growers in the commercial broiler sector, and 383 commercial egg producers (SAPA, 2012b).

With an estimated 7887 workers nationwide, the egg industry is an important player in rural employment. An estimated 6742 workers, 731 supervisors and 414 managers were employed in the industry during 2013, covering support staff, processing, packing, laying, rearing-pullet hatching, parents, parent-rearing and hatching, grandparent laying and rearing (SAPA, 2014d).

The per capita consumption of poultry meat and eggs in 2014 was 37.96 kg and 8.72 kg, respectively, with a combined per capita consumption of 46.68 kg (including backyard consumption). The per capita consumption of poultry meat and eggs in 2015 was 40.32 kg and 8.76 kg respectively, with a combined per capita consumption of 49.08 kg. Per capita consumption of beef, pork, and mutton and goat in 2014 was 18.14 kg, 4.57 kg, and 3.49 kg respectively, and 18.83 kg, 4.75 kg, and 3.56 kg respectively in 2015 (Figure 3) (SAPA, 2015a).

The gap is widening between the total consumption of poultry meat and eggs, and the total consumption of other types of meat (SAPA, 2015a) (Figure 3). During 2014, the total consumption of poultry meat and eggs was 2.543 million tons; 84% more than the combined 1.377 million tons of beef, pork, mutton and goat consumed over the same period. Of this, 2.049 million tons were poultry meat products (including imports) and 0.494 million tons were eggs and egg product (SAPA, 2014d).

During 2015, consumption of poultry meat and meat products (including imports) amounted to 2.234 million tons of eggs and 0.508 million tons of egg products, giving a total of 2.742 million tons. In comparison, 1.507 million tons of beef, pork, mutton and goat were consumed during the same period. Consumption of poultry meat and eggs therefore amounted to 64.5% of total animal protein consumed (excluding milk) (SAPA, 2015a).

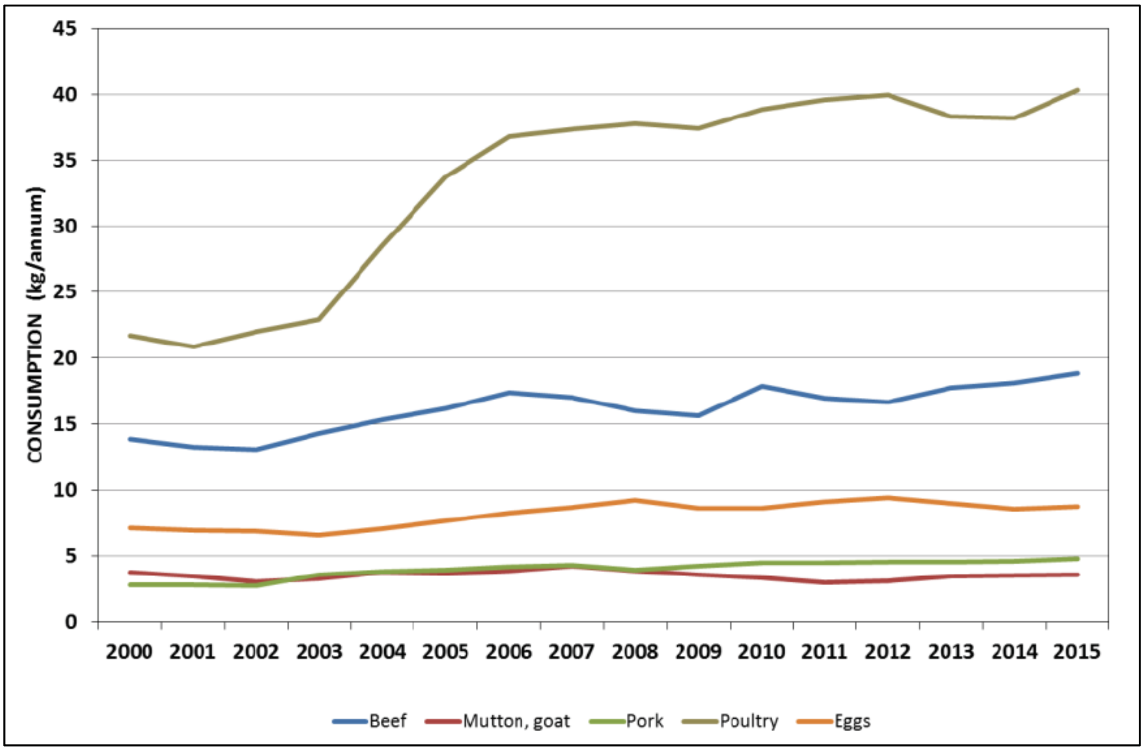


Figure 3 Per capita consumption of protein sources in South Africa from 2000-2015 (SAPA, 2015a)

1.1.1 Meat production

The 1989 Natsurv (Steffen, Robertson & Kirsten Consulting Engineers, 1989) reported that South Africa's poultry slaughtering requirements were carried out by approximately 140 abattoirs, of which 100 could be considered commercially sized. The total number of birds slaughtered in South Africa in 1988 was approximately 330 million. By 2015, this number had increased to approximately 1004 million (SAPA, 2015a).

Abattoirs are registered in terms of the Meat Safety Act (MSA), Act 40 of 2000. All abattoirs undergo a grading process and are bound to comply with statutory grading requirements according to the Poultry Regulations No. R153 of 24 February 2006, under section 22 of the MSA.

The grading of abattoirs is based on the throughput units, which is the number of animals that can be hygienically processed in a specified time, in addition to structural requirements. One unit in relation to a quantity standard for determining throughput for poultry abattoirs is defined as one fowl, one duck, one pheasant or one guinea fowl with the understanding that:

- One goose equals two units.
- One turkey equals four units.
- Four pigeons, two partridges, 12 quails or three baby fowls (*petit poissons*) equal one unit.

Abattoirs are then graded into three categories according to the structural requirements as well as the maximum throughput as specified in the regulations promulgated under the MSA. The throughputs and other grading requirements for poultry abattoirs are discussed in Part II A: of the Poultry Regulations R153 of 24 February 2006. This information is presented in Table 2.

Table 2 Throughput requirements for different abattoir grades according to the Poultry Regulations R153 of 24 February 2006

Abattoir grade	Throughput requirement
Rural abattoirs	Maximum throughput of 50 units per day
Low-throughput abattoirs	Maximum throughput of 2000 units per day
High-throughput abattoirs	More than 2000 units per day

Export abattoirs are usually, but not necessarily, high-throughput abattoirs that also meet the additional requirements of the importing countries (if any) and that have been allocated an export number (ZA number) by the National Department of Agriculture.

In 1989 when the previous survey was compiled, poultry abattoirs were graded according to the maximum daily slaughter that their facilities would allow, as indicated in Table 3. Of these, 93% poultry abattoirs could be accounted for by the 19 AP grade abattoirs in the country.

Table 3 Grading system in place at the time of the 1989 Natsurv (Steffen, Robertson & Kirsten Consulting Engineers, 1989)

Grade	Maximum daily slaughter allowed (birds/d)
AP	More than 10 000
BP	10 000
CP	500
DP	200
EP	50

1.1.1.1 Meat pricing

On a R/kg basis, broiler meat and eggs remain the most affordable of animal protein sources, with the exception of milk. In 2015, the average beef abattoir selling prices for classes A2/A3 and C2/C3 were R34.17 and R27.27/kg respectively. The average price for pork, all classes, was R22.83/kg. In comparison, the total realisation (less all discounts, rebates and secondary distribution) for broiler meat was R18.43/kg in 2015. Eggs were slightly cheaper at R16.65/kg. The producer prices and the annual percentage increases are shown in Figure 4. Average monthly beef, pork, broiler and egg producer prices for 2009-2015 are presented in Figure 5.

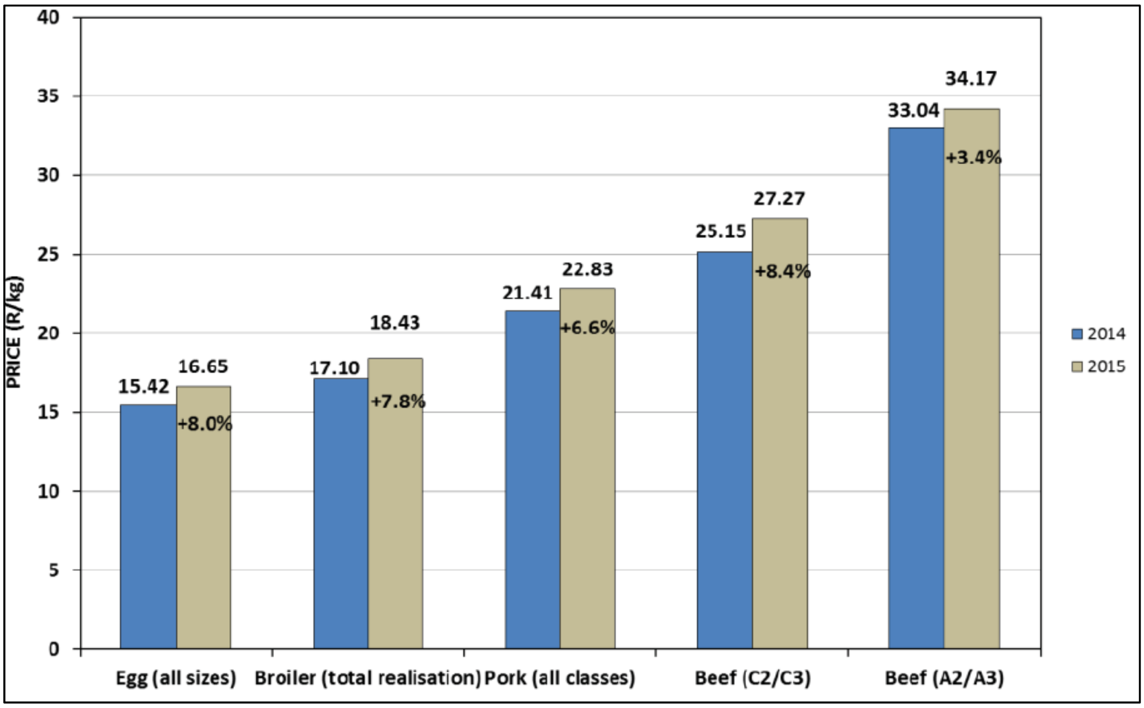


Figure 4 Comparison of the producer prices of different protein sources (SAPA, 2015b)

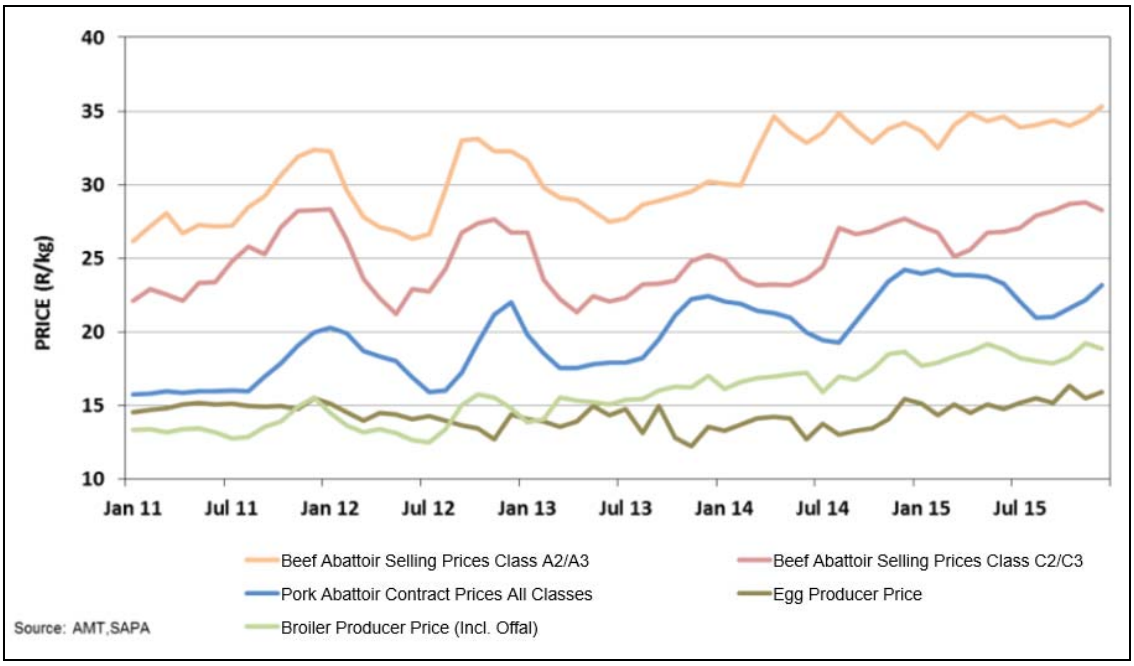


Figure 5 Monthly beef, pork, broiler and egg producer prices for 2009-2015 (SAPA, 2015a)

In terms of international price competitiveness, the United States Department of Agriculture (USDA) figures show that the average price in the northeast region of the United States of America (USA) for leg quarters was 30.86c/lb and for skinless deboned breasts, 148.36c/lb. Compared to 2014, the 2015 prices decreased by 33.8% and 15.1% respectively. Depicted in Rands and using the average exchange rate of R12.73 to the US Dollar for the year 2015, the leg quarter price equates to R13.09/kg and the skinless deboned breast price to R49.02/kg. The South African price for mixed individually quick frozen (IQF) portions was R16.97/kg and for filleted breast R23.87/kg.

Figure 6 shows the trend in these prices since 2011, which helps to explain why the USA is keen to dump the bone-in darker meat portions in South Africa.

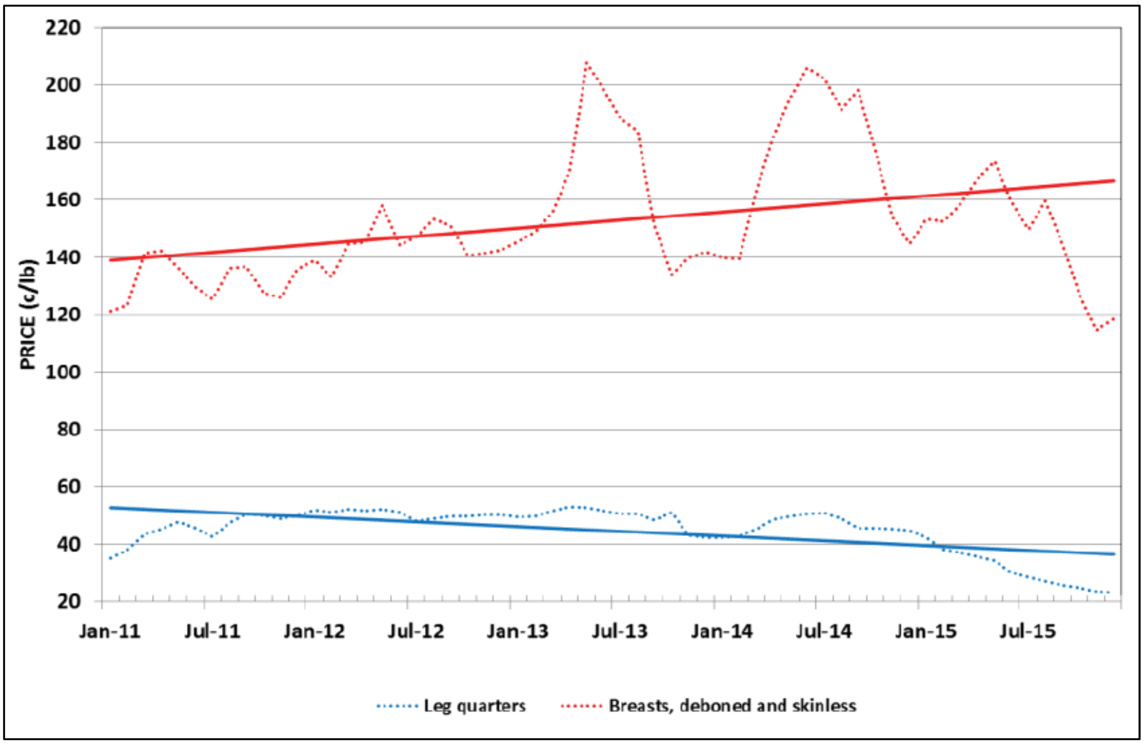


Figure 6 Trend in chicken prices for leg quarters and deboned chicken

1.1.1.2 Current production and growth projections

The South African broiler industry grew substantially between 2004 and 2008, averaging 6% per annum. Growth in the industry slowed down markedly to below 1% per annum (based on kilogrammes of meat produced) from 2009 to 2014. The earlier growth period was associated with increased demand for product and well-contained input costs. During the past seven years, production costs have increased, disposable income of consumers has declined and the importation of poultry meat products at low prices has eroded the demand for locally produced broiler products (SAPA, 2014d). Although the consumption of chicken meat is projected to maintain a rapid rate of expansion at approximately 4% per annum, it is not expected to match the sharp rise of 70% that occurred during the past decade. The reason is the projected lower rate of increase in real per capita income for the period from 2011 to 2020. It is anticipated that some 2.3 million tons of chicken meat will be consumed by 2020. Chicken meat production is anticipated to grow by 38% from 1.4 million tons to 1.9 million tons over the next decade. In 2014, total production of poultry meat was 1.697 million tons, whereas consumption amounted to 2.049 million tons. The per capita consumption of poultry meat for 2014 was 37.96 kg per annum. This includes the sale of spent hens from the broiler breeder and commercial layer industries, the sale of all the edible offal, the sale of the brine included in the brined products, as well as other poultry species (DAFF, 2014).

The average number of parent males and females in rearing during 2015 was 3.863 million per week; an increase of 150 200 birds (+4.05%) from 2014. Using a genetic pyramid, the estimated number of grandparent and great-grandparent stock in South Africa was 260 000 hens.

An average broiler breeder flock of 6.716 million hens was estimated for 2015. This showed an increase of 115 600 hens (+1.8%) from 2014 (SAPA, 2015b).

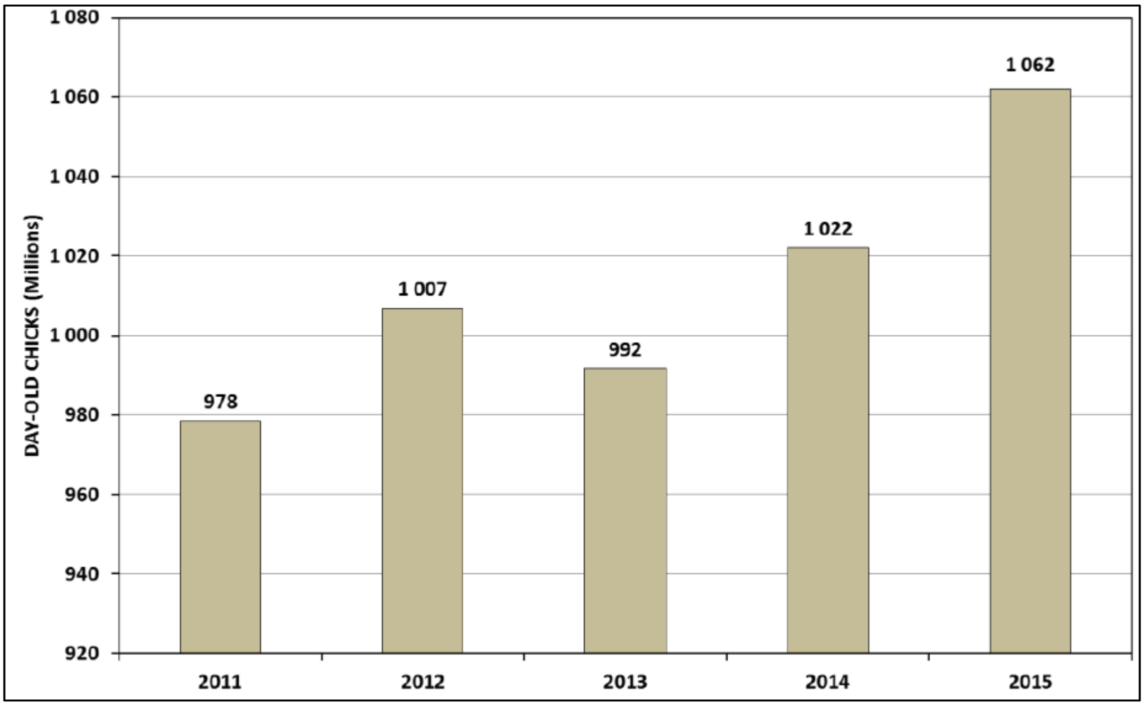


Figure 7 Annual broiler day-old chick production

The number of day-old parent females placed during 2015 increased by 7.0% from 2014. The broiler breeder flock is expected to increase in the first four months of 2016 by 3.2% to 6.93 million hens, when compared to the average size in 2015.

There was a 3.9% year-on-year increase in day-old chick production in 2015, with a total hatch of 1062 million chicks. The number of broilers slaughtered for the year was 1004 million, a 4.6% increase from 2014.

In total 960.34 million broilers were slaughtered/sold in 2014, an increase of 18 million (1.9%) from 2013. In 2015, 1004 million broilers were slaughtered, an increase of 44 million (4.6%) from 2014 (Table 4). Based on the number of day-old parent pullets placed to December 2015, the size of the breeder flock was expected to increase by 3.2% to 6.93 million during the first four months of 2016. The forecasting model to June 2016 predicted a potential hatch of 21.20 million chicks per week, and to July 2016 a potential production of broilers of 19.97 million per week (SAPA, 2015b).

Table 4 Broiler production and number of birds slaughtered (SAPA, 2015b)

Bird numbers (millions)								
	Avg. broiler parents		Breeding stock	Day-old broiler chicks produced		Broilers in rear	Broilers slaughtered	
	In rear	In lay	Avg. /week	Avg. /week	Total /annum	Avg. /week	Avg. /week	Total /annum
2014	3.712	6.601	10.313	19.673	1022.020	95.193	18.407	960.376
2015	3.863	6.716	10.579	20.359	1061.946	99.031	19.257	1004.515
Change	0.150	0.116	0.266	0.686	39.927	3.838	0.851	44.139
% Change	**4.05**	**1.75**	**2.58**	**3.48**	**3.91**	**4.03**	**4.62**	**4.60**

According to SAPA's estimates for 2015, the total production of poultry meat was 1 793 376 tons. This consisted of 1 722 705 tons (96.06%) from commercial production, an estimated 69 334 tons (3.87%) from subsistence farming, and 1336 tons (0.07%) from ducks. Chicken production therefore amounted to 1 792 040 tons. Commercial production (including offal) can be further broken down into:

- Broiler meat: 1 650 821 tons.
- Cull broiler breeder males and females: 33 356 tons.
- Cull layer hens: 38 529 tons.

According to SAPA's calculations, poultry consumption amounted to 2 181 445 tons. The per capita consumption of poultry meat for 2015 was 39.69 kg, compared to 37.53 kg in 2014. This includes imported products sale of spent hens from the broiler breeder and commercial layer industries, the sale of all edible offal, as well as other poultry species. Consumption of chicken, including brined meat, amounted to 2 423 444 tons; a per capita consumption of 44.10 kg compared to 41.71 kg in 2014 (SAPA, 2015b).

1.1.1.3 Feed

According to the Animal Feed Manufacturers Association (AFMA), national feed sales from 1 April 2014 to 31 March 2015 for breeders and broilers amounted to 3 368 591 tons; a 3.6% year-on-year increase. These figures exclude non-members of AFMA (Animal Feed Manufacturers Association, 2015).

In terms of feed usage, broiler breeding stock consumed 519 338 tons during 2014 (Table 5). In 2014, there was a 3.9% increase in the breeder feed price after three successive years of above-inflation increases of 27.8% in 2012 and 9.7% in 2013 (Figure 8) (SAPA, 2015b).

Table 5 The feed usage for broiler breeders and broilers (SAPA, 2015b)

Feed usage for the broiler industry (tons)								
	Broiler parents		Total breeding stock		Broilers		Total broiler industry	
	Rearing	Laying	Per annum	Per week	Per annum	Per week	Per annum	Per week
2014	94 875	409 614	504 489	9 675	2 880 366	55 240	3 384 855	64 915
2015	98 599	416 783	515 382	9 884	3 001 621	57 565	3 517 004	67 449
Change	3 724	7 170	10 894	209	121 255	2 325	132 149	2 534
% Change	**3.92**	**1.75**	**2.16**	**2.16**	**4.21**	**4.21**	**3.90**	**3.90**

The average broiler feed price for 2015 was R4934.22/ton. It increased by 2.2% from 2014. This followed massive year-on-year increases of 11.2% and 30.5% in 2011 and 2012 respectively. The broiler feed price includes distribution but excludes medication, additives and value-added tax (VAT). The movement in the feed price is shown in Figure 5.

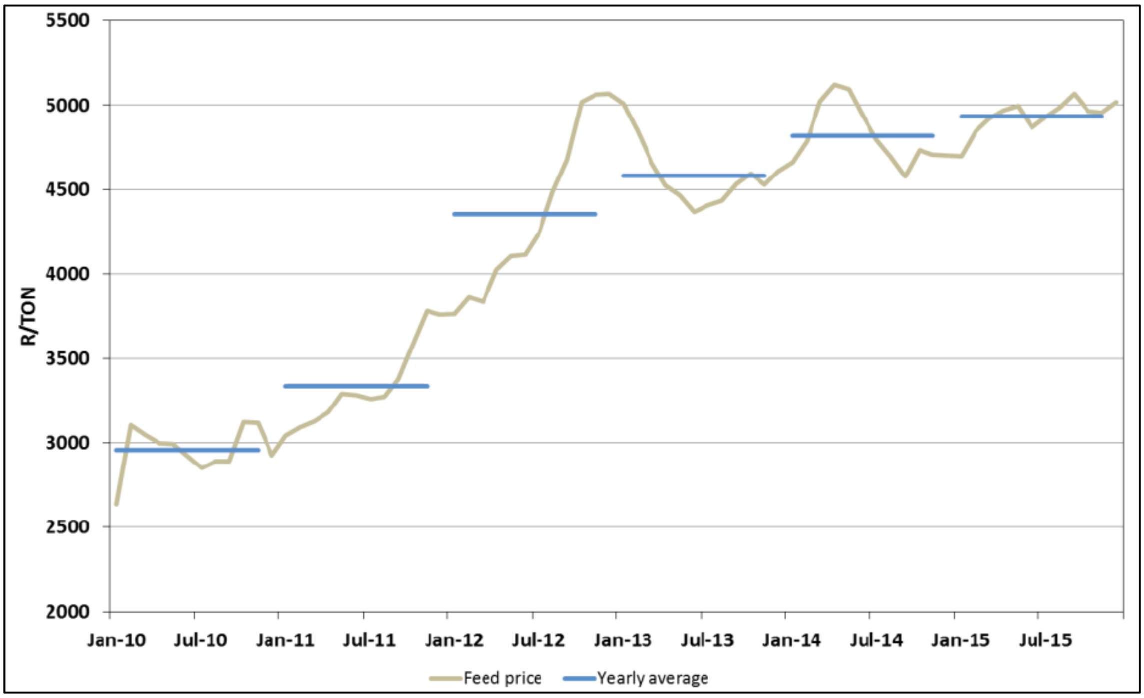


Figure 8 Broiler feed price trend from 2010-2015 (SAPA, 2015b)

The year-on-year percentage changes in broiler feed price and chicken price are shown in Figure 9. The graph clearly indicates why margins were under enormous pressure during 2012. While the feed price escalated by 30.5%, the broiler producer price increased by only 1.8% from 2011.

There was some recovery in 2013 and 2014. Feed prices increased on average by 5.2% each year, whereas producer prices increased by 11.4% and 10.6% respectively. The rapid increase in maize prices because of a drought will likely cause feed prices to increase again in 2016.

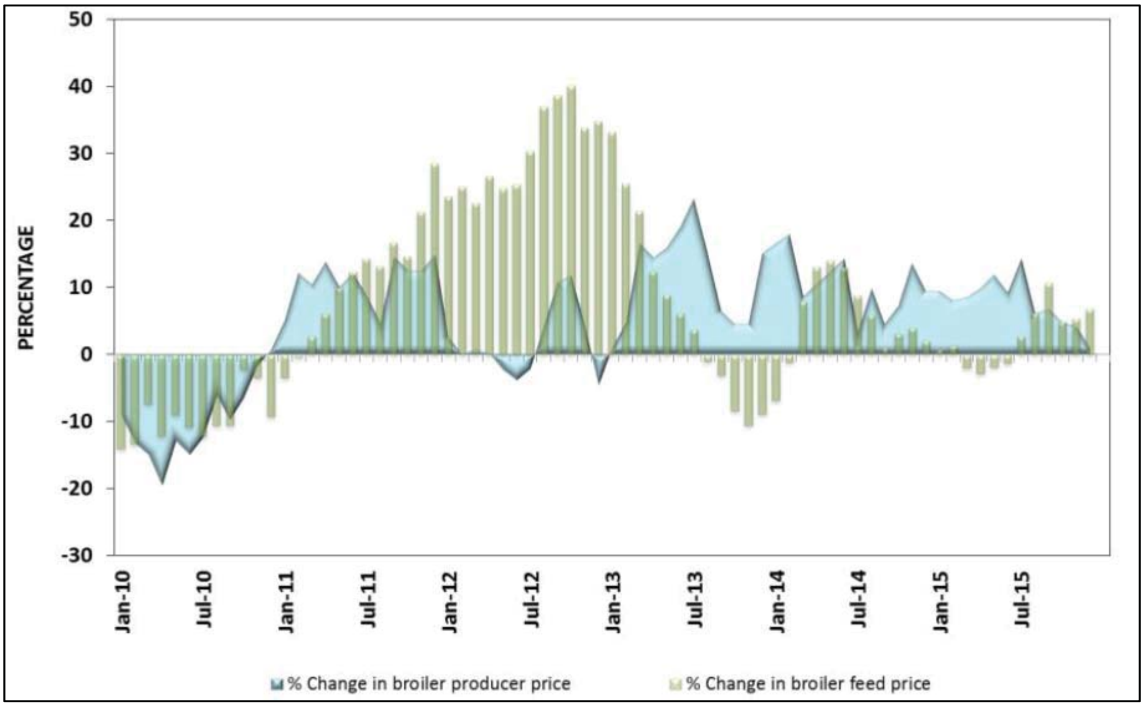


Figure 9 Yearly percentage change in chicken price and broiler feed price from 2010-2015 (SAPA, 2015b)

1.1.1.4 Imports and exports

Poultry imports during 2014 at free on board (FOB) level amounted to R4.1 billion, an increase of 4.4% from the previous year. Chicken meat and products were the major contributors to poultry imports, increasing to R3.7 billion in 2014 from the R3.4 billion in 2013, putting further pressure on the local chicken market. The annual broiler meat imports for 2014 totalled 368 805 tons, of which 99.8% was frozen. This figure represents 93.8% of the total poultry products imported, with the remaining being turkey imports at 6.2% and duck, geese or guinea fowl combined at 0.05%. Poultry imports according to main countries of origin for 2013 and 2014 are presented in Table 6. Annual frozen broiler meat imports from all countries from 2011 to 2015 is illustrated in Figure 10.

Table 6 Poultry imports according to main country of origin (SAPA, 2014c)

Country	Imports (tons) 2013	Import tons (2014)
Brazil	188 084	168 666
Netherlands	66 512	73 987
United Kingdom	39 190	43 009
Argentina	28 479	21568
Germany	23 271	21 821
United States	11 076	5 022
Canada	8 854	5 255
Denmark	7 422	6 133
Ireland	5 241	8 286
Hungary	3 889	7 758

According to figures audited by the South African Revenue Service (verified), annual poultry imports for 2015 totalled 478 447 tons (SAPA, 2015b). Chicken imports amounted to 457 374 tons, which represent 95.6% of total poultry imports and a 24.0% year-on-year increase. Of the total chicken meat imported, 99.9% was frozen.

Brazil was the main country of origin of poultry imports, accounting for 50.4% or 241 180 tons. The Netherlands was in second position, with 13% or 61 995 tons, followed by Belgium with 7.4% or 35 612 tons. As a whole, the European Union (EU) contributed 41.7% compared to 48.5% in 2014, reflecting the impact of trade bans on EU countries affected by avian influenza (AI).

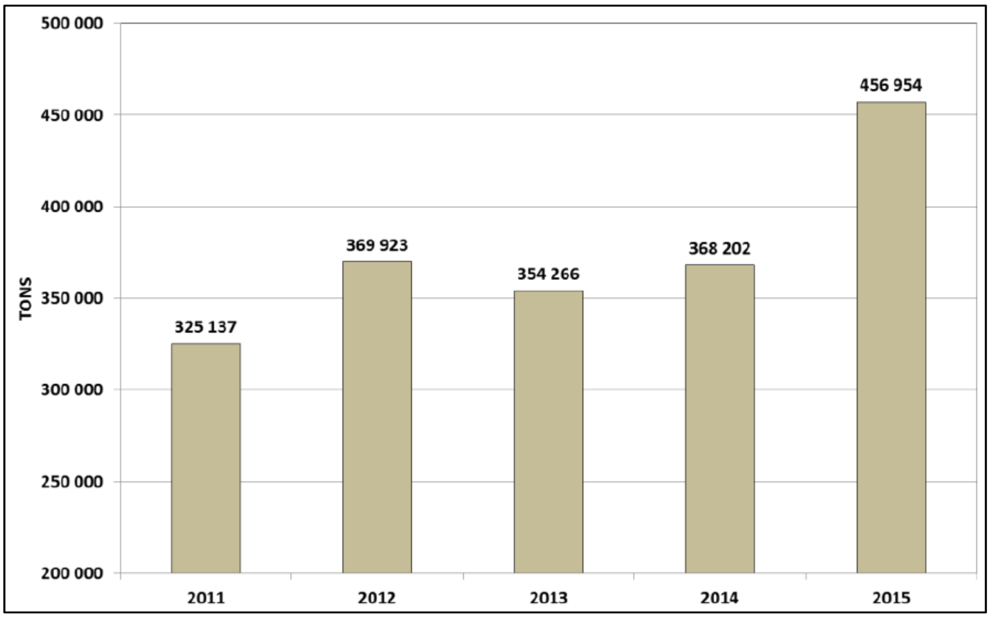


Figure 10 Annual frozen broiler meat imports from all countries from 2011 to 2015 (SAPA, 2015b)

Frozen broiler imports from Brazil increased from 154 280 tons in 2014 to 225 850 tons (+46.4%) in 2015 (Figure 11). Brazil's contribution to total imports increased from 42.9% in 2014 to 50.4% in the year under review. These imports were mostly mechanically deboned meat (MDM) (146 983 tons; 61% of total Brazilian imports).

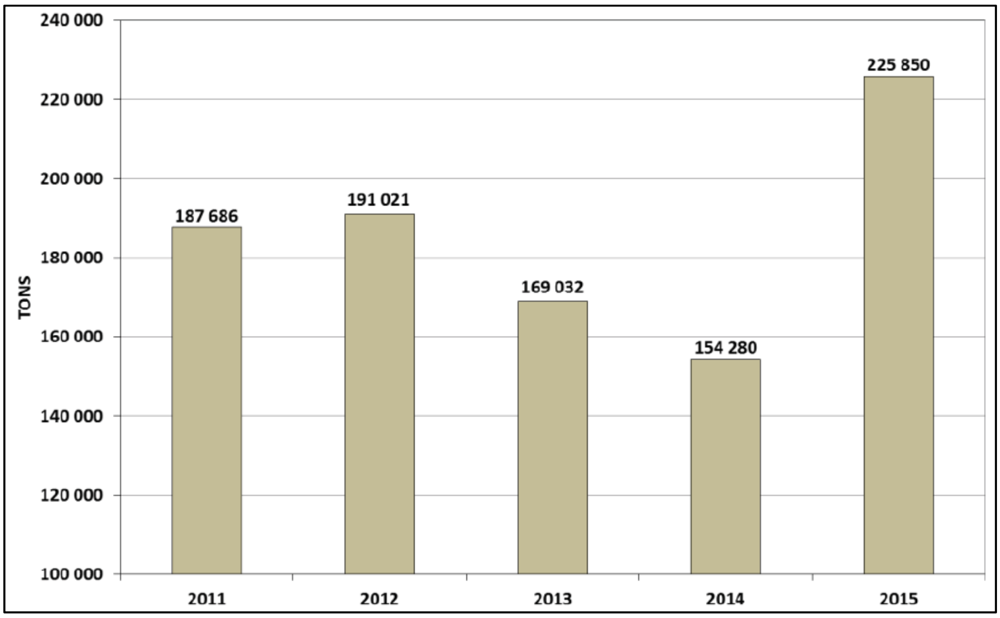


Figure 11 Frozen broiler imports from Brazil from 2011 to 2015 (SAPA, 2015b)

Imports from the EU increased from 188 079 tons to 194 685 tons, a 3.5% increase over 2014 levels (Figure 12). Imports from the Netherlands, the United Kingdom (UK), Hungary and Germany were affected by the temporary trade bans enforced in reaction to outbreaks of AI in these countries. Frozen bone-in portions made up 80.1% of EU imports. The EU was the source of 81% of all bone-in imports, down from 93% in 2014.

In 2015, the Netherlands was the biggest contributor to EU frozen broiler imports (31.8%), followed by Belgium (18.3%), Spain (13.0%), France (11.9%) and the UK (7.9%) (SAPA, 2015b).

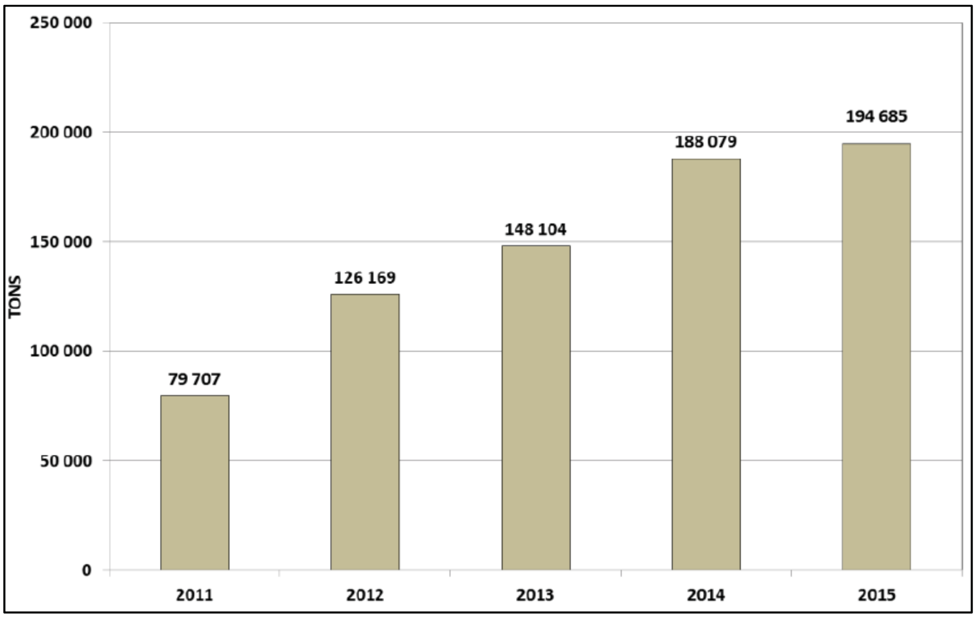


Figure 12 Annual frozen broiler imports from the EU (SAPA, 2015b)

On an FOB basis, the value of imports for 2015 amounted to R4.68 billion: a 14.5% increase from the value of total poultry imports for 2014. The value of chicken imports amounted to R4.298 billion, which is a 17.3% increase from 2014. The main contributors were frozen bone-in portions at R2.724 billion and frozen MDM at R723 million (63.4% and 16.8% of the value of chicken imports respectively).

Poultry exports amounted to 72 444 tons in 2015, which is an increase of 9.2% from 2014 (Figure 13). The FOB value of these exports was R1.232 billion. A total of 65 815 tons were chicken exports at an FOB value of R1.054 billion. Poultry exports made up 4.0% of poultry production in 2015, compared to 3.9% in 2014.

The main destination countries for poultry exports were Lesotho (28.7%), Mozambique (28.7%), Namibia (21.9%), Botswana (5.5%), Zambia (4.6%), Zimbabwe (4.5%) and Swaziland (2.6%). The remaining 37 destination countries collectively received 3.5% of the exports (SAPA, 2015b).

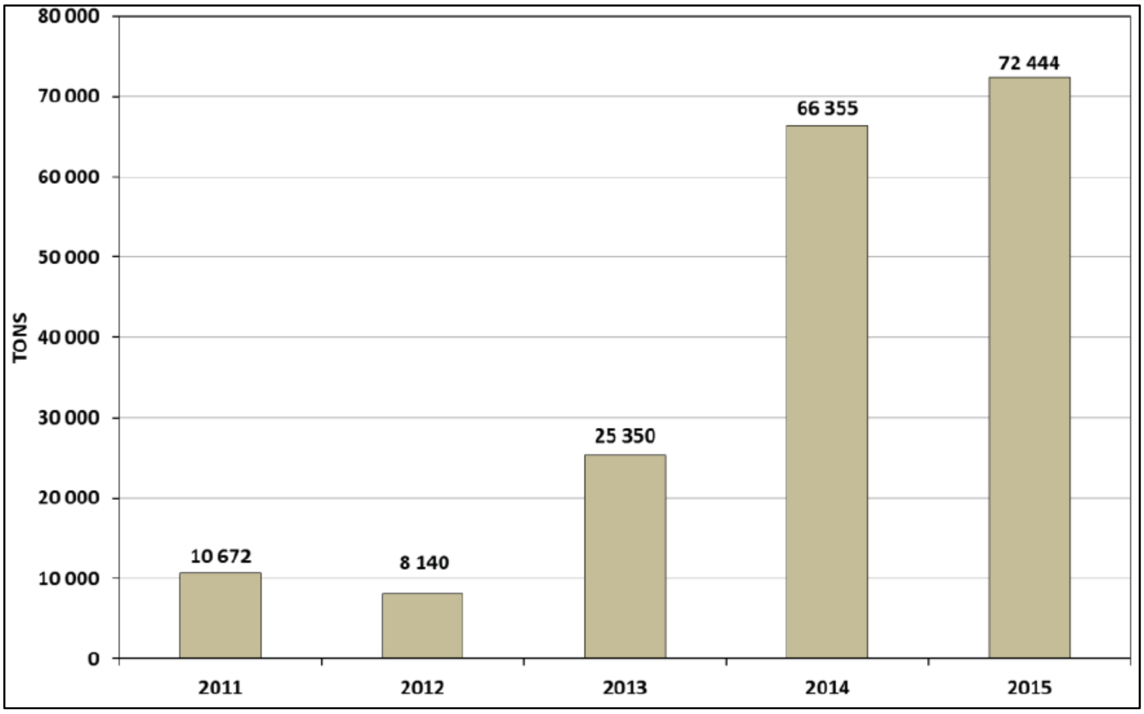


Figure 13 Annual poultry exports (SAPA, 2015b)

1.1.2 Egg producers

The egg industry used to be controlled by the Egg Board, which ceased to exist in 1993. Presently, the SAPA have organised most egg producers as “egg producer”, “chick producer” and “developing poultry producers” organizations (DAFF, 2010).

1.1.2.1 Egg pricing

According to Statistics SA (Stats SA), the average producer price for 2015 was R14.79/dozen, compared to R14.35 for 2014, which is a 3.1% increase. These averages are weighted according to the expected grade-out. They do not take rebates into account.

The retail price was R23.10/dozen large eggs. During the past five years, the markup on eggs has increased steadily from 51% in 2011 to 65% in 2015 (Figure 14).

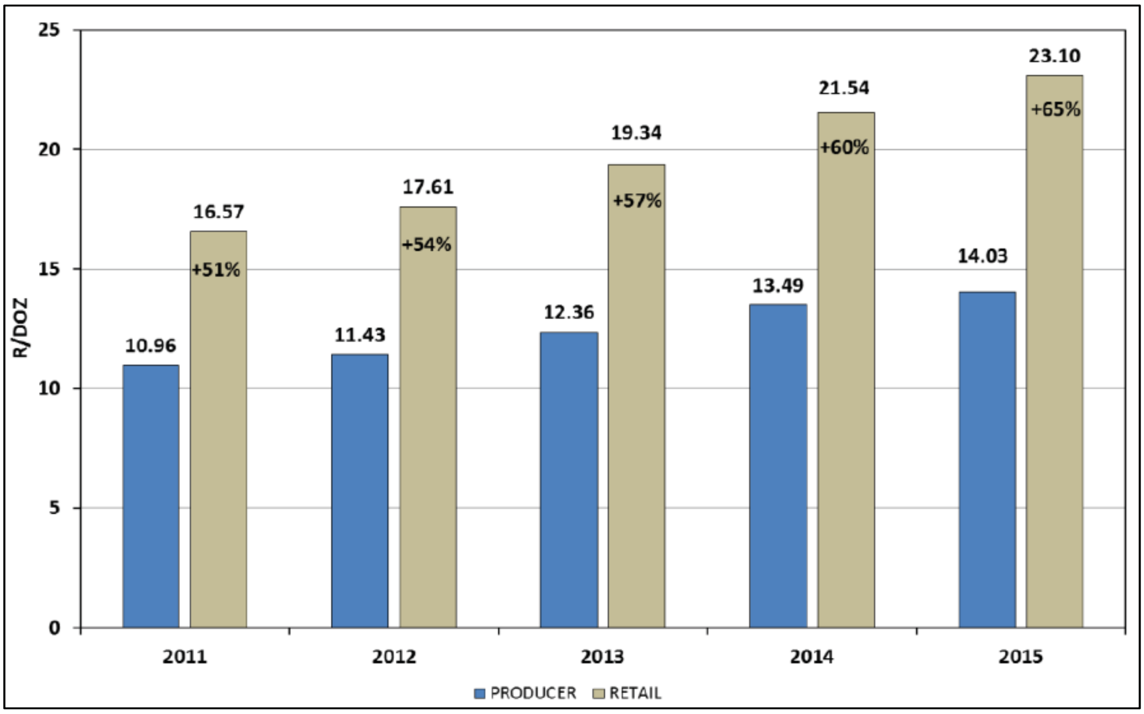


Figure 14 Annual price of large eggs in South Africa, showing retail markup (Stats SA, 2014, adapted from SAPA, 2015c)

With a gross turnover of R9.2 billion at producer level, eggs remain the fourth-largest animal product sector in agriculture in South Africa after poultry meat, beef and milk (DAFF, 2014). The total value at retail level was R14.7 billion for 2015. About 638 million dozen eggs were sold through various channels in 2015. The turnover increased by 6.9% compared to 2014. Eggs contributed 8.6% of the gross value of animal products and 4.2% of all agricultural production for 2015 (SAPA, 2015c).

Eggs remained an economical source of animal protein in 2015 at a price of R16.65/kg. This compared to R18.43/kg for broiler meat (at farm-gate level), R22.83/kg for pork (at abattoir level), and R27.27/kg and R34.17/kg for beef (class C2/C3 and A2/A3 respectively, at abattoir level).

In terms of international pricing competitiveness, the average price in 2015 in the north-eastern region of the USA for white, size large, was US$1.90; for white, size medium, US$1.57; for brown, size large, US$2.05 per dozen. Depicted in Rands using the average exchange rate of R12.73 to the US Dollar for the year 2015, white, size large, was R24.15; white, size medium, R20.02; brown, size large, R26.05 per dozen.

The USDA gives the average prices per dozen for the north-eastern region of the USA for extra-large, large and medium eggs as $1.78, $1.75 and $1.43 respectively (SAPA, 2015c).

1.1.2.2 Feed

The average layer feed price for 2015 was R3422/ton; an annual increase of 0.5%. This followed year-on-year increases of 23.7%, 12.0% and 4.8% in the previous three years. The layer feed price includes distribution but excludes medication, additives and VAT. The movement in the feed price is shown in Figure 15.

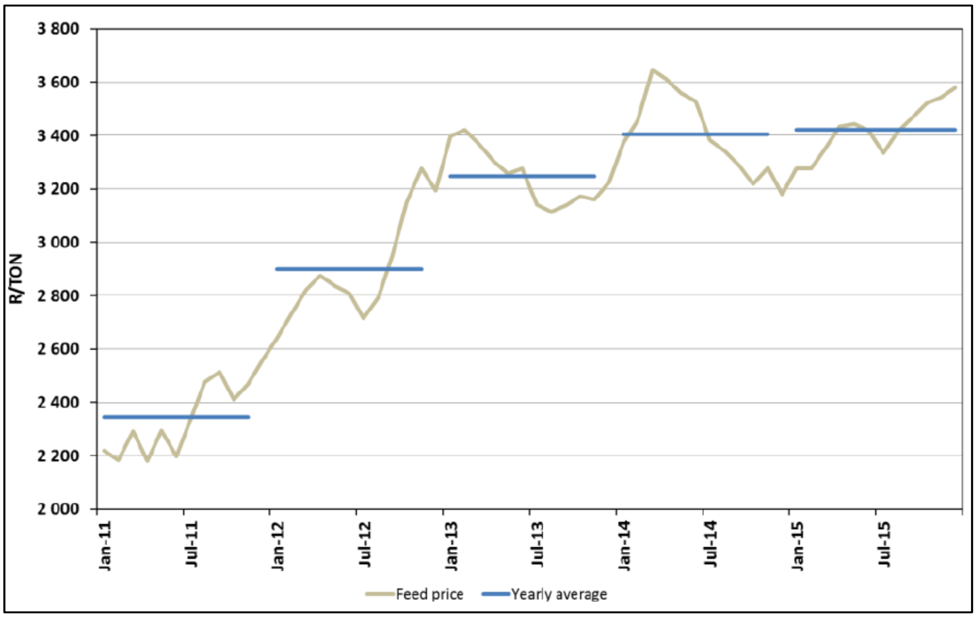


Figure 15 Layer feed price movement from 2011 to 2015 (SAPA, 2015c)

1.1.2.3 Current production and growth projections

Due to outbreaks of highly pathogenic avian influenza (HPAI) in the USA in 2015, there were difficulties importing grandparent stock into South Africa.

In 2015, there were an estimated 9000 layer breeding hens in the grandparent operations producing layer parents, and another estimated 328 000 layer breeding hens in the parent operations producing layers. There are no pure lines or great-grandparents in South Africa.

Day-old pullet placements increased by 1.9% in 2015, reaching a total of 24 901 100; an average of 477 390 per week (Figure 16). In terms of feather colour, 59.1% were silver and 40.9% were brown strains.

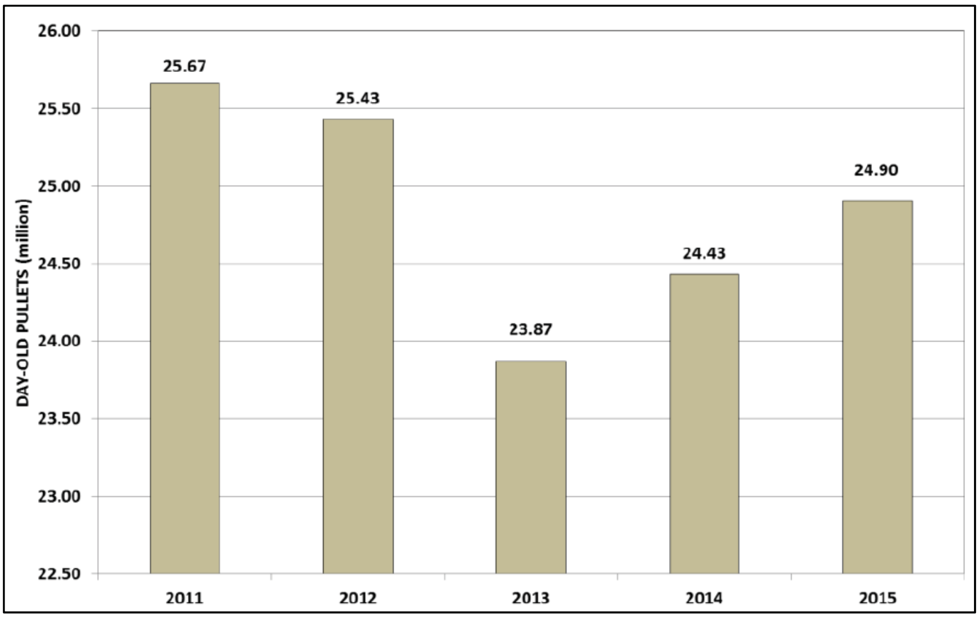


Figure 16 Trend in day-old pullets placed

The size of the national layer flock increased by 2.1% during 2015 to 24.85 million hens (Figure 17). An average flock of 25.05 million hens is projected for April 2016; an increase of 264 000 hens (+1.1%) compared to April 2015. The national layer flock increased by 2.1% in 2015 and is expected to grow by a further 0.6% in the first four months of 2016 to exceed 25.0 million hens. The average number of cases of eggs per week for the first four months of 2016 is expected to be 409 300, a 0.4% increase on the average weekly egg production for 2015.

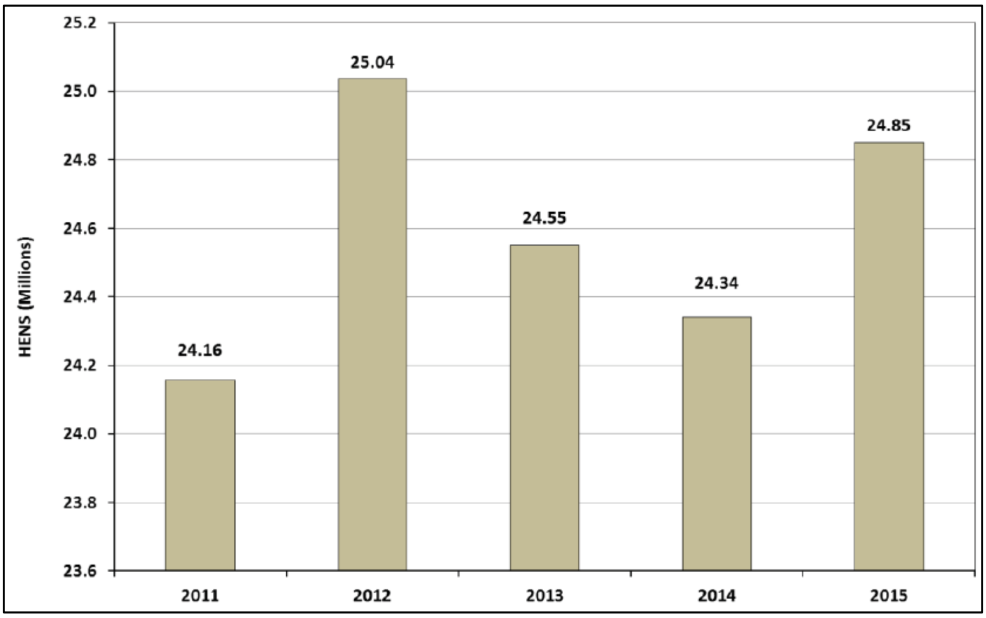


Figure 17 The national layer flock, showing average layers per annum (SAPA, 2015c)

The year 2015 saw a reversal in the downward trend in the egg production of the past two years (Figure 18). The average number of cases produced per week was 407 770, an increase of 8184 cases (+2.1%) per week. Total egg production in 2015 amounted to 21.26 million cases, or 638 million dozen eggs.

Of all the forecasted marketable graded eggs (Grade 1) that were sold in 2015, 8.8% were size medium, 45.0% were large, 42.4% were extra-large and 3.8% were jumbo. There was a 1.8% increase in extra-large and jumbo eggs compared to 2014, no doubt because of the longer laying cycle.

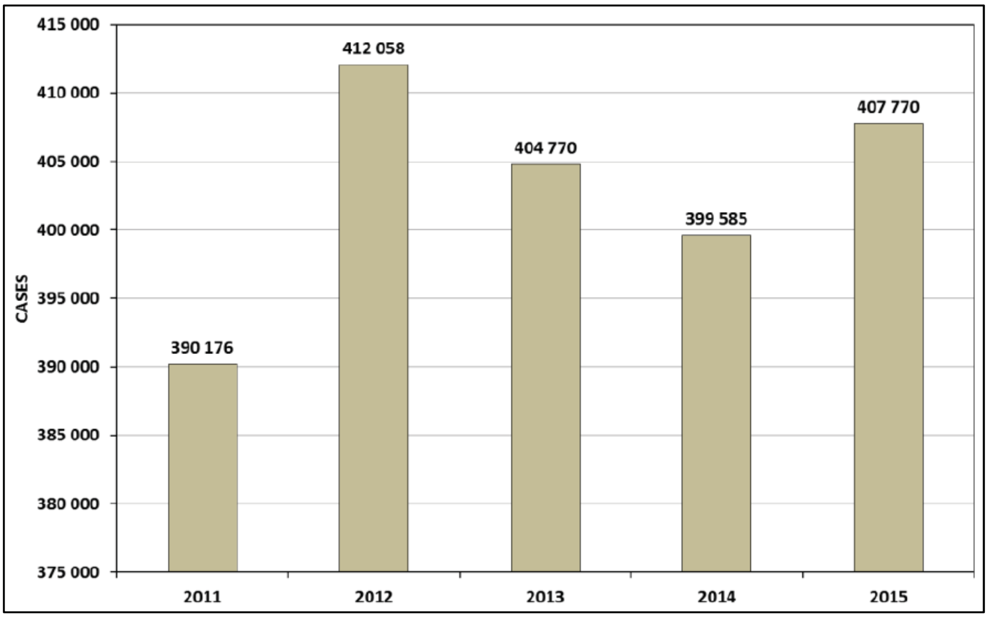


Figure 18 Average weekly cases of eggs produced (SAPA, 2015c)

Table 7 summarises bird numbers and egg production, showing the changes in 2014 and 2015 compared to the previous year.

Table 7 Bird numbers and egg production from 2013-2015

Year	Day-old pullets placed	Layer replacement pullets placed	Laying hens		Cases of eggs	
			Avg. No.	Depopulated	Avg./week	Total
2013	23 867 332	23 057 371	24 429 741	23 158 618	402 911	21 008 924
2014	24 432 190	23 421 446	23 531 482	20 910 374	387 194	20 189 422
Change	564 969	364 074	−899 259	−2 248 245	−15 716	−819 503
% Change	**+2.37**	**+1.58**	**−3.68**	**−9.71**	**−3.90**	**−3.90**
2014	24 432 190	23 421 446	23 531 482	20 910 374	387 194	20 189 422
2015	24 901 000	23 645 000	24 851 000	21 641 000		21 262 000
Change	469 000	223 000	511 000	31 000		425 000
% Change	**+1.92**	**+0.95**	**+2.1**	**+0.14**		**+2.04**

The number of point-of-lay pullets placed is expected to increase by 3.8% during the first four months of 2016, compared to the same period in 2015. An average flock of 25.0 million layers is projected for the first four months of 2016. This is an increase of approximately 250 000 layers (+1.0%) compared to the same period in 2015. Consequently, egg production is expected to increase by 0.8% (an average of 3370 cases per week) to an average of 409 300 cases per week in the first four months of 2016.

The per capita consumption for 2014 was 139 eggs per annum, 5.45% or 8 eggs per person less than in 2013. While the population increased by a mid-year estimate of 1.9%, the demand dropped (SAPA, 2014a). Peak egg consumption in South Africa occurred in 2012 at 153 eggs per person per annum (Figure 19).

The per capita consumption for 2015 was 150 eggs or 8.76 kg, compared to 147 or 8.55 kg in 2014). While the population increased by a mid-year estimate of 1.8%, the total consumption of eggs increased by 2.3%. Peak egg consumption in South Africa occurred in 2012 at 162 eggs per person (SAPA, 2015c) (Figure 19).

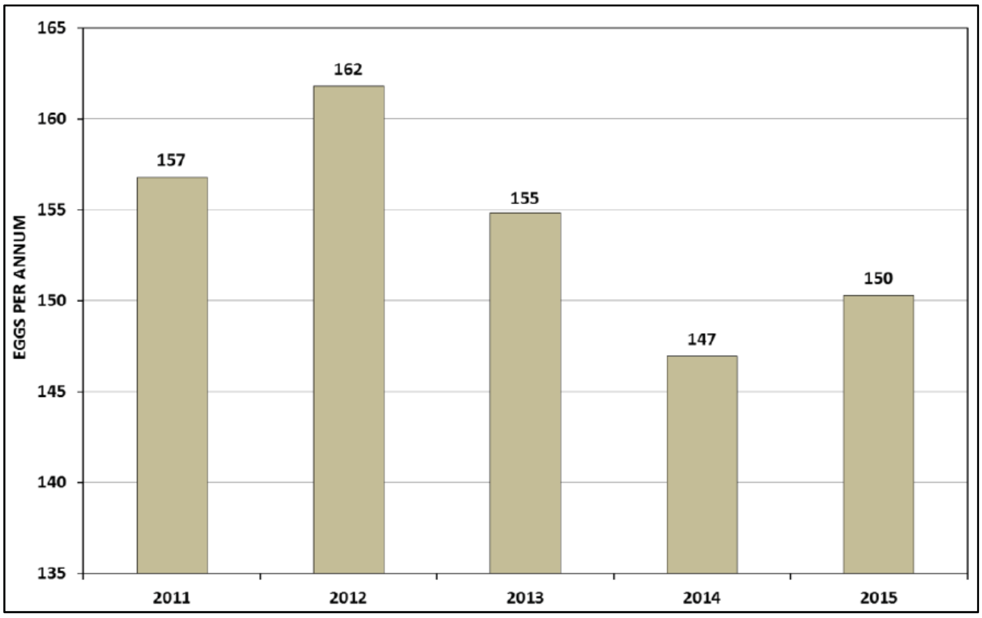


Figure 19 Per capita egg consumption in South Africa (SAPA, 2015c)

The annual per capita consumption of eggs for some of the top egg-eating nations is shown in Figure 20 (Windhorst, 2014). There is still considerable scope for increasing the per capita consumption of eggs in South Africa, particularly when considering the price competitiveness as a protein source compared with other animal proteins.

Global egg production is expected to increase from 64.2 million tons in 2010 to 86.8 million tons in 2030 (+35.2%). Just over 60% of the world's egg production is forecasted to take place in Asia, compared to 5.2% in Africa, with less than 1% of that being in southern Africa. The relative contributions of North America and Europe to global egg production are expected to decrease slightly. Global per capita consumption of eggs is expected to grow by 1.0 kg (approximately 17 eggs) per annum. By 2030, per capita consumption in southern Africa is forecasted to reach 12 kg, which is 203 eggs (Windhorst, 2014).

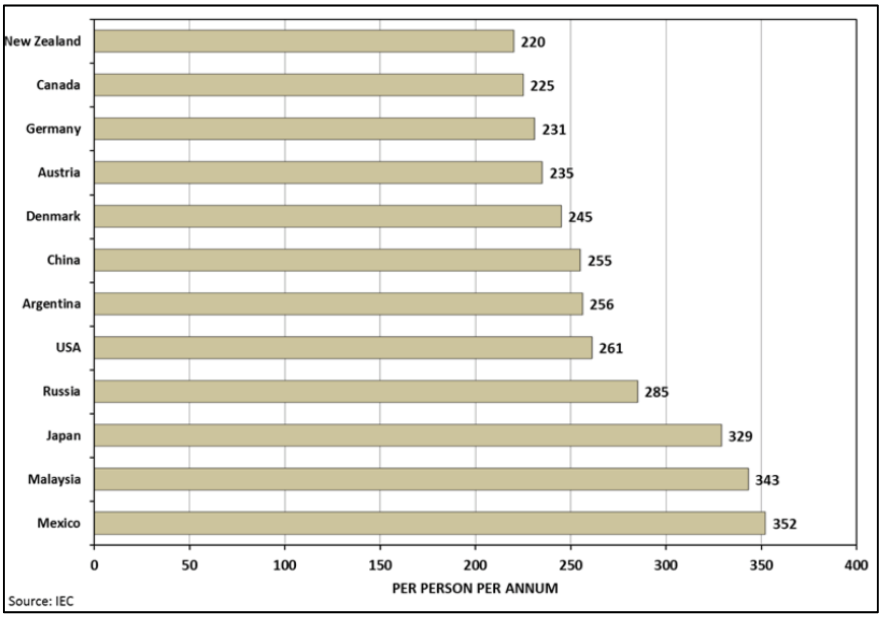


Figure 20 Per capita consumption of eggs (Windhorst, 2014)

1.1.2.4 Imports and exports

Total imports of eggs, including shell eggs and egg products (liquid and dried), was 342.7 tons in 2015; 120 tons less (−25.9%) than in 2014. The egg product component amounted to 333.7 tons, of which 332.5 tons were dried egg product. Imports of chicken shell eggs totalled 8.5 tons. The total value of the egg imports was R37.4 million; a 4.0% decrease from 2014 (SAPA, 2015c).

Total imports of eggs, including shell eggs and egg products (liquid and dried), was 463 tons in 2014; an increase of 147 tons (46.4%) from 2013. The egg product component amounted to 404 tons, of which 403 tons were dried egg product (SAPA, 2014a).

During 2015, exports of eggs for consumption totalled 9828 tons (9832 tons if preserved or cooked ostrich eggs are included). Chicken shell eggs (fresh and preserved) contributed 6203 tons (63.1%) to total egg exports, with shell eggs from other poultry types amounting to 2396 tons (24.4%). An amount of 4.1 tons of preserved or cooked ostrich eggs were exported. Egg product (yolk, raw pulp and albumin) contributed 1229 tons (12.5%). The egg product consisted of 200 tons (16.2%) of liquid egg product and 1029 tons (83.8%) of dried egg (Figure 21).

The total value of the egg exports for consumption was R227.7 million (including ostrich eggs above); a 10.5% increase from 2014.

In addition, 8920 tons of fertile chicken eggs and 365 tons of fertile eggs from other bird species were exported during the year. The export value of the fertile chicken eggs was R247 million and the value of the fertile eggs from other species was R5.4 million (SAPA, 2015c).

The destinations of egg exports (for consumption and fertilized) were mainly Mozambique with 56.2% of the total exports, followed by Zimbabwe with 12.3%, Angola 9.5%, Swaziland 8.8%, Lesotho 4.4% and Namibia 4.1%. These six countries received 95.6% of South African exports (SAPA, 2015c).

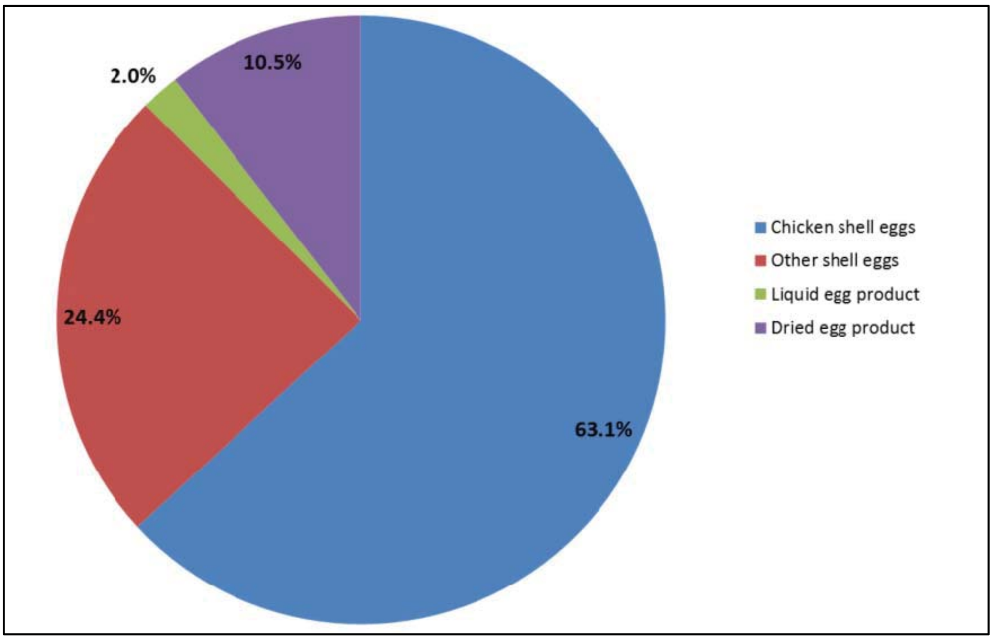


Figure 21 Egg and egg product exports for 2015 (SAPA, 2015c)

1.2 Project Objectives

The aim of this project was to survey the South African poultry industry to obtain an overview of operations, specific water use, specific effluent volume and the extent to which best practice is being implemented. This was achieved by reviewing appropriate literature, disseminating questionnaires, holding workshops, interviewing companies and undertaking site visits.

A previous survey of this industrial sector was conducted in 1989 by Steffen, Robertson and Kirsten Consulting Engineers (1989). Since this time, the industry has undergone several significant changes such as new legislation, new markets, social attitudes and change in ownership as well as using updated technology. In addition, there is growing awareness of the need to optimise water and energy use and reduce the production of waste. This should be reflected in the specific water consumption and effluent production. It was therefore considered an opportune time to review the water and waste water management practices of the poultry industry and identify the changes that have been made since the 1989 survey. The 1989 Natsurv for the poultry industry did not include information on egg producers, breeders/hatcheries or broilers. While the contribution of these sectors in terms of water use and waste water generation is relatively small compared to abattoirs, they nonetheless are integral to the industry as a whole and will be considered in this revision.

1.3 Methodology Summary

The approach used to undertake the survey consisted of a combination of online electronic surveys, detailed site visits with questionnaires, interviews and workshops. Both industry and regulatory stakeholders were contacted.

A detailed literature survey and review was undertaken to obtain an understanding of the poultry industry both within South Africa and internationally as well as the best practice opportunities for this sector. A production and process overview for each of the poultry industry sectors is presented, as well as the relevant legislation for the sector and a framework for industry best practice. Benchmarks of industry best practice in terms of water, waste and energy management are presented and the benchmarks are compared to international best practice in the industry. While statistics are presented where available for the duck and ostrich industry sectors, these were not included in the survey.

The main impact of the poultry industry in terms of water use and waste water generation is related to poultry processing, although egg producers, hatcheries and broilers also use water and generate waste water during their operations. Surveys were developed for each industry sector and sent to registered abattoirs, egg producers, hatcheries and broilers by the SAPA on behalf of VitaOne8, which included approximately 200 egg producers and 16 large broiler producers with abattoirs. Smaller non-SAPA members were contacted directly.

These surveys aimed to obtain an overview of production figures, water use and pretreatment, effluent generation and quality, as well as to identify the best practices implemented within the companies. The participants were given the option to indicate either a range in which their company falls for each category, or to specify an exact number or amount, and had the option to respond anonymously. All results are reported anonymously, and no indication of province is given to protect the identities of participants.

It is unfortunate that many of the producers contacted were unwilling to participate in the study, particularly among the smaller producers. Participation from large producers was good, which has resulted in the findings being skewed in their favour. However, it was observed that, as expected, the larger producers are setting the benchmarks in terms of industry best practice.

2 PROCESS OVERVIEW

2.1 Egg Producers

Egg production starts with importing genetic stock (known as grandparents) into South Africa as day-old chicks. The commercial layer industry uses the following breeds: Hy-Line (silver and brown), an American breed; Dekalb (Amberlink) and Lohmann (Lite), both of which emanate from Europe. For white shelled eggs, producers use Hy-Line W36, a Leghorn-type bird.

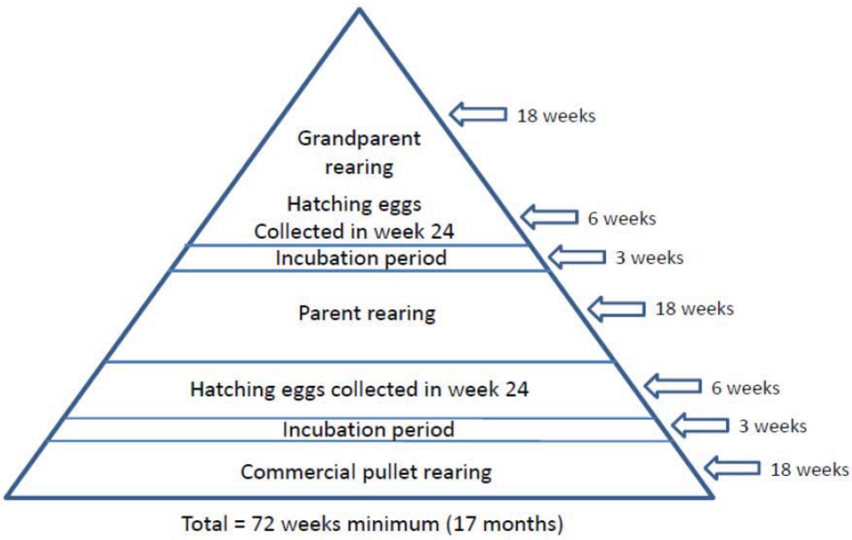
South Africa imports genetic stock (known as grandparents) as day-old chicks, as the first stage. The grandparents are reared to lay eggs, which are incubated to produce day-old chicks called parents. There are three major suppliers of day-old pullets in the commercial egg business in South Africa. Some of these supplier's form part of an integrated business, but most are independent suppliers of day-old chicks to large and small producers of commercial eggs. Day-old layers and fertilized eggs are also exported to other parts of Africa. Most day-old layer chick suppliers are currently situated in Gauteng, North West and the Western Cape. As with the broiler day-old chick suppliers, entry-level costs of this sector of the poultry industry are high, requiring substantial inputs of capital and skill to start such a business. This industry can be profitable, but is also very vulnerable. Profitability is highly dependent on feed price levels and the absence of disease challenges (SAPA, 2014d).

During the second stage, the parents are reared to maturity and produce fertile hatching eggs. The eggs produced by these parents are incubated. The day-old chicks that hatch are called pullets.

During the third stage, the pullets are reared on rearing farms until they mature at 21 weeks and are ready to lay commercial eggs, at which stage they are called point-of-lay hens. Some egg producers in South Africa rear their own point-of-lay hens. It is a very crucial phase in the life of a hen and the quality of the rearing process has direct bearing on the efficiency with which the hen will eventually produce eggs during her laying phase.

The fourth stage involves producing the final product, namely, eggs. This stage is dominated by three companies together making up 51% of the market share. The remaining 49% of eggs are produced mainly by small, medium and micro-sized enterprises (SMMEs).

Figure 22 illustrates the egg production process timeframe until the first descendant starts laying eggs. The egg industry does not import and rear pedigree layers. Grandparents are imported.



Grandparents are imported from pedigree stock overseas. Layers will produce at 50% on week 21; it will then take approximately 17 months before imports of grandparents have an effect in the industry

Figure 22 The egg production process timeframe from rearing of grandparent stock until point-of-lay (SAPA, 2014d)

Eggs are produced at a feed conversion ratio of 2.2 kg per kilogrammes of egg. Eggs are produced in varying sizes and graded and differentiated as described in Section 2.1.1 and Section 2.1.2. A process flow diagram illustrating the egg production process is presented in Figure 23. Point-of-lay hens have a lifespan of about a year after which they are culled and sold as spent hens, often in rural areas where demand is high through informal traders.

The fifth stage is the market. Output of the industry consists of eggs and spent hens. There are six main retailers, SMMEs and informal traders in South Africa who buy eggs from these farms and sell to approximately 48 million consumers countrywide. Informal traders play a significant role in distributing spent hens to consumers. The distribution chain in the egg industry tends to be short with approximately 75% of the total production being delivered to the formal trade sector. The greater the distance between producer and consumer, the more complex the marketing channel is. The whole production process from grandparent stage to the culling of hens, runs close to three years. In addition to these production processes, there are packing and value addition (liquid egg) functions that are important in the egg value chain. Large companies have integrated or formed subsidiaries to perform these functions while small farms are still struggling and continue to sell their eggs as cracked and ungraded (DAFF, 2010).

2.1.1 Egg grading

Agriculture and agri-food regulations define three quality grades that apply to eggs for sale to customers. These are:

- Grade A – sold at retail markets for household use.
- Grade B – used mostly in bakeries.
- Grade C – sent to egg breakers for processing.

Only Grade A eggs are sized according to the weight of each egg:

- Jumbo – at least 70 g.
- Extra-large – at least 63 g.
- Large – at least 56 g.
- Medium – at least 49 g.
- Small – at least 42 g.
- Pee wee – less than 42 g.

2.1.2 Differentiating eggs

Eggs are differentiated according to the production systems:

Organic free-range eggs

Organic free-range eggs are produced by free-range hens that are fed on grains and pulses grown without pesticides, chemical fertilizers or any other genetically engineered products.

Omega-3 enriched eggs

Omega-3 fats, which are excellent for brain functioning, the immune and nervous systems, and healthy hearts, are found in oily fish. The hens that lay omega-3 enriched eggs are fed salmon oil as part of their diet. Omega-3 enriched eggs are not necessarily free range.

Free-range eggs

The chickens that lay free-range eggs are exposed to sunlight and grass pastures. They have room to scratch, flap and bath in the dust. Their diet is not necessarily vegetarian; it could include insects or fishmeal.

Barn eggs

Barn eggs are produced by chickens that live inside, but are not kept in cages. Barn eggs are laid by chickens that are fed a vegetarian diet of grains and pulses.

Grain-fed eggs

Grain-fed chickens do not eat commercial feed, which can include fish and chicken meal. These eggs are not free range, and not necessarily barn. The chickens may be kept in cages.

Commercial eggs

Commercial eggs are the cheapest eggs to buy, and make up the bulk of eggs consumed in the country. The chickens are kept inside in cages. They are fed with meal, which includes commercially farmed grains and pulses, as well as processed fish and/or chicken meal. Electric lights are kept on much of the time to encourage the chickens to lay.

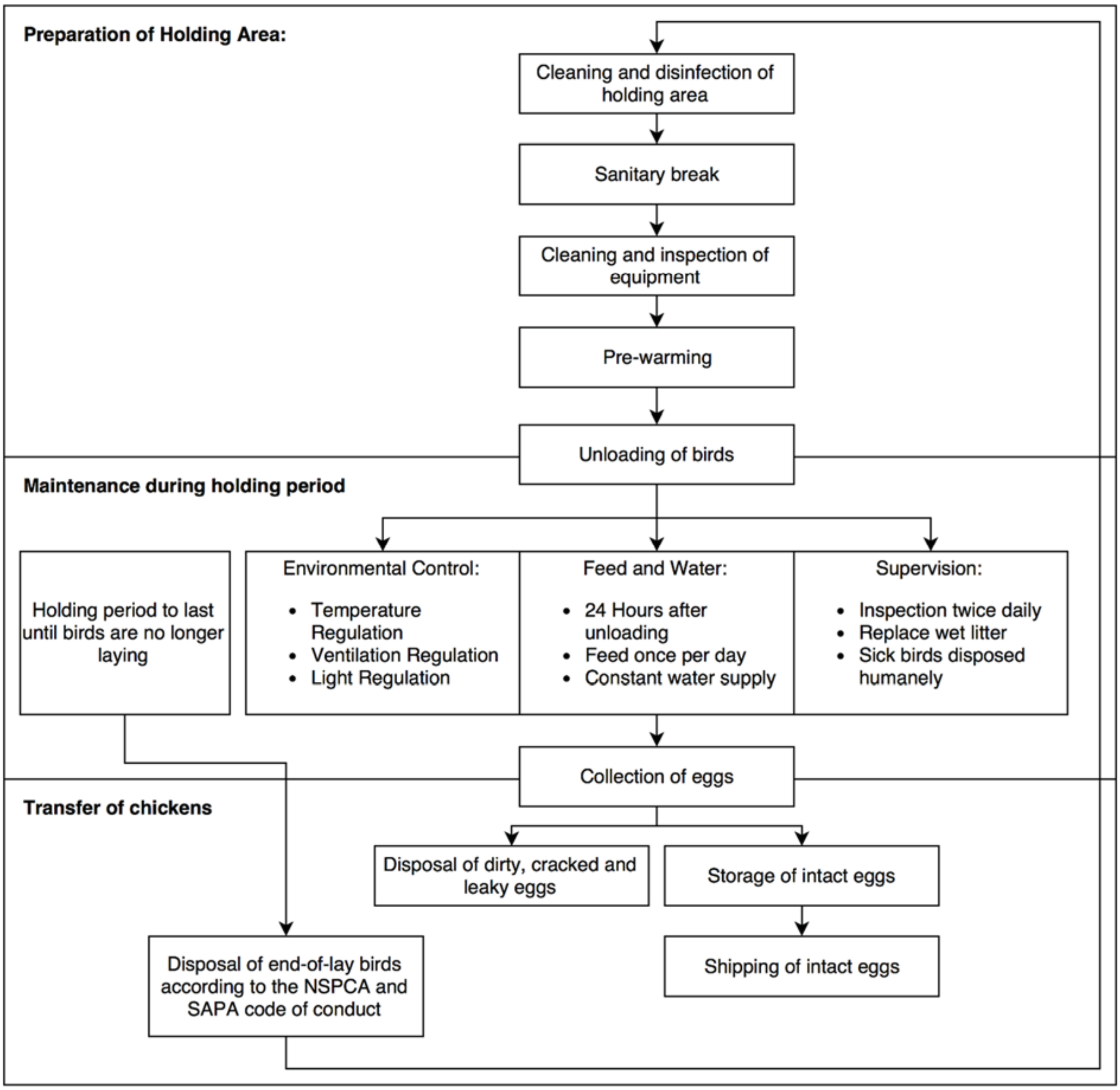


Figure 23 Flow diagram of egg production process

2.2 Broilers

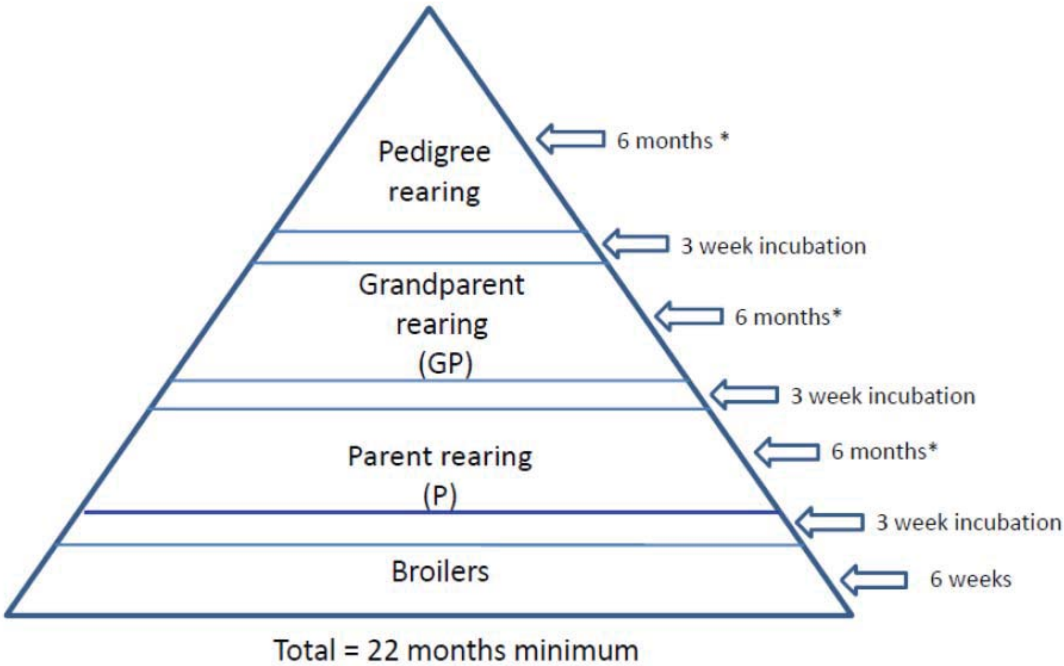
The broiler industry in South Africa uses predominantly three breeds: Cobb 500, Ross 308 and Arbor Acres. The breed societies for each of these breeds have granted the distribution rights of the parent stock to only three companies. The breed societies supply parent stock to integrated and non-integrated broiler hatcheries, where the parent stock is reared until they are ready to start producing fertilized eggs. The fertile eggs are transferred to hatcheries where the eggs are hatched to produce day-old broiler chicks, which are sold to independent broiler growers or are used in-house by fully integrated companies.

Since it requires a significant capital investment and specialised knowledge to start and run a day-old chick business, the industry consists predominantly of large producers. Only a few of the broiler day-old chick producers are not integrated businesses. The day-old broiler chick industry can be profitable, but is exposed to the same risks as the rest of the poultry industry. High feed costs, market-related risks and disease outbreaks put pressure on profit margins.

A small percentage of day-old chicks produced are exported to neighbouring African countries. There is a reasonably large export market for hatching eggs and most of the exports are done via a local company that is well connected to export markets.

The industry is spread over the whole of South Africa with higher concentrations of producers in Gauteng, the Cape, KwaZulu-Natal and regions of the North West (SAPA, 2014d).

The broiler production process timeframe from importation of breeding stock to slaughter is illustrated in Figure 24.



The process represents the time frame of breeding material being imported to the first commercial product slaughtered. It will therefore take approximately 22 months before imports affect the industry. It will take a full laying cycle of approximately 40 weeks to transfer all grandparent rearing and parent flock to the new breeding material.

* At six months, hens are moved to laying houses. It can take another few weeks before hatching eggs are set, depending on the breed, which therefore lengthens the production chain.

Figure 24 The broiler production process timeframe from importation of breeding stock to slaughter

Birds are housed in either floor or cage systems, or are free range with provision of a barn for protection from inclement weather conditions and both physical and thermal discomfort. A process flow diagram for broiler production is presented in Figure 25.

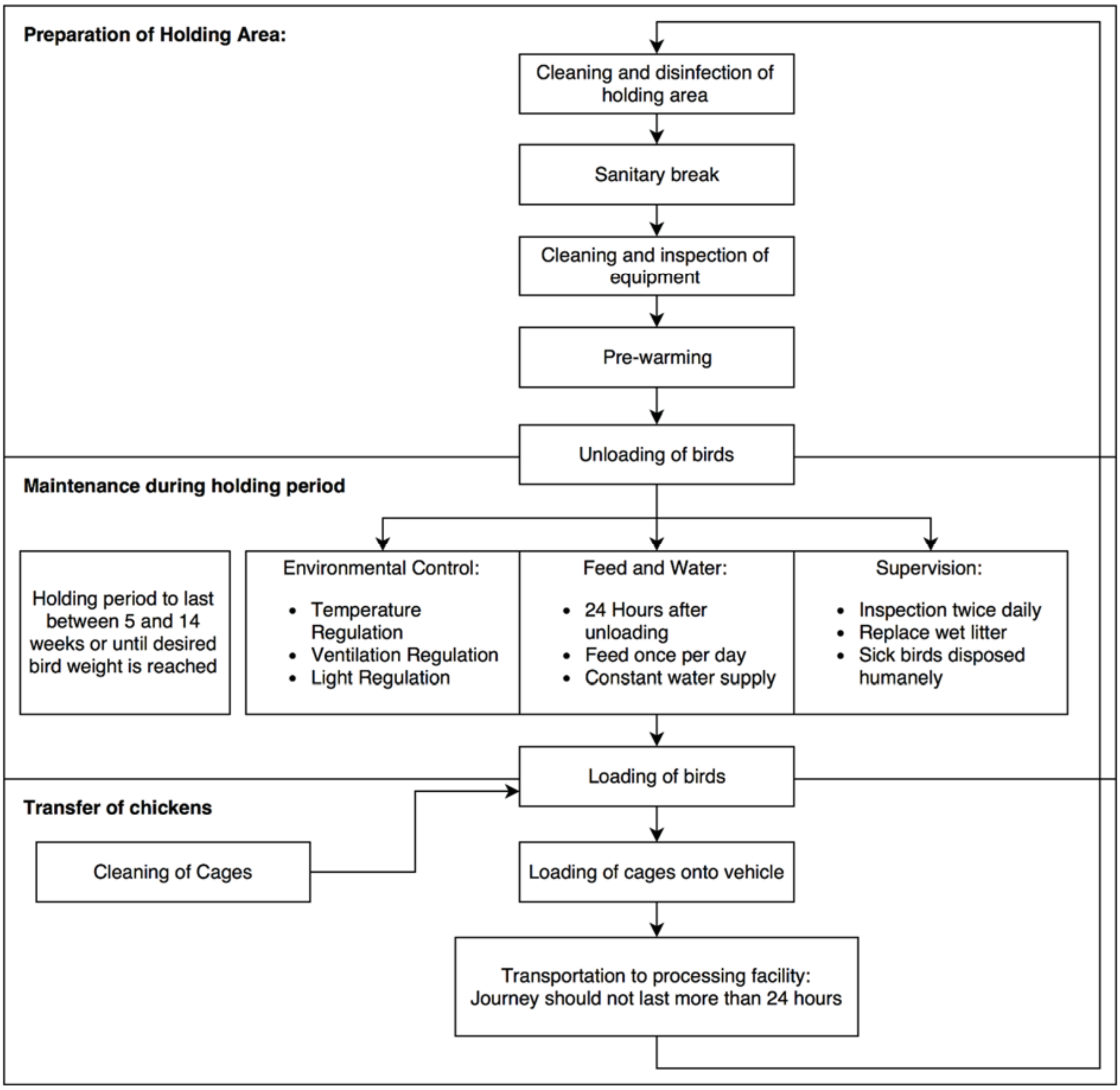


Figure 25 Process flow diagram for broiler producers

2.2.1 Preparation of holding area

The holding area is prepared in anticipation of receiving a new batch of day-old chicks by cleaning and sterilising the building and all equipment within the building. This must include complete removal and disposal of litter from the poultry building and surrounding area. Following cleaning and disinfection, a sanitary break assists in avoiding any carry-over of disease to the next flock. A minimum of seven days is recommended. The area is then pre-warmed to the required temperature in anticipation of the arrival of stock. Optimum temperature varies for different species and breeds, and the operators should be aware of the specific requirement for the species/breed under their control.

Chicks are removed carefully from the containers and placed in the brooding area specifically designed for rearing chicks. Chicks should be spread evenly over the brooding area in floor rearing. In the case of cage rearing, the appropriate number of chicks should be placed in the brooding tiers. Chicks shall be prevented from crowding or piling in corners in floor-rearing systems. For flocks to qualify for free-range broiler production, broiler chicks should never be allowed in any cage system.

2.2.2 Maintenance and management during the holding period

During the holding period, which may last between 5 and 14 weeks depending on the desired final weight, poultry houses need to be managed in a way that will provide adequate feed and water and the correct temperature, water, lighting and ventilation to the broilers and minimise litter moisture and improve litter quality. Sick and injured chickens should be attended to, and if necessary, disposed of humanely. A summary of these management requirements is discussed below.

2.2.2.1 Temperature control

Subject to housing insulation, breed and seasonal variations, supplementary heat at gradually decreasing levels is to be applied until no longer required. Bird behaviour is the best indicator of bird comfort. As birds become fully feathered, they can withstand and adapt to wider temperature fluctuation. Where extreme high temperatures are experienced, especially under climatic conditions of high humidity, procedures such as increased ventilation and airflow over birds, evaporative cooling equipment, reduced stocking density and supply of cool water, should be considered to deal with such extremes. Low temperature conditions should not be overcome at the expense of minimum rates of ventilation. Recognising the extremes possibilities of weather conditions, housing conditions for fully feathered birds during rearing should be within a temperature range from 15°C to 33°C with a maximum relative humidity of 80 (SAPA, 2012a).

2.2.2.2 Ventilation

A minimum rate of ventilation is required at all times to provide fresh air and to remove moisture and other metabolic gases from the building. This minimum rate of ventilation depends on the biomass in the building, which the operator shall be aware of. In rearing of birds, the minimum ventilation rate required therefore needs regular adjustment as the birds grow and increase in body weight. Carbon dioxide levels should be kept below 3000 ppm (3%). The presence of ammonia is usually a reliable indicator of build-up of noxious gases. A level between 10 ppm and 15 ppm of ammonia can be detected by smell. Once this level is reached, corrective action should be taken. Mechanical ventilated buildings should have a back-up power supply or alternative emergency ventilation systems linked to an alarm system to warn operators of power failure (SAPA, 2012a).

2.2.2.3 Lighting

Chicks are started at a higher light intensity (around 20 lux) for the first few days to teach them to find feed and drinker systems. Thereafter, the light intensity should be adequate to allow for birds to feed normally and allow for thorough inspection of the flock. Sudden changes in intensity should be avoided as this could lead to flight reaction in some strains. Various rearing light programmes are prescribed by suppliers of breeding stock in order to control body weight gain within acceptable limits. A total light period of less than 12 hours during rearing of broiler chicks should be discouraged (SAPA, 2012a).

2.2.2.4 Feed

Newly hatched broiler chicks must be provided with food within 24 hours of hatching. Broiler chicks must receive feed on a daily basis. Birds in rear should receive a diet that contains adequate nutrients to meet the daily requirement for good health and vitality and in sufficient daily quantities to enable an increase in body weight gain that is in accordance with the breed specifications. Feed should preferably be stored in closed containers. Vermin and wild birds should not have access to feed (SAPA, 2012).

2.2.2.5 Drinking water

Newly hatched broiler chicks should receive water within 24 hours of hatching, but sooner during hot weather. Birds should have access to sufficient potable water to meet their daily physiological requirements. Chickens shall not be deprived of water except for necessary management of vaccine application and therapeutic purposes. When the house temperature exceeds 30°C, interruption of water supply should not exceed two hours. Water should not be so hot that birds refuse to drink. The water should be tested regularly for chemical content and microbiological contamination (SAPA, 2012a).

2.2.2.6 *Litter quality and management*

Litter quality is important to achieve optimum bird performance, and is managed by correct heating and ventilation procedures. Wet litter promotes the growth of pathogens and is the primary cause of ammonia emissions from litter. Chickens are sensitive to ammonia, which can cause blindness, decreased growth rate, reduced feed conversion rate and condemnations.

The management of watering systems is also critical in maintaining good litter quality. Watering systems need to be checked often for leaks. Drinker height and water pressure need to be adjusted according to bird growth. When leaks or wet spots occur in the litter, the wet litter needs to be removed and replaced with dry bedding (Lavergne et al., 2011).

2.2.2.7 *Access to external environment in free-range production*

In free-range production, birds must have access to the external range for a minimum of six hours per day during natural daylight hours. It is accepted that it is counter-productive for birds to be outside during periods of extreme weather. Routine external access may therefore be restricted at such times (SAPA, 2012a).

2.2.3 Transfer of birds to processing

The chickens should be loaded in clean standardised transporting crates. All containers should have a lid or door that can be secured to prevent chickens from escaping. Birds should be caught individually and handled by both legs or full support of the body. Not more than four birds per hand may be carried per person at any one time. The number of chickens per crate should correspond to the floor space and body size of the transported chickens, with due regard to environmental conditions and duration of transport. Birds should only be transported in roadworthy vehicles by a responsible licensed driver trained in livestock transport.

The journey should not exceed 24 hours. Portable transporting crates with live chickens should preferably be moved in a horizontal position. Crates or birds should not be thrown or dropped. It is advisable to use a tie-down device preventing containers from overturning (SAPA, 2012a).

2.3 Abattoirs

According to the Poultry Regulations R153 of 2006, water must be under pressure and must conform to at least Class II according to South African National Standards (SANS) 241 standard for drinking water (SANS 241-1: 2006). It should be noted that more recent editions of the SANS 241 drinking water standards, the most recent being SANS 241-1:2015, no longer refer to water quality Classes. Only standard limits apply.

Water points must be provided with:

- Cold water.
- Water at 40°C and equipped with hosepipes for sanitising all areas of the abattoir.
- Hose reels to store hoses away from the floor unless vertical (drop) hoses are provided.

Poultry processing consist of a number of steps. Each step is followed by the next in strict sequence. Each step entails a specific task, which has to be performed effectively and hygienically. In low-throughput abattoirs, most functions are carried out by hand. However, in high-throughput abattoirs, these functions are mechanised. The differences between mechanical and hand-operated lines are presented in Table 8. A flow diagram of a typical poultry abattoir process is illustrated in Figure 26.

Table 8 Differences between mechanical and hand-operated lines

Equipment: Action	Mechanical line	Hand-operated line	Function
Offloading	Easy load system	By hand	To unload live birds from the trucks
Stunning	In-line electrical water bath	Dry method held by hand	To render the bird unconscious
Bleeding	After neck cutting in-line bleeding tunnel	After neck slitting, placed in bleeding cones	Bleeding out
Scalding	In-line scalding tank	Handheld in small water bath	To soften the skin and feathers to facilitate defeathering
Defeathering	In-line defeathering machines	Handheld or 5-10 birds at a time defeathering apparatus	To remove the feathers
Head and feet removal	In-line head pulling and hock cutting	Neck cut off with knife or scissors	To remove the heads and feet
Vent cutting	In-line vent cutter	Pneumatic vent drill, knife or scissors	To cut loose the cloaca
Abdominal slitting	In-line opening cutter	Knife or scissors	To open the abdominal cavity
Evisceration	In-line eviscerating machine	Manual eviscerating spoons	To lift organs out of the carcass
Cropping	In-line cropping machine	Manual removal of crop usually prior to evisceration	To remove the crop and oesophagus
Carcass and organ separation	Either done by hand or mechanically	Separated by hand	To separate the carcass and the organs
Offal separation	Automatically separate red offal from dirty offal	Offal separation done by hand	To separate the red offal from the dirty offal
Giblet harvesting	Automatically separate the intestines from the gizzard and clean the gizzard	Separation of gizzards and intestines done by hand, manual cleaning of gizzard	To separate the gizzard and intestines plus cleaning of gizzard
Neck pulling	In-line neck puller	Neck cut off with knife or scissors	Remove neck from carcass
Preparation for final inspection	In-line vacuum machine	Handheld vacuum tube	Sucks out any debris that remains behind, e.g. lungs, sexual organs etc.
Final washing	Inside-outside washer	Wash done by hand or shower-type sprayer	To give the carcass a final wash
Chilling	Spin chiller or air chiller	Commercial type freezers	To cool the carcass down as rapidly as possible
Portioning	In-line cutting machine	Cutting is done by hand	To divide the carcass into different parts
Packing	Automatic weighing and sorting systems, also done by hand	Sorting and packing is done by hand	Packing of portions/whole birds for retail purposes
IQF	Gyro freezer	Blast freezer (seldom done)	IQF portions

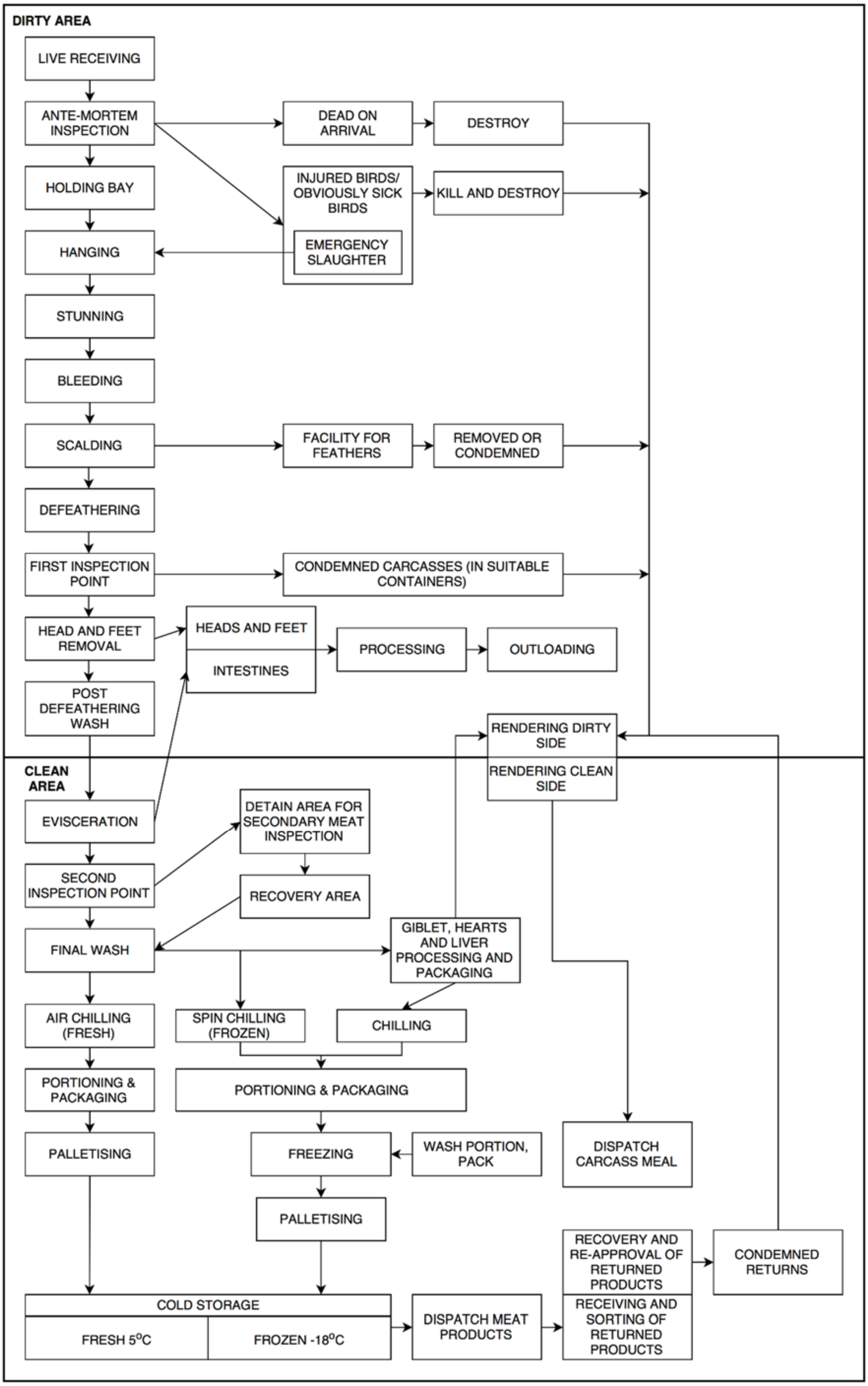


Figure 26: Flow diagram of poultry abattoir process

2.3.1 Holding and offloading

Live birds are normally delivered to the abattoir in crates. These are stored in a holding area until the birds are offloaded 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, this area must be kept clean, which is usually achieved by frequent washing down. Contaminants in this area include feathers, dirt and droppings. In addition, large abattoirs have crate-washing facilities, which represent another considerable water demand. Offloading facilities for live birds must include a roofed and well-ventilated area for trucks waiting to offload and for crates with birds that have been offloaded and are awaiting slaughter.

2.3.2 Stunning and bleeding

Bird are stunned by immersing the head and neck into an electrified water bath. In the case of hand lines, a manual electrical stunning apparatus is used. In the case of mechanical lines, a separate stunning and bleeding line is used that conveys the birds through an electrified water bath.

The throat can be slit (severing the neck arteries) mechanically or by hand. This should be done 10 to 15 seconds after stunning. The lapsed time of 10-15 seconds provides for a totally relaxed bird and therefore better bleeding. When slitting by hand, the slaughterer/operator severs either the right or left carotid artery at the base of the skull. The trachea and spinal cord must not be cut. One slaughterer should be able to slaughter approximately 4000 birds per hour. By not cutting the trachea and spinal cord, the birds will continue breathing, the heart will keep on pumping and therefore bleed out more effectively. When slitting mechanically, the birds go through a cutting apparatus with a guide that turns the head in the right position and a rotating blade on the other side that severs the jugular vein. The basics of the process is the same as is done by hand with the provision that close attention must be paid not to crush the bones of the neck vertebrae and skull.

The bird should bleed for at least 90 seconds. Respiration must stop and the bird must be dead before entering the scalding tank. This will prevent water in the scalding tanks from entering the lungs and air sacs and contaminating the carcass. More than 80% of the blood is lost within 40 seconds of slaughter. Thorough bleeding results in a lifeless, non-struggling carcass before immersion and soaking take place.

Most larger abattoirs using mechanical lines have a bleeding tunnel into which blood flows from the birds as they pass along the process line. Bleeding cones are used in the case of hand lines. Blood spillage is a potential source of high organic pollution from this area.

2.3.3 Scalding and defeathering

After bleeding, the entire carcass must be immersed in a scalding tank containing water at 50-55°C to loosen the feathers. Standard “hard” or “hot” scalding is done at ±54-60°C for 2-2.5 minutes. The epidermis is removed providing for a whiter looking carcass. Standard “soft” or “cold” scalding is done at ±50-53 °C for 3.0-3.5 minutes. The epidermis is not removed providing for a more yellowish looking carcass.

In the case of manual lines, scalding can be done in a drumlike scalding tank that can accommodate 1-10 birds at a time with a capacity of at least 20 ℓ hot water. The scalding temperature can be higher than that used in the mechanised systems, but the contact time will be much less, such as 60-65°C for 1 minute. In the case of mechanical lines, a system must be provided that moves the carcasses through a scalding tank with hot water. In this case, the design of the scalding tank must provide for continuous addition of hot water at a flow of at least 1 litre per bird 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. Water used in the defeathering machines should not exceed 20°C to prevent any further damage to the epidermis. The required amount of water in the pluckers should be between 0.25 ℓ and 0.50 ℓ per bird. The nozzles of the sprayers should be directed so that they easily wash all the feathers on the plucker discs and inside walls of the plucker machine away. Smaller grade abattoirs have various models of defeathering apparatuses that are used; they differ in size from 1-10 birds at a time. Birds are handheld in a drumlike machine.

The feathers can be processed further 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 has a considerable organic pollutant load.

A carcass washer, using water that may contain a bactericidal substance complying with the requirements of the Foodstuffs, Cosmetics and Disinfectants Act, 1972 (Act 54 of 1972) and is approved per protocol by the provincial executive officer at levels not harmful or injurious to health, must be available to wash carcasses before evisceration.

2.3.4 Removal of heads and feet

An automatic head-and-oesophagus puller removes the head together with the oesophagus. By pulling the head off, the oesophagus and trachea are pulled out of the neck. During this action, the crop is loosened to facilitate the removal of the viscera. The positioning of the head puller and feet cutter should be so that meat inspection can take place before the heads are removed. The correct setting of the machine ensures an undamaged neck skin and reduces contamination by the crop contents.

A hock cutter cuts the feet through the hock joint. The hock joint must be exposed for meat inspection purposes. After the feet have been cut, they are removed from the shackle line.

Heads and feet are cut off by hand in lower grade abattoirs.

2.3.5 Post defeathering/pre-evisceration wash

A carcass washer, which is maintained by adding potable water containing bactericidal levels of a chemical approved for use on foodstuffs, must be available to wash carcasses before evisceration. If chlorine is used, the concentration must be 5 ppm.

2.3.6 Evisceration

Carcasses are removed from the defeathering line and passed through a hatch connecting the dirty area with the clean area. An evisceration line with shackles must be provided to enable evisceration in a hanging position. Carcass evisceration comprises the separation and removal of the internal organs, neck and crop from the carcass.

The evisceration process comprises several tasks, which have to be performed in sequence, namely:

1. Vent cutting: A circular incision is made around the cloaca freeing it from the skin and pelvic tissues. On a mechanical line, this is done by an in-line vent cutter. In smaller abattoirs, this is done with a knife, scissors or with a pneumatic handheld vent drill.
2. Opening of the abdominal cavity: An incision from the cloaca to the end section of the breast bone is made in the abdominal wall to expose the intestines. On a mechanical line, an in-line abdominal slitting machine does this. Maintenance is very important because blunt blades can result in machine damage and contamination. In smaller abattoirs, the slitting is done with a knife or scissors. Scissors used must have a blunt point to prevent puncturing of the intestines or gall bladder. The incisions can be made horizontally or vertically.
3. Lifting out of the intestines (pack):
    - Mechanical line: An in-line-eviscerating spoon lifts the intestines out. Different makes of mechanical machines are available.
    - Hand-operated line: On the hand-operated evisceration line, the organ pack is removed by hand with an evisceration spoon. The lungs must be removed. The intestines now hung outside the carcass to expose the heart, liver, lungs, gizzard and gut, which makes it possible to carry out a thorough meat inspection.

Hygiene is vitally important at the evisceration stage 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 that do not pass this inspection stage are removed from the production line. Water used to transport inedible offal away from the evisceration area as screening is another potential source of high organic pollution loadings. It contains significant levels of blood, fat and grease, tissue and intestinal contents, which are only partially removed by screening.

2.3.7 Recovery

Facilities for recovering usable portions from detained carcasses must be provided if required and must include:

- Hand washbasins.
- Steriliser for equipment.
- Equipment for cutting and recovery of portions.
- Equipment for washing with water that may contain a bactericidal substance, which complies with the requirements of the Foodstuffs, Cosmetics and Disinfectants Act, 1972 (Act 54 of 1972) and is approved per protocol by the provincial executive officer at levels not harmful or injurious to health or other approved washing method for recovered portions.
- Marked, leakproof and theft-proof containers or other means to handle and hold condemned and inedible material prior to removal.

2.3.8 Final wash

The inside and outside of the carcasses are washed after evisceration, which must be with water that may contain a bactericidal substance, which complies with the requirements of the Foodstuffs, Cosmetics and Disinfectants Act, 1972 (Act 54 of 1972) and is approved per protocol by the provincial executive officer at levels not harmful or injurious to health.

2.3.9 Primary carcass chilling

For reasons of hygiene and particularly to minimise microbiological contamination, the birds are chilled to less than 10°C in prechilling or in-process chilling facilities. This can be done using a spin chiller (chilled water) or cold air. In lower grade abattoirs, chest freezers are often used. In the high-throughput abattoirs, chilling methods such as spin chilling and air chilling are used.

2.3.10 Spin chiller

A prechiller can precede the spin chiller. The temperature of the water in the prechiller or washer should be 18°C. The dwell time in the chiller must not exceed 10-15 min depending on the size of the tank. In the spin chiller, there is a continuous cold water inflow at not more than 4°C through an aerated water bath. The replacement rate of water at the carcass exit point is 1 ℓ of water for every bird entering the system. Water used in the spin chiller must have a chorine concentration of not less than 50 ppm. The product moves in contraflow to the water. The carcass core temperature entering the chiller is about 38°C. The deep bone temperature of carcasses leaving the spin chiller must be less than 7°C. The overall dwell time should not exceed 30 minutes. The spin chiller must be drained and cleaned at the end of each shift. Where two shifts are worked per day, cleaning can take place at the end of the second shift.

The outside temperature of the carcass is also very important as this is where bacterial growth starts. When the carcass temperature rises after spin chilling it causes weeping, which results in moisture loss and a subsequent yield loss. Carcasses chilled in this manner are used for frozen products. The water temperature, agitation and time is important for water pick-up. The maximum percentage of water pick-up allowed after spin chilling at the packing point is 8% for all chicken carcasses.

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

2.3.11 Air chilling

A predrying section can be used where the air temperature is ±22°C. The main purpose is to dry the carcass before it goes into the air chiller. A wet bird can sometimes show ice forming in the air chiller, which is unacceptable.

In the air chiller, cold air at ± 0°C is blown over the carcasses at 0.75 metres per second. This provides for a carcass that is dry and chilled. The deep bone temperature of these air-chilled carcasses should not exceed 7°C. These air-chilled carcasses are used for fresh meat production.

2.4 Portioning and Packing

Further processing must comply with the requirements set in the Regulations Governing General Hygiene Requirements for Food Premises and the Transport of Food, Regulation R918 of 30 July 1999 under the Health Act, 1977 (Act 63 of 1977).

Portioning is the cutting of a chicken into predetermined recognisable pieces (wings, thighs, drumsticks etc.). Portions must be roughly equal in size, and the skin covering portions must be complete. Cutting can be done mechanically or by hand. The number of portion cut per carcass depends on market demand. There is a five-, seven- or nine-cut method. Additional solid wastes arise from these operations.

Before any portion is packed, it is inspected and cleaned. All pieces of lungs, bronchial tubes, windpipes, blood clots and other debris are removed.

2.5 Chilling and Freezing

Sufficient chillers and freezers must be provided for final chilling, freezing and storage of packed products. Chilled poultry is cooled to and stored at 4°C, and frozen poultry at −12°C.

3 REGULATIONS

A summary of the legislation, guidelines and standards relevant to the South African Poultry Sector is provided in Appendix 1.

South Africa has a three-tier system of government, namely, national, provincial and local spheres of government. In accordance with the Constitution, each of the nine provinces has its own legislature. Provinces may have legislative and executive powers concurrent with the national sphere over agriculture, environment, trade and industrial promotion, among others. Provinces have the administrative capacity to assume effective responsibilities and have exclusive competency over several areas, which includes abattoirs.

On a local level, governance takes place through municipalities such that all areas, including urban and rural, fall under local municipal control. The Constitution provides for three categories of municipalities, namely, metropolitan, district and local. There are 278 municipalities in South Africa, comprising eight metropolitan, 44 district and 226 local municipalities. They are focused on growing local economies and providing infrastructure and service (DAFF, 2014).

3.1 National Legislation for Water, Waste Water and the Environment

The Bill of Rights in the Constitution of the Republic of South Africa, 1996 (Act 108 of 1996) enshrines the concept of sustainability; specifying rights regarding the environment, water, access to information and just administrative action. These rights and other requirements are further legislated through the National Water Act (NWA), 1998 (Act 36 of 1998). The NWA is the primary statute providing the legal basis for water management in South Africa. It has to ensure ecological integrity, economic growth and social equity when managing and using water.

The NWA introduced the concept of integrated water resource management (IWRM), comprising all aspects of the water resource, including water quality, water quantity and the aquatic ecosystem quality (quality of the aquatic biota and in-stream and riparian habitat). The IWRM approach provides for both resource-directed and source-directed measures. Resource-directed measures aim to protect and manage the receiving environment. Examples of resource-directed actions are formulating resource quality objectives and developing associated strategies to ensure ongoing attainment of these objectives such as the Catchment Management Strategy (CMS) and the establishment of catchment management agencies (CMAs) to implement these strategies.

Source-directed measures aim to control the impacts at source by identifying and implementing pollution prevention, water reuse and water treatment mechanisms. The integration of resource- and source-directed measures forms the basis of the hierarchy of decision-making aimed at protecting the resource from waste impacts.

Further information on some of the relevant policies is provided in this section.

3.1.1 Water policy

The Department of Water and Sanitation (DWS) [formerly the Department of Water Affairs (DWA) and the Department of Water Affairs and Forestry (DWAF)] is the water and sanitation sector leader in South Africa. DWS is the custodian of South Africa's water resources and of the NWA (Act 36 of 1998) and the Water Services Act (Act 108 of 1997). DWS is also the national regulator of the water services sector.

The NWA provides the legal framework for the effective and sustainable management of water resources within South Africa. The Act aims to protect, use, develop, conserve, manage and control water resources as a whole, promoting the integrated management of water resources with the participation of all stakeholders.

The NWA stipulates the requirements for, among others, developing a National Water Resource Strategy (NWRS) and CMS through appointed CMAs, protecting water resources through classification, setting reserves (basic human need and ecological), determining resource quality objectives and promoting pollution prevention, and providing penalties for non-compliance (DWAF, n.d.).

The Water Services Act deals mainly with water services or potable (drinkable) water and sanitation services supplied by municipalities to households and other municipal water users.

3.1.2 Waste water policy

The NWA (Act 36 of 1998) sets norms and standards for the purification of waste water prior to discharge. These consist of general and special standards and set limits for aspects such as pH, temperature, chemical oxygen demand (COD), suspended solids and metals. The test methods that are to be used to determine these are also specified. Areas where the special standards apply are listed. Any industries or municipal or private waste water treatment works discharging to river or sea must comply with these limits. In turn, the entity operating a waste water treatment works must set limits for industries discharging to the works such that the DWS final discharge limits can be met. Within each municipal area, by-laws are developed under the Water Services Act, which outlines the water supply and effluent discharge regulations and tariffs for that area (see Section 3.4).

3.1.3 Environmental policy

The environmental policy most relevant to the poultry sector is the National Environmental Management Act, 1998 (Act 107 of 1998) and in particular, the National Environmental Management: Waste Act, 2008 (Act 59 of 2008), or “Waste Act” and the National Environmental Management: Air Quality Act, 2004 (Act 39 of 2004). Broadly speaking, these acts outline the requirements for storing and handling waste on-site (hazardous and non-hazardous), licensing requirements, establishing waste management plans, setting limits for air emissions, and setting penalties for offences. Both these acts emphasise the need for the implementation of cleaner production and clean technologies to reduce the generation of pollution at source.

The National Waste Management Strategy (NWMS, 2011) is a legislative requirement of the Waste Act, with the purpose of achieving its objectives. The objectives of the Waste Act are structured around the steps in the waste management hierarchy, which is the overall approach that informs waste management in South Africa. The waste management hierarchy consists of options for waste management during the lifecycle of waste arranged in descending order of priority: waste avoidance and reduction, reuse and recycling, recovery, and treatment and disposal as the last resort (Figure 27). Details of the objectives, indicators and targets to achieve each goal are provided, as well as a toolbox of waste management measures.

Figure 27 Waste management hierarchy (NWMS, 2011)

3.2 Health and Safety

The Department of Health is responsible for regulating aspects related the health and safety of food and drink products. This department is responsible for ensuring the safety of food in South Africa based on the basic needs of communities and the right of South Africans to make informed food choices without being misled. The Act that covers all these aspects is the Foodstuffs, Cosmetics and Disinfectants Act, 1972 (Act 54 of 1972).

With respect to the poultry industry, various regulations under this Act apply. Regulations relating to the Advertising and Labelling of Food: Amendment, Regulation R429 of May 2014 govern the labelling and advertising of foodstuffs for compliance purposes. Regulations Governing Microbiological Standards for Foodstuffs and Related Matters, Regulation R692 of May 1997 and its amendments, specify the limits of the microbiological content of egg products and cooked poultry products and the test methods that must be used to determine these. A key requirement of all food and drink manufacturing sites is implementing a hazard analysis and critical control point (HACCP) system. This is also regulated under the above-mentioned Act according to Regulations Relating to the Application of the Hazard Analysis and Critical Control Point system (HACCP system), Regulation GNR 908 GG25123 of June 2003, and amendment R546, May 2008.

Food safety standards for egg production is governed by the Agriculture Products Standards Act (Act 119 of 1990), Regulations Regarding the Grading, Packing and Marking of Eggs Destined for Sale in the Republic of South Africa, Regulation Number R725, September 2011, and poultry abattoirs by the MSA (Act 40 of 2000), specifically Poultry Regulations, R153, 24 February 2006.

3.3 Quality Standards

The Standards Act, 2008 (Act 29 of 2008), provides for developing, promoting and maintaining standardisation and quality in connection with commodities and the rendering of related conformity assessment services; and for that purpose, providing for the continued existence of the South African Bureau of Standards (SABS) as the peak national institution; and providing for the establishment of the board of the SABS. Various SANS developed by the SABS relating to the food industry apply to the poultry industry (Appendix 1).

3.4 By-laws and Effluent Tariffs

The Water Services Act sets out the regulatory framework for institutions tasked with supplying water services and provide for different water services institutions to be established as follows:

- The water services authority (WSA), namely, the responsible municipality.
- The water services provider (WSP) whose role is to physically provide the water supply and sanitation services to consumers.

Generally, within each municipality (the WSA) there is a department or unit that is responsible for providing water and treating waste water or delivering sanitation (the WSP).

Based on current knowledge, no South African abattoirs operate on a closed water circuit, as in general, it is prohibitively costly to treat waste water to a water quality standard fit for recycling and/or reuse. Thus, most abattoirs discharge (after appropriate pre-treatment) to municipal sewers. These effluents have to comply with municipal by-laws, which typically have the following values:

- COD from 3000 mg/ℓ to 5000 mg/ℓ.
- Total soluble solids (TSS) of 500 mg/ℓ.
- NH_3-N from 200 mg/ℓ to 300 mg/ℓ.
- pH from 6 to 10.

Discharge costs due to the high organic loads in the untreated abattoir waste water are relatively high. Abattoirs normally also have difficulty in meeting municipal by-law quality standards for fats, oils, greases and suspended solids. A degree of on-site pre-treatment is thus necessary. However, to minimise waste volumes, water conservation and optimum water housekeeping are essential. In addition to good abattoir housekeeping, abattoir waste management should be progressively implemented commencing with low-cost, low-technology practices and thereafter progressing to more sophisticated technologies (GDARD, 2009).

The by-laws and tariffs for the eight metropolitan municipal areas, according to the terms of section 13(a) of the Local Government: Municipal Systems Act, 2000 (Act 32 of 2000), are described in more detail in Appendix 2: By-Laws for Metropolitan Municipalities.

4 SURVEY RESPONSES

Information on water, waste water and energy management practices in the South African poultry industry has been collated based on information received in response to the disseminated surveys.

4.1 Overview of Participating Companies

A summary of the responding companies is provided in Table 9. Each producer is presented in terms of their size based on number of employees, capacity in terms of egg, hatchling, broiler or number of birds slaughtered, as well as annual water consumption.

Table 9 Profile of companies participating in the survey

<table>
<tr><th rowspan="2" colspan="2"></th><th rowspan="2">Size (No. employees)</th><th>Capacity</th><th rowspan="2">Avg. annual water consumption</th></tr>
<tr><th>Number of laying hens
Number of eggs/day</th></tr>
<tr><td rowspan="6">Egg producers</td><td>1</td><td><50</td><td>65 900
66 000</td><td>1001-5000</td></tr>
<tr><td>2</td><td><50</td><td>21 600
18 000</td><td>10 001-20 000</td></tr>
<tr><td>3</td><td><50</td><td>110 000
100 000</td><td>–</td></tr>
<tr><td>4</td><td><50</td><td>85 000
70 000</td><td>5 000-10 000</td></tr>
<tr><td>5</td><td><50</td><td>104
34</td><td>–</td></tr>
<tr><td>6</td><td><50</td><td>169
150</td><td>0-1000</td></tr>
<tr><td rowspan="4">Hatcheries</td><td></td><td></td><td>Number of pullets
Number of laying hens
Number of eggs/day
Number of hatchlings</td><td></td></tr>
<tr><td>1</td><td>50-200</td><td>0
550 000
400 000
250 000</td><td>20 001-40 001</td></tr>
<tr><td>2</td><td>>450</td><td>234 000
427 000
214 286
274 000</td><td>100 001-120 000</td></tr>
<tr><td>3</td><td>>450</td><td>374 000
621 950
385 000
187 000</td><td>140 001-160 000</td></tr>
</table>

		Size (No. employees)	Capacity	Avg. annual water consumption
			Number of broilers housed	
Broilers	1	<50	124 000	–
	2	50-200	60 000	20 001-40 000
	3	<50	200 000	10 001-20 000
	4	<50	55 000	–
	5	<50	250 000	5 001-10 000
	6	<50	215 000	5 001-10 000
	7	>450	151 200	5 001-10 000
	8	<50	276 800	10 001-20 000
	9	<50	200	–
	10	<50	200	–
	11	<50	100	–
	12	<50	100	–
	13	<50	100	–
	14	<50	80	–
Abattoirs			Birds/year	
	1	>450	105 534 000	>800 000
	2	>450	70 200 000	>800 000
	3	>450	85 800 000	>800 000
	4	>450	39 000 000	420 001-440 000
	5	>450	23 660 000	360 000-380 000
	6	>450	28 080 000	400 000-420 000
	7	>450	25 480 000	300 000-320 000
	8	>450	14 300 000	180 001-200 000
	9	>450	49 400 000	480 001-500 000
	10	>450	1 820 000	600 000-700 000
	11	<50	78 000	5 001-10 000
	12	>450	33 800 000	340 001-360 000
	13	<50	104 000	0-1000
	14	<50	78 000	0-1000
	15	>450	83 200 000	>800 000

4.2 Water Use and Management

4.2.1 Source of water and pre-treatment

Participating companies were surveyed regarding the source of water and the type of pre-treatment. Depending on the source available to the producer, it is often necessary to treat the water to ensure consistent quality. This information is provided in Table 10.

Table 10 Summary of water source and pre-treatment processes

		Source of Water	Pre-treatment of water	Disinfectant used
Egg producers	1	Borehole	Reservoir storage	
	2	Borehole	None	
	3	Borehole	Reservoir storage, disinfection, water softening	
	4	Borehole	Reservoir storage	
	5	Borehole	None	
	6	Borehole	Filtration	
Hatcheries	1	Municipal	Reservoir storage, addition of antimicrobials	
	2	75% borehole, 25% municipal	Reservoir storage, softening	
	3	Borehole and municipal	Reservoir storage, disinfection, sand filtration, pH correction	
Broilers	1	Borehole	Reservoir storage, water softening	
	2	Borehole	Reservoir storage, disinfection	
	3	70% municipal 30% borehole	Reservoir storage, Sand filtration	
	4	Borehole	Reservoir storage	
	5	90% dam water, 10% borehole	Reservoir storage, sand filtration, pH correction, disinfection	
	6	Borehole	Reservoir storage	
	7	Municipal	Reservoir storage	
	8	Borehole	Reservoir storage, disinfection, pH correction	
	9	Borehole	Addition of vaccinations and other additives	
	10	Borehole	Addition of vaccinations and other additives	
	11	Borehole	Addition of vaccinations and other additives	
	12	Borehole	Addition of vaccinations and other additives	
	13	Borehole	Addition of vaccinations and other additives	
	14	Borehole	Addition of vaccinations and other additives	

		Source of Water	Pre-treatment of water	Disinfectant used
Abattoirs	1	Municipal	Reservoir storage	
	2	Municipal	Disinfection, pH correction, filtration with mechanical 300 micron filter	Calcium hypochlorite
	3	Irrigation scheme water	Reservoir storage, disinfection, sand filtration, pH correction, water softening, water softening of boiler makeup water	Chlorine gas
	4	Municipal	Reservoir storage, disinfection, pH correction, water softening	Chlorine dioxide
	5	Municipal	Reservoir storage; sand filtration, disinfection, water softening	Chlorine dioxide and sodium chlorite
	6	40% Borehole 60% Municipal	Reservoir storage; sand filtration, disinfection	Chlorine dioxide and sodium chlorite
	7	40% Borehole 60% Municipal	Reservoir storage; sand filtration, disinfection, water softening	Chlorine dioxide and sodium chlorite
	8	Borehole	Reservoir storage, DISINFECTION, pH correction	Calcium hypochlorite
	9	Municipal	Disinfection, pH correction, water softening, deionization	Chlorine dioxide
	10	Municipal	Disinfection	Chlorine gas
	11	Borehole	Reservoir storage, pH correction, softening	
	12	Municipal	Disinfection, softening (for boiler and cooling towers)	Calcium hypochlorite
	13	Borehole	No pre-treatment	
	14	Borehole	No pre-treatment	
	15	Municipal	Reservoir storage, disinfection, softening (for boiler)	Chlorine gas

4.2.2 Water metering and water use

The participating companies were asked to supply the number of water meters installed on-site, and the location of the meters in the process. This information for the responding egg producers, hatcheries, broilers and abattoirs is summarised in Table 11, Table 12 and Table 13. In addition, producers were asked to supply their water use as a percentage per major operations process; data is presented in Table 15, Table 16, Table 17 and Table 18 for egg producers, hatcheries, broilers and abattoirs respectively.

Table 11 Summary of the number and position of meters on-site at responding egg producers

		No. of meters	Cleaning of cages	Cleaning of trays	Washing of eggs	Washing of floors	Drinking water
Egg producers	1	6	–	–	–	–	–
	2	–	–	–	–	–	–
	3	–	–	–	–	–	–
	4	5	–	–	–	–	x
	5	1	–	–	–	–	–
	6	0	–	–	–	–	–

Table 12 Summary of the number and position of meters on-site at responding hatcheries

		No. of meters	Cleaning of cages	Cleaning of trays	Cleaning of nests	Washing of eggs	Washing of floors	Drinking water
Hatcheries	1	1	–	–	–	–	–	–
	2	75	x	x	–	–	x	x
	3	157	x	x	x	–	x	x

Table 13 Summary of the number and position of meters on-site at responding broiler producers

		No. of meters	Cleaning of cages	Washing of floors	Drinking water for birds
Broilers	1	4	–	–	x
	2	–	–	–	–
	3	9	x	x	x
	4	–	–	–	x
	5	7	x	x	x
	6	5		x	x
	7	6	–	–	x
	8	8	–	–	x
	9	0	–	–	–
	10	0	–	–	–
	11	0	–	–	–
	12	0	–	–	–
	13	0	–	–	–
	14	0	–	–	–

Table 14 Summary of the number and position of meters on-site at responding abattoirs

		No. of meters	Incoming water	Holding of live birds	Stunning	Cutting and bleeding	Scalding	Defeathering	Evisceration	Brine injection	Chilling	General washing (other than poultry)	Laundry	Ablutions	Gardening
Abattoirs	1	3	–	–	–	–	–	–	–	–	–	x	–	–	–
	2	34	–	x	x	x	x	x	x	x	x	x	x	x	
	3	11	–	–	–	–	x	x	–	–	x	x	–	–	–
	4	1	x	–	–	–	–	–	–	–	–	–	–	–	–
	5	10	–	x	–	x	x	x	x	x	x	x	–	–	–
	6	13	–	x	–	x	x	x	x	x	x	x	–	–	–
	7	13	–	x	–	x	x	x	x	x	x	x	–	–	–
	8	0	–	–	–	–	–	–	–	–	–	–	–	–	–
	9	12	–	–	–	–	x	x	x	x	x	x	–	–	–
	10	>50	x	x	x	x	x	x	x	x	x	x	x	x	x
	11	0	–	–	–	–	–	–	–	–	–	–	–	–	–
	12	3	x	–	–	–	–	–	–	–	–	–	–	–	–
	13	0	–	–	–	–	–	–	–	–	–	–	–	–	–
	14	0	–	–	–	–	–	–	–	–	–	–	–	–	–
	15	13	x	x			x	x	x		x	x			

Table 15 Summary of percentage water use at responding egg producers for major processes

		Cleaning of cages	Cleaning of trays	Washing of eggs	Washing of floors	Drinking water for birds
Egg producers	1	–	<10%	<10%	<10%	91-100%
	2	–	–	–	–	71-80%
	3	–	–	<10%	<10%	81-90%
	4	<10%	<10%	<10%	<10%	91-100%
	5	–	–	–	–	–
	6	<10%	<10%	<10%	<10%	41-50%

Table 16 Summary of percentage water use at responding hatcheries for major processes

		Cleaning of cages	Cleaning of trays	Washing of eggs	Washing of floors	Drinking water for birds
Hatcheries	1	–	–	–	–	–
	2	<10%	<10%	–	10-20%	81-90%
	3	<10%	<10%	–	10-20%	91-100%

Table 17 Summary of percentage water use at responding broiler producers for major processes

		Cleaning of cages	Washing of floors	Drinking water for birds
Broilers	1	–	10-20%	–
	2	<10%	–	–
	3	<10%	<10%	–
	4	–	–	–
	5	–	10-20%	–
	6	–	<10%	–
	7	10-20%	10-20%	81-90%
	8	<10%	<10%	81-90%
	9	–	–	–
	10	–	–	–
	11	–	–	–
	12	–	–	–
	13	–	–	–
	14	–	–	–

Table 18 Summary of percentage water use at responding abattoirs for major processes

		Holding of live birds	Stunning	Cutting and bleeding	Scalding	Defeathering	Evisceration	Brine injection	Chilling	General washing	Crate washing	Laundry	Ablutions	Gardening	Boiler make-up water
Abattoirs	1	<10%	<10%	<10%	10-20%	10-20%	10-20%	–	41-50%	10-20%	<10%	<10%	<10%	<10%	<10%
	2	<10%	<10%	<10%	<10%	10-20%	10-20%	–	10-20%	10-20%	<10%	<10%	<10%	<10%	<10%
	3	<10%	<10%		10-20%	10-20%	10-20%	–	<10%	31-40%	10-20%	<10%	<10%	–	–
	4	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	5	<10%	<10%	<10%	10-20%	10-20%	10-20%	10-20%	21-30%	21-30%	<10%	<10%	<10%	<10%	<10%
	6	<10%	<10%	<10%	10-20%	10-20%	10-20%	10-20%	21-30%	21-30%	<10%	<10%	<10%	<10%	<10%
	7	<10%	<10%	<10%	10-20%	10-20%	10-20%	10-20%	21-30%	21-30%	<10%	<10%	<10%	<10%	<10%
	8	<10%	<10%	<10%	<10%	<10%	21-30%	–	21-30%	10-20%	<10%	<10%	<10%	<10%	<10%
	9	–	–	–	21-30%	21-30%	21-30%	–	10-20%	10-20%	<10%		<10%	<10%	<10%
	10	<10%	<10%	<10%	10-20%	10-20%	10-20%	10-20%	21-30%	21-30%	<10%	<10%	<10%	<10%	<10%
	11	<10%	<10%	<10%	10-20%	10-20%	10-20%	10-20%	21-30%	21-30%	<10%	<10%	<10%	<10%	<10%
	12	<10%	<10%	<10%	10-20%	<10%	31-40%	–	<10%	21-30%	10-20%	10-20%	<10%	<10%	<10%
	13	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	14	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	15	<10%	–	–	<10%	<10%	10-20%	–	41-50%	<10%	<10%	–	<10%	–	10-20%

4.2.3 Water consumption and specific water intake

Water consumption figures and specific water intake (SWI) values per bird are summarised in Table 19. SWI values for egg producers are daily values per bird.

Table 19 SWI calculated for participating companies

		Capacity	Avg. annual water consumption (kl)	Actual annual consumption (kl)	SWI per bird	Additional process water
		Number of laying chickens				
Egg producers	1	65 900	1 001-5 000		<5 ℓ	<5 ℓ
	2	21 600	10 001-20 000		–	–
	3	110 000	–		–	–
	4	85 000	5 000-10 000		<5 ℓ	<5 ℓ
	5	104	–		<5 ℓ	<5 ℓ
	6	169	0-1 000		<5 ℓ	<5 ℓ
Hatcheries		**Number of hatchings**				
	1	250 000	20 001-40 001	28 200	<1 ℓ	
	2	274 000	100 001-120 000	99 792	<1 ℓ	
	3	187 000	140 001-160 000	151 585	<1 ℓ	
Broilers		**Number of broilers housed**				
	1	124 000	–	Unknown (borehole)	9-10 ℓ	
	2	60 000	20 001-40 000		<5 ℓ	7-8 ℓ
	3	200 000	10 001-20 000	10 000	6-7 ℓ	
	4	55 000	–			
	5	250 000	5 001-10 000	7 550	<5 ℓ	<5 ℓ
	6	215 000	5 001-10 000	97 500	5-6 ℓ	<5 ℓ
	7	151 200	5 001-10 000	7 044	5-6 ℓ	<5 ℓ
	8	276 800	10 001-20 000	12 057	5-6 ℓ	<5 ℓ
	9	200	–			
	10	200	–			
	11	100	–			
	12	100	–			
	13	100	–			
	14	80	–			

		Capacity	Avg. annual water consumption (kl)	Actual annual consumption (kl)	SWI per bird	Additional process water
		Birds/year				
Abattoirs	1	105 534 000	>800 000	1 383 200	13-14 ℓ	<5 ℓ
	2	70 200 000	>800 000	1 138 863	11-12 ℓ	<5 ℓ
	3	85 800 000	>800 000	1 135 541	10-11 ℓ	<5 ℓ
	4	39 000 000	420 001-440 000	427 897	10-11 ℓ	<5 ℓ
	5	23 660 000	360 000-380 000	370 000	12-13 ℓ	<5 ℓ
	6	28 080 000	400 000-420 000	411 720	11-12 ℓ	<5 ℓ
	7	25 480 000	300 000-320 000	312 704	10-11 ℓ	<5 ℓ
	8	14 300 000	180 001-200 000	182 000	12-13 ℓ	<5 ℓ
	9	49 400 000	480 001 – 500 000		13-14 ℓ	<5 ℓ
	10	1 820 000	600 000-700 000	616 000	9-10 ℓ	<5 ℓ
	11	78 000	5 001-10 000		15-16 ℓ	<5 ℓ
	12	33 800 000	340 001-360 000	349 200	>16 ℓ	<5 ℓ
	13	104 000	0-1 000	520	>16 ℓ	<5 ℓ
	14	78 000	0-1 000	520	>16 ℓ	<5 ℓ
	15	83 200 000	>800 000	1 104 000	13-14 ℓ	<5 ℓ

4.3 Waste Water Generation and Management

For hygiene reasons, abattoirs use substantial amounts of water in animal processing operations. This produces significant amounts of waste water that must be treated. Effective primary treatment before secondary treatment increases the overall effectiveness and efficiency of waste water treatment systems, as it is cheaper to physically remove the fat and solids than to treat them later in secondary and tertiary treatment facilities (GDARD, 2009)

Waste water produced in animal slaughter areas typically has a high biological oxygen demand (BOD). It may also be saline and have concentrations of nutrients, suspended solids and bacterial contamination.

The following systems are commonly used for secondary treatment of abattoir effluent:

- Anaerobic or settling ponds.
- Facultative ponds.
- Mechanically forced aerated ponds.
- Naturally aerated ponds.
- Dissolved air floatation (DAF) cells.
- Septic tanks.
- Other package treatment plants.

4.3.1 Effluent generation and pollution loads

A summary of the effluent volumes and characteristics of the respondents is presented in Table 20, indicating pollutant loading for COD, suspended solids (SS), electrical conductivity (EC), Total dissolved solids (TDS), total Kjeldahl nitrogen (TKN), ammonia nitrogen (NH_4-N), total phosphorus (TP), orthophosphate as phosphorus (PO_4-P), sodium (Na) and chloride (Cl). .

Table 20 Summary of effluent characteristics from participating companies

		Effluent as% of incoming	Total annual effluent (kl)	Average monthly effluent pollutant loading (mg/ℓ)									
				COD	SS	EC	TDS	TKN	NH_4-N	TP	PO_4-P	Na	Cl
Egg producers	1	<10%	–	–	–	–	–	–	0-10	21-50	0-5	0-100	–
	2	–	–	–	–	–	–	–	–	–	–	–	–
	3	–	–	–	–	–	–	–	–	–	–	–	–
	4	–	–	–	–	–	–	–	–	–	–	–	–
	5	–	–	–	–	–	–	–	–	–	–	–	–
	6	41-50%	–	–	–	–	–	–	–	–	–	–	–
Hatcheries	1			1000-2000	201-300	501-600	3000-4000	201-250			201-250	401-500	401-500
	2			–	–	–	–	–	–	–	–	–	–
	3	81-90%		–	–	–	–	–	–	–	–	–	–
Broilers	1	<10%	–	–	–	–	–	–	–	–	–	–	–
	2	71-80%	–	–	–	–	–	–	–	–	–	–	–
	3	–	–	–	–	–	–	–	–	–	–	–	–
	4	–	–	–	–	–	–	–	–	–	–	–	–
	5	11-20%	–	–	–	–	–	–	–	–	–	–	–
	6	<10%	–	–	–	–	–	–	–	–	–	–	–
	7			–	–	–	–	–	–	–	–	–	–
	8			–	–	–	–	–	–	–	–	–	–
	9			–	–	–	–	–	–	–	–	–	–
	10		56	–	–	–	–	–	–	–	–	–	–
	11			–	–	–	–	–	–	–	–	–	–
	12			–	–	–	–	–	–	–	–	–	–
	13			–	–	–	–	–	–	–	–	–	–
	14			–	–	–	–	–	–	–	–	–	–

		Effluent as% of incoming	Total annual effluent (kl)	Average monthly effluent pollutant loading (mg/ℓ)									
				COD	SS	EC	TDS	TKN	NH_4-N	TP	PO_4-P	Na	Cl
Abattoirs	1	81-90%	–	0-500	1 001- 1 500	100-150	1 000-2000	–	51-100	–	–	–	–
	2	71-80%	10 944 000	501-1 000	51-100	100-150	–	–	21-50	–	–	–	–
	3	91-100%	336 000	4 001-6 000	1 001-1500	100-150	1 000-2000	–	0-10	–	–	–	–
	4	71-80%	4 107 804	4 001-6000	–	601-700	1 000-2000	–	0-10	–	–	100-150	101-200
	5	71-80%	–	501-1000	–	75-100	–	–	0-10	–	0-5	–	–
	6	71-80%	–	501-1000	–	50-75	–	–	0-10	–	0-5	–	–
	7	71-80%	–	501-1000	–	75-100	–	–	0-10	–	0-5	–	–
	8	91-100%	–	–	–	–	–	–	–	–	–	–	–
	9	71-80%	4 147 200	1 001-2000	–	>2000	–	–	–	–	–	–	–
	10	71-80%	–	–	–	–	–	–	–	–	–	–	–
	11	71-80%	–	–	–	–	–	–	–	–	–	–	–
	12	71-80%	–	2001-4000	–	–	500-1000	–	–	–	–	–	–
	13		–	–	–	–	–	–	–	–	–	–	–
	14		–	–	–	–	–	–	–	–	–	–	–
	15	71-80%	–	501-1000	–	–	–	21-50	–	5-10	–	–	–

4.3.2 Effluent treatment and management

A summary of the effluent management processes implemented by the various survey respondents is presented in Table 21. This includes the percentage of water reuse, waste water treatment methods employed and the method of effluent disposal.

Table 21 Summary of effluent management implemented by participating companies

		Effluent as % of incoming	Total annual effluent (kl)	% water reuse	Effluent treatment methods in place	Effluent disposal
Egg producers	1	<10%	–	None		Irrigation to land
	2		–	None		Irrigation to land
	3		–	None	Anaerobic settling ponds, facultative ponds, mechanically forced aerated ponds	Irrigation to land, licensed disposal to a watercourse, dry manure is spread on fields
	4			None	Holding tank, septic tank	Irrigation to land, manure taken by local farmers
	5			None	None	Spread as manure on seed beds
	6	41-50%		None	Holding tank	Irrigation to land
Hatcheries	1			<10%	Holding tank, artificial wetland, facultative ponds	Holding dam/evaporation
	2				No treatment	Disposed to local sewer
	3	81-90%			No treatment	Disposal to local sewer
Broilers	1	<10%	–			Irrigation to land
	2	71-80%	–	<10%		
	3		–		No treatment	Irrigation to land
	4		–		No treatment	
	5	11-20%	–	<10%	Holding tank, segregation of concentrated process streams, artificial wetland	Evaporation in lined settling ponds
	6	<10%	–	<10%	No treatment	
	7			None	No treatment	
	8			None	No treatment	
	9					Irrigation to land
	10		56		No treatment	Irrigation to land
	11				No treatment	Irrigation to land
	12				No treatment	Irrigation to land
	13				No treatment	Irrigation to land
	14				No treatment	Irrigation to land

		Effluent as % of incoming	Total annual effluent (kl)	% water reuse	Effluent treatment methods in place	Effluent disposal
Abattoirs	1	81-90%	–		Screening, waste water treatment plant	Irrigation to land and awaiting final licence approval
	2	71-80%	10 944 000		Holding tank, screening, flocculation, segregation of concentrated process streams, DAF cells, trucking of effluent to off-site disposal	Disposal to local sewer
	3	91-100%	336 000		Holding tank, screening, flocculation, pH adjustment, segregation of concentrated process streams, artificial wetland, anaerobic settling ponds, mechanically forced aerated ponds, DAF cells	Irrigation to land, licensed disposal to a watercourse
	4	71-80%	4 107 804		Holding tank, DAF cells	Disposal to local sewer
	5	71-80%	–	11-20%	Screening; anaerobic biogas system	Disposal to local sewer
	6	71-80%	–	11-20%	Screening; anaerobic biogas system	Disposal to local sewer
	7	71-80%	–	11-20%	Screening	Disposal to local sewer
	8	91-100%	–		Screening, anaerobic digestion, anaerobic settling ponds, mechanically forced aerated ponds, DAF cells	Irrigation to land
	9	71-80%	4 147 200		Screening, flocculation, pH adjustment, segregation of concentrated process streams, DAF cells	Disposal to local sewer
	10	71-80%	–		Screening, anaerobic biogas system	Disposal to local sewer
	11	71-80%	–		Screening, anaerobic biogas system	Disposal to local sewer
	12	71-80%	–	11-20%	No treatment	Disposal to local sewer
	13		–		Screening, solids collected and incinerated	Irrigation to land
	14		–		No treatment	Disposal to septic tank
	15	71-80%		21-30%	Screening, flocculation, pH adjustment, DAF unit	Disposal to local sewer

4.4 Energy Use and Management

A summary of the types of energy used at each of the responding facilities and their energy consumption is presented in Table 22.

Table 22 Summary of information on energy management from participating companies

		Type of energy used	Specific energy used for heating	Lighting	Monthly energy consumption (kWh/month)	Specific energy consumption per bird (kJ)
Egg producers	1	Electricity	Electricity	LED	–	–
	2	Electricity, diesel for generators, diesel for trucks	Fuel oil [heavy fuel oil (HFO)]	LED	–	–
	3	Electricity, diesel for trucks		LED	12 287	–
	4	Electricity, diesel for trucks	No heating	LED, fluorescent	–	–
	5	Electricity; liquefied petroleum gas (LPG), diesel for generators, diesel for trucks, petrol		LED, fluorescent	–	–
	6	Electricity	Electricity, petrol	LED	–	–
Hatcheries	1	Electricity, gas (LPG), diesel for generators	Electricity	LED		
	2	Electricity, coal, gas (LPG), diesel for generators, diesel for trucks, petrol	Electricity, coal, gas (LPG)	Incandescent, fluorescent, energy savers		
	3	Electricity, coal, gas (LPG), diesel for generators, diesel for trucks, petrol	Electricity, coal, gas (LPG), diesel for generators	Incandescent, fluorescent, energy savers	845 585	
Broilers	1	Electricity, coal, diesel for generators	Coal	LED	350	–
	2	Electricity, coal, gas (LPG), diesel for trucks	Gas (LPG)	Fluorescent, LED	40	–
	3	Electricity, coal	Coal	Incandescent	–	–
	4				–	–
	5	Electricity, diesel for generators		LED	–	–
	6	Electricity, coal, diesel for generators, petrol	Coal	LED	4 365	73
	7	Electricity, coal, diesel for generators	Coal		–	–
	8	Electricity, coal, diesel for generators,	Coal	LED	–	–
	9	Electricity	Electricity	Incandescent	–	–
	10	Electricity	Electricity	Incandescent and LED	300	–
	11	Electricity	Electricity	Incandescent	–	–
	12	Electricity	Electricity	Incandescent and Infrared	–	–
	13	Electricity, petrol	Electricity	Incandescent	–	–
	14	Electricity, petrol	Electricity	Incandescent	–	–

		Type of energy used	Specific energy used for heating	Monthly energy consumption (kWh/month)	Specific energy consumption per bird (kJ)
Abattoirs	1	Electricity, coal, diesel for trucks	Coal	4 250 000	2016
	2	Electricity, coal, diesel for generators, diesel for trucks	Coal	3 186 124	2016
	3	Electricity, coal, gas (LPG), diesel for generators, diesel for trucks	Coal	3 900 000	2012
	4	Electricity, coal, diesel for generators, diesel for trucks	Coal	1 243 773	1 393
	5	Electricity, coal, fuel oil (HFO), Diesel for generators, diesel for trucks, petrol	Coal	1 056 045	1980
	6	Electricity, coal, gas (LPG), Diesel for generators, diesel for trucks	Coal	1 328 790	2016
	7	Electricity, coal, gas (LPG), diesel for generators, diesel for trucks	Coal	1 545 936	2 650
	8	Electricity, coal, diesel for generators, diesel for trucks	Coal	16 000	–
	9	Electricity, coal, fuel oil (HFO), gas (LPG), diesel for generators, diesel for trucks	Coal	–	–
	10	Electricity, coal, gas (LPG), diesel for generators, diesel for trucks, petrol	Coal	1 328 790	2016
	11	Electricity, coal, gas (LPG), diesel for generators, diesel for trucks, petrol	Coal	1 056 045	1980
	12	Electricity, coal, gas (LPG), diesel for generators, diesel for trucks	Coal	1 436 160	
	13				
	14				
	15	Electricity, coal	Coal	3 200 000	1 662

5 WORKSHOP FINDINGS: STAKEHOLDER ISSUES RAISED

Our workshop provided us the opportunity to interact with delegates and industry stakeholders on a one-to-one basis. Attendees included representatives from the DAFF, Gauteng. The Gauteng Department of Agriculture and Rural Development (GDARD) was also represented, as well as North West, Mpumalanga, Eastern Cape, Western Cape, Kwazulu-Natal and Limpopo, which allowed us to gain a national overview into the perspective of the department with respect to water management and challenges in the poultry industry. A total of 26 small-scale farmers from throughout the country (including layers, hatcheries, broilers and abattoirs) and four large-scale producers were also present.

The major challenges with respect to water and waste water management provided by the farming stakeholders included the following:

- **Poor borehole water quality:** Almost all rural farmers, which included layers/egg producers, hatcheries, broilers and small-scale abattoirs use boreholes as their primary water source. Most indicated problems with the quality in terms of hardness and scaling. Other specific issues raised include the presence of high concentrations of nitrates and bromide, as well as microbiological contamination.
- **Unknown borehole water quality:** Some rural farmers were concerned by the quality of their boreholes but did not have the means to get it tested, and did not know what should be tested for.
- **Access to funding for new boreholes:** The farms are dependent on their water source and it is a definite constraint to both daily operations and expansion potential. Two broiler farmers in Limpopo as well as a layer in the Eastern Cape indicated that they wanted to expand but could not afford the cost of drilling and equipping a new borehole. They said that they had been battling to get government funding for this purpose, and did not know what funding opportunities were available to them.
- **Boreholes drying up:** Numerous farmers indicated that their boreholes had recently dried up because of the drought. This was particularly prevalent for farms in the Eastern Cape and the Free State. This has resulted in reliance on surface water and rainwater in areas where neither is guaranteed. One Eastern Cape broiler farmer indicated a need for a better rainwater harvesting system.
- **Surface water quality problems:** Where farmers rely on surface water, problems mentioned included the following:
    - Microbiological contamination, necessitating a disinfection system.
    - Presence of algae, resulting in blocked watering nozzles, causing birds to take too long to drink and resulting in lower feed consumption and a slower growth rate.
    - Certain facilities, particularly on in the West Rand of Gauteng, rely on surface water that is recharged by mine discharge. Gold mine discharge is particularly concerning due to the presence of heavy metals and possibly radioactivity. Diarrhoea as a result of high magnesium and sulphate concentrations is a potential cause of low productivity observed at some of the broiler farms.
- **Lack of knowledge on how to reuse water:** Most farmers are interested in reusing their water, especially if the relative saving can allow for expansion where water resources are limited. However, there is a lack of knowledge or access to information on which treatment processes should be considered, what the constraints and limitations are to reuse, and how treated water can be safely applied in the process without risking the product quality (for example in cleaning processes or for irrigation).
- **How to educate staff on water saving behaviour:** There is still a prevalent cultural mindset that water is a freely available resource. The challenge is to educate staff members, particularly those involved in cleaning operations, regarding the importance of water saving and methods to do so, such as first sweeping floors before spraying with water.

- **Presence of chlorine in municipal water supply:** This may affect the efficacy of feed additives. Vaccinations in particular are affected, and may become inactive especially in the case of live vaccines. Some farmers using municipal water reported being unaware of this effect, and did not know how to remove chlorine from the water when additives are required.
- **Need for robust technologies for rural application:** The failure of a complicated "high tech" waste water treatment system was reported by a rural farmer, which resulted in the system being abandoned at great cost. There is a need for simple and robust waste water treatment systems to enable safe water reuse without the need for highly skilled operator involvement.
- **Water quality:** Many farmers admit that they do not understand the effects of water quality on bird health, product yield (particularly when brining) and mortality rates.

From a regulator perspective (DAFF and GDARD), the main concerns raised were:

- Need for training of rural farmers in the following water-related spheres:
    - Compliance requirements for source water quality and potential effects and impacts on bird health and product quality, and waste water compliance when discharging, or when reusing in process, or for irrigation.
    - What to test for when using borehole water.
    - How to treat source and waste water (simple rural systems through to large commercial production facilities) and what methodology should be used to select appropriate technologies.
- How to assist developing poultry farmers to gain access to funding to improve water supply infrastructure.
- Assisting farmers to achieve the South African Good Agricultural Practice (GAP) certificate.

6 BEST PRACTICE

A strategic approach towards water and waste management at poultry producers, particularly abattoirs as the largest water users and polluters, should routinely be followed. This approach should be in accordance with the DWS's water conservation, waste minimisation and progressive waste treatment philosophies (commencing with good housekeeping and low-cost technology and sequentially proceeding to sophisticated recovery and treatment technologies).

Water use licences and disposal site permits should make provision for conditions that will force producers to incrementally progress towards predetermined water quality and waste management objectives within specified time frames. General areas of waste management improvement should include:

- Minimising waste generation at source (including maximising the recovery of useful materials).
- Seriously curbing the practice of washing solids into drains (which transfers waste solids to the liquid medium).
- Promoting research into cleaner technology and recovery of higher value products from the waste stream.

6.1 Waste Management Best Practice

The management of abattoir waste is regulated through the National Environmental Management Act (NEMA), the NWA, 1998 (Act 36 of 1998), the MSA, and sections 24a and 24b of the Constitution of South Africa, 1996. Waste management should be guided by the pollution prevention philosophy based on the sequential approach of waste prevention followed by waste minimisation, reuse and recycling. Only then should waste discharge or land disposal at prescribed water quality or disposal standards (providing for exemption in well-motivated cases) follow.

As part of their service to the industry and public, abattoirs perform meat inspections to ensure that only meat products suitable for human consumption are approved and supplied to consumers. During these inspections, meat trimmings, organs and carcasses may be condemned and must be disposed of as waste material. Poultry waste includes this condemned material and other products not intended for human consumption, as well as faeces, blood, feathers and waste water (dealt with in Section 6.2). The nature and quantity of waste varies at each processing stage, as indicated in Figure 28, resulting in either solid or effluent-based waste. Solid waste includes condemned meat organs and carcasses, bone, feathers and manure, while effluent waste comprise dissolved solids, blood, sludge and wash water (Salminen & Rintala, 2002).

The condition of birds during catching, transportation as well as operational and pathological conditions can also determine the quantities of waste material produced (Wilson, 2002). According to Bilgil (2004) and Northcutt (2001), the main pathological conditions that increase waste production include abscesses, bruising, tumours and breast blisters, while operational conditions include contamination and overscalding.

In most modern plants, inedible offal in the form of feathers, feet, viscera and condemned organs are first contained in vessels such as troughs, skips or bins, which are especially designed for this purpose. Evisceration waste and wash waste are transferred in waste water streams. This waste water normally passes through screens that remove the larger solids until either treatment or final disposal takes place (Bilgil, 2004). Improperly managed waste can result in both environmental and health hazards to the community.

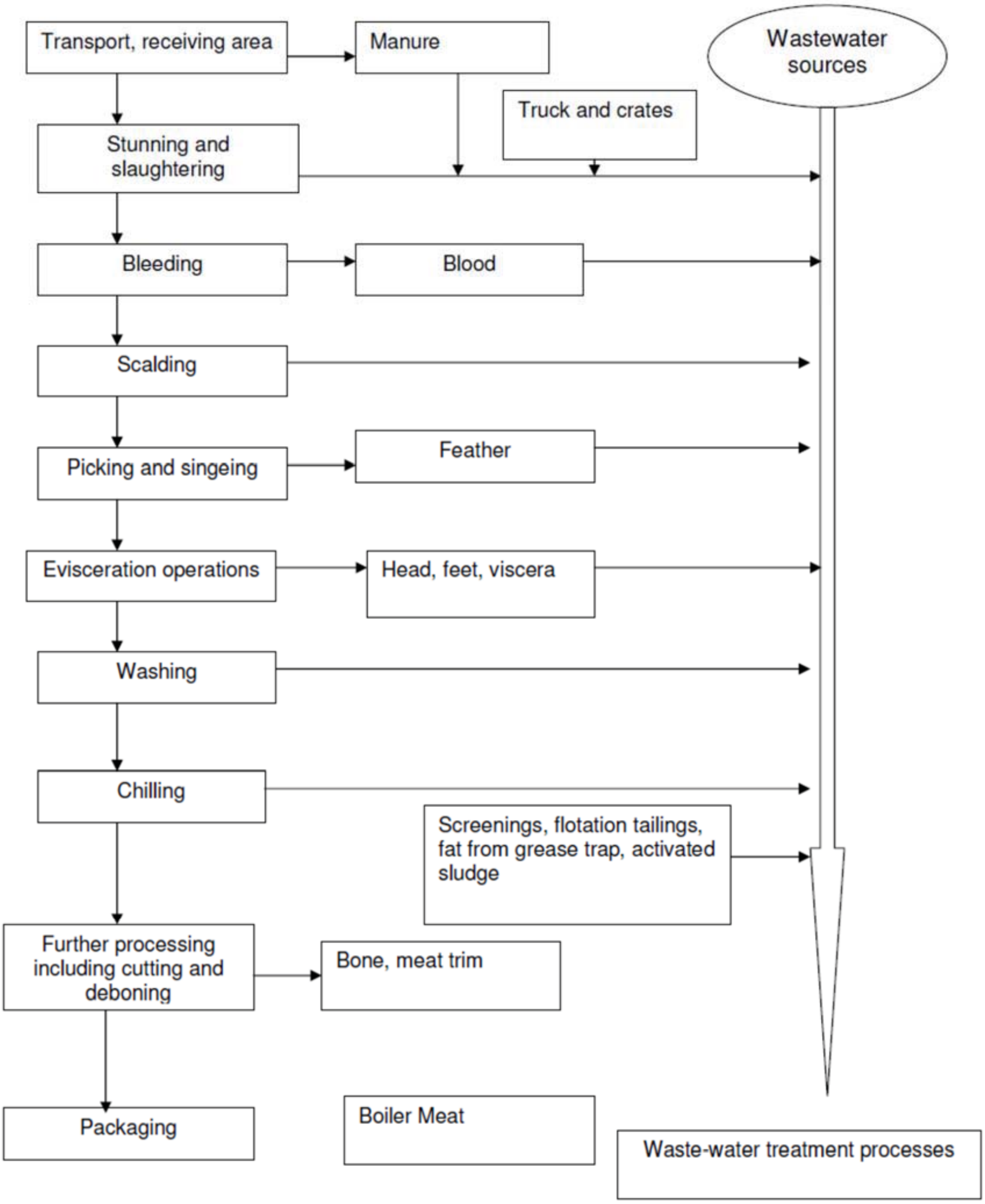


Figure 28 Waste production stages and waste material produced in poultry abattoir facilities (Salminen & Rintala, 2002)

6.1.1 Solid wastes

Sources of solid wastes generated at abattoirs include:

- Animal holding areas.
- Abattoir and processing areas.
- Waste treatment plant.
- Unwanted feathers, carcasses and carcass parts.

Manure is generated in animal holding areas. Materials not suitable for rendering, such as unwanted carcasses, come from the processing areas along with paper, cardboard and plastics. Primary and secondary effluent treatment sludges are generated in the treatment ponds.

Non-process wastes originate from kitchens and offices, dispersed or uneaten feed, and from general maintenance of gardens. Waste prevention and reduction, and separation of wastes for recycling or composting apply equally to these non-process wastes.

6.1.2 Solid waste disposal measures

The owner of an abattoir must implement a hygiene management programme for waste disposal, including condemned material, in terms of which:

- The owner of the abattoir must provide a written control programme for the removal of each different category of waste material including general refuse removal for approval by the provincial executive officer.
- Security arrangements to prevent condemned material from entering the food chain must be described. All “dead on arrival” and “dead in pen” animals must be disposed of as condemned material (Section 6.1.2.1). No carcass or part thereof that has been condemned may be brought into any part of the abattoir containing edible products.

6.1.2.1 Handling and treatment of condemned material as per the MSA

Carcasses, portions thereof or any edible products in an abattoir, which cannot be passed for human or animal consumption, must be:

- Portioned and placed in a theft-proof container that has been clearly marked “CONDEMNED”, in letters not less than 10 cm high, or conspicuously marked with a stamp bearing the word “CONDEMNED” using green ink.
- Kept in a holding area or a room or dedicated chiller provided for the purpose, except if removed on a continuous basis.
- Removed from the abattoir at the end of the working day or be secured in a dedicated chiller or freezer at an air temperature of not more than minus 2°C.

No person may remove a carcass, part thereof or any edible product, which has been detained or condemned, from an abattoir except with the permission of a registered inspector who is a veterinarian. This is subject to such conditions as he/she may impose. The abattoir owner is responsible for complying with the legal requirements or conditions relating to the safeguarding and disposal of any carcass, part thereof or any edible product that cannot be passed for human or animal consumption (GDARD, 2009).

Any condemned material must be disposed of by:

- Total incineration.
- Denaturing and burial of condemned material at a secure site, approved by the provincial executive officer and local government, by slashing and then spraying with, or immersion in, an obnoxious colorant approved for the purpose; and burial and immediate covering to a depth of at least 60 cm and not less than 100 m from the abattoir, providing such material may not deleteriously affect the hygiene of the abattoir.
- Processing at a registered sterilisation plant.

6.1.2.2 Disposal of other solid wastes

Some suggested appropriate techniques for disposing of solid waste generated by abattoirs:

Composting

Composting refers to controlled biological decomposition of organic solid waste under aerobic conditions (Salvato et al., 2003). It is normally carried out in windrows or reactors (Watts, 1994). Composting is among the methods commonly used to treat poultry abattoir waste, including screenings, floatation tailings, grease trap residues, manure, litter and feathers (Salminen and Rintala, 2002). Composting is a relatively fast biodegradation process, which typically takes four to six weeks to reach a stabilised form. It can be accelerated by providing the correct temperature, moisture content, density and feedstock mixture (Mittal, 2005).

When properly managed, composting is a bio-secure, relatively inexpensive and environmentally sound method for disposing of poultry waste by converting waste into odourless, humus-like material useful for soil enrichment (Blake, 2004). The process reduces odour and fly problems, and reduces the bulk of waste. Disadvantages associated with composting include loss of nitrogen and other nutrients, the requirement for significant land and earth-moving equipment, and reduction in land value (Kelleher et al., 2002).

The simplest method of composting involves digging a 1.2 m × 1.2 m hole of 1.5 m deep, in which waste materials are placed. This hole is then covered with a layer of earthen material. The earthen cover significantly reduces emissions and augments the degradation process. The location of composting ponds should be chosen carefully to prevent them from flooding. The composting ponds should be located at a considerable distance from existing water bays. They should preferably be sited in a downwind direction from residents. Composting could be an option at low-throughput or rural-throughput abattoirs, but not usually at high-throughput poultry abattoirs. However, waste can be efficiently and economically disposed by composting as long as offensive odours are not present.

For environmental and sanitation reasons, the composting of manure should be done in pits or bunkers instead of stacks and heaps. A pit is an ordinary hollowing of the earth, while a bunker is a chambered structure constructed with cement blocks or bricks above the ground. Both structures must be roofed or provided with sheds for security against rain. Waterlogged areas must be avoided when locating the structures. The manure in these pits and bunkers should be wetted slightly with some liquid waste water from the abattoir, then topped with leaves and covered with heavy boards or roofing sheets. Breakdown of the material proceeds slowly. After two to three weeks, the contents should be turned and mixed, repeating the process after four to five weeks. In about eight weeks or less, the composting process should be complete. Well-rotted manure should be fine textured and not contain much straw (GDARD, 2009).

Burial

There are similarities between burial and composting, but the main difference is that composted material can be used later as fertilizer while in burial no end product is produced. Burial normally takes place on farm premises where waste material fills up the burial pit. In order to control odour and flies and to discourage scavengers, a covering of at least 1.5 m of earth must be maintained. Burial pits used for disposal of poultry abattoir waste cause concerns including the decline in groundwater quality where pits are located (Blake, 2004). According to Salatin (1999), the residue does not decompose readily; soil may remain jammy and slick for over a year and can emit offensive odours. Open-bottom pits are one example of a cheap and easy burial method; though there may be problems such as slow loss of poultry residue and seepage of nitrogen, phosphorus and pathogens into groundwater (Scanes et al., 2004). In smaller abattoirs in South Africa, burial is mainly used to dispose of feathers.

Although prescribed by legislation, denaturing of the condemned material before burial is not always done. Proper denaturing of waste prior to its disposal should be exercised and monitored by abattoir management. Using this method can reduce health effects to scavengers that normally retrieve condemned materials from the burial pits or landfill sites.

Land application

Waste by-products generated at poultry meat production plants can generally be applied to the land as the final step of the producer's waste management strategy.

Under proper land application conditions, the nutrients and organisms in poultry waste pose limited environmental threat. Environmental contamination occurs when land application of poultry waste is more than the crop utilisation potential, or when it is done under poor management conditions, causing nutrient loss from environmental factors such as soil erosion or surface run-off during rainfall.

Environmental parameters of concern are nitrogen, phosphorus and certain metals (copper and zinc in particular) as well as pathogenic microorganisms that may be contained in poultry waste (Williams et al., 1999). Excessive application of poultry litter in cropping systems can result in nitrate (NO_3) contamination of groundwater. Bacteria in the soil and the human body can convert nitrate to nitrite. Until infants reach about six months of age, their digestive system secretes lower amounts of gastric acid and the pH level in their digestive system is higher than most adults. As a result denitrifying bacteria can proliferate, increasing the transformation of nitrate to nitrite. High levels of both nitrate and nitrite in drinking water can cause methemoglobinemia (blue baby syndrome), cancer and respiratory illness in humans, as well as fatal abortions in livestock (Kelleher et al., 2002).

Manure can be spread directly on land for assimilation of wastes into soil. There is a balance between effective waste disposal and creation of pollution problems using this disposal technique. Manure needs to be mixed with surface soil to prevent flies from breeding, reduce odour and avoid water pollution from surface run-off. Manure can also be stockpiled and dried before spreading on land. This technique needs to be managed to prevent fly outbreaks, odours from developing and seepage of the liquid phase into soil and groundwater.

Sludge removed from treatment ponds should be allowed to dry and spread as for manure. It is best to dry out sludge in summer to quickly develop a sealing crust and prevent odour emissions (GDARD, 2009).

Anaerobic digestion

During anaerobic digestion, organic material such as animal waste is broken down or degraded by microorganisms operating in an oxygen-free environment. The capital and other costs of anaerobic digestion are more uncertain than for other forms of waste treatment and disposal. Therefore, the application of this technology for handling abattoir wastes is still relatively scarce. Developments in this area show considerable promise as both a low-cost and low-pollution means of dealing with raw animal and other waste, with the option to produce biogas. Biogas is so-called because it is a mixture of gases produced as a result of anaerobic breakdown of organic matter by bacteria. The gases in the mixture are 60% methane, which is the main component and a source of fuel, and 36% carbon dioxide. Hydrogen, oxygen, nitrogen and hydrogen sulphide make up the remainder of the biogas mixture. Proven commercial plants must be procured if biogas production from animal wastes is contemplated. In this case, the digester gas utilisation must be based on a practical necessity such as requirement for heating water (by direct burning) to maintain sanitary services in the abattoir.

As with composting, digestion produces a nutrient-rich fertilizer that, with treated liquid waste, can be used in vegetable cultivation to yield revenue to offset costs (GDARD, 2009).

Disposal of wastes to appropriately permitted landfills

Many smaller abattoirs in South Africa do not have rendering plants and are prohibited from burying condemned material and blood. Due to the legal obligation to remove abattoir waste in a safe and sustainable manner, abattoirs attach significant importance to having an efficient and reliable collection service (wastes are collected daily and/or on a regular basis). Only small amounts of animal waste are currently disposed of to landfills because only a few sites are licensed to take it. Also, it is a legal requirement that abattoir waste must be sterilised adequately before being disposed in landfills (GDARD, 2009).

Rendering

Rendering of raw animal waste involves a series of drying and separating processes during which the material is sterilised and the fats and proteins are extracted to produce tallow, blood, and meat-and-bone meal. Rendering processes can be for either edible or inedible products. The rendering processes and raw materials vary from plant to plant depending on whether the end products are to be used for human consumption or for animal or pet food. This technique supports the beneficiation of waste into useful by-products and helps prevent air, soil and water pollution as all material is utilised.

Although limited processing of condemned material does take place in South Africa, improvement in this regard can be investigated for implementation. Based on the daily solid waste produced and disposed of without any in-house treatment, it could prove to be very useful to have a communal rendering facility where all abattoirs without rendering facilities could bring waste material to be rendered. This would reduce the disposal pollution load on municipal works from small abattoirs, especially those situated in rural areas where disposing of waste material is problematic. With a centralised communal rendering facility where geographically feasible, these problems would be largely obviated to the benefit of both the abattoir and municipality. The abattoir would benefit financially as by-products would be of considerable value, in addition to the saving on waste disposal costs.

The use of poultry waste as a dietary supplement in ruminant feed could have a considerable effect on reducing costs, insufficiency of protein in diet and in solving disposal problems. In a study conducted by Saleh et al. (2002), the chemical composition of poultry waste and its safe use in ruminant nutrition were investigated prior to its use as a dietary supplement. No appreciable differences in chemical composition were noted in poultry waste between oven- and sun-dried forms. The high protein content, energy and minerals in poultry waste indicate its importance as a partial substitute for concentrates in the diet of animals that were used as part of the mentioned study. Use of poultry waste as far as possible will minimise the requirement for disposal to the environment. Egypt implemented the use of poultry waste as a dietary supplement in 2002 (Shari, 2002) and no negative health-related concerns in this regard have been reported.

At the start of the process, the waste material has a water content of up to 70%. Water is removed from the waste material via several methods, depending on the abattoir. The water effluent produced also needs to be treated to avoid pollution. The organic nature of the material creates further problems of odour, requiring additional pollution abatement technology. New entrants to the industry face several major difficulties and cost barriers. Finding a suitable greenfield site and obtaining local authority planning permission are considerable obstacles as rendering is classified as an offensive trade subject to close environmental regulation. Pollution abatement equipment can represent a significant proportion of the capital costs of new entry. Additionally, a new entrant, or an existing renderer who wishes to expand, would need to secure supplies of waste material in a market that is inherently limited in size by the throughput of abattoirs and which the renderers themselves cannot therefore influence (GDARD, 2009).

Edible rendering processes are basically meat processing operations that produce lard or edible tallow for use in food products. It is generally carried out in a continuous process at low temperature (less than the boiling point of water). The process usually consists of chopping the edible fat materials (generally fat trimmings from meat cuts), heating them with or without added steam, and then carrying out two or more stages of centrifugal separation. The first stage separates the liquid water and fat mixture from the solids. The second stage further separates the fat from the water. The solids may be used in food products or pet foods, depending on the original materials. The separated fat may be used in food products, or if in surplus, it may be diverted to soap-making operations. In an alternative process, abattoir offal can be cooked to produce a thick lumpy stew, which is then sold to the pet food industry to be used principally as tinned cat and dog food. Such plants are notable for the offensive odour that they produce and are often located a distance away from human habitation.

Inedible rendering process are employed for materials that for aesthetic or sanitary reasons are not suitable for human food. Much of the inedible raw material is rendered using the ‘dry’ method. This may be a batch or a continuous process in which the material is heated in a steam-jacketed vessel to drive off the moisture and simultaneously release the fat from the fat cells. The material is first ground, then heated to release the fat and drive off the moisture, percolated to drain off the free fat, more fat is then pressed out of the solids, which at this stage are called ‘cracklings’ or ‘dry-rendered tankage’. The cracklings are further ground to make meat-and-bone meal. A variation of the dry process involves finely chopping the material, fluidizing it with hot fat, and then evaporating the mixture in one or more evaporator stages. Some inedible rendering is done using a wet process, which is generally a continuous process similar in some ways to that used for edible materials. The material is heated with added steam and then pressed to remove a water-fat mixture that is then separated into fat, water and fine solids by stages of centrifuging and/or evaporation. The solids from the press are dried and then ground into meat-and-bone meal (Hansen et al., 2007).

Although this is widely used, there are three major concerns related to this method of disposal, which include bio-security, proper feather breakdown and a suitable on-farm storage method to reduce transportation (Salminen & Rintala, 2002). Moreover, some environmental issues related to rendering include:

- Effluent from rendering plants contains very high loads of organic matter, it is therefore regarded as source of effluent contamination.
- The energy consumption for rendering is very high, especially for the drying step. However, modern systems can be quite energy efficient especially when multiple effect evaporators are used.
- Rendering materials are highly putrescible and, if not handled correctly, can cause extremely bad odours.
- The exhaust fumes from the rendering process are also extremely odorous. Therefore, it is often necessary to install an odour-controlling system to reduce odour emission to within required limits (Hansen et al., 2007).

Of the 15 abattoirs that responded to the survey, nine dispose their solid waste in a rendering process.

Figure 29 shows the inputs and outputs from a typical poultry rendering process. Similar processes take place in South African rendering plants. Waste products, which are later disposed, are generated during percolation, pressing and milling.

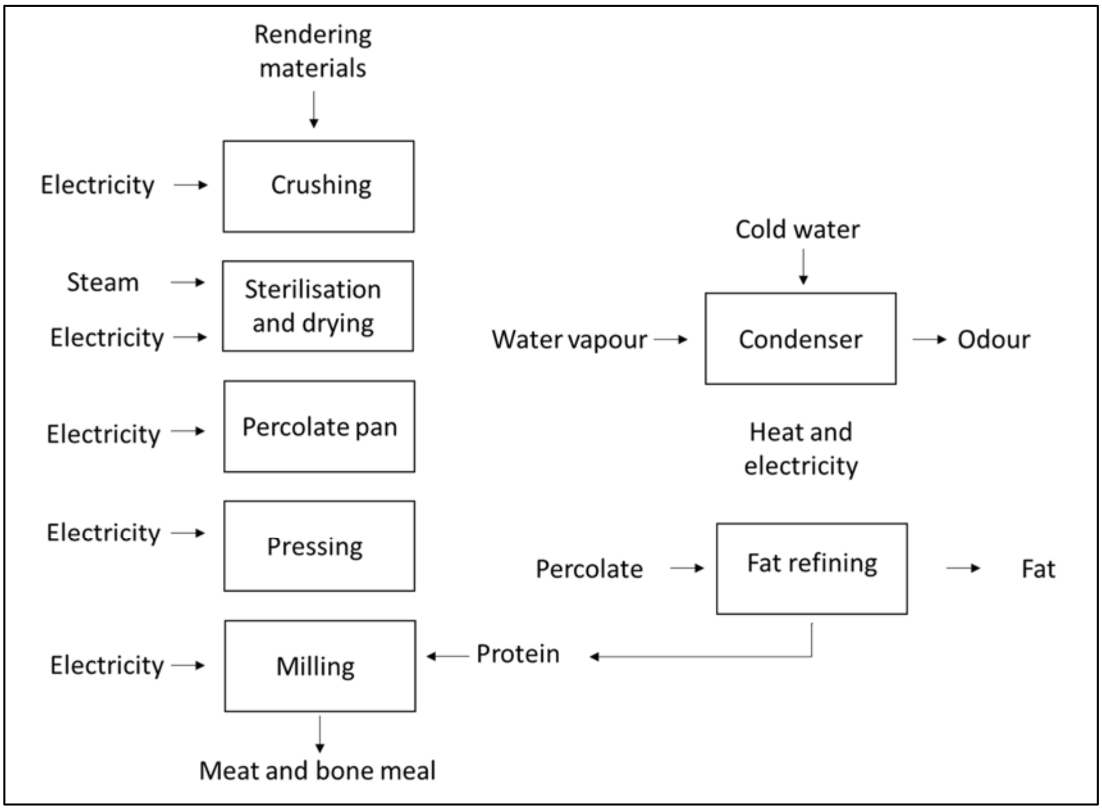


Figure 29 Inputs and outputs for the rendering process (Hansen et al., 2007)

Collection and rendering of blood

Blood is rich in nutrients, especially protein, but it is readily putrescible. If drained outside on abattoir grounds, sanitation problems arise due to its clotting property. Other nuisance factors created by clotted blood are stench, filth, attraction of rodents and breeding of flies. It is of utmost importance that when blood is collected it be handled in a hygienic manner and processed with minimum delay. Regulations prohibit the disposal of blood in drainage systems as blood overloads the purification works and unpleasant odours may emanate from septic tanks into which it is drained. Unfortunately, this remains common practice in smaller abattoirs in South Africa. Abattoirs that dispose of blood via the municipal sewers are normally charged a municipal levy. Larger abattoirs, in particular, experience problems with blood due to the quantities generated. The following different disposal methods are used:

- Municipal drainage.
- Oxidation dams.
- Burial.
- Running off or spraying onto fields and covering with a layer of soil.
- By-products.
- Septic tanks that are periodically collected by the municipality.

Small-scale processing

Where only a few animals are slaughtered per day, small-scale low-technology processing can be undertaken rather than spilling the blood to municipal sewers and creating sanitation problems. The blood is cooked in a tank to coagulate it and is drained of liquids that collect on top after cooling. The coagulum is then broken up and spread on a tarpaulin or plastic sheeting for drying. Alternatively, the coagulated mass can be placed in a simple solar dryer for drying.

Wet rendering

In plants with steam-rendering tanks, the fresh blood can be mixed with selected non-carcass components and wet-rendered. In this instance, the blood should substitute for water in the tank. An advantage here is that the protein content of the offal meal will be raised quantitatively with the addition of blood, although some amino acids may be damaged by the strong action of the heat while others may leach into the cooking water.

Commercial drying

A more productive approach is to process the blood under relatively reduced temperature conditions using a commercial blood drier. Special devices are provided within the tank to prevent blood from coating on the interior walls and reducing drying efficiency.

Blood is introduced into the tank as a coagulated mass, previously obtained by steam action. As much liquid as possible should be squeezed from the coagulum. Heating is initiated according to the MSA regulations. Drying is complete when the final moisture level in the dried product is about 12%. During drying, moisture is removed rapidly and constantly from the tank by means of condensers to which the tank is connected. Complete moisture removal is not desirable otherwise the final product would darken or char, while above the 12% level, the residual moisture can cause deterioration and loss of nutrients. The protein content of the finished product is about 80% (GDARD, 2009).

Incineration

Salminen and Rintala (2002) describe incineration as the burning of waste at high temperatures, converting it into gaseous emissions into the atmosphere and releasing residual ash. This is among the most effective methods for destroying potentially infectious agents. It functions as an alternative to landfilling, composting and anaerobic digestion. Incineration is the safest biological method of disposal, and may be considered for disease management (see Section 6.1.2.3). Waste can be disposed of as rapidly as it accumulates, and the resultant residue (ash) is easily disposed. However, it tends to be slow and expensive even when highly efficient incinerators are used.

Incineration appears to be more suitable for dealing with whole carcasses than for waste offal, which has high water content and a low calorific value. The costs of incineration are also relatively high. Incineration of materials throughout South Africa is generally being phased out and is not supported by most governmental departments (GDARD, 2009). None of the producers surveyed use incineration for solid waste disposal.

6.1.2.3 *Disease management: The need for a mass disposal area*

The mass outbreak of a disease at an abattoir is unlikely, it is more likely on a farm or at a feedlot. It there is an outbreak, a mass disposal area must be identified in the area where the outbreak occurred. Infected carcasses may not be removed from the outbreak area due to the risk of spreading the disease. However, should there be a sudden outbreak of disease at an abattoir, a bulk animal disposal area must be identified. Such an area should be away from watercourses and must not have the potential to pollute groundwater. The soil should be suitably friable for digging but also as impermeable as possible. Due to the low probability of this occurring at an abattoir, it is not necessary to permanently allocate a suitable area for bulk disposal of diseased animals at the abattoir. The veterinary service authorities will in such an instance develop a solution together with the abattoir owner on a case-by-case basis (Gilberto et al., 2003).

6.1.2.4 *Potential alternative solutions*

In poultry abattoirs, poultry wastes resulting from various operations require appropriate management daily. The disposal methods discussed above such as burial, incineration and landfill are becoming less acceptable or feasible in some areas because of excessive costs and restrictive regulations.

Although using alternative waste disposal methods is encouraged, it must be kept in mind that an abattoir owner must first obtain the written permission of the provincial executive officer to use a method other than those described in the MSA.

Several potential solution areas are found when abattoir wastes are dealt with holistically. While these cannot be ignored, they cannot be proposed as rigid recommendations, since they are all relatively innovative solutions that will require further investigation and pilot studies. It will be necessary to establish the loadings and volumes of wastes generated by the relevant abattoirs prior to any further steps being taken. Site-specific conditions prevailing at each different abattoir must not be overlooked, for example, arid versus humid conditions.

Internationally, several alternative technologies are available for sterilising infectious waste. The Sterifant system, for instance, works by sterilising waste by injecting heated water into sealed containers and maintaining a saturated steam atmosphere in the containers through microwave action. This is followed by shredding (see www.sterifant.com).

Abattoir owners are encouraged to explore these technologies to assess what works best in the South African context.

The following points should be considered as further recommendations:

- The feasibility for abattoir owners to transport their waste to a rendering facility at a larger nearby abattoir should be considered as a priority where this is financially feasible. The disadvantage of this approach is, however, that waste is transported by road. In such cases, it must be ensured that the risk of spillage of abattoir waste *en route* is minimised.
- Waste minimisation and separation of wastes at the source.
- Installation of solid and grease traps downstream of effluent sources to separate gross solids and fats from all effluents prior to discharge. Where there are mesh basket trap structures, it is recommended that that these be replaced by solid and fat traps.
- The use of microbes for the bio-remediation of all abattoir effluents and solid wastes.
- Vermiculture – the use of earthworms to decompose and filter abattoir wastes and blood.
- The use of man-made, lined, wetland (reed bed) or vlei systems to treat effluent.
- Affordable locally developed and produced physical and chemical treatment processes should be supported.

6.1.3 Airborne wastes

6.1.3.1 Odours

Potential sources of odours in abattoir operations are:

- Cooking and rendering processes.
- Waste effluent treatment plants.
- Product storage and handling areas.
- Material drying areas.
- Waste disposal techniques such as burning dead stock.
- Animal holding pens.
- Livestock transport vehicles.
- Holding of carcasses before disposal.
- Untreated effluent.

Sources of odours in the rendering plant include stale materials and fugitive emissions from cookers. Odours in animal holding pens are produced by manure.

Abattoir odours come from solid wastes such as blood residues. Anaerobic waste treatment ponds may produce gases such as methane, ammonia and hydrogen sulphide, which give rise to objectionable odours. Livestock transport vehicles entering the abattoir through residential areas may cause odour problems.

Odour emission management

Below are recommended techniques for minimising odour emissions from various abattoir activities.

Rendering plants

- The building housing the rendering works must be vented to the atmosphere via a discrete stack to allow retrofitting of odour-controlling equipment. The stack should be at least 3 m above the building roof ridge, have an efflux velocity not less than 15 m/s, and be fitted with emission sampling provisions. Retrofitting would only be permitted with existing installations.
- New or upgraded installations must have full odour controls installed.
- The most common odour abatement method in the cooking process is condensation and condensate sub-cooling, followed by incineration or afterburning of the non-condensable.
- Alternative odour abatement methods include biofilters, chemical scrubbers using hypochlorite, multistage acid and alkali scrubbing, which is followed by chlorination and incineration in boilers.
- Biofiltration is very effective for managing odour problems. All odorous gases are released under the ground to a biofilter bed. The biofilter bed is constructed of materials such as concrete, blockwork and earth. The beds are layered with products such as compost, coarse gravel, sand, pine bark and woodchips. Microorganisms in the bed break down organic and inorganic odours in aerobic microbial activity under damp conditions (humidification of odours).
- Odour-controlling equipment should be fitted with monitoring equipment with recorders to monitor key parameters.
- Good housekeeping is essential to stop odours from developing. Dropped material or spilt tallow should not be left to develop odours.
- Quick processing of materials to minimise odours generated from bacterial degradation is essential.
- Rendering material should be stored in an enclosed receptacle. Any material not removed for rendering within 24 hours of production should be refrigerated as per the MSA regulations until it is removed from the site or processed.
- Equipment and machinery are to be kept clean of raw materials and residues.
- Effective and reliable operation of burners and chemical scrubbers is essential.

- Using continuous cookers over batch cookers can reduce odours.
- Bins for holding raw material and rendering products need to be shrouded or covered. Grinding, processing and conveying equipment must be completely enclosed.
- Storage bins can be designed to prevent any liquid or solid wastes from accumulating; the wastes should be drained or pumped from a sump on a continuous basis.
- Storage bins may need to be designed so that they can be cleaned with high-pressure hot and/or cold water at least once a day.
- Implement a procedure for monitoring odour as well as investigating and resolving complaints.
- All processed meats that have become tainted or putrid must be stored in enclosed containers and refrigerated until they are removed from the premises.
- All boilers, steam-raising plant and afterburners must use clean fuels free of heavy metals and toxic wastes.
- All conveyors and pipe runs for waste animal matter transfer operations are capable of being dismantled for effective cleaning. Offal and waste animal matter must be received in a fully enclosed building.

Abattoir and processing areas

Use the following to minimise odours:

- Airtight bags and bins.
- Enclosed conveying and filling systems.
- Good housekeeping.

Animal holding areas

- Odours produced from manure and urine in animal holding areas can be greatly reduced by scraping up and removing the manures in sealed holding yards, then washing them down using low-volume high-pressure sprays.
- Manure should be collected daily and stored in vermin-proof containers.
- Lime should be added to the soil in unsealed holding areas.

Effluent treatment plants

During commissioning, odours produced by anaerobic waste treatment ponds can be reduced by:

- Allowing some grease and manure solids to pass through the primary treatment system, establishing a crust of 100 mm thick on the surface.
- Layering hay on the surface of the anaerobic pond.
- Using an artificial cover (such as plastic) that breaks down over time and mixes with the fat on the surface.
- Using detergents and chemicals during the operational phase in the abattoir suitable for the biological treatment process.
- Using an appropriate starter culture or enzyme to re-establish pond equilibrium in the event of a pond failure.
- Desludging ponds continuously by siphoning prevents disturbance of the pond crust.
- Designing, operating and maintaining effluent treatment plants adequately to minimise odour emissions.

6.1.3.2 Fuel-burning activities

Fuel burning gives rise to atmospheric emissions. Materials burned at an abattoir include:

- Coal or gas fuel for boilers and steam production.
- Diseased animals.
- Sludge.
- Packaging.

Practical control measures needed to minimise the effects of fuel-burning equipment on surrounding land users are:

- All boilers, steam-raising plant and afterburners should use clean fuels free from heavy metals and toxic wastes.
- Combustion equipment and air pollution control equipment should be designed and operated to minimise the production and emission of air pollutants.
- Stacks should be high enough to prevent ground-level concentrations of pollutants from reaching undesirable levels.
- The amount of fuel used should be minimised by heat conservation and reuse strategies to limit the greenhouse gas emissions.

6.1.3.3 Dust

Potential sources of dust emissions at an abattoir are:

- Unsealed roads.
- Paddocks, sale-yards and holding pens.
- Stockpiled products and materials.
- Construction activities.

6.1.4 Noise

Noise from the abattoir and by-products area is generated by mechanical plants (such as conveyors), ventilation, air-conditioning, stunning boxes, compressed air equipment, pumps and rendering plants. Some of this equipment may need to operate 24 hours a day. An abattoir is serviced by a variety of vehicles including trucks and forklifts.

Ventilation fans, which normally operate continuously, are the nosiest equipment from an environmental noise perspective. As these fans operate continuously, they contribute the most to the equivalent noise levels, on which environmental noise levels are based. A typical abattoir will not exceed industrial noise level limits during operating hours, except where the ventilation fans are concerned, and only marginally at night.

The South African Occupational Health and Safety Act (Act 85 of 1993) states that no employer shall allow any employee to work in an environment with an equivalent noise level equal to or exceeding 85 dB(A). The noise-induced hearing loss regulations promulgated under this Act stipulate that the employer shall reduce the equivalent noise level to below 85 dB(A) or to levels as low as practicable. Where this is not possible, boundaries and entrances to all identified noise zones must be demarcated. The employer shall prohibit any person from entering this noise zone unless wearing hearing protectors.

The Australian New South Wales industrial noise policy defines typical noise levels for abattoirs (Table 23). A (T) after a noise level indicates that it is likely to have a tonal or impulsive character. No adjustments have been made to account for noise character. These levels may serve as best practice guidelines in South Africa (GDARD, 2009).

Table 23: Typical abattoir noise levels

Equipment	Process noise level in dB(A) at 7 metres
Plant noise	55-65 (T)
Air compressors	55-69 (T)
Fan noise	46-69 (T)
Boiler blowdown	68-75 (T)
Rail transport	42-67 (T)
Trucks/forklifts	51-73 (T)
Front-end loaders	63-71 (T)
Hooters/sirens	57-70 (T)

6.2 Water Management Best Practice

Both the quality and quantity of waste water generated from poultry abattoir is important for identifying and designing technology for treatment. The oil and grease concentration of this waste water can reach a level that might adversely affect the subsequent treatment steps in units such as aeration tanks and settlers (Zhang, 2001). If untreated, the disposal of these substances can have significant environmental and public health implications. Therefore, any waste water generated is treated before any discharge or reuse. In South Africa, the degree of treatment required is determined by the specified discharge limitations as defined by the Water Services by-laws as per Municipal Systems Act (South Africa, 2000b). The by-laws differ from one province to another. A summary of the current by-laws for the eight major metropolitan municipalities is presented in Appendix 2: By-Laws for Metropolitan Municipalities.

6.2.1 Waste water treatment

Treatment ponds should service all contaminated storm water, wash water and waste water.

The method for treatment of poultry abattoir effluent consists of primary treatment, secondary treatment and advanced treatment. Primary (pre-treatment) involves removing floating materials, coarse solids and grit. Secondary treatment is usually biological treatment, generally to remove BOD/COD (organic material) and nutrients. This is followed by secondary clarification to remove biomass formed in the process prior to further treatment or disposal. Advanced (tertiary) treatment and polishing involve the physical and or chemical removal of pollutants that are not removed by conventional biological processes (Mittal, 2005). The degree of treatment required by poultry processors will determine which option can be used. The treated effluent may be partially reused for truck or floor wash in some cases, and the rest is disposed of by land application such as irrigation. In cases where land application is not possible, the partially treated effluent is discharged to the municipal sewer.

The waste water treatment methods employed by the responding producers are presented in Table 21. Their final water quality parameters, where measured, are presented in Table 20.

6.2.1.1 Pre-treatment and primary treatment

Pre-treatment and primary treatment include a broad range of waste-water processing elements, including screening catch basins, gravity separation of solids, and air floatation. Before any pre-treatment or primary treatment is considered, an adequate survey is done. Such surveys include flow measurement, composite sampling and chemical analysis to determine the extent of the problem and the possibilities for treatment (Mittal, 2005). Some of the treatment options as practised in poultry abattoirs include the following:

Screening

Screening is often the first, simplest and most inexpensive form of waste water treatment and serves a dual purpose in a poultry abattoir’s waste water stream (Liu et al, 2002). Firstly, screening recovers offal materials (feathers, viscera, meat particles) that are valuable by-products for the poultry rendering industry. Secondly, screening prepares waste water for further treatment by removing the larger solids particles from the waste stream that might otherwise affect the operation including maintenance of downstream equipment and treatment processes (Kiepper, 2001).

The size of the screens varies depending upon the size of the solids to be removed. Screen designs that can be used to remove coarse solids include among others (1) stationery/incline screens, (2) rotary cylindrical screens, (3) brushed screens, and (4) vibrating screens. Common problems associated with screening include mechanical failures and blanking due either to the overloading of the screen or under sizing of screen gaps (Mittal, 2005).

Fat traps

After removing coarse solids, the effluent stream still contains fine suspended solids, fats and grease. These have high BOD values and form a floating scum, which adheres to the sides of tanks and pipes. The scum causes blockages in pipelines that reduce the efficiency of aeration and block the small-bore irrigation outlets on filter beds. Fine solids, fats and grease have financial value. The scum can be skimmed off and used as an animal feed, or processed as raw material for soap and cosmetics manufacture (Mittal, 2005).

The method of removing fatty matter depends upon the amount produced and its quality. For small quantities of low-grade material, a simple fat trap is necessary. However, for large volumes of effluent and high-grade fatty waste a more efficient gravity separation flow through system should be used. In the fat traps, settleable solids can remain long enough to settle out to the bottom of the tank, while grease and fine solids rise to the surface. Continuous sludge removal and skimming of the surface to remove scum are essential.

Dissolved air floatation

DAF separates solids from the waste water by introducing fine gas bubbles (usually air) into the waste water stream. DAF with or without chemical flocculation can be installed to remove oil, grease, fats and other suspended matter in waste water (Kiepper, 2001; Mittal, 2005). There are several advantages of using the DAF system when pre-treating waste water. Pre-treatment includes straightforward operations with a high capacity to handle shock loads and requires relatively low capital costs, particularly when compared with biological treatment systems (Masse & Masse, 2000).

The waste water stream is pressurised and injected with compressed air to create supersaturated conditions. The supersaturated waste water is allowed to reach equilibrium with atmospheric pressure. The reduction in pressure causes the air to leave the solution as very fine bubbles that adhere to any oil, fat or suspended solids in the waste water carrying them to the surface. Using flocculants makes the process easier than using DAF on its own. The layer of solid materials can then be swept off or recovered for rendering, and the effluent can be discharged into the sewer or onto agricultural land as part of an irrigation scheme.

Settling tanks

Settling tanks are used to remove grease and finely suspended solids by means of gravity. The specially designed tanks allow water to flow slowly so that the solid particles have time to sink to the bottom of the tank while grease and fine solids rise to the surface. A skimmer is used to remove grease and scum off the top. The particles collect at the bottom to form sludge and from time to time the sludge is removed from the bottom of the tank for further treatment. The water, which is now clearer, leaves from the top of the tank. Primary settling separates most of the solid waste. Sludge from this process is called primary/raw sludge. At a later stage, secondary settling takes place after the water from the primary settling tank has been treated biologically (Mittal, 2004).

6.2.1.2 Secondary and tertiary treatment system

Various secondary and tertiary treatment steps including biological treatment systems can be implemented to improve effluent quality. Biological treatment refers to the removal of organic compounds and nutrients from effluent using microorganisms in a controlled environment. The microorganisms convert biodegradable organic particles and some inorganic materials in waste water into a more stable cellular mass and other by-products that are later removed from the remaining water. There are two approaches related to this, namely anaerobic and aerobic treatment (Nemerow & Dasgupta, 1991).

Anaerobic treatment

Anaerobic treatment is carried out in the absence of free oxygen. The system is totally enclosed to prevent the entry of air. The involvement of microorganisms enables the use of suitable organic substrates. The system operates as a two-stage fermentation process. Both stages occur simultaneously within the digester, where during the first stage bacteria breaks down complex organic substances into simpler compounds such as volatile fatty acids, carbon dioxide, water, hydrogen gas, hydrogen sulphide and ammonia. Maintaining a suitable pH value (7.0-7.2) is important. Temperature also plays an important part in the production of methane in the second stage if the goal of treatment is the production of biogas.

Up-flow anaerobic sludge blanket reactor (UASB)

In the UASB reactor, the effluent enters at the bottom of the digester, flows upward through a compact layer of bacteria (the sludge blanket), and exits at the top of the reactor. It operates in three distinct phases: the liquid phase (residual water that is being treated), solid phase (sludge) and gas phase. As the gas forms, it flows upwards, transporting particles to the top of the reactor. These return to the sludge blanket so that they remain inside the reactor (Caixeta et al., 2002). Successful operation depends on the formation of bacterial flocs or granules that accommodate and settle easily at the digester bottom. A good fat separator is usually installed to prevent excessive scum layers formation in the reactor (Mittal, 2005).

Fixed-film reactors

In fixed-film anaerobic reactors, a large amount of biomass remains attached to filter media to secure solid retention despite a short hydraulic retention times. These reactors have several advantages over aerobic and anaerobic reactors such as higher organic loadings, lower hydraulic retention times and smaller reactor volumes. Lower sludge and suspended solid quantities can also be achieved in these reactors. One drawback to fixed-film digesters is that manure solids can plug the media. A solid separator is needed to remove particles from the manure before feeding the digester. The efficiency of the system depends on the efficiency of the solid separator; therefore, influent solids concentration should be adjusted to maximise separator performance. Some potential biogas is lost due to removing manure solids (Del Pozo et al., 2000).

Beneficiation of biogas

The biogas generated in the anaerobic digestion process, which consists of a mixture of carbon dioxide and methane, can be used to generate heat and electricity in a combined heat and power (CHP) system, also known as cogeneration. Trigeneration or combined cooling, heat and power, is the process by which some of the heat produced by a cogeneration plant is used to generate chilled water for air-conditioning or refrigeration. An absorption chiller is linked to the CHP to provide this functionality. Quad generation takes this process one step further with the addition of systems to purify carbon dioxide from the engine exhaust. Combined cooling and power is where electricity and cooling are used alone.

There are several benefits to trigeneration, including:

- On-site high efficiency production of electricity and heat.
- Reduced fuel and energy costs.
- Lower electrical usage during peak summer demand.
- Engine heat can be used to produce steam of hot water for on-site use.
- Significant reductions in greenhouse gas emissions.
- No harmful chemical pollutants since water is used as the refrigerant.
- Beneficial for improving building’s energy efficiency ratings.

Aerobic treatment

Aerobic treatment involves the degradation of organic substrates by microorganisms in the presence of oxygen. These microorganisms require free dissolved oxygen to reduce the biomass in the waste water. Aerobic treatments are very effective in reducing odours and pathogens. Some of the aerobic treatment methods include aerobic lagoons, activated sludge processes (extended aeration, oxidation ditches, sequencing batch reactors) and trickling filters (Mittal, 2005).

Aerobic treatments can follow directly after primary treatment (pre-treatment) but require daily maintenance. The system also requires a large amount of space, maintenance and energy to ensure adequate oxygenation takes place. Abattoir waste water contains a high concentration of organic carbon, which requires high aeration. This may lead to high sludge disposal costs.

Aerobic systems

An aerobic system may be aerated with mechanical aerators or compressors with diffusers, or the effluent may be passed down a trickling filter to come into contact with atmospheric oxygen. Rotating biological contactors is a fixed-film aerobic process similar to the trickling filter process except that the media is supported horizontally across a tank of waste water. The microbial film absorbs and metabolises organic matter, which provides energy and nutrients for microbial growth and maintenance (Mittal, 2005). The media upon which the bacteria grow is continuously rotated so that it receives oxygen from the atmosphere.

These systems enhance the growth of microorganisms, which oxidise carbohydrates to carbon dioxide and water while the proteinaceous wastes are converted into nitrates and sulphates (Kiepper, 2001).

The incoming effluent displaces the treated material, which flows over a weir to the settling tanks. Some of the solids are returned to the oxygenation vessel to maintain the microbial culture in peak condition while the sludge is disposed after treatment if necessary (Mittal, 2005). The effluent can then be discharged into a watercourse while the sludge can be disposed in the landfill site or spread onto agricultural land.

Aerobic lagoons/maturation ponds

Aerobic lagoons or maturation ponds are large, shallow earthen basins in which algae are used in combination with other microorganisms to treat water in a more passive manner. Oxygen is supplied naturally by the wind, through photosynthesis and by mechanical means (Jarvis et al., 1999).

6.2.2 Treated waste water reuse and disposal

The disposal methods for each of the responding producers are presented in Table 21. Options for disposing of treated waste water are as follows:

6.2.2.1 Irrigation to land

Irrigation involves applying waste water to maintain or increase crop production. It ranges from low-volume irrigation, designed to meet the needs of soil and crops, to high-volume irrigation where disposal of large volumes of effluent is the main objective. The area of land required for irrigation disposal depends on the volume and constituents of effluent discharged, the landform soil type, the rainfall and the frequency of flooding in the area.

Irrigation disposal should meet the following requirements:

- Effluent must not leave the site.
- There must be no irrigation in times of high rainfall; this could lead to contaminated storm water run-off.
- A sampling point should be maintained on the pipe transporting to the effluent irrigation system.
- The effluent irrigation rate should be metered.

Monitoring programmes are needed to ensure that long-term irrigation disposal does not affect soil and groundwater quality. Irrigation sites should be chosen and/or designed so that the crop/soil system can assimilate the wastes and maintain the hydraulic balance so that surface run-off does not occur. Vegetated buffer zones help protect watercourses from potentially contaminated run-off (GDARD, 2009).

6.2.2.2 *Disposal to local sewer*

In South Africa, abattoir effluent discharge must comply with municipal water services by-laws (see Appendix 2). Each abattoir is expected to comply with the municipal by-laws within its area of jurisdiction. To meet these requirements, abattoirs generally discharge their waste water into the municipal sewer system after some degree of primary or secondary pre-treatment has taken place. Most authorities require a balanced flow and often encourage off-peak discharge.

Some advantages when using this option are that there is no need for the processor to invest in costly and complex treatment systems, or to employ more staff to manage and monitor as well as to maintain the treatment system. The sewer needs to be within reach of the processing plant and the capacity of treatment works should be large enough to receive additional flow. Disposal to municipal sewer systems is subject to payment of effluent discharge tariffs.

6.2.2.3 *Licensed disposal to a watercourse*

It would normally be difficult to treat abattoir effluent to a level suitable for discharge to a watercourse and this is thus not the preferred option.

6.2.3 Storm water run-off

Storm water can become contaminated when it comes into contact with animal holding pens, sludge stockpiles and treated waste water irrigation areas. This contaminated storm water can have detrimental environmental effects on surrounding ecosystems.

According to the Poultry Regulations, No. R153 of the MSA (Act 40 of 2000), provision must be made for storm water drainage at abattoirs. Companies were asked whether they had storm water management processes in place. In general, by-laws of metropolitan municipalities state that all industries must guard against contaminating storm water (Appendix 2).

Storm water should be controlled using the following techniques (GDARD, 2009):

- Storm water should be diverted away from intensively used holding areas, bulk chemical storage and liquid waste collection areas and treatment and disposal areas. This can be done by roofing or isolating unloading areas, stockyards and processing plants, as well as by building diversion drains and bunding.
- Contaminated storm water should be collected in lagoons, aerated and irrigated without any off-site run-off.
- Clean storm water must be kept away from contaminated areas and directed to the storm water drainage system. It may be collected for stock watering or washing down.
- All chemical storage areas and chemical-based odour-controlling equipment must be located on impermeable concrete floors with bunding capable of containing 110% of any spillage.

Producers who have storm water management measures in place are indicated in Table 24, Table 27, Table 30 and Table 33. Two of the six egg producers, all three hatcheries, two of the 14 broiler producers and six of the 15 abattoirs have implemented storm water management.

6.2.4 Water conservation

Measures for water conservation may include:

- **Dry-cleaning:** Using dry clean-up methods rather than using water is recommended to reduce the amount of water used throughout the abattoir. This can also reduce the BOD and TSS loading to the effluent water stream. Some of the most effective dry clean-up methods include scraping fat and grease off conveyor belts, installing strainers along the evisceration line and other areas to keep poultry by-products off the floor, and sweeping or shovelling materials off the floor before wet clean-up. Poultry by-products can be cleaned up or moved without using water. Keeping by-products out of the water stream can reduce BOD, TSS and phosphorus loading in the waste water. Abattoirs should consider replacing water troughs with conveyors for moving organs from the evisceration line to the next process area. Blood and other liquids can be collected from the birds using troughs and curbs to direct their flow. Solid by-products, blood and other fluids can also be collected in holding tanks using a vacuum hopper system that does not require water.
- **Pressure washing**: Using a pressurised spray for cleaning surfaces is very effective and uses less water. Dry-cleaning should always be undertaken before washing with water. An initial wash-down can be done using recycled water.
- **Water metering**: Daily water use should be metered, and annual water use recorded and monitored. Measuring waste water volumes can also help in the planning of pollution prevention measures and effluent treatment. Flow meters can quickly indicate water overuse; fluctuations may indicate leaks, wasteful water use or inefficient equipment. Installing meters in high water-use areas such as chillers, scalders, wash cabinets, evaporators and condensers can monitor fluctuations.
- **Pressure reducers**: Install pressure reducers and shut-off valves/automatic shut-off taps to reduce water consumption.
- **Train personnel**: Abattoir management should take the initiative in providing training on water conservation, water monitoring, blood collection and good cleaning practices. Training programmes on how to use the minimum required amount of water needed for the job and on cleaning practices, can save the abattoir money (World Bank Group, 1998).
- **Equipment modifications**: Drains should be fitted with screens and traps to prevent solid materials from entering the effluent, and spray nozzles should be regularly checked for blockages (Kupusovic et al., 2007). Water loss can also be reduced by repairing all leaks in the facility. Abattoir personnel should conduct weekly inspections of equipment such as valves, tanks, hoses and nozzles.

6.3 Pinch Analysis

In general, pinch analysis is a unique process design expertise dedicated to maximising process energy efficiency at minimum capital expenses (Savelski & Bagajewicz, 1999). The various methods focus on improving a single unit or partial region of the consuming system; however, pinch analysis treats the flow system as an organic whole, considers the distribution quality and quantity of water, energy or raw materials between different unit and finally reaches the optimisation of the whole system, including:

- Maximising the match between supply and demand of each individual commodity (principally energy, hydrogen or water).
- Minimising the importing of purchased utilities.
- Minimising the discharge of relevant waste.

In order to find out the minimum water requirement in the plant, the pinch analysis method is often used in two steps (Wang & Smith, 1994):

- Step 1: Determine the process minimum energy usage.
- Step 2: Find the design that meets this minimum value.

In practice, it is a complex problem involving various aspects of a project, like construction, operation and profits. An effective way to approach the complexities of energy, water and raw material systems is to divide the problem into different phases. Figure 30 shows a breakdown of tasks normally performed during a typical pinch study. The dark-blue (heavily shaded) boxes are main activities; the light-blue (lightly shaded) boxes are activities that can be used separately or in combination.

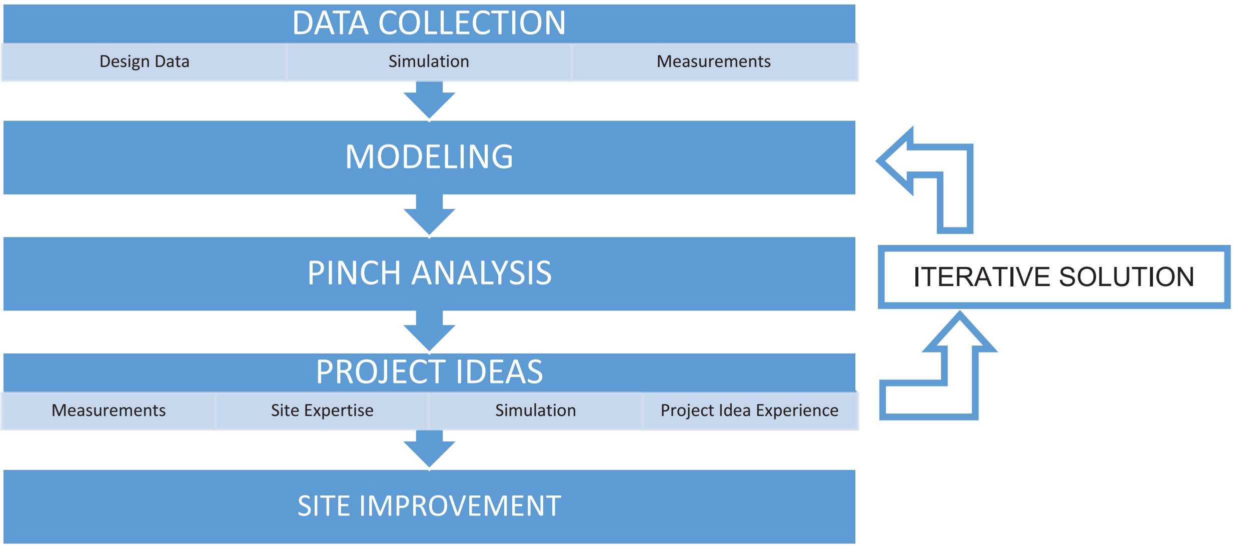


Figure 30 Structured approach to pinch analysis

In the data collection phase, all three types of data are valuable for performing a pinch analysis:

- Measurements are the most appropriate basis for evaluation, which define the process currently in operation.
- Simulation is the best data source for a study, which includes the previous category and a consistent usage and consumption balance.
- Design data may be used where measurements cannot be performed.

Project ideas need to be evaluated with one or more methods. These ideas are then adjusted through the modelling process. This may be an iterative solution, because all these processes may need to be repeated several times.

6.3.1 Energy pinch

Energy pinch analysis is a methodology for reducing energy consumption of processes by calculating thermodynamically feasible energy targets (or minimum energy consumption) and achieving them by optimising heat recovery systems, energy supply methods and process operating conditions. It is also known as process integration, heat integration or energy integration. These pinch analyses result in substantial financial savings.

The method is based on thermodynamic principles and allows the best heat exchangers, network and utility system to be determined. It analyses possible heat exchanges between cold streams (requiring heat) and hot streams (releasing heat) to minimise irreversibility. The process data is represented as a set of energy flows, or streams, as a function of heat load (or enthalpy) against temperature. This data is combined for all the streams in the plant to give composite curves: one for all hot streams (releasing heat) and one for all cold streams (requiring heat). The point of closest approach between the hot and cold composite curves is the pinch temperature (pinch point or just pinch). This is where design is most constrained. Hence, by finding this point and starting designing there, the energy targets can be achieved using heat exchangers to recover heat between hot and cold streams. During a pinch analysis, cross-pinch exchanges of heat are often found between a stream with its temperature above the pinch and one below the pinch. Removal of those exchanges by alternative matching allow the process to reach its energy target.

The main advantages of this approach include:

- It is mainly a graphical method that allows the engineer to keep a physical approach of the involved phenomenon while other optimisation techniques are purely numerical.
- The energy (or exergy) minimisation is performed without any knowledge of the heat exchanger network, which is designed afterwards.
- A very deep knowledge of the analysed process is not required to apply the method and retrieve substantial savings.
- It considers the whole process or the whole plant and provides a systematic approach instead of focusing on a specific unit or equipment.
- It is demonstrated that its use can reduce both capital and operating costs. Emissions are consequently also minimised.

Several software packages are available on the market to calculate energy targets, plot composite curves, and automatically design the heat exchanger network (Prosim, n.d.).

6.3.2 Water pinch

Water pinch analysis (WPA) originates from the concept of heat pinch analysis. WPA is a systematic technique for reducing water consumption and waste water generation by integrating water-using activities or processes (Polley & Polley, 2000). WPA was first introduced by Wang and Smith (1994). Since then, it has been widely used as a tool for water conservation in industrial process plants.

The key target of WPA is maximising water reuse and minimising the amount of waste water. Techniques for setting targets for maximum water recovery capable of handling any type of water-using operation including mass-transfer-based and non-mass-transfer based systems include the source and sink composite curves and water cascade analysis (Savelski & Bagajewicz, 1999). By specifying the maximum allowable inlet and outlet contaminant concentrations for each operation unit, a composite curve is built of all units. Then, on the basis of the composite curve, a limiting profile can be constructed. These are combined to form a limiting composite curve, against which a water supply line can be matched.

Traditional industrial practice usually sees most water demands being satisfied with fresh water that is used once and then discharged to the effluent system in a contaminated (or even sometimes uncontaminated) state. The principle of WPA is that many water demands might be satisfied by a supply of water that has a slight level of contamination present. This acceptable level of contamination is such that it will not influence the way in which the process functions or affect the product quality. The level is determined beforehand. Under these constraints, some poorer quality water (effluent) that has already been use within the system is reused completely or in combination with fresh water, and is supplied to operations that will accept it, which reduces freshwater abstraction and effluent generation (Gianadda, et al, 2002).

Of the producers surveyed, two egg producers (Table 24) and one broiler producer (Table 30) have implemented WPA. No hatcheries are planning to implement WPA. Of the responding abattoirs, three are in the planning stages of WPA and three are in process of implementing (Table 33).

6.3.3 Management strategies

Techniques and procedures to integrate all waste management options should be adopted wherever possible. A beneficial reuse strategy should be initiated after the waste management strategy. Cleaner production and waste minimisation aims directly at the source of the waste generation and attempts to eliminate waste before it is produced, or to reduce the amount generated. Wastes should be disposed of only after all preventive and minimisation measures have been taken.

All generators of waste are ultimately solely responsible for managing their own wastes. Abattoir operators should develop management strategies for proposed and existing premises. The strategies should aim to:

- Minimise the quantity of wastes generated.
- Prevent pollution arising from the disposal of wastes.
- Prevent nuisance pollution such as odours, dust and smoke.
- Minimise environmental health risks.
- Improve the efficiency of processes through energy savings.

Opportunities for recycling exist in all types of industry, in commercial and government organisations and public groups. Operators should nominate a staff member to supervise recycling schemes.

Training employees is a vital part of any environmental management practice. Abattoir staff should be aware of the environmental management programme and environmental controls at varying levels of detail, depending on their duties. All staff need to be advised that if they fail in their duties, they are just as liable to prosecution and penalty as their employer is in terms of several bodies of legislation. Training programmes should contain common elements such as familiarisation with the company environmental policy and commitment to waste prevention, recycling and raw materials conservation. Employees should be encouraged to suggest new ideas. It is the responsibility of the occupier of the premises to ensure that all operational staff are instructed in the use of equipment, processes and emergency conditions that might result in pollution.

The key production and control practices that will lead to compliance with emissions guidelines may be summarised as follows (World Bank Group, 1998):

- Design and operate the production systems to achieve target water consumption levels.
- Dry clean product areas before washing and provide grids and fat traps on collection channels.
- Eliminate wet transport of waste.
- Recover blood and other materials and process into useful by-products.
- Send organic material to the rendering plant.
- Design and operate the rendering plant to minimise odour generation.

6.3.3.1 ISO accreditation

Striving for and achieving International Organization for Standardization (ISO) accreditation demonstrates a producer's commitment to high standards of safety, quality and sustainability. The ISO standards applicable to the poultry industry include:

- ISO 22000: International Food Safety Management.
- ISO 9001: Requirement for Quality Management Systems.
- ISO 50001: Energy Management Systems.
- ISO 14001: Environmental Management Systems.

An ISO international standard represents a global consensus on the state of the art in the subject of that standard. Producers with ISO accreditation are indicated in Table 26, Table 29, Table 32 and Table 35.

ISO 22000

The International Food Safety Management Standard, ISO 22000, was developed in response to a need for a worldwide standard supported by an independent, international organisation. The standard would encourage harmonization of national and private standards for food safety management. ISO 22000 uses generally recognised methods of food safety management such as interactive communication across the food chain, system management, control of food safety hazards through prerequisite programmes and HACCP plans and continual improvement as well as periodic updating of the management system. ISO 22000:2005 integrates both the quality management system (ISO 9001:2000) and the HACCP system (Ahmed et al., 2013).

Of the responding producers, ISO 22000 was implemented at one egg producer, and seven of the 15 abattoirs. No hatcheries or broilers had implemented ISO 22000 or had plans to do so.

ISO 9001

The ISO 9000 family addresses various aspects of quality management and contains some of ISO's best-known standards. The standards provide guidance and tools for companies and organisations looking to consistently meet customer requirements with their products and services and consistently improve on quality. The ISO 9001:2015 sets out the requirements of a quality management system and is the only standard in the family that can be certified to, although this is not a requirement. Any organisation, regardless of size or field of activity can apply the ISO 9001:2015.

Using ISO 9001:2015 helps organisation to ensure that customers get consistent, good quality products and services, which in turn brings many business benefits. Several quality management principles are applied in this standard, including a strong focus on customers, motivation and implications for top management, process approach and continuous improvement (International Organisation for Standardisation, https://www.iso.org/iso-9001-quality-management.html).

Of the responding producers, ISO 9001 was implemented at one egg producer, and four of the 15 abattoirs. It was planned at two further abattoirs. There were no plans for implementation at any of the broiler producers or hatcheries.

ISO 50001

ISO 50001:2011, Energy Management Systems – Requirements with Guidance for Use, is a voluntary international standard developed by ISO. ISO 50001 provides organisations with the requirements for energy management systems. The system can provide benefits for large and small organisations in both public and private sectors and establishes a framework for industrial plants; commercial, institutional, and governmental facilities; and entire organisations to manage energy.

It is estimated that the standard could influence up to 60% of the world's energy use through its broad applicability across national economic sectors. Individual organisations have no control over energy prices, government policies or the global economy, but they can improve the way they manage energy. Improved energy performance can provide rapid benefits for an organisation, reducing both energy cost and consumption by maximising the use of its energy sources and energy-related assets. The organisation also has the opportunity to make a positive contribution towards reducing the depletion of energy resources and mitigating global warming (EnergyTeam, http://www.energyteam.it/en/service-section/energy-management-systems/iso-50001-what-is-it/).

The standard is intended to provide organisations with a recognised framework for integrating energy performance into their management practices. This will enable multinational organisations to have access to a single, consistent standard for implementation across the organisation with a consistent methodology for the identification and implementation of improvements (International Organisation for Standardisation, https://www.iso.org/news/2011/06/Ref1434.html).

The standard is intended to accomplish the following:

- Assist organisations to make better use of their existing energy consuming assets.
- Create transparency and facilitate communication regarding the management of energy resources.
- Promote energy management best practices and reinforce good energy management behaviours.
- Assist facilities to evaluate and prioritise the implementation of new energy-efficient technologies.
- Provide a framework to promote energy efficiency throughout the supply chain.
- Facilitate greenhouse gas emission reduction projects.
- Allow integration with other organisational management systems such as environmental, and health and safety.

At this stage ISO 50001 has not been implemented at any of the responding producers, although it is planned at one abattoir.

ISO 14001

The ISO 14000 family of standards provides practical tools for organisations that want to manage their environmental responsibilities. ISO 14001:2015 and its supporting standards such as ISO 14006:2011 provide the necessary systems to achieve this.

The other standards within the ISO 14001 family provide systems for audits, communications, labelling and life cycle analysis, as well as environmental challenges such as climate change (International Organisation for Standardisation, https://www.iso.org/iso-14001-environmental-management.html).

Of the responding producers, ISO 14001 was implemented at one egg producer, and two of the 15 abattoirs. It was planned at five further abattoirs. There were no plans for implementation at any of the broiler producers or hatcheries.

6.3.4 Best practice aspects surveyed

A summary of the best practice aspects surveyed for the egg producers, broiler producers and abattoirs are presented in Table 24 to Table 35.

Table 24 Best practice aspects considered for egg producers: Water and waste water management

		Storm water management	Water sub-metering	Water footprinting	Life cycle analysis	Water pinch analysis	Water management training	Solid waste segregation	Rainwater harvesting
Egg producers	1	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented
	2	Not planned	In progress	In progress	–	–	In progress	Implemented	Planned
	3	Implemented	Not planned	Not planned	Not planned	Not planned	Not planned	Implemented	Not planned
	4	Not planned	Implemented	Not planned	Not planned	Not planned	Not planned	Not planned	Not planned
	5	Not planned	Not planned	Not planned	Not planned	Not planned	Not planned	Not planned	Implemented
	6	Not planned	Not applicable	Implemented	in progress	Implemented	Not applicable	In progress	In progress

Table 25 Best practice aspects considered for egg producers: Energy use and management

		Energy sub-metering	Heat recovery	Carbon foot printing	Energy management training
Egg producers	1	Implemented	Implemented	Implemented	Implemented
	2	–	In progress	Planned	Planned
	3	Not planned	Not planned	Not planned	Not planned
	4	Not planned	Not planned	Not planned	Not planned
	5	Not planned	Not planned	Not planned	Not planned
	6	Implemented	Not applicable	Planned	Not applicable

Table 26 Best practice aspects considered for egg producers: Management systems

		Monitoring and targeting	ISO 22000	ISO 9001	ISO 14001	ISO 50001
Egg producers	1	Implemented	Implemented	Implemented	Implemented	Not planned
	2	–	–	–	–	Not planned
	3	Not planned	Not planned	Not planned	Not planned	Not planned
	4	Not planned	Not planned	Not planned	Not planned	Not planned
	5	Not planned	Not planned	Not planned	Not planned	Not planned
	6	In progress	Not applicable	Not applicable	Not applicable	Not planned

Table 27 Best practice aspects considered for hatcheries: Water and waste water management

		Storm water management	Water sub-metering	Monitoring and targeting	Water foot printing	Life cycle analysis	Water pinch analysis	Solid waste segregation	Rainwater harvesting
Hatcheries	1	Implemented	Planned	Not planned	–	–	–	–	Planned
	2	Implemented	In progress	Implemented	Not planned	Not planned	Not planned	In progress	Not planned
	3	Implemented	Implemented	Implemented	Not planned	Not planned	Not planned	In progress	Not planned

Table 28 Best practice aspects considered for hatcheries: Energy management

		Energy sub-metering	Heat recovery	Carbon foot printing	Energy management training
Hatcheries	1	Planned	Planned	–	–
	2	Implemented	Not planned	Not planned	In progress
	3	Implemented	Not planned	Not planned	In progress

Table 29 Best practice aspects considered for hatcheries: Management systems

		Water management training	ISO 22000	ISO 9001	ISO 14001	ISO 50001
Hatcheries	1	In progress	–	–	–	Not planned
	2	In progress	–	–	–	Not planned
	3	In progress	–	–	–	Not planned

Table 30 Best practice aspects considered for broiler producers: Water and waste water management

		Storm water management	Water sub-metering	Water foot printing	Life cycle analysis	Water pinch analysis	Water management training	Solid waste segregation	Rainwater harvesting
Broilers	1	Not planned	Not planned	Not planned	Not planned	Not planned	Not planned	Not planned	Not planned
	2	Not planned	–	–	–	–	–	–	Implemented
	3	Not planned	–	–	–	–	–	–	–
	4	Not planned	–	–	–	–	–	–	–
	5	Implemented	Implemented	Not planned	Not planned	Not planned	Planned	Implemented	–
	6	Implemented	–	–	–	–	–	–	–
	7	Not planned	Not planned	Not planned	Not planned	Not planned	Not planned	Not planned	Not planned
	8	Not planned	Not planned	Not planned	Not planned	Not planned	Not planned	Not planned	Not planned
	9	Not planned	–	Implemented	Implemented	–	–	–	Implemented
	10	Not planned	–	Implemented	Implemented	Implemented	–	–	Implemented
	11	Not planned	Planned	Implemented	Implemented	–	–	–	Implemented
	12	–		Implemented	Implemented	–	–	–	Implemented
	13	Not planned	–	–	–	–	–	–	–
	14	Not planned	–	–	–	–	–	–	–

Table 31 Best practice aspects considered for broiler producers: Energy use and management

		Energy sub-metering	Heat recovery	Carbon foot printing	Energy management training
Broilers	1	Not planned	Not planned	Not planned	Not planned
	2	–	–	–	–
	3	–	–	–	–
	4	–	–	–	–
	5	In progress	Not planned	Not planned	Planned
	6	–	–	–	–
	7	Not planned	Not planned	Not planned	Not planned
	8	Not planned	Not planned	Not planned	Not planned
	9	–	Implemented	–	–
	10	–	Implemented	Implemented	–
	11	Planned	Not planned	–	–
	12	–	Implemented	–	–
	13	–	–	–	–
	14	–	–	–	–

Table 32 Best practice aspects considered for broiler producers: Management systems

		Monitoring and targeting	ISO 22000	ISO 9001	ISO 14001	ISO 50001
Broilers	1	Not planned	Not planned	Not planned	Not planned	Not planned
	2	–	–	–	–	
	3	–	–	–	–	
	4	–	–	–	–	
	5	In progress	–	–	–	Not planned
	6	–	–	–	–	
	7	Not planned	Not planned	Not planned	Not planned	Not planned
	8	Not planned	Not planned	Not planned	Not planned	Not planned
	9	In progress	Not planned	Not planned	Not planned	Not planned
	10	Implemented	Not planned	Not planned	Not planned	Not planned
	11	Not planned	–	–	–	–
	12	Implemented	–	–	–	–
	13	–	–	–	–	–
	14	–	–	–	–	–

Table 33 Best practice aspects considered for abattoirs: Water and waste water management

		Storm water management	Water sub-metering	Water foot printing	Life cycle analysis	Water pinch analysis	Water management training	Solid waste segregation	Rainwater harvesting
Abattoirs	**1**	Implemented	Planned	In progress	In progress	Not planned	Implemented	Planned	Planned
	2	Implemented	Implemented	Implemented	Planned	Planned	In progress	Implemented	Not planned
	3	Implemented	In progress	Implemented	–	Planned	In progress	Implemented	Not planned
	4	Not planned	Planned	Not planned	Not planned	Not planned	Not planned	Planned	Not planned
	5	Not planned	Implemented	In progress	Planned	In progress	In progress	Planned	Implemented
	6	Not planned	Implemented	In progress	Planned	In progress	In progress	Planned	Implemented
	7	Not planned	Implemented	In progress	Planned	In progress	In progress	Planned	Implemented
	8	–	–	–	–	–	Implemented	–	–
	9	Implemented	Implemented	Implemented	In progress	Not planned	In progress	Implemented	Planned
	10	Not planned	Implemented	In progress	In progress	Planned	In progress	Implemented	Implemented
	11	Not planned	Not planned	Not planned	Not planned	Not planned	Not planned	Not planned	Not planned
	12	Implemented	Not planned	Not planned	Not planned	Not planned	Not planned	Implemented	Not planned
	13	Not planned	Not planned	Not planned	Not planned	Not planned	Not planned	Not planned	Not planned
	14	Not planned	Not planned	Not planned	Not planned	Not planned	Not planned	Not planned	Not planned
	15	Implemented	Implemented	Implemented	–	–	In progress	Implemented	Implemented

Table 34 Best practice aspects considered for abattoirs: Energy management

		Energy sub-metering	Heat recovery	Carbon foot printing	Energy management training
Abattoirs	1	Planned	In progress	In progress	Implemented
	2	Implemented	Planned	Implemented	In progress
	3	In progress	In progress	Implemented	In progress
	4	–	Planned	Not planned	Not planned
	5	Implemented	Implemented	Planned	In progress
	6	Implemented	Implemented	Planned	In progress
	7	Implemented	Implemented	Planned	In progress
	8	–	Implemented	Planned	–
	9	Implemented	Implemented	In progress	In progress
	10	Implemented	Implemented	In progress	In progress
	11	In progress	Not planned	Not planned	Not planned
	12	Not planned	Not planned	Not planned	Not planned
	13	Not planned	Not planned	Not planned	Not planned
	14	Not planned	Not planned	Not planned	Not planned
	15	Implemented	Implemented	In progress	In progress

Table 35 Best practice aspects considered for abattoirs: Management systems

		Monitoring and targeting	ISO 22000	ISO 9001	ISO 14001	ISO 50001
Abattoirs	1	Planned	Planned	Planned	Planned	In progress
	2	Implemented	Implemented	Not planned	Not planned	Planned
	3	In progress	In progress	In progress	In progress	Not planned
	4	In progress	Planned	Planned	Planned	Not planned
	5	Implemented	Implemented	Implemented	Planned	Not planned
	6	Implemented	Implemented	Implemented	Planned	Not planned
	7	Implemented	Implemented	Implemented	Planned	Not planned
	8					Not planned
	9	Implemented	Implemented	Not planned	Not planned	Not planned
	10	Implemented	Implemented	Not applicable	Implemented	Not planned
	11	Not planned	Not planned	Not planned	Not planned	Not planned
	12	Not planned	In progress	Not planned	Not planned	Not planned
	13	Not planned	Not planned	Not planned	Not planned	Not planned
	14	Not planned	Not planned	Not planned	Not planned	Not planned
	15	Implemented	Implemented	Implemented	Implemented	Not planned

7 COMPARISON OF FINDINGS WITH PREVIOUS NATSURV

The 1989 Natsurv (Steffen, Robertson and Kirsten Consulting Engineers, 1989) reported that South Africa's poultry slaughtering requirements were carried out by approximately 140 abattoirs, of which 100 could be considered commercially sized. Approximately 330 million birds were slaughtered in South Africa in 1988. By 2015, this number had increased to 1004 million (SAPA, 2015a), approximately three times more than in 1989. Only abattoirs were surveyed in the 1989 study.

Of the eight AP grade abattoirs (those slaughtering >10 000 broilers/day) assessed in 1989, the highest reported SWI (ℓ/bird) was 20, with an average of 17. For the four BP grade abattoirs (those slaughtering a maximum of 10 000 broilers/day), the highest reported SWI was 25, with an average of 20.75. On average, it was determined that large abattoirs were more water efficient, and had a narrower range or SWI than smaller ones; for A grade abattoirs, the SWI range was found to be 14-20 ℓ/bird while for other grades it was found to be 15-30 ℓ/bird.

For the AP abattoirs assessed with daily slaughter numbers of 20 370-174 900, the water intake range was 380-2800 m^3/d, and the waste water discharge range 340-2640 m^3/d (84-90%).

Of the responding abattoirs in the current survey, 12 of the 15 are classified as high-throughput abattoirs (more than 2000 units per day) according to the new grading legislation contained in the Poultry Regulations R153 of 24 February 2006. Of these, 11 would have been classified as AP grade abattoirs according to the previous grading system. Of the high-throughput abattoirs, the water intake range was 500-3800 m^3/d, with percentage waste water discharge of 70-90% on average, and SWI ranging from 9 ℓ/bird to 14 ℓ/bird.

There has therefore been significant growth in the industry since the previous survey, as well as an improvement in terms of water use.

8 CONCLUSION

Updating *Natsurv 9: Water and Wastewater Management in the Poultry Industry* has been a difficult task due to the limited participation of the producers and the resultant lack of data. Those companies that did participate provided valuable information. However, further data is required before trends and averages can be determined with any degree of accuracy. Table 36 summarises the main findings from the survey based on the responses from the participating producers.

On average, the poultry sector has grown approximately three times (in terms of meat production) since the 1989 survey. However, at the same time, the average SWI for abattoirs decreased from an average 17 ℓ/bird to 12.8 ℓ/bird. This indicates that the sector is becoming more efficient in terms of water consumption.

The contribution of egg producers, hatcheries and broiler producers in terms of water use and waste water generation is relatively small when compared with abattoirs. All egg producers who provided information on their water use were within the range of 3000-20 0000 kl/year in terms of water use, with an overall average of 6375 kl/year. The SWI for the egg producers was <5 ℓ/bird. Hatcheries were within the range of 28 200-151 585 kl/year, with an average annual consumption of 93 192 kl, and an SWI of <1 ℓ/bird. Broiler producers were within the range of 5001-40 000 kl/year, with an average annual water consumption of 11 250 kl and average SWI of 6 ℓ/bird.

The movement of producers, particularly larger abattoirs, towards best management practices indicates that the sector is committed to sustainable production.

Table 36 Summary of survey findings

		No. of producers	Range	Overall average
Egg producers	Production (eggs/year)	6	34-100 000	42 364
	Water use (kl/year)	4	0-20 000	6 375
	SWI (ℓ/bird)	4	<5 ℓ	<5 ℓ
	Waste water (kl/year)	0		
	COD (mg/ℓ)	0		
	SS (mg/ℓ)	0		
	EC (mS/m)	0		
	TDS (mg/ℓ)	0		
	TKN (mg/ℓ)	0		
	NH_4-N (mg/ℓ)	1	0-10	
	TP (mg/ℓ)	1	21-50	
	PO_4-P (mg/ℓ)	1	0-5	
	Na (mg/ℓ)	1	0-100	
	Cl (mg/ℓ)			
Hatcheries	Production (hatchlings/year)	3	187 000-274 000	237 000
	Water use (kl/year)	3	28 200-151 585	93 192
	SWI (ℓ/bird)	3	<1 ℓ	<1 ℓ
	Waste water (kl/year)	0		
	COD (mg/ℓ)	1	1000-2000	
	SS (mg/ℓ)	1	201-300	
	EC (mS/m)	1	501-600	
	TDS (mg/ℓ)	1	3 000-4000	
	TKN (mg/ℓ)	1	201-250	

		No. of producers	Range	Overall average
	NH_4-N (mg/ℓ)			
	TP (mg/ℓ)			
	PO_4-P (mg/ℓ)	1	201-250	
	Na (mg/ℓ)	1	401-500	
	Cl (mg/ℓ)	1	401-500	
Broilers	Capacity (birds housed)	14	80-276 800	95 199
	Water use (kl/year)	6	5001-40 000	11 250
	SWI (ℓ/bird)	7	<5-10	6
	Waste water (kl/year)	0		
	COD (mg/ℓ)	0		
	SS (mg/ℓ)	0		
	EC (mS/m)	0		
	TDS (mg/ℓ)	0		
	TKN (mg/ℓ)	0		
	NH_4-N (mg/ℓ)	0		
	TP (mg/ℓ)	0		
	PO_4-P (mg/ℓ)	0		
	Na (mg/ℓ)	0		
	Cl (mg/ℓ)	0		
Abattoirs	Production (birds/year)	15	78 000-105 534 000	37 368 933
	Water use (kl/year)	15	520-1 383 200	571 705
	SWI (ℓ/bird)	15	9->16	12.8
	Waste water (kl/year)	4	336 000-10 944 000	4 883 751
	COD (mg/ℓ)	9	<500-6000	1 850
	SS (mg/ℓ)	3	51-1500	860
	EC (mS/m)	8	50->2000	420
	TDS (mg/ℓ)	4	500-2000	1 300
	TKN (mg/ℓ)	1	26-50	38
	NH_4-N (mg/ℓ)	7	0-100	20
	TP (mg/ℓ)	1	5-10	7.5
	PO_4-P (mg/ℓ)	3	0-5	2.5
	Na (mg/ℓ)	1	100-150	125
	Cl (mg/ℓ)	1	101-200	150

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APPENDIX 1: RELEVANT LEGISLATION AND STANDARDS

	Regulation	Poultry Product Covered	Main Aspects
Department of Health	Foodstuffs, Cosmetic and Disinfectant Act (Act 54 of 1972)	Breeders, broilers, egg producers, abattoirs	To control the sale, manufacture and importation of foodstuffs, cosmetics and disinfectants; and to provide for incidental matters.
	Foodstuffs, Cosmetics and Disinfectants Act (Act 54 of 1972): Regulations Relating to the Labelling and Advertising of Foods: Amendment Regulation R429 of 29 May 2014	Egg producers, abattoirs	Regulations relating to the labelling and advertising of food for compliance purposes.
	Regulations Governing Microbiological Standards for Foodstuffs and Related Matters: Regulation R692 of May 1997, amended by Government Notice No. R706 of 2 September 2011	Egg producers, abattoirs	Microbiological standards for egg products and cooked poultry and methods for their determination.
	Regulations Relating to the Application of the Hazard Analysis and Critical Control Point System (HACCP system): Regulation GNR908 GG25123, 27 June 2003 and Amendment R546, 23 May 2008	Egg producers, abattoirs	Application of the HACCP system to ensure food safety.
	National Health Act (Act 62 of 2003)	Breeders, broilers, egg producers, abattoirs	To provide a framework for a structured uniform health system within the Republic, considering the obligations imposed by the Constitution and other laws on the national, provincial and local governments regarding health services; and to provide for matters connected therewith.
	Regulations Governing General Hygiene Requirements for Food Premises and the Transport of Food: Regulation R918 of 30 July 1999	Egg producers, abattoirs	Standards required for a food premises, food containers, handling of meat and requirements for the transport of foodstuffs.
	Occupational Health and Safety Act (Act 85 of 1993), as amended by Occupational Health and Safety Amendment Act (Act 181 of 1993)	Breeders, broilers, egg producers, abattoirs	To provide for the health and safety of persons at work and for the health and safety of persons regarding the use of plant and machinery; the protection of persons other than persons at work against hazards to health and safety arising out of or regarding the activities of persons at work; to establish an advisory council for occupational health and safety; and to provide for matters connected therewith.

	Regulation	Poultry Product Covered	Main Aspects
Department of Agriculture, Forestry and Fisheries	Animal Improvement Act (Act 62 of 1998)	Breeders, broilers; egg producers	To provide for the breeding, identification and utilisation of genetically superior animals to improve the production and performance of animals in the interest of the Republic; and to provide for matters connected therewith.
	Animal Diseases Act (Act 35 of 1984)	Breeders, broilers, egg producers, abattoirs	To provide for the control of animal diseases and parasites, for measures to promote animal health, and for matters connected therewith.
	Animal Protection Act (Act 71 of 1962)	Breeders, broilers, egg producers, abattoirs	To consolidate and amend the laws relating to the prevention of cruelty to animals.
	Meat Safety Act (Act 40 of 2000)	Abattoirs	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.
	Poultry Regulations: R153 of 24 February 2006	Abattoirs	Specific regulations applying to poultry abattoirs under section 22 of the Meat Safety Act (Act 40 of 2000).
	Agriculture Products Standards Act (Act 119 of 1990)	Egg producers, broilers, abattoirs	To provide for control over the sale and export of certain agricultural products, control over the sale of certain imported agricultural products; and control over other related products; and for matters connected herewith. Specific regulations for egg producers regarding the restrictions on sale, regulations around sizes, standards and grades, requirements for packaging and methods for examination.
	Regulations Regarding the Grading, Packing and Marking of Eggs Destined for Sale in the Republic of South Africa: Regulation R725 of 16 September 2011	Egg producers	Specific regulations for egg producers regarding the restrictions on sale, regulations around sizes, standards and grades, requirements for packaging and methods for examination.
	Regulations for Poultry Meat: Regulation R846 of 27 March 1992, as amended by Government Notice R988 of 25 July 1997	Broilers, abattoirs	Regulates the treatment of poultry carcasses with chemical solution, which will include brine.
	Fertilizer, Farm Feeds, Agriculture Remedies and Stock Remedies Act (Act 36 of 1947)	Breeders, broilers, egg producers	To provide for the appointment of a registrar of fertilizers, farm feeds and agricultural remedies; for the registration of fertilizers, farm feeds, agricultural remedies, stock remedies, sterilising plants and pest control operators; to regulate or prohibit the importation, sale, acquisition, disposal or use of fertilizers, farm feeds, agricultural remedies and stock remedies; to provide for the designation of technical advisers and analysts; and to provide for matters incidental thereto.

	Regulation	Poultry Product Covered	Main Aspects
Department of Agriculture, Forestry and Fisheries	Genetically Modified Organisms Act and Regulation (Act 15 of 1997)	Breeders, broilers, egg producers	To provide for measures to promote the responsible development, production, use and application of genetically modified organisms; to ensure that all activities involving the use of genetically modified organisms (including importation, production, release and distribution) shall be carried out in such a way as to limit possible harmful consequences to the environment; to give attention to the prevention of accidents and the effective management of waste; to establish common measures for the evaluation and reduction of the potential risks arising out of activities involving the use of genetically modified organisms; to lay down the necessary requirements and criteria for risk assessments; to establish a council for genetically modified organisms; to ensure that genetically modified organisms are appropriate and do not present a hazard to the environment; and to establish appropriate procedures for the notification of specific activities involving the use of genetically modified organisms; and to provide for matters connected therewith.
	Livestock Brands Act (Act 25 of 1977)	Breeders, broilers, egg producers	To regulate the registration of a brand in the name of an owner of livestock for the purpose of identifying the livestock.
	Marketing Act (Act 59 of 1968)	Breeders, broilers, egg producers, abattoirs	To provide for the introduction of a system of control over the marketing of agricultural products and regulates the quantitative control over the import or export of these products.
	Perishable Products Export Control Act (Act 9 of 1983)	Breeders, broilers, egg producers, abattoirs	To provide for the control of perishable products intended for export from the Republic of South Africa and for the continued existence of a statutory board to bring about the orderly and efficient export of perishable products from the Republic.
	Abattoir Hygiene Act (Act 121 of 1992)	Abattoirs	To provide for the maintenance of proper standards of hygiene in the slaughtering of animals and in the handling of meat and animal products.

	Regulation	Poultry Product Covered	Main Aspects
Department of Environmental Affairs	National Environmental Management Act (Act 107 of 1998)	Breeders, broilers, egg producers, abattoirs	To provide for cooperative environmental governance by establishing principles for decision-making on matters affecting the environment, institutions that will promote cooperative governance and procedures for co-ordinating environmental functions exercised by organs of state; to provide for certain aspects of the administration and enforcement of other environmental management laws; and to provide for matters connected therewith. The management of abattoir and other waste of animal origin falls under the ambit of NEMA.
	National Environmental Management: Waste Act (Act 59 of 2008)	Breeders, broilers, egg producers, abattoirs	Sets norms and standards on a national and provincial level; outlines the requirements for waste management plans; outlines waste management measures such as reduction, reuse, recycling and recovery; storage collection and transportation; treatment, processing and disposal; licensing requirements; and registration on the waste information system.
	National Environmental Management: Air Quality Act, 2004 (Act 39 of 2004)	Breeders, broilers, egg producers, abattoirs	To reform the law regulating air quality to protect the environment by providing reasonable measures for the prevention of pollution and ecological degradation; to provide for national norms and standards regulating air quality monitoring, management and control by all spheres of government. Encourages the implementation of cleaner production and clean technology.
	Environment Conservation Act (Act 73 of 1989)	Breeders, broilers, egg producers, abattoirs	To provide for the effective protection and controlled use of the environment and for matters incidental thereto.

	Regulation	Poultry Product Covered	Main Aspects
Department of Water and Sanitation	National Water Act (Act 36 of 1998)	Breeders, broilers, egg producers, abattoirs	Provides the legal framework for the effective and sustainable management of South African water resources, namely, rivers, streams, dams and groundwater. It contains rules about the way that the water resource (surface and groundwater) is protected, used, developed, conserved, managed and controlled in an integrated manner.
	• Regulation 991 18 May 1984: Requirements for the Purification of Waste Water or Effluent • Discharge limits and Conditions set out in the NWA, Government Gazette No. 20526, 8 October 1999 • National Water Act Waste Discharge Standards DWA 2010 Guidelines	Breeders, broilers, egg producers, abattoirs	Prescribes the requirements for the purification of waste water or effluent produced by or resulting from the use of water for industrial purposes and sets limits for effluent characteristics such as pH, temperature, COD, suspended solids, metals etc. and the test method to be used. Areas where the special standards must be applied are provided.
	National Water Amendment Act (Act 45 of 1999) National Water Amendment Bill (1999)	Breeders, broilers, egg producers, abattoirs	To amend the NWA, 1998 to effect textual improvements, to change the procedure for the appointment of members of the Water Tribunal and to provide for matters connected therewith.
	Water Services Act (Act 108 of 1997)	Breeders, broilers, egg producers, abattoirs	Deals mainly with water services or potable (drinkable) water and sanitation services supplied by municipalities to households and other municipal water users. It contains rules about how municipalities should provide water supply and sanitation services.
	Water Services Amendment Act (Act 30 of 2004)	Breeders, broilers, egg producers, abattoirs	To amend the Water Services Act, 1997, to enable water boards to perform activities outside the borders of South Africa; and to provide for matters connected therewith.
	Water Conservation and Demand Management National Strategy (Draft May 1999)	Breeders, broilers, egg producers, abattoirs	i. Contributes to the water conservation/demand management (WC/DM) components of the NWRS. ii. Serves as the nesting framework for the development of water WC/DM sectoral and regional strategies. iii. Describes and promotes a common understanding and interpretation of WC/DM principles for South Africa.
	Second National Water Resource Strategy (2012)	Breeders, broilers, egg producers, abattoirs	Set out strategies, objectives, plans, guidelines and procedures for the overall management of the national water resource as outlined in the NWA. The NWRS2 outlines the key challenges, constraints and opportunities in water resource management and proposes new approaches that ensure a collective and adequate response for the benefit of all people in South Africa.

	Regulation	Poultry Product Covered	Main Aspects
Department of Trade and Industry	Standards Act, 2008 (Act 29 of 2008)	Breeders, broilers, egg producers, abattoirs	To provide for the development, promotion and maintenance of standardisation and quality in connection with commodities and the rendering of related conformity assessment services; and for that purpose, to provide for the continued existence of the SABS, as the peak national institution; to provide for the establishment of the Board of the SABS; to provide for the repeal of the Standards Act, 1993; to provide for transitional provisions; and to provide for matters connected therewith.
	Water Treatment Chemicals for Food Industry (SANS 1827)	Breeders, broilers, egg producers, abattoirs	
	Cleaning Chemicals for Food Industry (SANS 1828)	Breeders, broilers, egg producers, abattoirs	
	Disinfectants and Detergent – Disinfectants for Use in The Food Industry (SANS 1853)	Breeders, broilers, egg producers, abattoirs	
	Application of Pesticides in Food-handling, Food-Processing and Catering Establishments (SANS 10133)	Breeders, broilers, egg producers, abattoirs	
	Food Hygiene Management (SANS 1049)	Breeders, broilers, egg producers, abattoirs	
	Requirement for HACCP Systems (SANS 10330)	Breeders, broilers, egg producers, abattoirs	

	Regulation	Poultry Product Covered	Main Aspects
International Organisation for Standardization	ISO 22000:2005 Food Safety Management Systems – Requirements for Any Organization in the Food Chain	Breeders, broilers, egg producers, abattoirs	ISO 22000:2005 specifies requirements for a food safety management system where an organisation in the food chain needs to demonstrate its ability to control food safety hazards to ensure that food is safe at the time of human consumption. It is applicable to all organisations, regardless of size, which are involved in any aspect of the food chain and want to implement systems that consistently provide safe products. The means of meeting any requirements of ISO 22000:2005 can be accomplished using internal and/or external resources. ISO 22000:2005 integrates both the quality management system (ISO 9001:2000) and HACCP System.
	ISO 9001 Requirements for Quality Management Systems	Breeders, broilers, egg producers, abattoirs	ISO 9001:2015 specifies requirements for a quality management system when an organisation: a) Needs to demonstrate its ability to consistently provide products and services that meet customer and applicable statutory and regulatory requirements. b) Aims to enhance customer satisfaction through the effective application of the system, including processes for improvement of the system and the assurance of conformity to customer and applicable statutory and regulatory requirements. All the requirements of ISO 9001:2015 are generic and are intended to be applicable to any organisation, regardless of its type or size, or the products and services it provides.
	ISO 14001: 2015 Environmental Management Systems – Requirements and Guidelines for Use	Breeders, broilers, egg producers, abattoirs	ISO 14001:2015 specifies the requirements for an environmental management system that an organisation can use to enhance its environmental performance. It is intended for use by an organisation seeking to manage its environmental responsibilities in a systematic manner that contributes to the environmental pillar of sustainability. The Standard helps an organisation achieve the intended outcomes of its environmental management system, which provide value for the environment, the organisation itself and interested parties.
	ISO 50001: Energy management systems – Requirements with Guidance for Use	Breeders, broilers, egg producers, abattoirs	ISO 50001:2011 is a voluntary international standard developed by ISO. ISO 50001 gives organisations the requirements for energy management systems. It provides benefits for organisations large and small, in both public private sectors, in manufacturing and services, in all regions of the world, and will establish a framework for industrial plants; commercial, institutional, and governmental facilities; and entire organisations to manage energy.

APPENDIX 2: BY-LAWS FOR METROPOLITAN MUNICIPALITIES

1 BUFFALO CITY (EAST LONDON)

According to the Buffalo City Municipality Water Services By-law (2011), a person to whom permission has been granted to discharge trade effluent must ensure that no industrial effluent is discharged into the municipal system unless it complies with the quality conditions set out in Schedule A and Schedule B of the By-laws. These state the limits for discharge to sewer or via a municipal sea outfall, as well as conditions of quantity, time, or rate of flow. The volume of effluent discharged into the municipal sewer or sea outfall should be measured by either a calibrated recording device, or as a percentage of water supplied by the municipality, making due allowances for domestic water uses and water use during manufacturing and in the final manufactured product.

Industrial effluent charges are on a volume basis, and a monthly charge per kilolitre shall be assessed by an authorised officer. The charge shall be assessed in accordance with the formula presented in Equation 1, (Buffalo City, 2011, 2012, 2013) on the basis of an arithmetic average of the results of analysis of not less than six samples of industrial effluent. This formula may be adjusted from time to time.

$$K1 + K2A + K3B + K4C + K5D \qquad 1.$$

Where:

- A = Volume in millilitres of settleable matter in one litre of trade effluent up to a volume of 10 ml.
- B = Volume in millilitres of settleable matter in one litre of trade effluent in excess of 10 ml.
- C = Permanganate value (settled trade effluent) in excess of 30 mg/ℓ up to 1000 mg/ℓ.
- D = Permanganate value (settled trade effluent) in excess of 1000 mg/ℓ.

Values for K1, K2, K3, K4 and K5 are given in Table 37.

Table 37: Tariff costs for trade effluent for the Buffalo City Municipality Including VAT (Buffalo City Metropolitan Municipality, 2011, 2012, 2013)

Year	Effluent charge (R)					Water (R/kl)
	K1	K2	K3	K4	K5	
2010/2011	394.05	9.99	9.99	7.77	7.77	9.16
2011/2012	432.66	10.97	10.97	8.54	8.54	10.41
2013/2014	481.54	12.21	12.21	9.50	9.50	11.98

In addition to these charges, any samples of trade effluent that are found not to comply with any provisions of this by-law or any of the permit conditions in terms of industrial limit values on more than one day in any month then a surcharge shall become payable.

The results for non-compliant samples shall be averaged and a surcharge payable at a rate of 100% for substances listed in item 1(a) of Schedule A, 50% surcharge for pH values, per pH unit or part thereof above or below the prescribed limit, and a *pro rata* surcharge for all other limits prescribed.

2 CITY OF CAPE TOWN

The City of Cape Town's Wastewater and Industrial Effluent By-Law (City of Cape Town, 2013) sets out the requirements and limits for industrial effluent discharge, and the Treated Effluent By-law (City of Cape Town, 2010) outlines the permitted use of treated effluent. Permission must be granted by the City to discharge industrial effluent into the sewer or any waste water system if the capacity and condition of the sewer system is sufficient and suitable for the conveyance, effective treatment and lawful disposal thereof. The City may impose conditions of discharge and limit the times during which disposal may take place.

Any person who has been granted consent to discharge, or permits the discharge of industrial effluent into a municipal sewer, must pay to the City, a charge calculated in accordance with Schedule 1 of the by-law and the Tariff By-law (City of Cape Town, 2007). Charges of volume based are presented in Table 38.

Table 38: Water and sanitation tariffs for City of Cape Town including VAT (City of Cape Town, 2013/2014-2015/2016)

Year	Industrial disposal (R/kl)	Water supply (R/kl)
2012/2013	10.01	13.02
2013/2014	10.97	14.26

Limits are set for effluent discharge with respect to general pollution loads such as COD (<5000 mg/ℓ) electrical conductivity (<500 mS/m), suspended solids (<1000 mg/ℓ), oils and greases, waxes and fats (<400 mg/ℓ), as well as for metals and inorganic content (Schedule 1 of the Wastewater and Industrial Effluent By-Law, 2013). Failure to comply with these limits results in the application of a surcharge factor.

3 EKURHULENI METROPOLITAN MUNICIPALITY (EAST RAND)

According to The Ekurhuleni Metro Municipality's Tariffs: Sewerage Disposal Services and Incidental Charges, Schedule 4 (Ekurhuleni Metro Municipality, 2015b), in addition to any other fee or charges payable in terms of this schedule of tariffs, where industrial effluent is discharged into the council's sewage disposal system, a treatment and conveyance charge shall be payable to the council, being an amount calculated on the industrial effluent discharged, the strengths and the permitted (allowed) concentrations of the industrial effluent discharged during the relevant month and in accordance with the following formula (Equation 2):

$$T_i = \frac{C}{12}\left(\frac{Q_i}{Q_t}\right)\left[a + b\left(\frac{COD_i}{COD_t}\right) + d\left(\frac{P_i}{P_t}\right) + e\left(\frac{N_i}{N_t}\right) + f\left(\frac{SS_i}{SS_t}\right)\right] \qquad 2.$$

Where:

- T_i = charges due per month for the treatment and conveyance of industrial effluent.
- C = the C value is a factor in percentage for the full cost of effluent treatment and therefore includes among other components, treatment, distribution, admin and resources charges, etc. The percentage adopted is 15% of the sanitation budget. The estimated C value for 2015/2016 is R1 140 000 000.00.
- Q_i = sewage flow (as defined in the Council's waste water by-laws) originating from the relevant premises in kilolitres per day determined for the relevant month.
- Q_t = five-year average of total sewage inflow (as defined in the Council's waste water by-laws) to the Council's sewage disposal system in kilolitre per day.
- COD_i = average COD of the sample originating from the relevant premises in milligrams per litre determined for the relevant month.
- COD_t = five-year annual average COD of the sewage in the total inflow to the Council's sewage disposal system in milligrams per litre.
- P_i = average orthophosphate concentration originating from the relevant premises in milligrams phosphorus per litre determined for the relevant month.
- P_t = five-year annual average orthophosphate concentration of the sewage in the total inflow to the Council's sewage disposal system in milligrams phosphorus per litre.
- N_i = average ammonia concentration originating from the relevant premises in milligrams nitrogen per litre determined for the relevant month.
- N_t = five-year annual average ammonia concentration of the sewage in the total inflow to the Council's sewage disposal system in milligrams nitrogen per litre.

- SS_i = average suspended solids concentration originating from the relevant premises in milligrams per litre determined for the relevant month.
- SS_t = five-year annual average suspended solids concentration of the sewage in the total inflow to the Council's sewage disposal system in milligrams per litre.
- a = portion of the fixed cost of treatment and conveyance.
- b = portion of the costs directly related to the removal of COD.
- d = portion of costs directly related to the removal of phosphates.
- e = portion of the costs directly related to the removal of ammonia.
- f = portion of the costs directly related to the removal of suspended solids.

To calculate the treatment charges according to the above formula, the system values that will apply are presented in Table 39.

Table 39 Values used for treatment charges (Ekurhuleni Metro Municipality, 2014, 2015b)

	2013/2014	2014/2015	2015/2016
Q_t	667 303	698 605	718 370
COD_t	766	757	753
P_t	4.8	4.4	3.81
N_t	23.1	23.1	22.7
SS_t	299	294	296
-a	0.29	0.29	0.29
-b	0.26	0.26	0.26
-d	0.16	0.16	0.16
-e	0.15	0.15	0.15
-f	0.14	0.14	0.14

Water supply tariffs, as specified by Schedule 3, Tariffs: Water Supply Services and Incidental Charges (Ekurhuleni Metro municipality, 2015a) are presented in Table 40.

Table 40 Water supply tariff summary Including VAT (Ekurhuleni Metro Municipality, 2015a)

Tariff summary	Tariff R/kl 2014/2015	Tariff R/kl 2015/2016
0-5000 kl/month	16.20	18.56
5001-25 000 kl/month	16.47	18.87
25 001 or more kl/month	17.19	19.69

4 ETHEKWINI MUNICIPALITY (DURBAN)

Important policy documents from the eThekwini Municipality include the Policies and Practices of the eThekwini Water and Sanitation Unit (eThekwini, 2012), which outline the policy related to provision of water and sanitation services, the Water Services Development Plan (eThekwini, 2011), the Sewage Disposal By-laws (eThekwini, 1999) and Sewage Disposal User Charges (eThekwini, 2014). A new Sewage Disposal By-law (eThekwini, 2015) has been drafted and is currently open for public comment.

According to the Sewage Disposal By-laws (eThekwini, 2015), any industry wishing to discharge to a waste water treatment works must apply for a trade effluent permit. Requirements for this permit include the undertaking of a cleaner production assessment to identify measures to reduce the consumption of water and generation of waste water at source. Trade effluent will not be accepted if it contains concentrations of substances above the standards and criteria set out in Schedule A and Schedule B (acceptance of trade effluent for discharge into the sewage disposal system or either directly or indirectly into sea outfalls). Separate limits are provided for sewerage works with a capacity greater and less than 25 Ml/d (eThekwini, 2015).

The municipality may prescribe trade effluent charges on a volume basis and amend such charges as it deems necessary. A person who holds a permit for the discharge of trade effluent in excess of the prescribed minimum volume of “T” kilolitres per month, is liable for a minimum charge per kilolitre of trade effluent, which is equivalent to the charge for the disposal of standard domestic effluent. In addition, a permit holder who discharges a trade effluent with a strength or quality greater than standard domestic effluent is liable for an additional charge in respect of high strength sewage.

The rate per kilolitre for the additional charge for the disposal of trade effluent to the sewage disposal system shall be determined in accordance with Equation 3:

$$X + V\left(\frac{C}{R}\right) + Z\left(\frac{B}{S}\right) \qquad 3.$$

Where:

a) X = prescribed rate for the conveyance and preliminary treatment of sewage.
b) V = prescribed rate for the treatment in the treatment works of the council of standard domestic effluent having a prescribed COD value.
c) R = prescribed COD value referred to in (b).
d) Z = prescribed rate for the treatment in the treatment works of the council of standard domestic effluent having a prescribed settleable solids.
e) S = prescribed settleable solids value referred to in (d) as expressed in millilitres per litre.
f) C = COD in one litre of the settled trade effluent as expressed in milligrams per litre.
g) B = volume to the nearest millilitre of settleable matter in one litre of the trade effluent, measured after settlement in the laboratory for one hour.

In addition, a permit holder who discharges a trade effluent with a strength or quality greater than standard domestic effluent (COD >360 mg/ℓ, SS >9 ml/ℓ) shall be liable for an additional charge in respect of high strength sewage calculated in accordance with Equation 4:

$$V\left(\frac{C}{R} - 1\right) + Z\left(\frac{B}{S} - 1\right) \qquad 4.$$

The volume of trade effluent discharged is determined by either a trade effluent meter, which is read every month and readings forwarded to the municipality, or through a water balance questionnaire, which is filled in by the company. The water balance questionnaire subtracts the volume of domestic effluent, water used in product, in the process and loss due to evaporation from the incoming volume to give a percentage of trade effluent produced. Limits for effluent quality are set depending on the size of the receiving waste water treatment works.

Data on basic unit cost for water and effluent and the values for *V* and *Z* are provided in Table 41.

Table 41: Basic unit costs for water and effluent: eThekwini Municipality (values include VAT) (eThekwini, 2014)

Period	Effluent			Water
	R/kl	COD charge (V)	SS charge (Z)	R/kl
2013/2014	6.07	0.65	0.59	16.63
2014/2015	6.54	0.71	0.64	18.78
2015/2016	7.06	0.76	0.69	20.84

5 CITY OF JOHANNESBURG

According to The Water Services By-law (City of Johannesburg, 2008), every person desiring to dispose of industrial effluent must apply in writing for written permission to discharge industrial effluent into the sewage disposal system of the council, and must thereafter provide such additional information and submit such sample as the council may require. A person to whom permission has been granted must ensure that no industrial effluent is discharged into the sewage disposal system of the council, unless it complies with the standards and criteria set out in section 62 and Schedule D of the by-law. An application for relaxation on these limits can be made, but this is dependent on several criteria being met including the use of best available technologies and the implementation of a waste minimisation programme. The council may install, in such position as it determines, in any drainage installation conveying industrial effluent to a sewer, any meter or gauge or other device for the purpose of ascertaining the quantity or composition of the industrial effluent.

Trade effluent tariffs are calculated based on the formula given in Equation 5, as specified in the City of Johannesburg Approved Tariffs for 2015/2016:

$$\left[C + T\frac{COD}{700}\right] + \left[T\ \frac{(Metal - factor)}{factor}\right] + C(7 - pH) + (C + T)\frac{FOG - 200}{200} \qquad 5.$$

Where:

- C = 561.36 c/Kl (excl. VAT).
- T = 612.18 c/Kl (excl. VAT).
- COD = Chemical oxygen demand.
- FOG = Fats, oils and grease.
- pH term applies if pH is less than 4.
- FOG term applies if FOG is greater than 200 mg/ℓ.

All concentrations of metals (mg/ℓ) must be greater than the factor presented below for the formula to apply:

	As	Cd	Pb	Hg	Mo	Se	Zn	Cr	Cu
Factor	2.5	2.5	10	1	5	2.5	20	20	20

For 2015/2015, the tariffs for commercial water are R26.03 per kilolitre per month up to 200 kl, and R27.23 per kilolitre per month for consumption above 200 kl.

6 MANGAUNG METROPOLITAN MUNICIPALITY (BLOEMFONTEIN)

According to the By-laws Relating to Tariffs (Mangaung Metropolitan Municipality, 2013), no person, other than a consumer on Service Level 1, shall gain access to services from the water supply system, sewage disposal system or through any other sanitation services unless he or she has applied to the municipality on the prescribed form for such services for a specific purpose and to which such application has been agreed. The municipality may, in addition to the prescribed fees for water services actually provided, levy a monthly fixed charge, annual fixed charge or once-off fixed charge in respect of the provision of water services in accordance with its Tariff Policy (Mangaung Metropolitan Municipality, 2015) or resolution passed by the council in this regard, any by-laws in respect thereof; and any regulations in terms of section 10 of the Act and regulations made thereunder.

According to the Municipality's Tariff Policy (Mangaung Metropolitan Municipality, 2015), sewerage tariffs are directly linked to market value of each property, and industrial customers will be billed on a fixed charge per month (R/month) for water consumption based on the amount of water used by way of a step tariff per kilolitre usage in the following blocks; 1 to 60 kl, 61 to 100 kl, and 101 kl and above.

The 2014/2015 rates and fees schedule (Mangaung Metropolitan Municipality, 2014) specifies the non-residential sewage charges at 0.3405 c/R on the rateable value of the property (VAT excl.), with a minimum of R107.57 (VAT excl.) per erf per month. For water consumption, the minimum charge of R413.24 per month will apply, plus cost for water consumed as follows:

- R14.52 per kilolitre per month for 0 to 60 kilolitres.
- R16.80 per kilolitre per month for 61 to 100 kilolitres.
- R18.74 per kilolitre per month for each kilolitre more than 100 kilolitres.

7 NELSON MANDELA BAY METROPOLITAN MUNICIPALITY (PORT ELIZABETH)

According to Nelson Mandela Bay Metropolitan Municipality's (NMBM) Water and Sanitation Services By-law (NMBM, 2010), the sewage discharge factor represented by the ratio of the volumes of water leaving the premises as sewage to the total volume of water from whatever source used on the premises for all purpose, will be used to determine the amount payable, together with the measured strength of the sewage. Sewage must conform to the requirements set out in sections 130-132.

If sewage to be discharged does not consist solely and consistently of domestic sewage, no person may discharge this sewage into the sewage system unless an authorised contributor has made an application to the municipality and a permit has been issued. NMBM may stipulate in the permit the standards with respect to volume, rate of flow, quality and any other aspects it may deem fit, which will apply to sewage prior to discharge, as well as pre-treatment requirements, conditions for operation of a pre-treatment facility and disposal of waste from the treatment process.

The 2015/2016 tariff for industrial water supply is specified as R10.67 /kl (excl. VAT) in the Water Service: Schedule of Charges and Tariffs 2015/16 Financial Year (NMBM, 2015b).

The charges for industrial sewage discharge where there is a metered potable water supply and the effluent complies with the requirements for discharge specified in the by-law are specified in the Sanitation Service: Schedule of Approved Charges and Tariffs: 2015/16 Financial Year (NMBM, 2015a), and are calculated as follows (Equation 6):

$$P = KVC \qquad 6.$$

Where:

- K = discharge factor (0.95).
- V = volume between readings (kl), minimum 11 kl.
- C = prescribed tariff (R14.33/kl for 2015/2016, VAT Included).

Effluent surcharge should be calculated in accordance with the following formula (Equation 7):

$$P = KVT \qquad 7.$$

Where:

- K = effluent discharge factor determined as defined above.
- V = volume (kl) of effluent discharged determined as defined above.
- T = prescribed treatment charge (Equation 8).

$$T = \left[\left\{Y\left(\frac{COD_i - COD_d}{COD_w}\right) + Z\right\} + \left\{Y\frac{A_L - B_L}{B_L}\right\}\right] \quad 8.$$

Where:

- Y = variable treatment cost per kilolitre (R1.87 for 2015/2015 VAT included).
- Z = fixed cost per kilolitre (R1.80 for 2015/2015 VAT included).
- COD_i = average COD of the industry measured between 1 April and 31 March annually.
- COD_w = average COD of the treatment works (1000 mg/ℓ).
- COD_d = average COD of domestic sewage (400 mg/ℓ).
- A_L= listed parameter exceeding stipulated limit as per the permit and by-law.
- B_L = stipulated limit as per the permit and by-law.

8 CITY OF TSHWANE (PRETORIA)

According to the Sanitation By-laws (City of Tshwane, 2003a), no person may discharge or cause or permit to be discharged into any sewer any industrial effluent or other liquid or substance other than soil water or waste water without the written permission of the municipality first being obtained, and then only in strict compliance with all of the conditions of the permission. The owner or occupier must subject the effluent, before it is discharged into the sewer, to such pre-treatment as will ensure that the effluent at no time fails to conform in all respects with the requirements of section 35(1) and Appendix A, or must modify the effluent cycle of the industrial process to an extent and in a manner which, in the opinion of the municipality, is necessary to enable the waste water treatment plant receiving the effluent. Discharge of effluent must be restricted to certain specified hours.

The owner or occupier must pay, in respect of the industrial effluent discharged from the premises, such charge as may be determined in terms of the tariff. The quantity of industrial effluent discharged into the sewage disposal system shall, where a measuring device is installed, be determined by the quantity of industrial effluent discharged from the premises as measured by means of that measuring device; or until such time as a measuring device is installed, be determined by a percentage of the water supplied by the municipality to that premises (City of Tshwane, 2003a).

There are three categories for industrial effluent charge, as described in Schedule 4, Sanitation Tariff (City of Tshwane, 2014) as follows:

1. **Normal conveyance and treatment cost**: This cost covers the normal conveyance and treatment of waste water, of quality equal to that of domestic waste water to a waste water treatment plant, set at R5.64/kl (excl. VAT) for 2014/2015. This cost is calculated by multiplying the combined unit conveyance and treatment cost by the volume discharged. Industrial consumers will be charged the tariff cost with a rebate of 10%.
2. **Extraordinary treatment cost:** Applies when the pollution loading exceeds that of normal waste water. The cost is calculated as given in Equation 9:

$$Tc = Qc.t[0.6\ \frac{(CODc - CODd)}{CODd} + 0.25\ \frac{(Pc - Pd)}{Pd} + 0.15\ \frac{(Nc - Nd)}{Nd}] \quad 9.$$

Where:

- T_c = extraordinary cost to the consumer.
- Q_c = waste water volume (kl).
- t = unit treatment cost of waste water (R/kl).
- COD_c = total COD in mg/ℓ of waste water including biodegradable and non-biodegradable.
- COD_d = total COD of domestic waste water in mg/ℓ.
- P_c = orthophosphate concentration of waste water in mg phosphate/ℓ.
- P_d = orthophosphate concentration of domestic waste water in mg phosphate/ℓ.

- N_c = ammonia concentration of waste water in mg nitrogen/ℓ.
- N_d = ammonia concentration of domestic waste water in mg nitrogen/ℓ.

2014 tariffs:

- t = R0.94/Kl.
- COD_d = 710 mg/ℓ.
- Pd = 10 mg/ℓ.
- N_d = 25 mg/ℓ.

3. **Non-compliance with by-law limits**: Where the pollution loading (quality) of waste water discharged to the sewer exceeds the limits of allowable load as specified in the by-laws, the following will apply (Equation 10)

$$T_c = \frac{Q}{D.N\left(C_{AIP} - \frac{B_{LL}}{W_{PL}}\right)t_{NC}} \qquad 10.$$

Where:

- T_c = charge for non-compliance.
- Q = monthly volume in kl.
- D = working days in the month.
- N = number of days exceeding by-law.
- C_{AIP} = average concentration of parameter exceeding by-law.
- B_{LL} = by-law limit.
- W_{PL} = Water Affairs standard limitation on parameter exceeding by-law.
- t_{NC} = tariff (R0.65 /kl for 2014/2015).

Schedule 3: Supply of Water Tariff (City of Tshwane, 2014) specifies the cost for industrial water as presented in Table 42. The effluent tariff is also presented.

Table 42: Basic unit costs for water and effluent in Tshwane

	2012-2013	**2013-2014**	**2014-2015**	**2012-2013**	**2013-2014**	**2014-2015**
0-10 000 kl	11.89	13.08	14.39			
10 001-100 000 kl	11.29	12.42	13.66			
More than 100 000 kl	10.52	11.57	12.73			
Charged at 60% of incoming water				4.66	5.13	5.64

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