



WASTE MANAGEMENT IN HONG KONG ABATTOIRS

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ABSTRACT

This paper reports the results of an extensive investigation on the waste management in Hong Kong abattoirs with the following objectives: (i) to identify the existing waste management practices in relation to sources and quantity of wastes generated, methods of storage and handling of wastes, any in-house treatment, and final disposal of wastes, (ii) to identify the problems of existing waste management practices, and (iii) to evaluate the future development. To obtain up-to-date data and reliable information, site visits were conducted and the management of the abattoirs were interviewed in detail about the operation and waste management practices. For each abattoir and one associated by-product plant, detailed material balances were established for liquid and solid wastes. Complete quantitative results on waste loads, water consumption and material/waste flows are presented. Operational problems regarding wastewater treatment, as well as waste reduction and potential for reuse or recycle of solid wastes are discussed in the context of Hong Kong. Finally, information on the proposed new slaughterhouse (design capacity 5000 pigs and 400 cattle daily) is provided which will include a novel underground wastewater treatment plant. © 1999 IAWQ
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KEYWORDS

Abattoirs; abattoir waste; by-products plant; slaughterhouses; waste management.

INTRODUCTION

Hong Kong is a highly developed metropolitan region where technical and economic development have made it possible to support 6.2 million people (in mid-year 1995) on approximately 110 km² of built-up land, resulting in one of the highest population densities of the world. The prosperity of Hong Kong is reflected in the high meat consumption which amounts to approximately 92 kg per capita and year (16 kg beef, 44 kg pork, 2 kg lamb/mutton/goat, 30 kg poultry); additionally, about 58 kg of seafood are consumed annually per capita (*Consumer Asia*, 1997). There are five abattoirs in Hong Kong where the mostly imported food animals (pigs, cattle and goats) are slaughtered for the production of fresh meat. No poultry slaughter houses are operated since traditionally only live chickens are sold in the public retail markets. Abattoirs in Hong Kong are either government owned or licensed private abattoirs which conduct slaughtering only. All of them act as service agencies and do not at any stage own any of the animals slaughtered. The owners of the animals use other operators to provide services of live animal transport as well as marketing, storing and transport of meat.

Abattoir wastes consist of manure, condemned meat and carcasses, blood, stomach and intestine contents, hairs or bristles of animals, and inedible animal material and are classified as special wastes (EPD, 1997). They are essentially organic and biodegradable materials which exhibit a tendency to rapid acidification and

fermentation (Degremont, 1991). Improper disposal of such wastes, especially inedible and condemned animal material, will create serious problems of public health and environmental nuisance. Thus, special handling, treatment and disposal arrangements have to be made. Since the abattoirs in Hong Kong were mostly built before the enactment and implementation of stringent pollution control legislation (Waste Disposal Ordinance and Water Pollution Control Ordinance of 1980), the facilities and operation of abattoirs need to be modified in order to comply with the legal requirements; however, no detailed study on waste management practices in Hong Kong abattoirs has ever been conducted. While waste management in abattoirs of developed countries is well documented (Hrudey, 1984; Jaepelt and Neumann, 1986), especially with regard to effluents, waste management practices in Hong Kong abattoirs may not be the same because of differences in abattoir operation, climate, traditional diets and customs. As abattoirs are also important sources of organic pollution in the coastal urban areas of Hong Kong, it was therefore considered of interest to conduct an extensive investigation on the waste management practices in Hong Kong abattoirs.

The purpose of this study was thus (i) to identify the existing waste management practices in relation to sources and quantity of wastes generated, methods of storage and handling of wastes, any in-house treatment, and final disposal of wastes, (ii) to identify the problems of existing waste management practices, and (iii) to evaluate the future development.

METHODS

To obtain up-to-date data and reliable information, site visits were conducted and the management of the abattoirs were interviewed in detail about the actual operation and waste management practices; no monitoring programmes or surveys on wastewater or solid wastes in abattoirs were carried out. For each abattoir and an associated by-product plant, waste loads, water consumption and material/waste flows were quantified and detailed material balances were then established. Available data from literature and unpublished reports of various government departments of Hong Kong were used in order to compare existing practices with the international state-of-the-art. Information on a proposed new slaughterhouse was obtained by interviewing staff of a project contractor.

RESULTS AND DISCUSSION

Abattoirs in Hong Kong

Of the five abattoirs in Hong Kong, Kennedy Town Abattoir and Cheung Sha Wan Abattoir are located in the densely populated urban areas of Hong Kong Island and Kowloon, while Tsuen Wan Slaughterhouse, Yuen Long Slaughterhouse and Cheung Chau Slaughterhouse are located in the New Territories. They were commissioned in 1968, 1969, 1983, 1984 and 1991, respectively. The smallest abattoir is Cheung Chau Slaughterhouse, which serves the public in Cheung Chau Island and other out-lying islands nearby and is the only abattoir planned and built after the enactment and implementation of pollution control legislation. All other abattoirs are centralised plants to supply fresh meat to their respective districts. By fresh meat is meant meat which reaches the customer before rigor mortis has begun to wear off; which at no time is subject to chilling or other preservative processes; and which is sold and eaten sufficiently quickly so that the meat has not got time to deteriorate or to become infected with disease organisms. Demand for fresh meat is high; in 1995, 7,540 head of pigs and 360 head of cattle were consumed each day in Hong Kong (*Hong Kong 1996*). This demand for fresh meat imposes severe constraints on the amount of time that can be allowed for transport of meat from the abattoir to the retailer. Therefore, Hong Kong abattoirs can not be closed down or moved to mainland China for economic reasons, as the livestock industry has done. At present, only about 7% of the pigs slaughtered in abattoirs are locally produced, all other food animals are imported live from mainland China. Kennedy Town Abattoir also includes a by-product plant for treatment of animal materials unfit for human consumption as well as an animal crematorium for disposal of pets, collected dead animals and seized meat. Cheung Sha Wan Slaughterhouse and the by-product plant including its crematorium are run by the Urban Council. All other abattoirs are privately managed and operated under licences issued by the Urban Council or Regional Council, respectively. The number of animals slaughtered in Hong Kong

abattoirs and other important operational data are summarised in Table 1. The discrepancy in the total number of animals slaughtered is caused by different beginning dates of the accounting year.

Table 1. Number of animals slaughtered in Hong Kong abattoirs in the year 1995/96

Abattoir	Area occupied (ha)	Method of slaughtering	Pig	Cattle (heads)	Goat	Source
Kennedy Town	1.25	mechanical	758,126	26,296	3,484	this study
Cheung Sha Wan	1.80	mechanical	553,549	42,944	-	"
Tsuen Wan	1.09	mechanical	825,623	-	5,602	"
Yuen Long	0.44	manual	457,781	30,184	-	"
Cheung Chau	0.16	manual	18,250	-	-	"
Total	4.74		2,613,329	99,424	9,086	"
			3,029,518	109,064	8,827	(Hong Kong, 1996)

Sources and characteristics of abattoir wastes

The amount and composition of wastes depend on the type of animal slaughtered, slaughtering methods, type of equipment used, product and by-product utilisation as well as local practices and customs. The main wastes in simple abattoirs for slaughtering only originate from lairage, killing, hide removal or dehairing, offal handling and clean-up operations. Part of the waste enters the effluent stream; its raw waste load depends on in-plant control of water use, by-products recovery, waste separation at the source and plant management. Management practices are of paramount importance in minimisation of waste generation, since the proportion of products, by-products and wastes per animal are more or less fixed (Boehm, 1990). Of special significance for the control of effluent raw waste load are the methods for evacuation of manure, offal collection and blood recovery. Estimates of specific raw waste loads of COD, BOD₅, suspended solids and total nitrogen in kg per tonne live weight killed (LWK) or per tonne of carcass have been widely reported (Degremont, 1981; Hrudehy, 1984; Jaepelt and Neumann, 1986). The sources of waste generation in Hong Kong abattoirs are summarised in Figure 1.

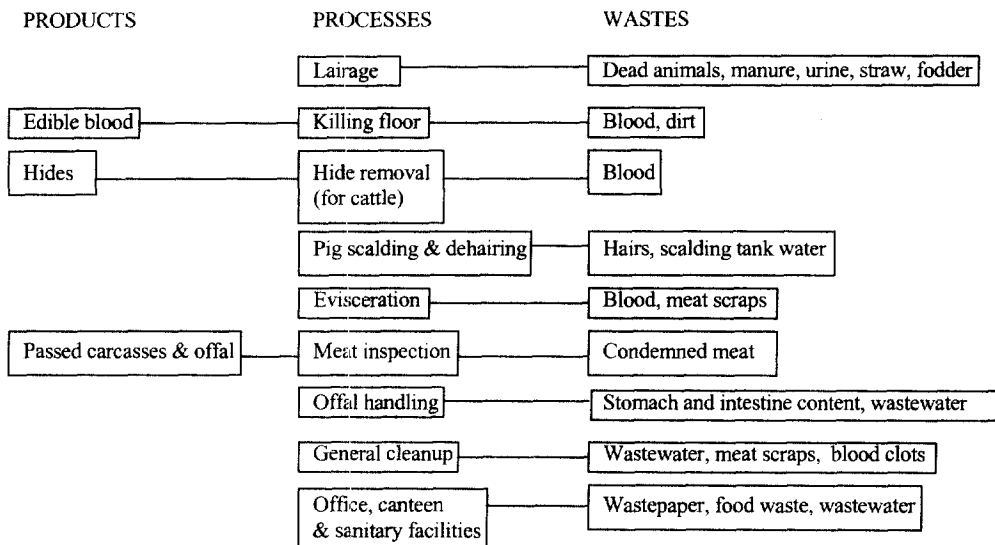


Figure 1. Flow diagram showing the sources of wastes in abattoirs.

Existing waste management practices in abattoirs**1. Solid waste**

The material input, output and waste generation in Hong Kong abattoirs in the year 1995/96 is summarised in Table 2. A comparison of the mass of the live weight killed (LWK) and all other edible products, by-products and wastes shows a difference of 46,139 tonnes or 15.7% of LWK which could not be accounted for in detail. These materials are generally transferred to the effluent or atmosphere. For example, materials are lost or are transferred during the following processes:

1. manure and other lairage wastes are settled in manure dumps and the settled solids are collected by special cleaning vehicles;
2. some blood and stomach contents are discharged directly to the sewer;
3. water in blood is evaporated during coagulation of blood and manufacturing of by-products;
4. some animal material is discharged with the effluent.

Table 2. Material input and output in Hong Kong abattoirs in the year 1995/96, in tonnes

Abattoirs/ Slaughter- houses	live weight killed (LWK)	edible blood	meat & edible products	hides	coagulated blood	dead animals & condemned meat	solid wastes	water consumption
Cheung Sha Wan	71,912	150	54,245	1,353	1,477	538	2,555	1,280,000
Kennedy Town	83,925	355	65,417	828	1,567	432	2,920	620,000
Tsuen Wan	78,546	-	62,818	-	1,450	215	2,190	330,000
Yuen Long	57,072	648	43,348	950	-	81	2,100	438,000
Cheung Chau	1,734	10	1,387	-	-	3	4	4,300
By-product Plant	-	-	-	-	-	-	10	65,000
Total	293,189	1,163	227,215	3,131	4,494	1,268	9,779	2,730,000

For specific solid wastes, abattoirs in Hong Kong are adopting different management strategies which are briefly described in the following.

Coagulated blood. Some blood is collected during bleeding for edible purposes. However, most discarded blood is collected in bleeding troughs and further dehydrated as coagulated blood before final disposal in landfills. 3,044 tonnes of coagulated blood generated from Cheung Sha Wan and Kennedy abattoirs is processed in the by-product plant for manufacture of dried blood meal which is sold as animal feed. Coagulated blood from Tsuen Wan Slaughterhouse is landfilled. In Yuen Long and Cheung Chau slaughterhouses, discarded blood is drained away through the surface drains in the slaughterhalls and discharged through the wastewater stream.

Dead animals and condemned meat. Dead animals and condemned meat are temporarily stored in condemned meat rooms before sanitary disposal. While Yuen Long and Cheung Chau slaughterhouses cremated the dead animals and condemned meat in cremators inside the slaughterhouses, the dead animals and condemned meat of the other abattoirs were processed in the By-product plant for manufacture of meat, bone meal and animal grease.

Solid wastes. Solid wastes other than coagulated blood, dead animals and condemned meat are stored in bulk containers in the abattoirs and daily disposed in landfills.

Lairage wastes. Lairages are hosed down and solids are collected by drain traps along the surface drains. Screenings are collected manually. In Cheung Sha Wan and Kennedy abattoirs, manure sumps are installed for settling of suspended solids in wastewater from lairage. Residues from the sumps are cleared once a month by special cleansing vehicles and disposed of in landfills.

Stomach and intestine content. Stomach and intestine contents are washed out. The slurry passes through screens before discharge into surface drains in the offal handling rooms. Screenings are collected and stored with other solid wastes pending delivery to landfill.

Pig hairs. Pig hairs are collected manually from slaughterhalls and collected and stored with other solid wastes pending delivery to landfill.

Solids in wastewater and effluent treatment plants. Solids in wastewater are screened by drain traps. Screenings are collected manually and stored in bulk containers. Flotate and sludge from effluent treatment plants in Kennedy Town Abattoir and Yuen Long and Tsuen Wan Slaughterhouses are stored in bulk containers and delivered to landfill for disposal. Flotate in Yuen Long Slaughterhouse is further dewatered by press filter before disposal.

2. Effluent waste

There are generally three drainage networks in each abattoir for the collection of:

1. wastewater from the lairage, slaughterhalls, offal rooms and blood handling rooms;
2. wastewater from the sanitary facilities, canteen and cooling system (discharged directly to public sewer); and,
3. runoff from the roof and open space (discharged directly to storm water drain).

In Kennedy Town and Cheung Sha Wan Abattoirs, a separate drainage system with manure dumps is installed to collect wastewater from the holding lairages.

Wastewater treatment plants are installed in Kennedy Town Abattoir, Yuen Long and Tsuen Wan Slaughterhouses for treatment of wastewater from slaughterhalls, offal handling and blood handling rooms. In the Kennedy Town Abattoir and Yuen Long Slaughterhouse, wastewater passes through a grease trap, fine screens, an equalisation tank and dissolved air flotation (DAF) units, while in the Tsuen Wan Slaughterhouse equalisation is followed by complete biological treatment with nitrogen removal in an underground treatment plant. No wastewater treatment facility, except settling/screening by traps, is provided in Cheung Sha Wan Abattoir. The Cheung Chau Slaughterhouse discharges effluent directly to the adjacent public sewage treatment plant.

Based on available results of final effluent concentrations and estimated effluent discharge (approximately 90% of water consumption according to Enviro-Chem, 1995), the effluent waste load was determined for all abattoirs with the exception of Cheung Chau Slaughterhouse. In addition, the specific waste loads per tonne of carcass were determined. The results are summarised in Table 3.

Table 3. Effluent waste load from Hong Kong abattoirs in the year 1995/96

Abattoir	Water consumption (m ³ /t carcass)	Suspended solids		BOD ₅		COD	
		tonnes	kg/t carcass	tonnes	kg/t carcass	tonnes	kg/t carcass
Kennedy Town	11.1	n.a.	n.a.	201	3.1	553	8.5
Cheung Sha Wan	27.7	5,381	99	3,104	57	9,106	168
Tsuen Wan	6.0	76	1.2	264	4.2	381	6.1
Yuen Long	11.8	603	14	710	16	1,526	35
Cheung Chau	3.6	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Total	12.0	>6,060		4,279		11,566	

The specific water consumption in different abattoirs shows large variations due to different physical installations as well as varied attention given by management. The total and specific effluent waste loads also exhibit a large variation and clearly reflect the level of wastewater treatment in the different abattoirs. For comparison, modern, well-managed slaughterhouses report a specific water consumption of less than 5 m³/t carcass and specific raw effluent waste loads of 10, 13, and 30 kg/t carcass of suspended solids, BOD₅, and COD, respectively (Degremont, 1991). It is of interest to note that Cheung Sha Wan Abattoir, which has

the highest specific water consumption and effluent waste load, is the only publicly operated abattoir in Hong Kong.

Using a population-equivalent (PE) of 55g BOD₅ per capita, the effluent waste load amounts to approximately 210,000 PEs which corresponds to 3.3% of the population of Hong Kong. In the absence of a significant agro-industry, abattoirs constitute thus the most important industrial organic waste dischargers to the sewers and surface waters of Hong Kong.

Using a conversion factor of 1.5 g COD per g waste material, the effluent waste load amounts to approximately 7,710 tonnes per year. This corresponds to only 16.7% of the unaccounted 46,139 tonnes in the overall material flow. Hence there remain significant gaps in the material balance which would require more detailed investigation.

Existing waste management practices in by-product plant

Operation and products. The by-product plant is an integrated part of the Kennedy Town Abattoir and was commissioned in 1968. Its major function is to process animal materials and condemned meat from abattoirs to useful products; the other function is to sanitarily dispose, by cremation, of those animals which died of dangerous diseases. In addition, dead pets and animals collected in the urban area are cremated.

In the by-product manufacturing line, the following products are produced:

1. dried blood meal: all coagulated blood from Kennedy Town Abattoir and Cheung Sha Wan Slaughterhouse is dried in steam-heated blood driers, then converted to powder by grinding and sifted before it is packed up in 25 kg paper bags.
2. meat and bone meal: dead animals are cleansed, dehaired or dehided, split up if required and are charged into pre-breakers together with the condemned meat and viscera. The broken up material is then heat-treated and dried under pressure for three hours. After separation of grease by centrifuge, the dried residues are desintegrated, cooled, ground to powder and packed into 25 kg gunny bags. All dead animals and condemned meat from Kennedy Town, Cheung Sha Wan and Tsuen Wan Abattoirs, in addition to 12 tonnes from Ma Tau Kok Quarantine Depot, were thus processed.
3. animal grease: the extracted grease is added to a settling drum, where it is heated for four hours, then pumped to a separation tank for separation of the animal grease. The animal grease is filled into 200 l drums and sold as animal feed.
4. raw hides and buffalo horns: hides of dead cattle and horses are removed and sold at 80% of the market value of raw hides derived from healthy animals. Sterilised horns salvaged from dead buffaloes are sold to contractors.

In general, about 25% of the input materials can be recovered as products, the remainder being mostly evaporated. Regarding cremation, a small cremator is used for small animals (dogs, cats) and a larger one is capable of handling loads up to 500 kg which is about the weight of a beef carcass.

Waste management. Two types of solid wastes are generated: ashes in the cremators and pig hairs collected from dead pigs before feeding them to the pre-breaker. They are stored in bulk containers with other solid wastes from Kennedy Town Abattoir and collected twice daily for disposal. Wastewater is generated from cleaning operations as well as in the scrubbers of the deodorisation system of the plant. In 1995/96, about 65,000 m³ wastewater were collected and discharged to the wastewater treatment plant in the Kennedy Town Abattoir.

Overall material flow

Figure 2 summarises the overall material flow for all abattoirs in Hong Kong including the by-product plant. Waste for landfill amounts to 11,299 t for 1995/96, considerably higher than the reported value of 9,125 t (EPD, 1996).

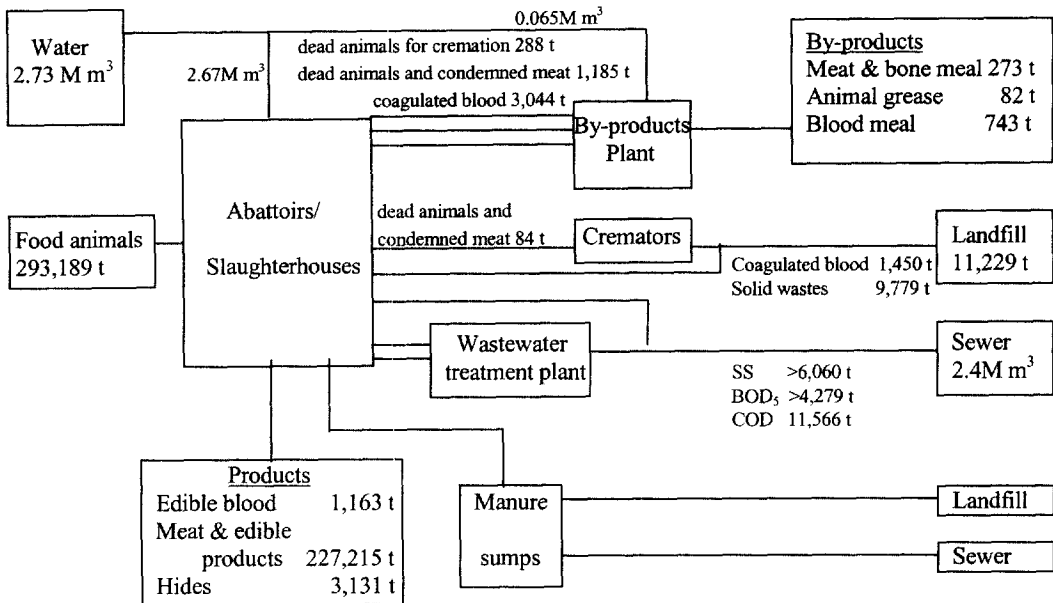


Figure 2. Overall material flow diagram for Hong Kong abattoirs and by-product plant for the year 1995/96.

Critical review of waste management practices

Wastes handling and disposal in Hong Kong abattoirs are not satisfactory. With the exception of Tsuen Wan Slaughterhouse, wastewater treatment is rudimentary and cannot meet effluent discharge standards. In addition, incomplete wastewater collection from livestock loading areas and vehicle washing results in uncontrolled waste discharges. Collection and processing of blood is generally carried out inefficiently, leading to undesirable landfilling of coagulated blood or a high organic concentration in the wastewater. Stomach and intestine contents are not dewatered prior to disposal in landfills. Cremation of dead animals and condemned meat in the Yuen Long and Cheung Chau Slaughterhouses causes smoke problems. The by-product plant has insufficient processing capacity, is using old technology, and hence is faced with complaints about malodour, but also operates at a deficit. For some time already, a modern centralized incineration facility with a capacity of 31 tonnes per day (EPD, 1996) has been proposed for hygienic disposal of dead animals, condemned meat and coagulated blood. This facility was also intended for the safe destruction of clinical waste and animals with highly infectious diseases; however, due to the high capital and operating cost as well as opposition from hospitals, the project has not yet been approved. The recent mass slaughter of 1.5 million chickens (1,800 tonnes) in December 1997 due to bird flu virus infection as well as the mass kill of 1,500 tonnes of fish due to a toxic red tide in April 1998 revived the debate about safe disposal of dead animals. In the absence of any other adequate facility, landfills had to be used for emergency disposal of more than 3,000 tonnes of infectious dead animals, raising serious concern about future public health risks.

Future development

The existing abattoirs in Cheung Sha Wan and Kennedy Town as well as the Ma Tau Kok Cattle Depot are located in densely populated parts of the urban area causing serious environmental nuisances. Hence the Government has decided to replace these facilities, together with the Yuen Long Slaughterhouse, by a huge new slaughterhouse, currently under construction on a 7.5 ha site in Sheung Shui near the border to mainland China (Enviro-Chem, 1995). Sheung Shui Slaughterhouse will have a slaughtering capacity of 5,000 pigs and 400 cattle per day. Following efficient blood segregation and screening out of hair and bristles, wastewater will be treated in a 0.7 ha underground treatment plant with a capacity of 5,000 m³/d in order to meet the strict effluent discharge standards. Despite higher construction cost, an underground plant

was selected because it facilitates collection of all wastewater by gravity flow, contains odours for mitigation, and provides above-ground space for an optional by-products plant in the future. Unit processes applied comprise flow equalisation, screening, fat and grease removal by chemically enhanced primary dissolved air flotation (DAF), biological treatment with nitrogen removal, and clarification by secondary DAF. Solids collected by screens will be dewatered in screw presses, while solids from primary DAF together with the surplus activated sludge from secondary DAF will be mechanically dewatered to 30% total solids content. It is anticipated, that 22 t/d pressed screenings and 54 t/d dewatered sludge will be generated for daily disposal to landfill. In addition, at least 35 t/d of conventional abattoir waste (12 t/d coagulated blood, 10 t/d paunch contents, 4 t/d manure, 5 t/d hair and bristles, 4 t/d condemned meat) will need disposal.

Table 4. Estimated waste loads from the three existing abattoirs and the proposed new slaughterhouse

Parameter	three existing Abattoirs	proposed Sheung Shui Slaughterhouse		modern abattoir	
		raw	treated		
Effluent waste load					
Flow	m ³ /a (m ³ /t carcass)	2,086,200 (12.8)	1,825,000 (11.9)	1,825,000 (11.9)	767,000 (5)
SS,	t/a (kg/t carcass)	>5,984 (>36.7)	3,139 (20.5)	< 456 (3.0)	1,507 (10)
BOD ₅ ,	t/a (kg/t carcass)	4,050 (24.6)	5,453 (26.7)	< 456 (3.0)	2,019 (13)
COD,	t/a (kg/t carcass)	11,185 (68.6)	8,700 (56.7)	n.a.	4,345 (30)
Solid wastes, t/a (kg/t carcass)					
coagulated blood	>3,044 (>19)		4,380 (28.6)		
dead animals/condemned meat	1,051 (6.4)		1,314 (8.6)		
other solid wastes	7,575 (46.5)		7,000 (45.6)		
dewatered screenings and sludge	-		27,740 (181)		
Total	>11,670 (>61.9)		40,434 (263.8)		

Table 4 compares the estimated waste loads from the three existing abattoirs (combined daily slaughter of 4,848 pigs, 273 cattle and 10 goats in 1995/96), the new abattoir (design capacity 5,000 pigs and 400 cattle) and modern abattoirs (assumed capacity of 5,000 pigs and 400 cattle). The design waste loads for the new slaughterhouse appear to be quite high and based on conservative assumptions, since modern management practices are able to lower the raw effluent waste loads considerably. Reduction in effluent waste load by wastewater treatment leads to a large increase in solid wastes in the form of sludge. Unfortunately, recovery and processing of valuable by-products is not included in the current design, because of inability to economically mitigate the potential odour problems. Hence, large amounts of animal matter still need to be landfilled, even though this practice has been outlawed for a long time in many developed countries.

CONCLUSIONS

Based on the investigations carried out, the following conclusions are made:

1. In 1995/96, 293,189 tonnes of food animals were slaughtered in the five abattoirs of Hong Kong, generating 4,494 tonnes of coagulated blood, 1,268 tonnes of dead animals and condemned meat, and 9,779 tonnes of other solid wastes.
2. 2,400,000 m³ of final effluent were discharged with an organic waste load equivalent to 210,000 PEs, making abattoirs the most important industrial water polluter in Hong Kong.
3. Waste management practices are not satisfactory as indicated by high water consumption, incomplete wastewater collection and inadequate waste segregation, rudimentary wastewater treatment, and only partial recovery of by-products.
4. The new slaughterhouse under construction will greatly improve waste management practices; however, in the absence of a new by-product plant, reduced effluent waste load will lead to increased solid waste loads.

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