COMPREHENSIVE INDUSTRY DOCUMENT SERIES :
COINDS/38/1992

COMPREHENSIVE INDUSTRY DOCUMENT ON SLAUGHTER HOUSE, MEAT AND SEA FOOD PROCESSING

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FOREWORD

The series of publications entitled 'Comprehensive Industry Document Series' (COINDS), are designed to cover the various types of industries in the country with respect to their pollution potential and unit processes that are available to control discharges/emissions of pollutants from these types of industries. The Minimal National Standards are evolved as part of these documents. The present document on Slaughter House, Meat and Sea Food Processing is one in the series. These industries are significant in terms of generation of pollutants. Basic report on the industry was prepared by M/s National Productivity Council for CPCB. The present document is based on the report and data collected by the Central and State Pollution Control Boards. Co-operation extended in the field studies, by various Slaughter Houses, Meat and Sea Food Processing Industries are gratefully acknowledged. It is believed that the document would be useful to the industries, Regulatory Agencies, Consultants and others interested in pollution control activities.

New Delhi
June 5, 1992

A. BHATTACHARJYA
CHAIRMAN

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GLOSSARY OF TERMS

Activated sludge process	Removal of organic matter from wastewater by saturating it with air and biological active sludge.
Bacon	A cut of pork, consisting of hind quarter of a pig and smoked.
Biochemical Oxygen Demand (BOD)	The amount of oxygen in milligram per liter used by micro-organisms to consume biodegradable organic matter in wastewater under aerobic condition.
Bone ash	It is obtained by burning of bones with free access to air and contain 15%-16% phosphorous. It is used as a feed supplement.
Bovines	Hollow-horned ruminants e.g. cattle buffaloes and calves. They are characterised by cloven hoofs, four compartments in the stomach, absence of incisors in the upper jaw and duplex forms of cannon bones.
Brine	Water that is saturated or strongly impregnated with sodium chloride.
Broiler	Bird raised and marketed at the age of 7-10 weeks for table purpose.
Calves	Young bovines from birth to six months.
Carcass	The part of an animal body that is used for meat.
Cartoid artery	The principal artery leading to the head.
Coagulation	State of becoming jelly like or of uniting into coherent mass.
Composite wastewater sample	A combination of individual samples of wastewater taken at selected interval to minimise the effect of the variability of the individual sample.
Dissolved Air Floatation.	Separation of low density contaminant from water using minute air bubbles attached to individual particle to increase the buoyancy of the particle.
Evisceration	The process of removing the inner organs of the body, particularly organs of the thorax and abdomen such as the intestines, heart, lung, liver and kidneys.
Facultative	A bacterium that grow under either aerobic or anaerobic conditions.
Fasting	A rest for digestive apparatus is indicated. It helps to eliminate toxins from body.
Fish meal	Whole fish and/or waste parts which have been cooked, dried and ground.
Flocculate	To collect in bunches in wastewater treatment it refers to the process of precipitating suspended solids out of the wastewater stream.
Flocculation	The aggregation of the colloidal parts held in suspension.

Flume	A chute or through for carrying water.
Gut	These parts of elementary canal having a primary digestive function.
Ham	A cut of pork, consisting of hind quarter of a pig from hock to the hip including thigh and the buttock.
Hoisting	Lifting of carcasses to a height sufficient for subsequent processing.
Hygiene	The science of health and its preservation.
Jugular Vein	The large vein on each side of the neck which returns the blood from the head to the heart.
Lagoon	A man-made pond for holding wastewater for removal of solids, stabilization of organic matter by biological oxidation.
Landfill	Disposal of solid waste by dumping at an approved site.
Lairage	Facility of a slaughter house where animals are delivered & rested prior to slaughtering.
Lard	Processed pig fat processing is done by boiling of raw fat material.
Mantle	A membranous flap in the body wall of a mollusk.
Offal	Part of the animal that remains after the carcass have been removed.
Pen	Livestock shed divided into compartments. Each compartment is known as pen.
Pickling	Preservation of meat in common salt or vinegar is called pickling.
Poultry	Species of birds which render man an economic service and reproduce freely under his care.
Pre-treatment	Physical treatment of wastewater at source before disposal.
Primary treatment	The first stage in wastewater treatment in which floating and settleable solids are mechanically removed by screening and sedimentation.
Process wastewater	Any water which, during processing comes into direct contact with or results from the production or use of any raw material finished product, by product or waste product.
Receiving Water	Rivers, lakes, oceans and other water courses that receives wastewaters.
Rectum	Terminal portion of the large intestine in vertebrates.
Rendering	Facility for processing by-product from slaughter house and meat processing units into animal feed, bone meal etc.

Retort	In the context of food processing, to autoclave, i.e. to heat in air-tight chambers with pressurized steam, or other means which do not entail boiling, to temperatures above 100°C.
Rumen	The first stomach of ruminants.
Ruminants	Animals like cow, buffalo and sheep which ruminates or in other words chew a culd.
Scalding	Processing step used to relax the muscles for easy removal of hair/feathers.
Sedimentation or settling	The process of subsidence and deposition of suspended matter carried by wastewater by gravity.
Singeing	Removal of hair/feather by burning with blue flame.
TLWK	Tonne live weight killed.
Toxin	The compound produced by micro-organism and are toxic to animal.
Udder	A highly developed gland of cow.
Veal	Meat from young bovines (calves).
Viscera	The organ of the great cavities of body which are removed during slaughtering.

CHAPTER 1

BACKGROUND, CLASSIFICATION, INDUSTRIAL GROWTH

1.1 SLAUGHTER HOUSE

1.1.1 Background

India has the world's largest population of livestock, nearly 191 million cattle. 70 million Buffaloes, 139 Million Sheep & Goat, 10 Million Pigs and over 200 million poultry. About 36.5% of Goat, 32.5% of sheep, 28% of pigs, 1.9% of Buffaloes and 0.9% Cattle are slaughtered every year. The reported per capita availability of meat in India is about 1.4 kg per annum which is rather low compared to 60-90 kg in European countries.

As reported by the Ministry of Food Processing, a total of 3616 recognised slaughter houses, as on 1989, slaughter over 2 million cattle & buffaloes, 50 million Sheep & Goat, 1.5 million Pigs and 150 million poultry annually, for domestic consumption as well as for export purposes. Statewise distribution of existing slaughter houses is given in Table 1.1. A map indicating the statewise distribution of the units is shown in Figure 1.1.

Table 1.1 Statewise distribution of slaughter houses

1	2
Andhra Pradesh	343
Assam	5
Bihar	47
Gujarat	38
Haryana	43
Himachal Pradesh	36
Jammu & Kashmir	33
Karnataka	633
Kerala	715
Madhya Pradesh	261
Maharashtra	282
Nagaland	7
Orissa	75
Punjab	89
Rajasthan	380

1	2
Tamil Nadu	183
Tripura	3
Uttar Pradesh	407
West Bengal	11
Sikkim	21
Chandigarh	1
Delhi	1
Pondicherry	2
TOTAL	3616

The slaughter houses come under the purview of the animal husbandry division of Ministry of Agriculture mainly for the purpose of funding towards expansion and modernization activities. However, the respective local bodies are responsible for day-to-day operation/maintenance of the slaughter houses. Mostly slaughter houses in the country are service-oriented and perform only the killing and dressing of animals without an onsite rendering operations. Most of the slaughter houses are more than 50 years old with inadequate basic amenities viz. proper flooring, ventilation, water supply, lairage and transport etc.

1.1.2 Classification

At present there are no official norms for classification of slaughter houses. However, depending upon the type of animals slaughtered, variations in quantity and quality of wastewater and solid waste generation, the slaughter houses are classified into:

— Large animal i.e. cattle, buffalo and veal slaughter house

— Goat and sheep slaughter house

— Pigs slaughter house

— Poultry slaughter house

In order to assess the variations in pollution load with respect to number of animals slaughtered, Bovines and Goat & Sheep slaughter houses are further classified into following categories:

* Large Scale	—	More than 200 large animals i.e. Bovines per day or more than 1000 goat and sheep per day.
* Medium Scale	—	More than 50 & upto 200 large animals or more than 300 upto 1000 goat and sheep/day.
* Small Scale	—	Less than 50 Bovines and 300 goat and sheep per day.

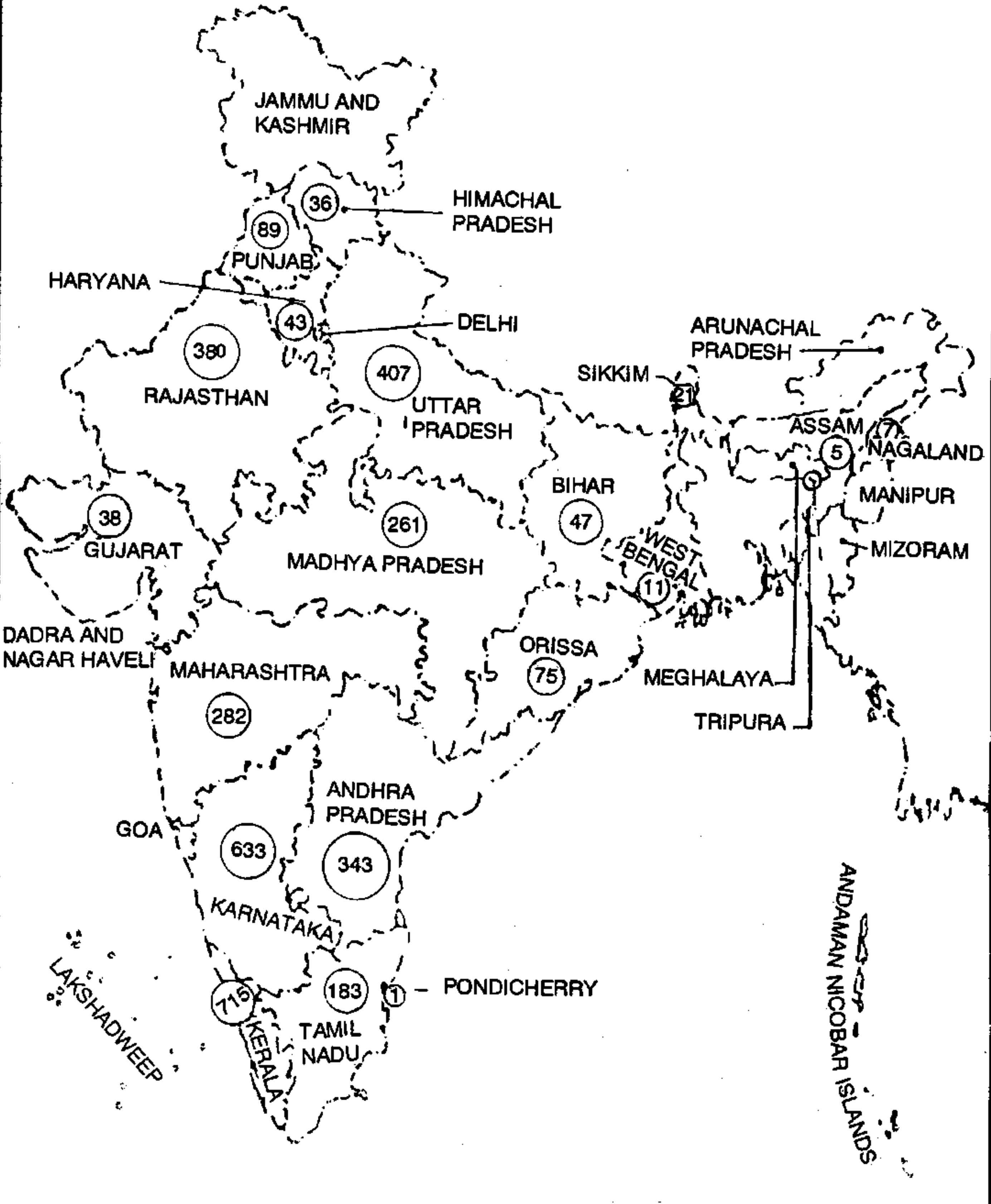


Figure 1.1. Statewise distribution of sloughter Houses in India

Large scale slaughter houses are located mainly in big cities, medium slaughter houses in district/towns while the small scale slaughter houses are scattered all over the country.

Barring one exception, Pig and Poultry slaughtering is not done in organised public slaughter houses. Therefore slaughter houses of Bacon and Broiler processing units were studied. During these studies, no significant variations in waste generation with respect to number of animals slaughtered were observed therefore the classification of large, medium and small is not valid for Pig and Poultry slaughter houses.

1.1.3 Industry Growth Potential

India has more than 50% of the world livestock population. Cattle and buffaloes are not reared for meat production, rather at the end of productive life they are slaughtered. Growth in animal population in India during last two decades is presented below:

	1965 (in millions)	1986	Percentage increase
Cattle	175	191	9.1
Buffaloes	52	70	34.0
Sheep/Goat	103	139	35.0
Pigs	5	10	100.0
Poultry	114	196	72.0

Growth potential of this sector is high, particularly in Buffalo and Poultry. A meat market worth about 1500 crore in foreign exchange exists today for Buffalo meat from surplus 12 million Buffaloes. National Commission on Agriculture has projected that the annual per capita availability for Poultry meat will increase from present 150 gms per year to 650 gms by 2000 A.D. compared to 20 to 30 kg per person per year in some developed countries.

1.2 MEAT PROCESSING

1.2.1 Background

Meat is the dressed flesh derived from Cattle, Buffalo, Sheep, Goat, Pigs and Poultry. Meat from Cattle, Sheep & Pigs are respectively known as beef, mutton and pork. Indian meat industry produces approximately 1.2 million ton of meat per year and is expected to increase 1.7—2.1 million ton by the year 2000 A.D.

The quantity or yield of dressed meat obtained per animal mainly depends on the live weight, size and breed. The average dressing yield in terms of the original live weight are 35% for Cattle, 40% for Sheep & Goat and 65% for Pigs. Beside the dressed meat, certain other parts, hereafter referred as edible offals, are also sold as meat.

Meat being a highly perishable product, can be kept in a fresh condition only through proper processing and storage. When meat gets spoiled, it becomes slimy or sticky, turns dark brown and develops an unpleasant smell and taste. Meat is preserved in a number of ways such as freezing, curing, smoking, dehydration and canning.

Traditionally, Indians prefer fresh meat (hot meat) and preservation of meat is not practiced in India on a large commercial scale. Only a small part of the total meat production (approximately 6%) is preserved i.e. frozen and processed into different products such as ham, bacon and sausages.

1.2.2 Classification

In the meat industry, no organised classification is existing on the basis of production capacity. However based on variation in processing and the corresponding Government registration, the meat processing industry is classified by the Department of Animal Husbandry, Ministry of Agriculture, Government of India into the following two groups:

Frozen meat

Registered with Agricultural Produce Export Development Authority (APEDA).

Processed meat

Registered with Meat and Food Product Order (MFPO), Directorate of Marketing & Inspection, Ministry of Agriculture.

1.2.2(a) Frozen meat

In the frozen meat sector, as per the latest APEDA statistics (1989), a total of 32 units are registered with them. There are no official norms for classification of the frozen meat sector. However for the purpose of the present study and in consultation with APEDA, the units are classified into large, medium and small size (based on their daily freezing capacity) as given below:

Categories		Licenced Capacity	No. of units registered with APEDA
Large Scale	:	25 Ton and above/day	9
Medium Scale	:	> 10 Ton and upto 24 Ton/day	7
Small Scale	:	< 10 Ton/day	16

A statewise distribution of units in various categories is given in table 1.2.1. A map indicating the statewise distribution of the units is shown in fig. 1.2.1.

Figure 1.2.2. (a) Statewise distribution of frozen Meat units in India

Table 1.2.1: Statewise distribution of frozen meat units

State	Category			
	Large	Medium	Small	Total
Maharashtra	4	3	6	13
Delhi	3	—	3	6
Kerala	—	—	3	3
U.P.	2	3	1	6
Karnataka	—	—	2	2
Tamil Nadu	—	1	1	2
Total	9	7	16	32

As it can be seen from the above table, the frozen meat industry is concentrated in Delhi and Bombay. Though the industry operates throughout the year, capacity utilisation, (approx. 50% in medium and small scale units and 80% in large scale units) depends on the demand from importing countries.

1.2.2 (b) Processed meat

The processed meat industry comes under the purview of Meat Food Product Order (MFPO) which is responsible for issuing licences and quality control. As per the MFPO classification these units are categorised as:

Class - A — Animal slaughtered in their own Slaughter House

Class - B — Units using animal salughtered in Public Slaughter House

Class - C — Units procuring meat from the local market (mainly shop/establishment)

As per the latest MFPO statistics—1989, a total of 121 meat processing units are in operation, out of which 22 class-A licencee, 35 units in class-B and 64 units in class-C.

A statewise distribution of the units in various categories are given below in table 1.2.1(a), map indicating the statewise location of the various units is shown in Figure 1.2.2(b).

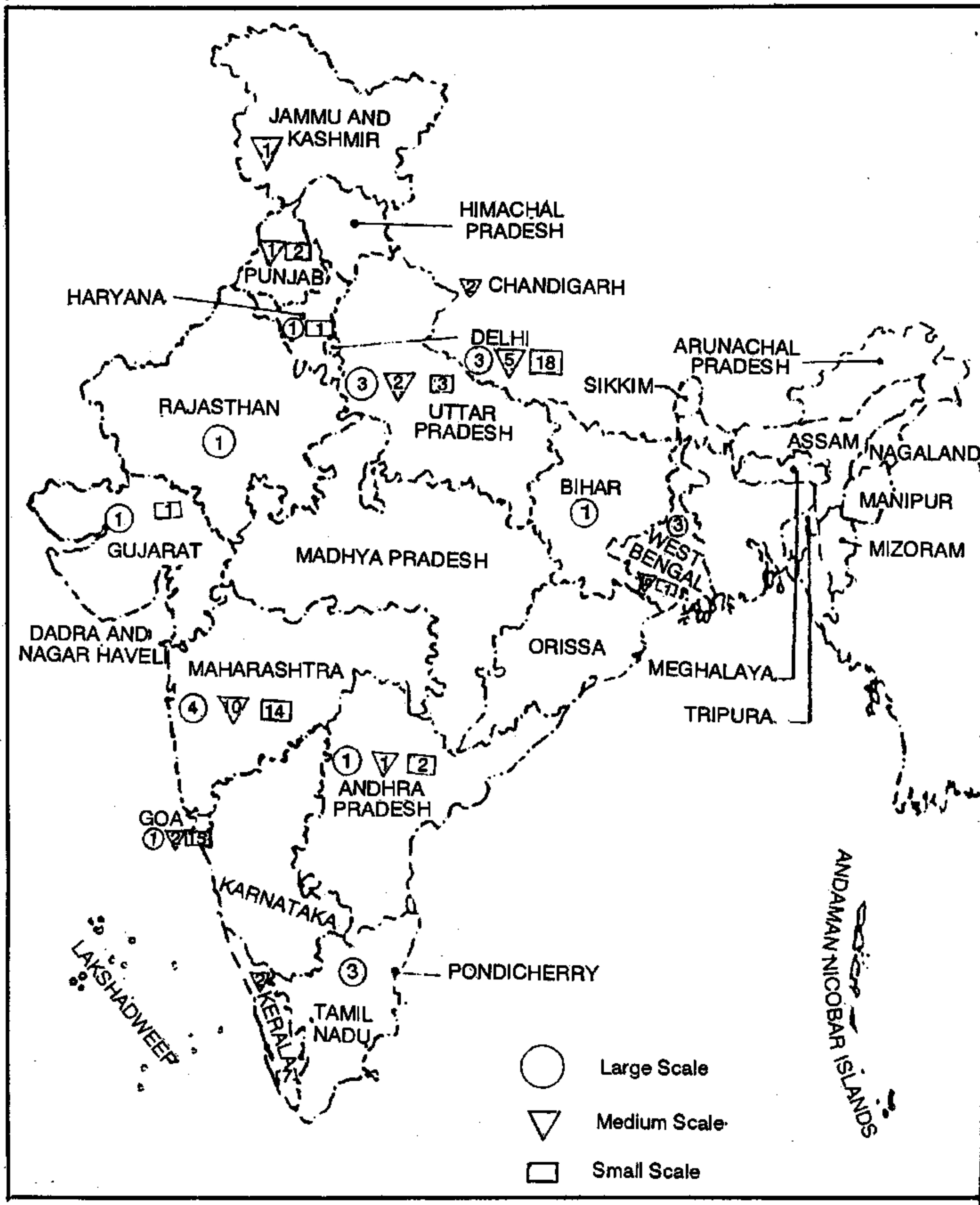


Figure 1.2.2. (b) Statewise distribution of Meat processing units in India

Table 1.2.2 (a): Statewise distribution of processed meat units

State	Category A	Category B	Category C	Total
Andhra Pradesh	1	1	2	4
Assam	—	2	7	9
Tamil Nadu	3	—	—	3
Bihar	1	—	—	1
W. Bengal	3	10	1	14
Gujarat	1	—	1	2
Maharashtra	4	10	14	28
Goa	1	2	15	18
Haryana	1	—	1	2
J & K	—	1	—	1
Punjab	—	1	2	3
Rajasthan	1	—	—	1
U.P.	3	2	3	8
Chandigarh	—	2	—	2
Delhi	3	5	18	26
Total	22	35	64	121

As can be seen from the above table, the units are concentrated either in Metropolitan cities viz. Bombay and Delhi or costal states like Goa and West Bengal. Seven Government Bacon factories were established to cater Defence as well as civil demand of processed meat, out of which 3 are on the verge of closure and other units generally process lesser than their installed capacity.

1.2.3 Industry Growth Potential

Out of the total live stock, around 45 million Sheep & Goat, 2 million Cattles and Buffaloes, 1 million Pigs and 150 million Poultry are slaughtered every year. Out of the total meat production 54% comes from Goat/Sheep, 23% from Buffalo & Cattles, 8% from Pigs and 13% from Poultry.

The percentage slaughter of different animals and contribution of various kinds of meat is given below in Table 1.2.3.

Table 1.2.3

Animal	% Slaughtered	% Contribution of Total production
Buffalo & Cattle	1.4	23.0
Goat	36.5	30.5
Sheep	32.5	13.6
Pig	28.0	8.0
Poultry	—	13.0

The present production of meat in the country in relation to world production is less than 1% inspite of huge live stock wealth. The low utilisation is due to food habits, socio-ethenic factors and partly due to infrastructure short falls like absence of modern slaughter houses, processing plant and cold chain linking for export purposes.

Production potential of meat in the country with reference to domestic consumption & surplus available for export is given below:

Meat production potential in India
(Figures in 1000 MT)

Kind of meat	Production potential	Domestic consumption	Surplus for export
Beef & Veal	90	90	—
Buffalo	1000	240	760
Sheep/Goat	484	424	60
Pork (Pig)	130	130	—
Poultry	124	124	—
Others	140	140	—
Total	1968	1148	820

The per capita availability of meat in India as per recent estimate is lowest in the world. The per capita annual meat consumption is projected to increase from the present 1.4 Kg to between 1.7 Kg—2.3 Kg in 2000 AD.

1.3 SEA FOOD PROCESSING

1.3.1 Background

India is one of the major fishing nations of the world and has moderately developed fish processing industry. The fisheries sector comprises basically marine and inland fisheries. The marine fishing sector remains the most important both in volume and value of production as well as the number of people involved. Its production increased from 0.7 million ton (MT) in 1961 to 1.5 MT in 1975 and to 1.8 MT in 1984. The inland fishery section showed an even more impressive growth from 0.26 MT.in 1961 to 0.78 MT in 1975 and 1.0 MT in 1984.

The Indian marine fisheries has been identified as a 'shrimping' industry as shrimp is the main money earner both for fishermen and processors/exporters. Recently a trend towards a more diversified production and exports pattern has developed. Secondary items like cuttle fish, squids and jelly fish are also processed exclusively for export market.

However so far Indian sea food processing industry is working mainly as the supplier of raw material for reprocessor in importing countries. Recently efforts have been made to process sea food into consumer packs for export. The Indian fish processing industry is essentially a private sector activity. The Government is involved in this sector through various advisory and regulatory bodies particularly in the field of quality control and improvement.

1.3.2 Classification

Sea food processing industry comes under the purview of Ministry of Agriculture and all marine product exporters and processing units are registered under Marine Product Export Development Authority (MPEDA).

Based on the variations in processing operations, Indian sea food processing industry can broadly be classified into following categories:

a) Fish meal
b) Curing/drying
c) Canning
d) Freezing

Canning:

Due to high cost and non-availability of appropriate cans, the fish canning industry has been declared as sick industry and most of the units are not operational at present. It was further confirmed by the MPEDA officials that the fish canning industry may not be revived in the near future. Hence this category is not considered in this document.

Fish Meal:

Fish meal in India is made from by-catch (trash fish) and solid waste generated from fish processing plants. There are 7 units registered for producing fish meals by pulverising the dried trash fishes. No wastes are generated by this category except for odour. Hence, this category is not considered in this document.

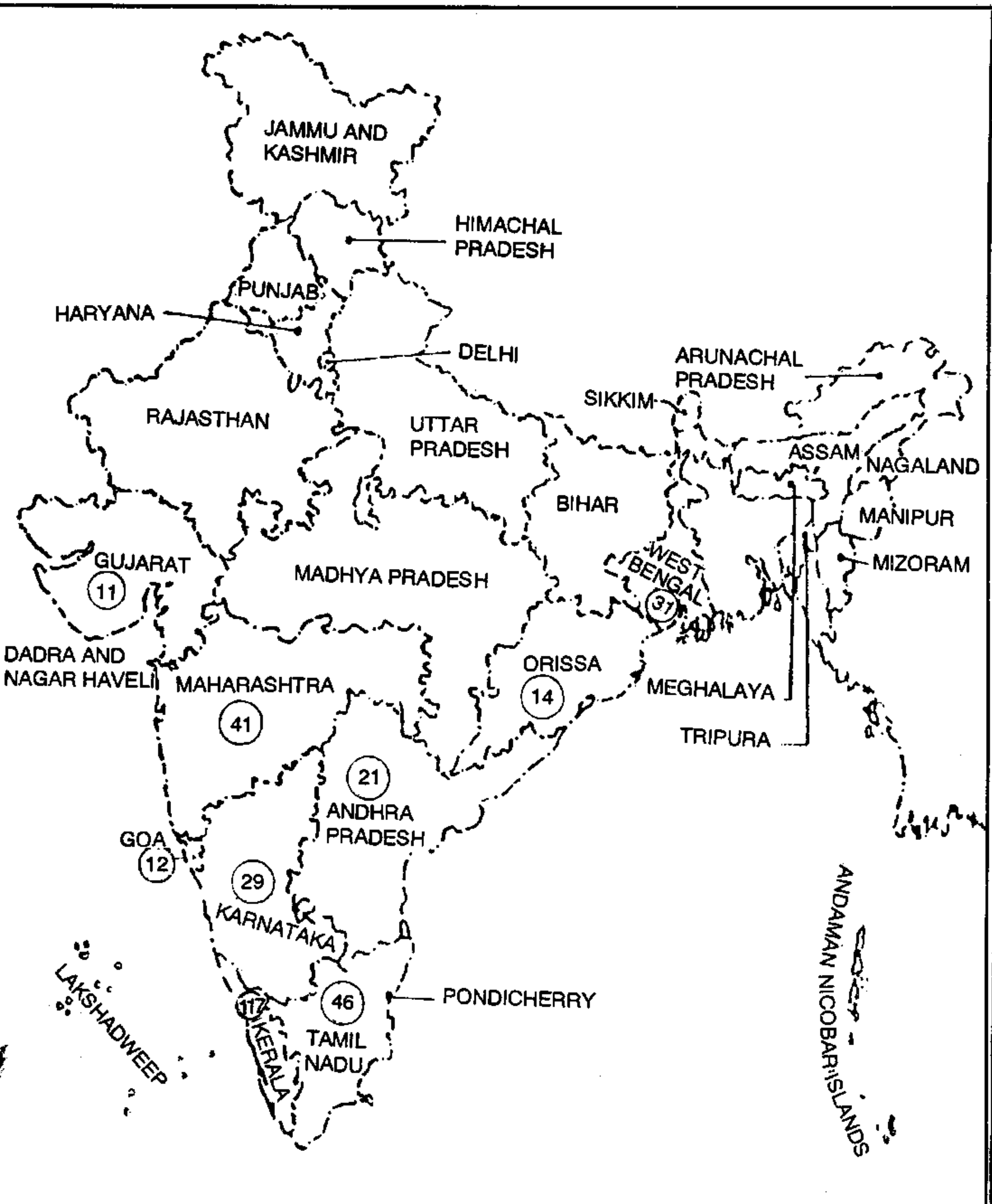


Figure 1.3.2. Statewise distribution of Sea food processing units in India

Curing:

Curing Industry is an unorganised sector and the age old practice of drying of fish mostly on the sea shore is practiced by this category of units. Even the few units which were exporting cured fish (after salting) are in the verge of closure due to decreasing export market demand. Hence, this category is also not considered in this document.

Freezing:

There are 322 freezing plants in India which are operating only for export. Some of them have set up individual quick freezing (IQF) facilities to export sea food in value added form. Since these freezing plants process marine product and the supply of raw material is seasonal, most of them have set up higher capacity to freeze maximum quantity during the season. Therefore, the capacity utilisation of these freezing plants is on an average only 15—20%. Shrimps, squids, cuttle fish, and fin fishes are processed for export. Statewise distribution of freezing plants is given below in Table 1.3.2. A map indicating the statewise distribution of the units is shown in Fig. 1.3.2.

Table 1.3.2: Statewise distribution of refrigeration facilities

State	No.
Kerala	117
Karnataka	29
Tamil Nadu	46
Andhra Pradesh	21
Maharashtra	41
Gujarat	11
Goa	12
Orissa	14
West Bengal	31
Total	322

As per MPEDA there is no official classification of sea food units. However, in the present document, the units are classified on the basis of installed capacity as given below:

Classification	Installed production capacity
Large Scale	Over 20 Ton/day
Medium Scale	Over 5 Ton upto 20 Ton/day
Small Scale	Less than 5 Ton/day

1.3.3 Industry Growth Potential

Because of the fast expanding world market the export demand for sea food is growing rapidly. The overall demand for sea food is expected to be doubled by the turn of the century. Total fishery production in India in 1979 was 2.23 million ton which has increased to 2.8 million ton in 1984 and to 3.15 million ton in 1988-89. Only part of the marine landings (about 0.1 million tons of frozen product) are processed for export purpose. Sea food export touched a peak in 1988-89 with 99777 ton in volume and Rs. 597.85 crores in value compared to 86187 ton in volume and 384.29 crores in value in 1984-85 (MPEDA-1989). Recently India has lost its former position as the top shrimps producer/exporter to Thailand, China, Taiwan and Indonesia where Shrimp industry has been developed rapidly.

Tuna and cephalopods fishing has been identified as the potential area for growth in sea food export. The world market for tuna is 936700 ton and for cephalopods is 507100 ton. Both tuna and cephalopod markets are expected to expand fast in the coming years from the present level of about 23,000 ton per year. The trade of fresh frozen fish, fish fillets and surimi products is also promising and these products can be exported in value added consumer packs.

The potential for developing aquaculture industry is vast but export based aquaculture is still in the infant stage in India. Only a fraction of the coastal area is being utilised for farming. It has been estimated that export of aquaculture fisheries alone from India can be in billion dollars.

CHAPTER : 2

PRODUCTION PROCESSES, WATER USAGES, WATER CONSUMPTION AND WASTEWATER QUANTITY

2.1 SLAUGHTERING PROCESS

Normal sequence of unit operations for bovines, goat and sheep, pigs and chicken slaughtering are shown in Figs. 2.1 (i-iv) respectively. While the basic slaughtering operations for large and small animals are identical, variations in scalding, dehairing and singeing operations are observed in case of pig and chicken slaughtering.

Large animals (Bovines) and Goat & Sheep

As shown in Figs. 2.1(i) & 2.1(ii) the various unit operations include: lairage, slaughtering, bleeding, dressing, evisceration and carcasss splitting.

Animals are required to be given sufficient rest, fodder and water, approximately for 24 hours before slaughtering, in order to avoid glycogen depletion, which generally occurs during transit. Then the animals are to be inspected by veternary surgeons, known as ante mortem health inspection and the non-confirming animals rejected for slaughtering.

Lairage

After ante mortem health inspection, the animals are given enough quantity of water but no fodder, for 12 hrs prior to slaughtering, in order to flushout the pathogenic microorganisms. However, it was observed that only very few slaughter houses (less than 1%) have lairage facilities.

Slaughtering & Bleeding

Large animals are slaughtered as per the Islamic Rites by HALAL method. The animal is pushed on the floor and the jugular vein is out manually by the butcher to drain blood. In majority of the slaughter houses the blood is allowed to spill on the floor and join the wastewater drain. Only in a few large slaughter houses, part of the blood is collected by some agencies for manufacture of medicine/tonics.

Dressing

The dressing operation consist of:

— Sticking of heart to ensure complete bleeding

— Removal of horns, hind legs, head trimming and demasking

— Flaying of abdomen and chest

— Removal of hide

Evisceration

Dressing is followed by Evisceration, where edible and non edible offals are segregated. While the edible offals are cleaned with water and sold, the non edible portions are disposed of as solid waste. Care is taken not to puncture the intestine during evisceration to avoid contamination of carcass with intestinal contents.

Carcass Splitting

Before splitting the carcass into quadrets the carcass is washed with water. Normally the carcass splitting is done manually by the axe. However in some of the large scale slaughter houses the carcass is split with an electrically operated circular saw.

The split carcass is transported to meat dealer's shop/processor unit either by slaughter house's meat delivery van or in dealers own transport. in modem slaughter houses, the split carcass is washed with high pressure water before transportation.

Pigs

Basic unit operations viz. lairage, sticking and bleeding, dressing, evisceration and carcass splitting are identical as discussed for bovines and goat and sheep slaughtering. Only the additional operations i.e. stunning, scalding and dehairing are discussed in brief as below:

Stunning

The animal is stunned with an electronic instrument. Subsequently sticking is done and hoisted on rail to ensure complete bleeding.

Scalding

For dehairing, the carcass is dipped into hot water at 60°C for 5 minutes, to relax the muscles and make the dehairing operation easier.

Dehairing

After scalding, the animal is transferred to a mechanical dehairing machine. The final dehairing is done manually or by using blue flame (burning of hair). Thereafter the dehaired carcasses are washed in a chamber with high pressure water sprays.

Chicken

In India, due to consumer preferences, the birds are mostly killed and dressed as per consumer directions in the market places. However demand for processed and frozen chicken meat is on the increase and some organised poultry processing units have been established. Chicken slaughtering includes killing, draining of blood and removal of feathers—popularly known as dressing, evisceration and cutting of the carcass into parts.

Slaughtering

Birds are hung on a coveyer bar shackle for 2-3 minutes before slaughtering to relax it's muscle. While the head is held by one hand, a sharp knife is used for cutting the veins below the ear lobe and allowed to bleed completely.

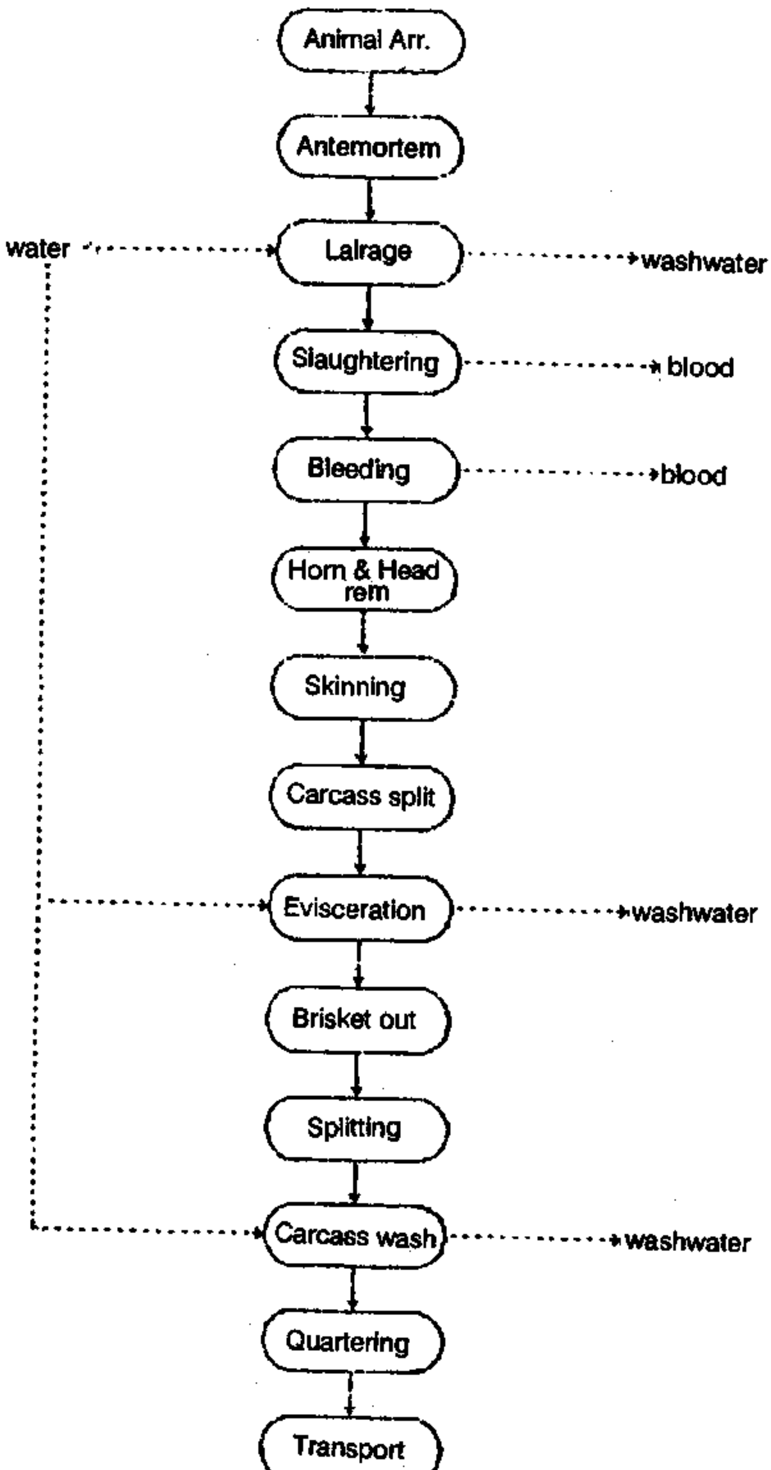
Scalding

Scalding in hot water at a temperature of about 60°C for 60-90 seconds is done before defeathering, to relax the feather muscles.

Defeathering

Just after scalding, feathers are removed either manually or mechanically. In case of mechanical defeathering, the remaining pin and other feathers are removed by hand. Carcasses are then washed throughly, normally with fresh water spray and scrubbing by hand or machine.

Figure 2.1(i): Processing flow chart for Bovines slaughtering



in addition wastewater is generated from floor washing activities

Figure 2.1(ii): Processing flow chart for Goat/Sheep slaughtering

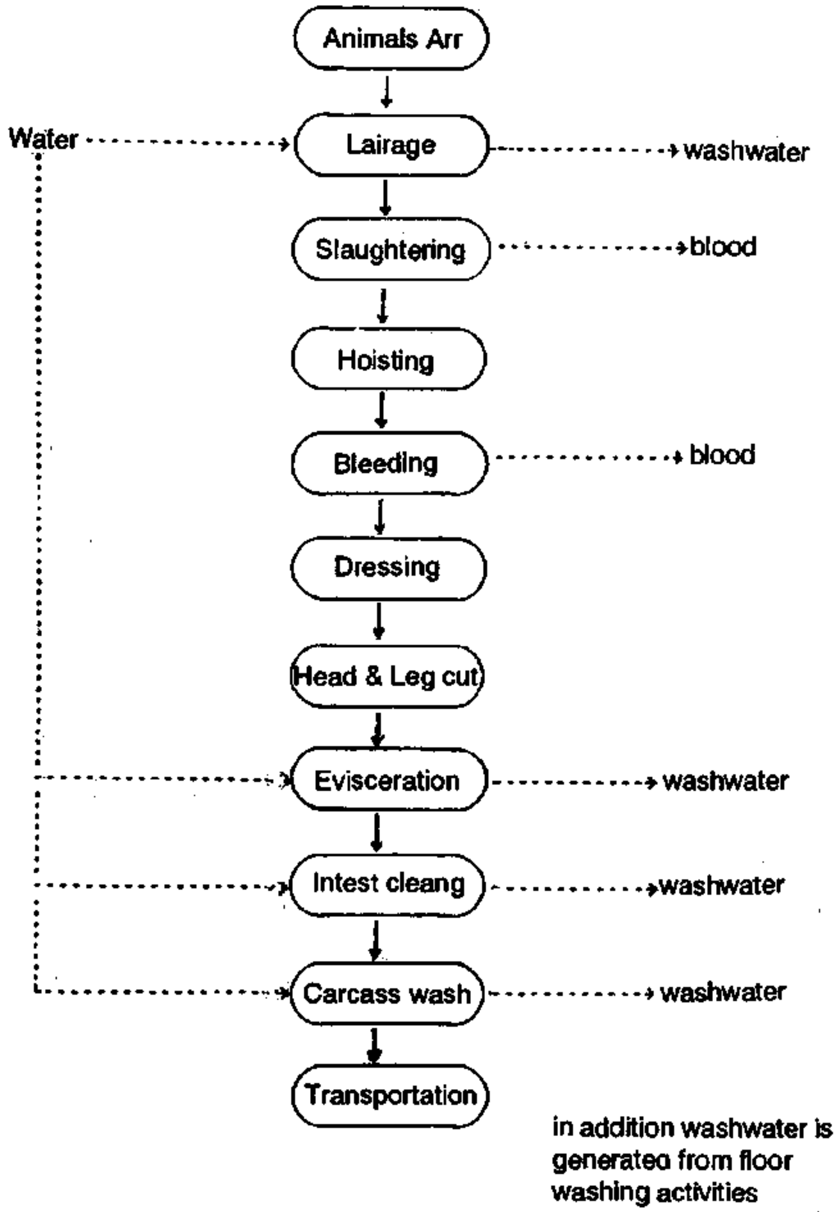
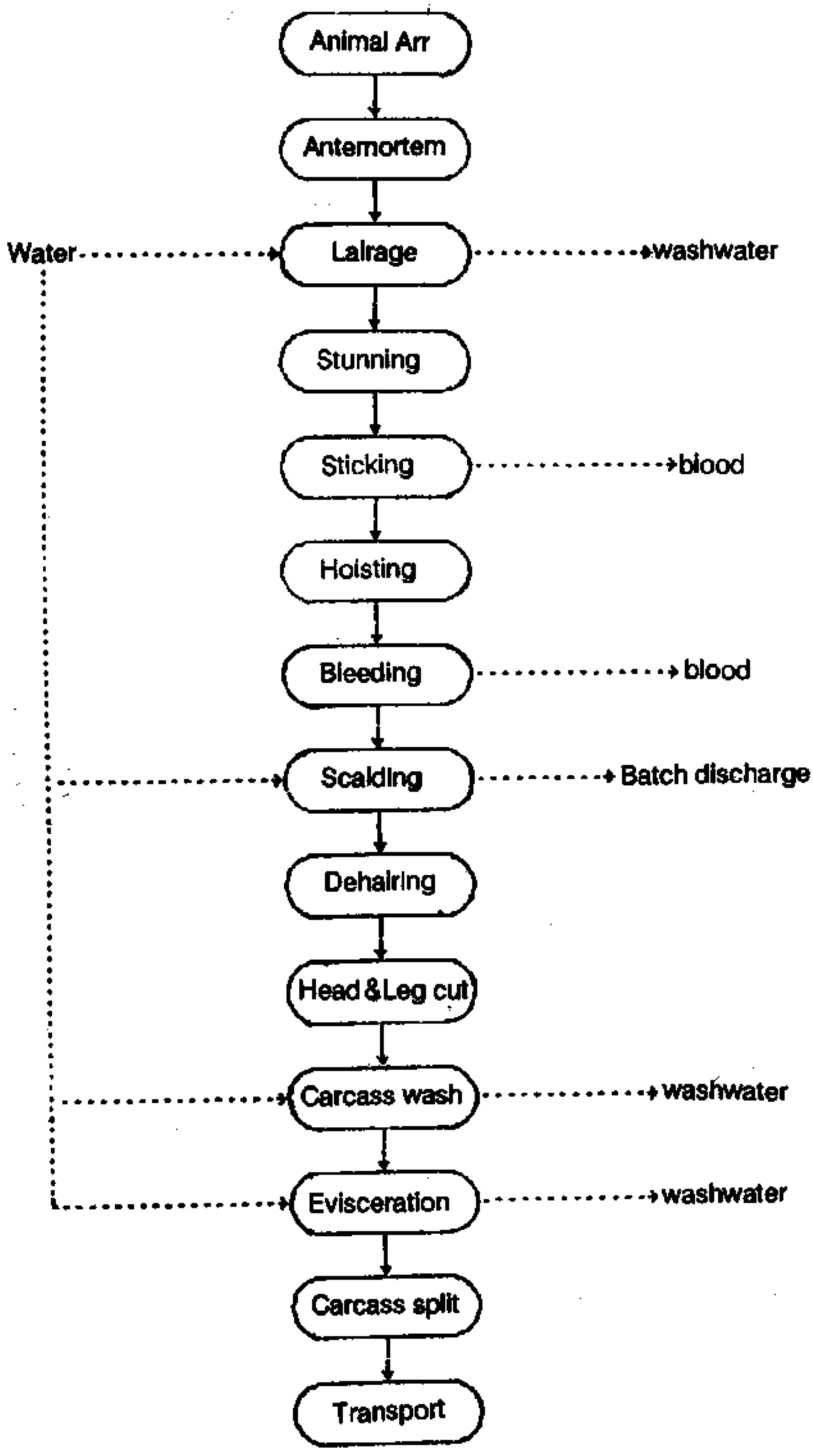
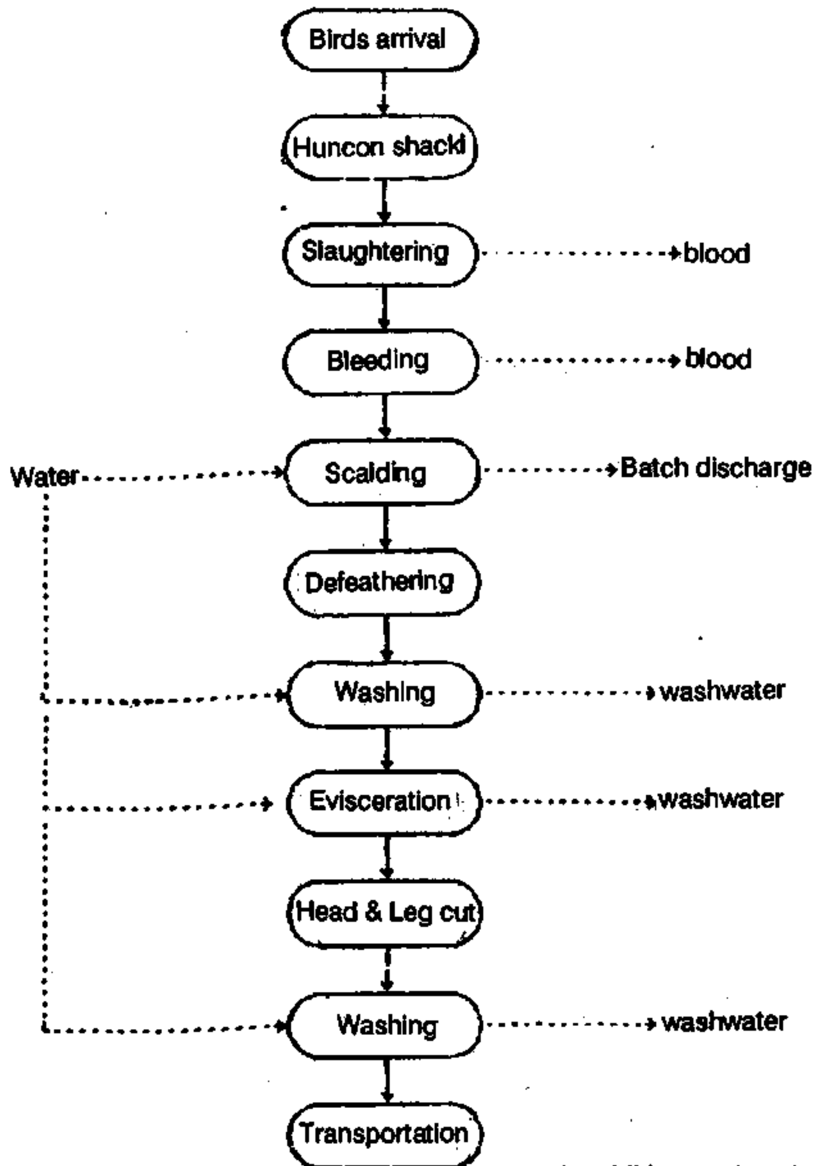


Figure 2.1(iii): Processing flow chart for Pig slaughtering



In addition wastewater is generated from floor washing activities

Figure 2.1(iv): Processing flow chart for Chicken slaughtering



in addition wastewater is generated from floor washing activities

Evisceration

Dressed carcasses are eviscerated before selling as dressed chicken or are chilled frozen for further processing.

2.1.1 Water Usages

The process water consumption areas are:

— Drinking water for animals during lairage

— Washing of slaughtering & bleeding floor

— Washing of dressing hall

— Washing of carcasses

— Cleaning of intestines

— Cleaning of knife, axes, tables & any other equipments used in slaughter house

The domestic water consumption areas are:

— Toilets

— Canteen (only in case of large Slaughter Houses)

— Drinking and hand washing of meat dealers, animal dealers, butchers and transporters.

2.1.2 Specific Water Consumption

Animal	Category	No. of units visited	Specific water consumption			
			L/head		M^3/TLWK	
			Range	Avg.	Range	Avg.
1	2	3	4	5	6	7
Buffalo	Large	5	50—200	102	0.17—0.67	0.34
	Medium	4	25—100	45	0.08—0.33	0.15
	Small	2	100—400	250	0.33—1.33	0.83
Goat/ Sheep	Large	3	15—40	25	1.00—2.77	1.67
	Medium	3	50—70	54	3.33—4.77	3.60
	Small	3	35—50	40	2.30—3.33	2.67
Pig	Large	3	300—500	370	5.00—8.30	6.17
	Medium	3	300—800	470	5.00—13.3	7.8
	Small	2	200—400	300	3.30—6.67	5.0

1	2	3	4	5	6	7
Chicken	Large	1	12		12.0	
	Medium	2	10—20	15	10.0—20.0	15.0
	Small	2	5—10	7.5	5.0—10.0	7.5

(TLWK = Tonnes of Live weight killed)

* In some cases, domestic water consumption is also included in the reported figures.

* Modern & semi-modern slaughter houses consume more water/head killed as compared to conventional old slaughter houses, because of additional water consumption for carcass cleaning, frequent floor & equipments washings.

Wide variations in the computed specific water consumption figures are probably due to following reasons:

* Variation in availability of adequate water supply in the slaughter house—in many of the units there was no piped water supply.

* Variations in slaughtering practices i.e. floor slaughtering followed by whole operation of dressing, evisceration and cutting of carcass on floor or floor slaughtering & bleeding but dressing operations in hung position or modern slaughtering with all operations done in multihoist point.

* Large slaughter houses located in Metropolitan cities have facilities like lairage, chilling room, frozen storage resulting in more water usage and subsequently more wastewater generation.

* Most of the units have no records of water consumption and the reported figures are based on rough estimates.

2.1.3 Wastewater Quantity

Based on the data reported by various units, the specific wastewater generation—litre per head and m^3/tonne of live weight killed (TLWK) for each category have been computed and given below:

Animal slaughtered	Category	No. of units visited	Specific water consumption			
			Litre/head		M^3/TLWK	
			Range	Avg.	Range	Avg.
1	2	3	4	5	6	7
Buffalo	Large	5	40—200	93	0.13—0.67	0.31
	Medium	4	25—100	45	0.08—0.33	0.15
	Small	2	100—400	250	0.33—1.33	0.83

1	2	3	4	5	6	7
Goat/ Sheep	Large	3	12—35	21	0.8—2.33	1.4
	Medium	3	40—70	50	2.67—4.67	3.3
	Small	3	30—50	37	2.0—3.33	2.47
Pigs	Large	3	250—450	350	4.17—7.5	5.8
	Medium	3	300—700	433	5.0—11.67	7.22
	Small	2	150—400	275	2.5—6.67	4.58
Chicken	Large	1	8.0		8.0	
	Medium	2	10—20	15	10.0—20.0	15.0
	Small	2	5—10	7.5	5.0—10.0	7.5

Except for domestic water consumption and drinking water provided for animals in lairages, the major portion of the water supplied would be discharged as wastewater. Hence the reasons attributed for variations in specific water consumption are applicable for the above variations in the computed specific wastewater generation figures.

2.2 PRODUCTION PROCESS (MEAT)

Meat being a highly perishable product, can be kept in a fresh condition only through proper processing and storage. When meat gets spoiled, it becomes slimy or sticky, turns dark brown and develops an unpleasant smell and taste. Meat is preserved in a number of ways such as freezing, curing, smoking, dehydration, canning and irradiation. Preservation of meat is not practiced in India on a large commercial scale though it is widely practised in advanced countries and only part of it is preserved and processed into different products such as ham, bacon and sausages.

Frozen meat

Storage of meat at chilling temperatures above the freezing temperature of meat (—2.2°C) is known as refrigerated storage and below the freezing point is known as frozen storage. The desired tenderization occurs after prolonged refrigeration e.g. 16-18 hrs. for sheep and goat, 24 30 hrs for pig carcass and 2 days for buffaloe carcass. The two commercially adopted freezing methods are blast freezing and plate freezing, the former being used for irregularly shaped items and small carcasses and the latter for items of regular shape. Duration of rapid freezing by blast freezers or plate freezers are 8 hours and 2 hrs respectively. This quick freezing process ensures that only the smallest ice crystals are formed in the microstructure of the meat and thereby prevents the rupture of the cells, preserving the meat in its original state of freshness. The normal sequences of unit operation are shown in Fig. 2.2(i).

The frozen meat is packed finally in corrugated kraft paper cartoon, strapped with polyproplene straps which are heat sealed by automatic machines. The entire carton is then shrink wrapped and transferred to a cold storage chamber where the temperature is maintained at —18 to —20°C. The consignment is then sent to Bombay by refrigerated trucks for intransit refrigerated storage prior to shipment for export.

Processed meat

Almost all the meat produced in India is consumed as fresh meat, only pork and a very small quantity of mutton and beef is preserved and processed into different products. Normal sequences of unit operation & processes is shown in Fig. 2.2(ii). Brief description of various unit operations and processes followed are given below:

Figure 2.2(l): Processing flow chart for frozen meat

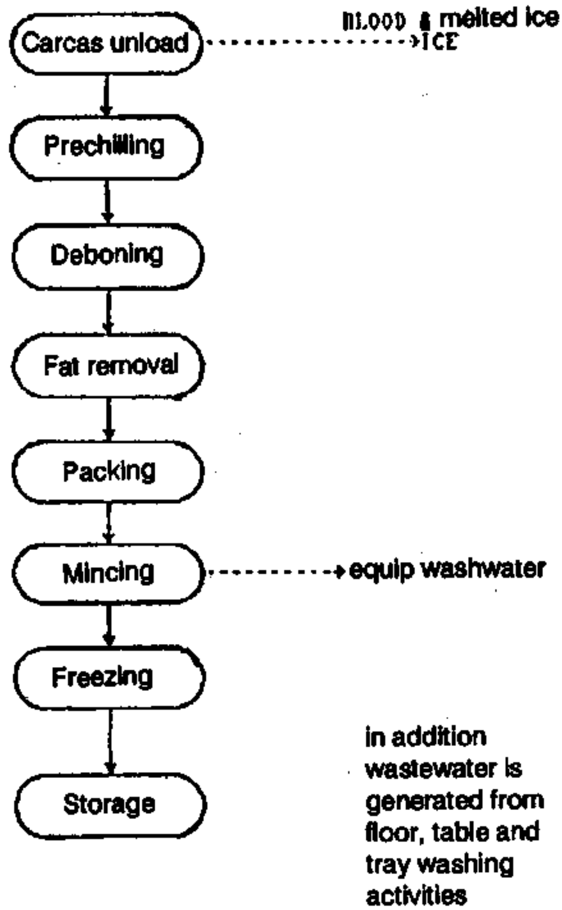
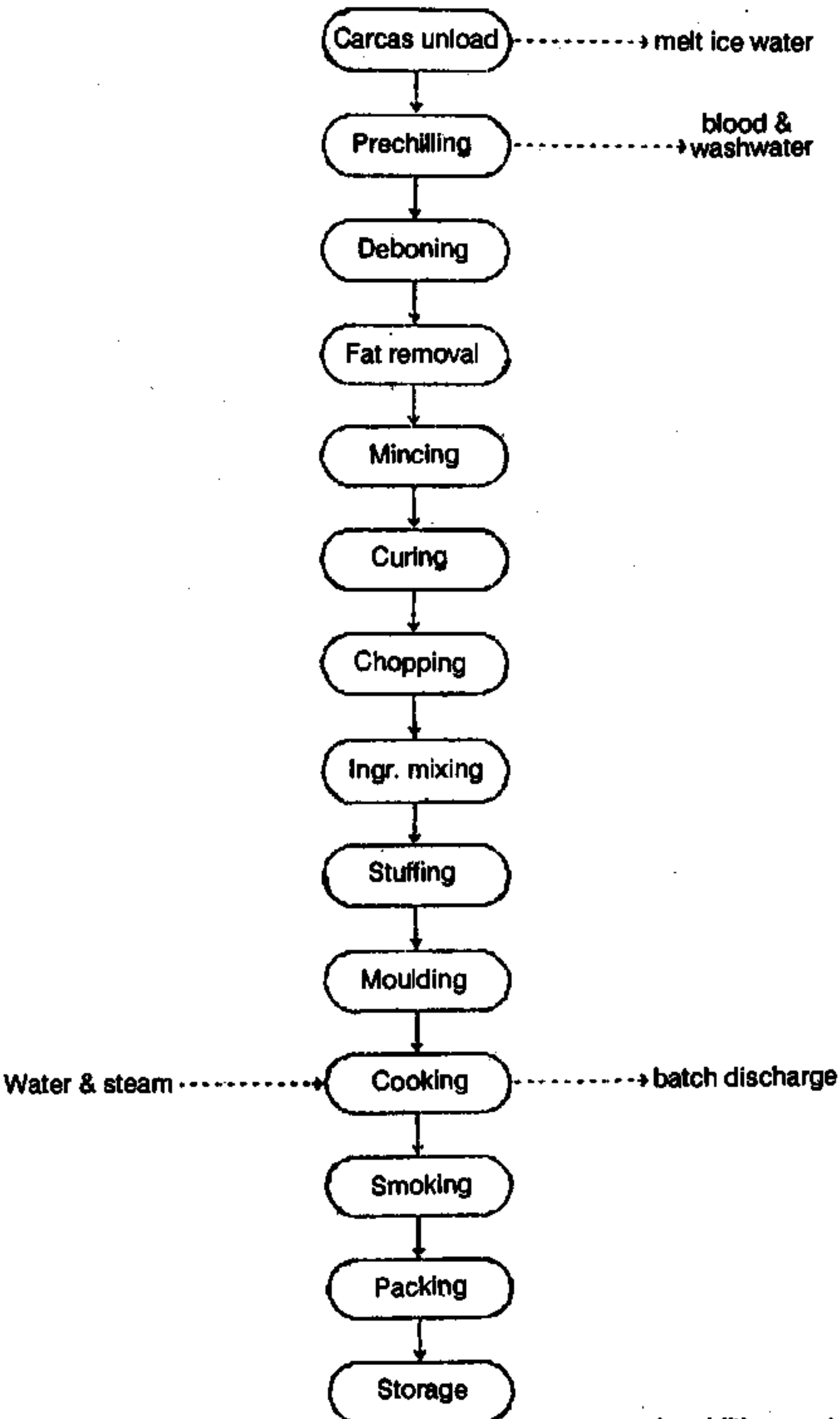


Figure 2.2(ii): Processing flow chart for processed meat



in addition wastewater is generated from floor, table, trolley and tray washings

Curing

Methods generally followed for curing the meat are sweet pickle curing, dry salt curing, dry curing and injection curing.

In the sweet pickle process, which is mostly used for curing ham and its cuts, the meat is kept with a mixture of salt, brine, sugar or similar sweeteners, and a small quantity of sodium nitrate in large water tight vats maintained at 2—4.5°C for 15—45 days. Salt extracts the water from the tissue and make it hard and dry, while sugar softens and neutralizes the harshness of salt and improves the flavour of the product and sodium nitrate helps to maintain the attractive reddish or pink colour of the meat.

In the dry salt method salt is rubbed on the meat surface and stacked with salt all around. This method is used for preserving some heavier cuts.

In the dry curing method, which is used for bacon, the meat is packed very lightly in water-tight containers with a sprinkle of salt, sugar and sodium nitrate between the layers so that it gets mildly cured in its own juices.

In the injection method, the curing ingredients in solution are forced in under pressure through a hollow needle inserted in the exposed ends of the arteris of hams and shoulders. The curing time is greatly reduced in this process.

Smoking

Many meats like ham and bacon are smoked in addition to being cured. The cured cuts are usually washed with a water spray before smoking. Smoking of meat, besides acting as a preservative, makes it possible to improve the keeping quality of the product without refrigeration. It also imparts a characteristic flavour to the product. Smoking is carried out in smoke-houses in which the heat is supplied by gas burner or weed smoke. The temperature of smoking is usually maintained below 46°C. The smoking time and temperature differ according to the product. Bacon is usually smoked for 18-24 hr. at less than 55°C. Smoking of cured bacon yields a product with a characteristics smoky odour, and a mild sweet flavour.

Dehydration

The meat slices are brined in 10 per cent saline solution for three minutes, spread out on trays and dried for 8-10 hrs. in dehydration tunnels maintained at 63—68°C. The slices appearing as flakes are packed in tins, salted and sealed.

Canning

Meat/meat products are canned primarily for preservation without refrigeration and hence are heated to a sufficiently high degree to sterilize them. Beef cuts, ham, pork (shoulder loin and other cuts) are among the chief products for canning. The time and temperature required for the destruction of bacteria depends on the nature of products, its pH, presence of curing salts, shape and size of the can, etc. Some products are packed hot into the can and others cold. After preliminary cooking the meat is trimmed free of fat, gristles, bones, etc. cut into smaller pieces if necessary, canned, sealed under vacuum and sterilized.

Processing of poultry products

The first step in poultry processing is cutting and portioning whole birds into havlves, quarters and eight pieces followed by segmenting this range further into legs, drumsticks, wing & breasts. The second step is dressing the parts i.e. coating them with crispy bread crumbs or marinating them with seasonings. By spicing the meats before dressing the product range is increased further and yet the product remains as recognizable part of a chicken.

Canned chicken

In India, there is a great demand for canned chicken from the defence services, in the form of whole boneless chicken, cut-up chicken without bones, cut-up chicken with bones, and selected parts such as breast, thigh etc.

Sausages

Besides canning, the comminuted meat from old hens, roosters and culled birds are used, at 50 per cent level after blending with vegetables and seasoning with spices, in manufacture of chicken sausage.

2.2.1 Water Consumption

The specific water consumption (m^3/tonne of finished product) has been computed based on the reported total water consumption and production capacity for different categories of frozen and meat processing units are given below:

Type of product	Category	No. of units	Specific water cons. M^3/T	
			Range	Avg.
Frozen Meat	Large	4	0.35 — 1.5	0.62
	Medium	5	0.25 — 1.3	0.68
	Small	4	0.4 — 2.0	1.00
Processed Meat	A	6	12 — 35	22.40*
	B	6	6 — 15	12.00
	C	5	5 — 16	17.70

* from meat processing activity only.

In frozen meat sector the basic unit operations are same for all the categories and no significant variations in specific water consumption was reported. However, in the processed meat sector variations were observed among different categories and are attributed to the following reasons:

— Class-A meat processing units have boilers for their captive steam consumption thereby using more water per tonne of meat processed.

— Since Class-A units work round the clock, more water is used for domestic activities like toilets, workers hand washing & bathing.

— Class-B & C units are basically shop establishments. Part of the processing is done either at entrepreneurs home or elsewhere. Thus water consumption data reported by such units are based on monthly water bill exclusively for their activity at shop establishment.

— Variations in types of meat processed i.e. pork, mutton or chicken reflects variations in specific water consumption. Processing of pork meat require more water due to inherent high fat contents, as compared to mutton and chicken meat.

— Variations in water consumption is also attributed to variations in processed products mix, viz sausages, ham, bacon, salami, biryani, canned products etc.

2.2.2 Wastewater Quantity

The specific wastewater generation (m^3/tonne of finished product) computed on the basis of reported total wastewater volume and production capacity for different categories of meat processing units are given below:

Type of product	Category	No. of units	Specific Wastewater generation M^3/Tonne of finished product	
			Range	Average
Frozen Meat	Large	4	0.30 — 1.2	0.54
	Medium	5	0.25 — 1.25	0.63
	Small	4	0.4 — 2.0	1.00
Processed Meat	A	6	11 — 29.4	19.6*
	B	6	5 — 15	11.0
	C	5	5 — 15.5	11.2

* from meat processing activity only.

In meat processing industry water is not consumed by the products, total water supplied reappears as wastewater. Hence, the observed variations in specific wastewater generation in meat processing units are due to some reasons, as discussed above, for the variations in specific water consumption.

2.3 SEA FOOD PROCESSING

Sea Food Processing Industry comes under the purview of Ministry of Agriculture and all marine product exporters and/processing units are registered under Marine Product Export Development Authority (MPEDA). Process flow charts for shrimps and cuttle fish are depicted in Figures 2.3 (i) and 2.3 (ii).

The sea food processing industry can broadly be classified into following categories:

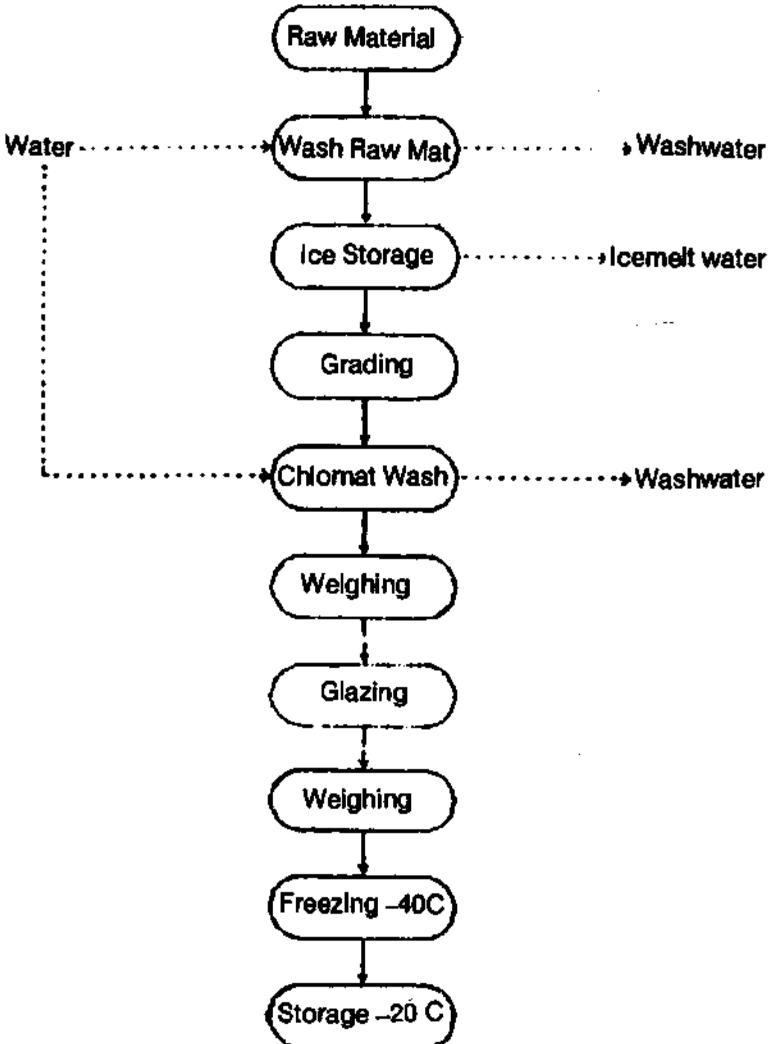
a) Fish meal
b) Curing/drying
c) Canning
d) Freezing

As fish meal, curing and canning do not result in wastewater discharge, these processes are not discussed. Freezing is discussed below.

Freezing

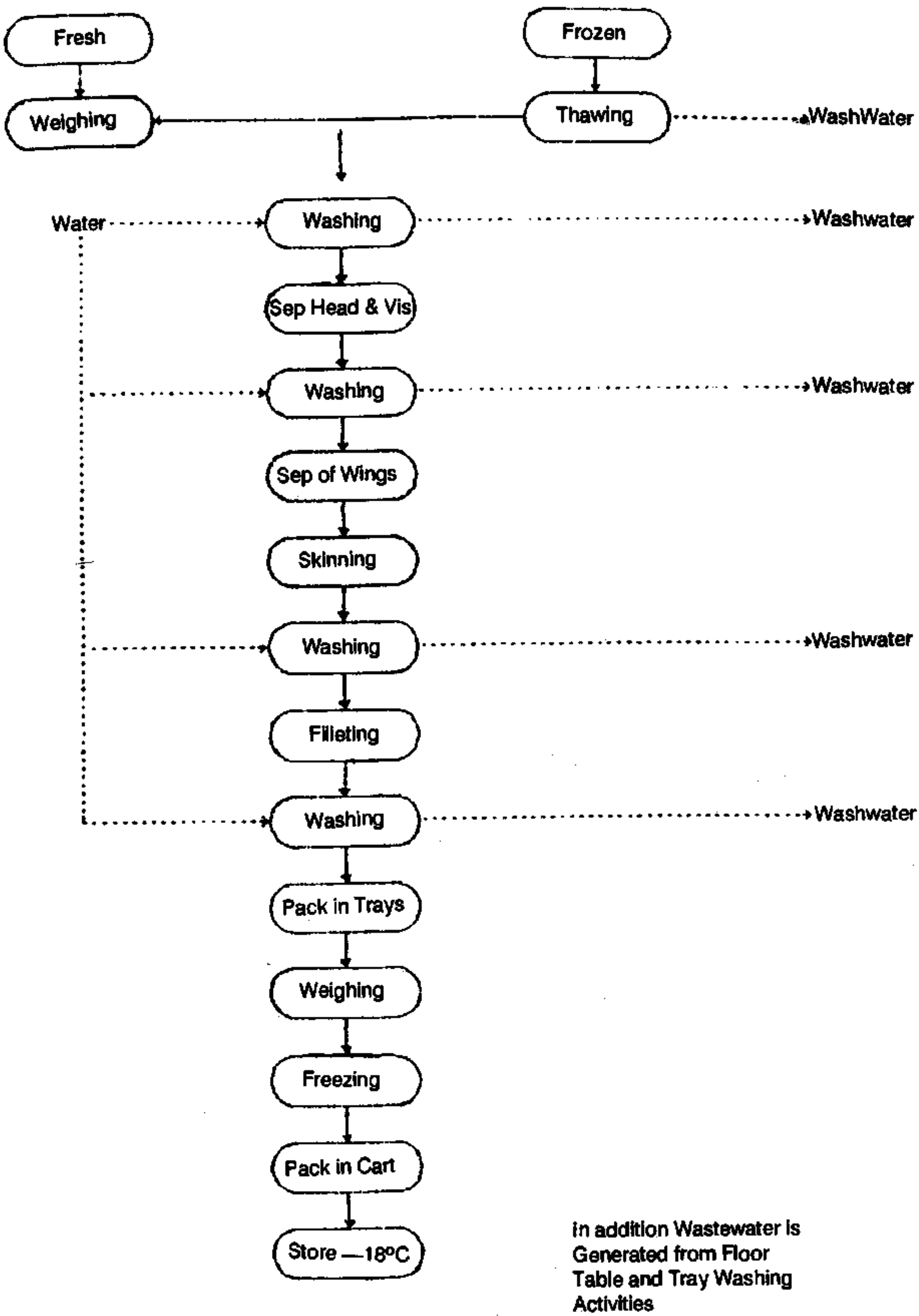
There are 322 freezing plants in India and all are export oriented. Some of them have set up 'individual quick freezing' (IQF) facilities to export sea food in value added form. Since these freezing plants process marine product and the supply of raw material is seasonal, most of them have set up higher capacity to freeze maximum quantity during the season. Therefore, the capacity utilisation of these freezing plants is on an average 15-20%. Shrimps, squids, cuttle fish, and fin fishes are processed for export.

Figure 2.3 (i): Processing flow chart for whole shrimp



In addition wastewater is generated from floor, table and tray washing activities

Figure 2.3 (ii): Processing flow chart for cuttle fish fillets



2.3.1 Water Usage

The water use areas are as follows:

a) Industrial water consumption:

- Washing of fishes (chlorinated water)
- Ice making
- Cleaning of process equipments
- Tray and trolley cleaning
- Floor washings
- Cooling

b) Domestic water consumption:

- Toilets and urinals
- Washing & bathings
- Canteen if any
- Gardening

The specific water consumption has been evaluated as given below:

Product	No. of Units Visited	Specific Water Consumption (M3/T)	
		Range	Average
Frozen Shrimps			
— Large	3	1.8 — 7.3	4.9
— Medium	10	1.2 — 17.5	6.9
— Small	8	2.3 — 5.5	4.1
Cephalopods	3	2.3 — 4.7	3.6
Squids/Cuttle Fish	3	2.4 — 6.5	4.4
Fresh Fishes	2	1.8 — 3.6	2.7

Variations in the computed specific water consumption values are probably due to following reasons:

— The water consumption is directly proportionate to the type of fishes processed, which vary from unit to unit and season to season.

— Depending upon the availability of water, the specific water consumption varies from location to location, e.g., units in Kerala consume more water compared to units at Bombay where water is mostly purchased in tankers.

— Depending upon the type of raw materials received e.g. raw shrimps, peeled, headless & peeled, peeled & deveined, the specific water consumption varies.

— The reported figures were the rough estimates by the units and no actual measurements have been carried out.

2.3.2 Wastewater Quantity

Based on the production capacity (T/d) and wastewater quantity reported by the units, specific wastewater generation (M^3/ton) has been evaluated and is given below:

Product	No. of Units Visited	Specific Water Consumption (M^3/T)	
		Range	Average
Frozen Shrimps			
— Large	3	1.7 — 6.2	4.1
— Medium	10	1.2 — 15.6	6.2
— Small	8	2.0 — 4.5	3.2
Cephalopods	3	1.9 — 4.2	3.0
Squids/Cuttle Fish	3	2.2 — 6.0	4.1
Fresh Fishes	2	1.2 — 2.7	2.0

In the sea food processing industry, the entire water used for processing/washing, (except for evaporation losses) reapears as waste water. Hence the reasons for variations in the computed specific water consumption are applicable for the reasons for variations in the computed specific wasterwater generation.

CHAPTER 3

WASTEWATER CHARACTERISTICS & POLLUTION LOAD GENERATION

3.1 BOVINES

3.1.1 Wastewater Characteristics

Composite wastewater samples of the combined wastewater were collected at a 30 minutes interval during the entire slaughtering operations. In case of batch discharges, samples were collected from individual sources and flow proportionate composite samples were prepared and analysed for pH, BOD, COD, TSS, O/G, Total Kjeldhal Nitrogen (TKN) and total P. The red colour of the wastewater is due to discharge of blood (haemoglobin) which is easily biodegradable and, therefore, treated wastewater will not be having colour problem. The wastewater characteristics are presented in the following table:

Category	Unit	pH	BOD (mg/l)	CCD (mg/l)	TSS (mg/l)	O/G (mg/l)	TKN (mg/l)	P total (mg/l)
Large	1	8.1	5,565	10,911	3347	357	1082	60
	2	8.0	- 4,042	8,786	3090	255	505	49
Medium	1	8.2	43,950	89,693	11,650	3,250	11,100	630
	2	7.9	11,066	21,699	2,130	1,400	2,107	112
Small	1	8.0	6,600	13,750	2,600	1,100	1,150	65
	2	7.6	1,750	3,539	875	219	—	—

The higher BOD, COD, TSS, O/G, TKN and P_t concentrations in the wastewater from medium scale slaughter houses are due to lower water usage resulting in more concentrated effluents.

The calculated specific pollution load in terms of kg of pollutant per ton of liveweight killed are shown in the following table:

Category	Units	Specific Pollution Load (Kg/TLWK)					
		BOD	COD	TSS	O/G	TKN	P total
1	2	3	4	5	6	7	8
Large	1	3.8	7.5	2.1	0.2	0.74	0.06
	2	5.5	11.9	4.5	0.3	0.68	0.06
Medium	1	3.1	6.3	0.8	0.2	0.80	0.04

1	2	3	4	5	6	7	8
	2	5.0	9.8	1.0	0.6	0.96	0.05
Small	1	6.6	14.3	2.6	1.0	1.15	0.06
	2	6.0	12.5	3.0	0.7	—	—

Variations in the specific pollution loads are due to following reasons:

— Only in a few units the blood is collected by some private enterprises for manufacture of medicines/tonics/. However in most of the slaughter houses the blood is allowed to drain on the floor and depending on the drainage facilities the blood partly gets into wastewater drain and partly (coagulated) is disposed off alongwith solid waste.

— Depending on the facilities available and the practice followed for intestinal cleaning, by various slaughter houses, varying amount of intestinal contents is discharged into the wastewater drain.

— Depending on the handling of rumen digesta i.e. total dumping (flushing of entire content directly to wastewater drain), wet dumping (content is washed out and screened) and dry dumping (entire content is collected and dumped as solid waste) etc., wasteload generation varies.

3.1.2 Specific Wastewater and Pollution Load Generation Factor

Large scale

Since unit 2 represents the type of a modern large scale slaughter house into which the other large scale slaughter house in the country should be developed, having lairage facility, using hot water for carcass washing etc., the following specific pollutant factor calculated for this unit will be used for subsequent effluent standard setting purposes:

Freshwater consumption (m^3/TLWK)	Wastewater generation (m^3/TLWK)	BOD load (kg/TLWK)	COD load (kg/TLWK)
1.5	1.4	5.5	i1.9

Medium scale

Partial collection of blood by a pharmaceutical company is done in unit 1 which reduces the organic load by about 25% whereas in most of the medium scale slaughter houses, blood collection is normally not practiced.

In addition due to non-availability of piped water supply in unit 1, the major portion of the remaining blood coagulates and is subsequently disposed off as solid waste.

Because of these reasons the following specific pollutant factors calculated for unit 2 are adopted for medium scale bovine slaughter houses.

Freshwater consumption (m^3/TLWK)	Wastewater generation (m^3/TLWK)	BOD load (kg/TLWK)	COD load (kg/TLWK)
0.5	0.5	5.0	9.8

Small scale

Because of very high wastewater volume generation in unit 2 resulting from open taps and excessive water usage the following specific pollutant factor calculated for unit 1 will be used for small scale Bovine slaughter houses:

Freshwater consumption (m^3/TLWK)	Wastewater generation (m^3/TLWK)	BOD load (kg/TLWK)	COD load (kg/TLWK)
1.0	1.0	6.6	14.3

Comparison between the specific wastewater and pollution generation factors of large, medium and small scale Bovine slaughter houses

Parameter	Large	Medium	Small
Specific fresh water consumption (m^3/TLWK)	1.5	0.5	1.0
Specific wastewater generation (m^3/TLWK)	1.4	0.5	1.0
Specific BOD load (kg/TLWK)	5.5	5.0	6.6
Specific COD load (kg/TLWK)	11.9	9.8	14.3
Specific TSS load (kg/TLWK)	4.5	1.0	2.6
Specific O/G load (kg/TLWK)	0.3	0.6	1.0

The above figures indicate that large size bovine slaughter houses use more water per unit because of higher hygienic requirements. Small scale bovine slaughter houses have the highest specific BOD & COD load because of the absence of any blood collection system. The high specific TSS load in large scale bovine slaughter houses is because of more frequent floor washing and subsequent flushing of intestine contents into the wastewater drain.

3.2 GOAT AND SHEEP

3.2.1 Wastewater Characteristics

Composite wastewater samples of the combined wastewater were collected at every 30 minutes interval during the entire slaughtering operations. In case of batch discharges, samples were collected from individual sources and flow proportionate composite samples were prepared and analysed for pH, BOD, COD, TSS, O/G, Total Kjeldahl Nitrogen (TKN) and Total P. The red colour of the wastewater is due to discharge of blood (haemoglobin) which is easily biodegradable, therefore, treated wastewater will not be having colour problem. The wastewater characteristics are presented in the following table:

Unit Nos.	pH	BOD (mg/l)	COD (mg/l)	TSS (mg/l)	O/G (mg/l)	TKN (mg/l)	P_{total} (mg/l)
1	8.1	16,900	14,375	6,420	173	1200	121
2	7.8	2,371	4,649	2,491	15	398	41
3	7.9	3,000	5,874	1,462	95	532	47

The higher BOD, COD, TSS, O/G, TKN and P_t concentrations in the wastewater from unit 1 is due to lower water usage resulting in more concentrated effluents.

The calculated specific pollution load in terms of kg of pollutant per ton of liveweight killed are shown in the following table:

Unit	Specific Pollution Load (KG/TLWK)					
Nos	BOD	COD	TSS	O/G	TKN	P_{total}
1	6.9	14.4	6.4	0.2	1.2	0.12
2	8.2	16.1	8.6	0.5	1.4	0.14
3	8.1	15.9	4.0	0.3	1.4	0.12

The lower pollution load in unit 1 is due to

— Jhatka slaughtering, resulting in less drainage of blood during bleeding operations.

— Cleaning of intestines is carried out by the contractor outside the slaughter house.

The higher TSS load in unit 2 is due to excessive water usage for cleaning activities resulting in entry of more solids into wastewater drain.

2 Specific Wastewater and Pollution Load Generation Factor

The monitoring data from unit 1 is from jhatka slaughtering section whereas in majority of the slaughter houses in India Halal slaughtering is done.

Intestinal cleaning in unit 1 is done by contractors outside the slaughter house whereas in other units intestinal cleaning is done by butchers within the units.

Because of these reasons the following specific pollutant factors calculated for the average of units 2 & 3 are adopted for goat & sheep slaughter houses.

Freshwater consumption (m^3/TLWK)	Wastewater generation (m^3/TLWK)	BOD load (kg/TLWK)	COD load (kg/TLWK)
3.3	3.0	8.1	16.0

The above figures indicate that goat & sheep slaughter houses use more water per unit compared to bovine slaughter houses because of additional water requirements for intestine cleanings.

C PIGS

1 Wastewater Characteristics

Composite wastewater samples of the combined wastewater were collected at 30 minutes interval. In case of batch discharges, samples were collected from individual sources and flow proportionate composite samples were prepared and analysed for pH, BOD, COD, TSS, O/G, Total Kjeldahl Nitrogen and Total P. Similar to Bovines, in Goat/Sheep slaughtering also there is no addition of chemicals in the process, therefore, the parameter like TDS, % Sodium, Sulphate and Chloride etc. are not relevant hence not analysed. The red colour of the wastewater is due to discharge of blood (haemoglobin) which is easily biodegradable, therefore, treated wastewater will not be having colour problem. The wastewater characteristics are presented in the following table:

Unit Nos.	pH	BOD (mg/l)	COD (mg/l)	TSS (mg/l)	O/G (mg/l)	TKN (mg/l)	P_{total} (mg/l)
1	7.5	3,294	7,320	1,448	63	317	20
2	7.1	3,833	8,156	1,018	150	442	17
3	7.4	995	1,974	363	77	180	7
4	7.8	3,818	7,954	873	153	307	29

The lower BOD, COD, TSS, O/G, TKN AND P_t concentrations in the wastewater from unit 3 is due to higher water usage resulting in diluted effluents.

The calculated specific pollution load in terms of kg of pollutant per ton of liveweight killed is shown in the following table:

Unit	Specific Pollution Load (KG/TLWK)					
	BOD	COD	TSS	O/G	TKN	P_{total}
1	20.4	45.4	9.0	0.4	2.0	0.12
2	23.0	49.0	6.1	0.9	2.6	0.10
3	18.9	37.5	6.9	1.4	4.0	0.14
4	17.5	36.6	4.0	0.7	1.4	0.13

The lower pollution load in unit 4 is due to

— Some portion of the blood is collected by the butchers/workers for making blood sausages.

— Unlike in other units the cleaning of intestines for sausage casing, is not done within the unit.

— Due to less water usage for carcass washings and cleaning activities, carryover of solids and organic pollutant to wastewater drain is less.

— In contrast to other units dehairing is done manually, exerting less pollution load compared to mechanical dehairing.

Higher O/G load from unit 3 is due to rendering of fats into leaf lard whereas in other units fat is sold alongwith pig fry.

3.3.2 Specific Wastewater and Pollution Load Generation Factor

For the purpose of evolving specific wastewater and pollution load generation factors, applicable for Pig slaughter houses it is recommended to adopt the average of factors computed for units 1 & 2 because of the following reasons:

Partial collection of blood by workers is done in units 3 and 4 for making blood sausages, which reduces the organic load by about 20%, whereas in most of the other Pig slaughter houses, blood collection is normally not practiced. In addition dehairing operation is done manually in unit 4 compared to mechanical dehairing in other units.

Because of these reasons the following specific pollutant factors are adopted for Pig slaughter houses.

Freshwater consumption (m^3/TLWK)	Wastewater generation (m^3/TLWK)	BOD load (kg/TLWK)	COD load (kg/TLWK)
7.1	6.1	21.7	47.2

3.4 POULTRY

3.4.1 Wastewater Characteristics

Composite wastewater samples of the combined wastewater were collected at every 30 minutes interval. In case of batch discharges, samples were collected from individual sources and flow proportionate composite samples were prepared and analysed for pH, BOD, COD, TSS, O/G, Total Kjeldahl Nitrogen (TKN) and total P. Similar to Bovines, in Poultry slaughtering also there is no addition of chemicals in the process, therefore, the parameter like TDS, % Sodium Sulphate and Chloride etc. are not relevant hence not analysed. The red colour of the wastewater is due to blood (haemoglobin) discharge which is easily biodegradable, therefore, treated wastewater will not be having colour problem. The wastewater characteristics are presented in the following table.

Unit Nos.	pH	BOD (mg/l)	COD (mg/l)	TSS (mg/l)	O/G (mg/l)	TKN (mg/l)	P_{total} (mg/l)
1	7.8	2,026	4,312	1333	224	401	9
2	7.5	555	1,213	296	55	130	4
3	7.8	1,650	3,412	950	180	279	7

The lower BOD, COD, TSS, O/G, TKN and P_t concentrations in the wastewater from unit 2 is due to higher water usage resulting in diluted effluents.

The calculated specific pollution load in terms of kg of pollutant per ton of liveweight killed is shown in the following table.

Unit	Specific Pollution Load (KG/TLWK)					
	BOD	COD	TSS	O/G	TKN	P_{total}
1	19.0	39.6	12.5	2.1	3.8	0.08
2	12.0	25.5	6.4	1.2	2.8	0.08
3	13.2	27.3	7.6	1.4	2.2	0.06

The higher pollution load in unit 1 is due to

— Unit 1 being an integrated broiler processing unit of its own kind in the country is having hot and cold water facility for carcass as well as equipments and floor washings. In addition, sanitisers used for cleaning also add to the total pollution load.

— Non-edible offals are discharged into wastewater stream whereas in other units they are collected and disposed off as solid waste.

— Defeathering of scalded birds is done mechanically using rotating rubber finger, which generates higher pollution load compared to manual defeathering.

3.4.2 Specific Wastewater and Pollution Generation Factor

For the purpose of evolving specific pollution load generation factor applicable for Poultry slaughter houses it is recommended to adopt the average of factor computed for units 2 & 3 because of the following reasons:

Unit 1 being the only integrated broiler processing unit in the whole country cannot be considered as a representative unit of the Poultry slaughter houses.

Because of these reasons the following specific pollution factors are adopted for Poultry slaughter houses:

Freshwater consumption (m^3/TLWK)	Wastewater generation (m^3/TLWK)	BOD load (kg/TLWK)	COD load (kg/TLWK)
17.0	14.8	12.6	26.4

3.5 FROZEN MEAT

3.5.1 Wastewater Characteristics

Composite wastewater samples of the combined wastewater were collected at every 30 minutes interval. In case of batch discharges, samples were collected from individual sources and flow proportionate composite samples were prepared and analysed for pH, BOD, COD, TSS, O/G, Total Kjeldahl Nitrogen (TKN) and total P. Similar to slaughter houses, in meat processing units also there is no addition of chemicals in the process, therefore, the parameters like TDS, % Sodium, Sulphate and Chloride etc. are not relevant hence not analysed. The wastewater characteristics are presented in the following table:

Category	Units	pH	BOD (mg/l)	COD (mg/l)	TSS (mg/l)	O/G (mg/l)	TKN (mg/l)	P_{total} (mg/l)
Large	1	8.1	1,182	3199	421	135	251	14.6
	2	7.8	525	1076	211	50	122	—
Medium	1	7.9	510	1209	179	114	114	10.0
	2	7.6	1026	2102	240	184	184	12.0
Small	1	7.8	237	512	275	87	87	—
	2	7.7	282	594	501	167	183	—

The higher BOD & COD concentration in the wastewater from unit 1 of large category is due to lower water usage resulting in concentrated effluents.

The calculated specific pollution load in terms of kg of pollutant per ton of liveweight killed is shown in the following table:

Category	Units	Specific Pollution Load (Kg/Ton)					
		BOD	COD	TSS	O/G	TKN	P_{total}
Large	1	0.9	2.4	0.3	0.1	0.2	0.01
	2	0.9	1.8	0.4	0.1	0.2	—
Medium	1	1.1	2.7	0.4	0.1	0.3	0.02
	2	1.5	3.1	0.3	0.1	0.3	0.02
Small	1	0.6	1.4	0.7	0.2	0.2	—
	2	0.7	1.5	0.5	0.2	0.2	0.02

The relatively higher pollution load in medium category is due to:

— Cleaning of carcass transporting trucks within the unit.

- Carcass is procured from the slaughter houses having no carcass washing facility, therefore, carcass washing is done within the unit.

- In both the medium scale units, no bar screen was provided in the wastewater drains whereas in other units monitored, screening of wastewater is done before disposal.

- Packing of minced meat is done by packing machines in large scale and medium scale units. Washings of packing machine is done once a shift irrespective of the volume of production. Therefore, specific pollution generation from this operation in medium category is more compared to large category.

- Comparatively lower pollution load in small category is due to procurement of washed carcass from contractors and better house keeping measures viz., immediate disposal of green & spoilt meat and bones.

3.5.2 Specific Wastewater and Pollution Load Generation Factor

For the purpose of evolving specific pollution load generation factor applicable for the frozen meat sector it is recommended to adopt the average of factor computed for all the 6 units monitored because of the following reasons:

- Basic unit operations followed are the same in all categories.

- In most of the units a mix of washed and unwashed carcass depending on availability of carcass is processed and pollution generation from smaller units represent processing of washed and pre-chilled carcass, medium class units represent typical operations including carcass washing and pre-chilling and out of two large unit surveyed one pre-chilling and out of two large units surveyed one processes washed and chilled carcass. Therefore, average of factor for all the units will be representative for this sector.

Freshwater consumption (m^3/ton)	Wastewater generation (m^3/ton)	BOD load (kg/ton)	COD load (kg/ton)
2.1	1.9	0.95	2.15

3.6 PROCESSED MEAT

3.6.1 Wastewater Characteristics

Composite wastewater samples of the combined wastewater were collected at a 30 minutes interval. In case of batch discharges, samples were collected from individual sources and flow proportionate composite samples were prepared and analysed for pH, BOD, COD, TSS, O/G, Total Kjeldahl Nitrogen (TKN) and Total P. Similar to slaughter houses, in meat processing units also there is no addition of chemicals in the process, therefore, the parameters like TDS, % Sodium, Sulphate and Chloride etc. are not relevant hence not analysed. The wastewater characteristics are presented in the following table:

Category	Units	pH	BOD (mg/l)	COD (mg/l)	TSS (mg/l)	O/G (mg/l)	TKN (mg/l)	P_{total} (mg/l)
Class-A	1	7.4	982	2145	421	135	251	14.6
	2	7.3	510	1155	535	65	—	—
	3	7.3	745	1273	758	98	188	22.0
Class-B	1	7.2	972	2054	1113	191	141	—
	2	7.3	688	1569	1200	67	67	—
Class-C	1	7.2	1656	3895	1067	120	113	—
	2	7.3	792	1688	800	147	—	—
	3	7.2	3690	9225	1800	301	167	—

The calculated specific pollution load in terms of kg of pollutant per ton of product is shown in the following table:

Category	Units	Specific Pollution Load (Kg/Ton)					
		BOD	COD	TSS	O/G	TKN	P_{total}
Class-A	1	14.3	31.2	30.5	0.3	—	—
	2	12.5	28.3	13.1	1.6	—	—
	3	11.7	22.7	11.9	1.5	3.0	0.3
Class-B	1	7.1	15.0	8.2	1.0	1.0	—
	2	6.9	15.3	11.8	0.7	0.7	—
Class-C	1	10.0	24.2	6.7	0.7	—	—
	2	7.9	16.9	8.0	1.5	—	—
	3	11.0	27.6	5.4	0.9	0.5	—

Variations in the pollution load are due to the following reasons:

— Variations in the processed product mix, viz sausages, smoked products like ham and bacons, canned products etc.

— Class-A units have fat rendering facilities within the unit, and thereby generating additional pollution load, with an estimated BOD content of about 32,000 mg/l.

— Variations in the type of meat processed i.e. unit 1 of class-A category is processing chicken and therefore generates more BOD, COD and TSS load compared to other units.

— In the units, procuring pre-chilled meat from slaughter houses or contractors, washing and pre-chilling step is eliminated, which reduces the total pollution load.

3.6.2 Specific Wastewater and Pollution Load Generation Factor

Class-A

For the purpose of evolving specific pollution load generation factor applicable for processed meat sector class-A it is recommended to adopt the average of the factors computed for units 2 & 3 because of the following reasons:

Unit 1 being the only poultry precessing unit in the whole country cannot be considered as a representative unit of the class-A meat processing sector.

Because of this reason the following specific pollution factors are adopted for class-A category:

Freshwater consumption (m^3/ton)	Wastewater generation (m^3/ton)	BOD load (kg/ton)	COD load (kg/ton)
23.5	20.1	12.1	25.5

Class-B

Since there is no significant variation in both the specific wastewater generation and the pollution generation factors of the units of class-B category, it is recommended to adopt the average factors computed for both units as given below:

Freshwater consumption (m^3/ton)	Wastewater generation (m^3/ton)	BOD load (kg/ton)	COD load (kg/ton)
9.1	8.6	7.0	15.5

Class-C

Because of wide variation in product mix and ingredient used during processing in Class-C units the average of the specific pollutant factors calculated for all units monitored will be used.

Freshwater consumption (m^3/ton)	Wastewater generation (m^3/ton)	BOD load (kg/ton)	COD load (kg/ton)
6.4	6.4	9.3	22.9

Comparison between the specific wastewater and pollution generation factors of meat processing units

Parameter	Class-A	Class-B	Class-C
Specific fresh water consumption (m^3/TLWK)	23.5	9.1	6.4
Specific wastewater generation (m^3/TLWK)	20.1	8.6	6.4
Specific BOD load (kg/TLWK)	12.1	7.0	9.3
Specific COD load (kg/TLWK)	25.5	15.1	22.9
Specific TSS load (kg/TLWK)	12.5	10.0	6.7
Specific O/G load (kg/TLWK)	1.5	0.9	7.0

The above figure indicate that class-A units use more water per unit because of higher hygienic requirements and have highest specific BOD & COD loads because of rendering of by products viz. fat into lard. The high specific TSS load in class-A units is because of more frequent floor washing and subsequent flushing of solids into the wastewater drain.

3.7 SHRIMP PROCESSING

3.7.1 Wastewater Characteristics

Composite wastewater samples of the combined wastewater were collected at 30 minutes interval. In case of batch discharges, samples were collected from individual sources and flow proportionate composite samples were prepared and analysed for pH, BOD, COD, TSS, O/G, and Total Kjeldahl Nitrogen (TKN). Similar to slaughter houses and meat processing in sea-food processing units also there is no addition of chemicals in the process, therefore, the parameters like TDS, %·Sodium, Sulphate and Chloride etc. are not relevant hence not analysed. The wastewater characteristics are presented in the following table:

Category	Units	pH	BOD (mg/l)	COD (mg/l)	TSS (mg/l)	O/G (mg/l)	TKN (mg/l)
Large	1	7.5	618	1230	388	141	92
	2	7.2	684	1341	442	138	97
Medium	1	6.9	615	1337	235	78	63
	2	7.1	480	1053	232	153	51
Small	1	7.4	539	1212	417	167	56
	2	7.3	782	1600	305	167	86

The calculated specific pollution load in terms of kg of pollutant per ton of fish processed is shown in the following table:

Category	Units	Specific Pollution Load (Kg/Ton)				
		BOD	COD	TSS	O/G	TKN
Large	1	2.7	5.4	1.7	0.62	0.40
	2	3.2	6.2	2.0	0.65	0.45
Medium	1	5.3	11.5	2.0	0.70	0.55
	2	3.2	6.9	1.5	0.50	0.33
Small	1	3.5	7.3	2.5	1.00	0.33
	2	3.9	8.0	1.5	0.58	0.43

The variations in the specific pollution load is due to:

— The number of washing stages practiced resulting in the wastewater characteristics and pollution load variation from unit to unit.

— Handling techniques practiced for transport of shrimps within the plant i.e. usage of water for transport or dry handling techniques.

— In fish processing industry pollution load is directly related to amount of water used for washing of fishes during various operations.

3.7.2 Specific Wastewater and Pollution Load Generation Factor

For the purpose of evolving specific pollution load generation factor applicable for frozen shrimp processing sector, where basic unit operations followed are same for all the categories, it is recommended to adopt the average of the factors computed for all units monitored and given below:

Freshwater consumption (m^3/ton)	Wastewater generation (m^3/ton)	BOD load (kg/ton)	COD load (kg/ton)
6.6	5.9	3.6	7.6

3.8 SEA FOOD PROCESSING

3.8.1 Wastewater Characteristics

Composite wastewater samples of the combined wastewater were collected at 30 minutes interval. In case of batch discharges samples were collected from individual sources and flow proportionate composite samples were prepared and analysed for pH, BOD, COD, TSS, O/G, and Total Kjeldahl Nitrogen (TKN). Similar to slaughter houses and meat processing in sea-food processing units also there is no addition of chemicals in the process, therefore, the parameters like TDS, % Sodium, Sulphate and Chloride etc. are not relevant hence not analysed. The wastewater characteristics are presented in the following table:

Category	Units	pH	BOD (mg/l)	COD (mg/l)	TSS (mg/l)	O/G (mg/l)	TKN (mg/l)
Cephalopods	1	6.9	708	1686	265	60	70
	2	7.2	588	1376	320	60	73
Fresh fish	1	7.3	288	532	192	83	47
	2	7.4	576	1412	193	101	132

The calculated specific pollution load in terms of Kg of pollutant per Ton of fish processed is shown in the following table:

Category	Units	Specific Pollution Load (Kg/Ton)				
		BOD	COD	TSS	O/G	TKN
Cephalopods	1	4.0	9.6	1.5	0.40	0.40
	2	4.4	10.3	2.4	0.45	0.55
Fresh fish	1	0.8	1.4	0.5	0.22	0.13
	2	1.4	3.5	0.5	0.25	0.33

The higher specific pollution load in cephalopod processing is due to:

— Waste contribution from ink glands is peculiar of cephalopod processing.

— Thawing of freeze raw material contributes additional pollution load.

— In fish processing industry pollution load is directly related to amount of water used for washing of fishes during various operations, due to more washing stages practiced. The pollution load from cephalopods is higher.

— Usage of water for transport of cephalopods within the plant, compared to dry handling of fresh fishes generates additional pollution load.

3.8.2 Specific Wastewater and Pollution Load Generation Factor

Cephalopods

For the purpose of evolving specific pollution load generation factor applicable for cephalopod processing sector it is recommended to adopt the average of the factors computed for the units monitored as given below:

Freshwater consumption (m^3/ton)	Wastewater generation (m^3/ton)	BOD load (kg/ton)	COD load (kg/ton)
7.1	6.6	4.2	10.0

Fresh frozen fishes

For the purpose of evolving specific pollution load generation factor applicable for fresh fish processing sector it is recommended to adopt the average of the factors computed for the units monitored as given below:

Freshwater consumption (m^3/ton)	Wastewater generation (m^3/ton)	BOD load (kg/ton)	COD load (kg/ton)
2.8	2.6	1.1	2.5

CHAPTER 4

EXISTING WASTEWATER TREATMENT & DISPOSAL

SOLID WASTE GENERATION

POLLUTION ABATEMENT MEASURES

4.1 BOVINES

4.1.1 Existing Wastewater Treatment and Mode of Effluent Disposal

During the surveys it was observed that only three modern slaughter houses have some wastewater treatment facility. All other slaughter houses discharge their wastewater without any treatment either into domestic sewer or on land. Performance evaluation of the only operational wastewater treatment plant (Physico-chemical treatment followed by single stage activated sludge process), was carried out and presented below:

Parameter	Influent	Effluent	% Removal
BOD (mg/l)	1750	130	92
COD (mg/l)	3539	300	91
TSS (mg/l)	875	105	88
O/G (mg/l)	219	10	95

4.1.2 Solid Waste Generation

Based on the data collected during the survey, the solid waste quantity and specific solid waste generation kg/head slaughtered and kg/ton live weight killed is shown below:

Category	Unit	Solid Waste Ton/Day	Specific Solid Waste	
			Kg./Head	Kg./TLWK
Large	1	200	93	270
	2	41	82	270
Medium	1	7	90	250
	2	5	106	300
Small	1	0.5	100	250
	2	2.8	80	320

Average solid waste generation from Bovine slaughter houses is 275 kg/TLWK equivalent to 27.5% of the liveweight of the animal.

In large scale Bovine slaughter houses the entire solid waste is collected and disposed off as land fill, whereas in medium & small scale slaughter houses dung and rumen digesta is collected separately for composting by contractors and non-edible offals are dumped around slaughter houses which is partly consumed by scavangers.

4.1.3 Pollution Abatement Measures

Effective segregation of wastes like blood, offals, stomach contents etc., and their subsequent utilisation for manufacture of pharmaceuticals/chemicals, cattle feed, manure etc., will reduce the pollution load from slaughter houses substantially as discussed below:

— The major pollutant from the slaughtering operation is Blood which constitute 4—6% of liveweight killed of animal and having BOD concentration of 1,50,000 to 2,00,000 mg/l. Proper collection and dry handling of blood i.e. dried for use as an animal feed supplement or fertilizer will not only reduce the water requirement for cleaning of killing area but also will reduce the total BOD load by approximately 20%.

— Discharge of stomach content in wastewater results in substantial increase in TSS and BOD & COD load. Dry handling of stomach contents i.e. proper collection and offsite disposal as fertiliser or soil conditioner by farmers will eliminate this pollution load.

— Dry handling of inedible offals viz. intestine, oesophagus, bladder and hair etc. will reduce TSS and BOD & COD load substantially in the wastewater stream.

— Collection of solids from dressing and eviscerating areas and their subsequent reuse as by product will reduce the organic and solid waste loads substantially.

4.2 GOAT AND SHEEP

4.2.1 Existing Wastewater Treatment & Disposal

Majority of all slaughter houses (Goat & Sheep) dispose their untreated wastewater either into the Municipal sewerage system or on land. A few had a chemical coagulation & flocculation system for treatment of the slaughtering waste. The wastewater after physico-chemical treatment is discharged into Municipal sewer.

4.2.2 Solid Waste Generation

Based on the data collected during the survey, the solid waste quantity and specific solid waste generation kg/head slaughtered and kg/ton live weight killed is shown below:

Unit Nos.	Solid Waste Ton/Day	Specific Solid Waste	
		Kg./Head	Kg./TLWK
1	2.5	2.5	167
2	2.0	2.5	167
3	0.14	2.6	173

The average specific waste generation (kg/ton of live weight killed) is calculated as 170 kg. In large scale Goat & Sheep slaughter houses the method of disposal followed is mostly as land fill whereas in small & medium scale slaughter houses it is dumped around slaughter house which is partly consumed by scavangers.

4.2.3 Pollution Abatement Measures

In order to develop the most economic pollution control solution in terms of investment and operational costs, it is recommended that pollution abatement measures at source should be introduced prior to installation of treatment systems. Feasibility of various in-plant pollution abatement measures were assessed and are given below:

Effective segregation of wastes like blood, offals, stomach contents etc., and their subsequent utilisation for manufacture of pharmaceuticals/chemicals, cattle feed, manure etc., will reduce the pollution load from slaughter houses substantially as discussed below:

- Blood constitutes the major source of BOD from the slaughtering operation, therefore, proper collection and dry handling of blood will reduce the total wastewater pollution load by approximately 20%.
- Intestines used as casings for sausages are emptied, deslimed and washed. Dry rendering of intestinal content will reduce the pollution load substantially. Rendering is a heating process for meat industry waste whereby fats are separated from water and protein residue. In-edible rendering is carried out by means of dry processes i.e. no direct contact between steam and raw material. These may be either batch or continuous process where indirect heating is used. As a result process waste load is limited to material moisture content only.
- Separation of solids from wastewater stream by screening within the unit and their subsequent reuse as by-product will reduce the BOD & COD load and TSS load.
- Application of dry cleaning methods viz. scrubbing, brooming etc. should be adopted before wet cleaning of processing area, equipments etc.

4.3 PIGS

4.3.1 Majority of all Pig slaughter houses, dispose their untreated wastewater either into the Municipal sewerage system or on land. In Unit 1 wastewater after biological treatment (stabilisation pond) is discharged on land for irrigation. Unit 2 is having a chemical coagulation & flocculation system providing partial treatment of the wastewater before discharging into Municipal sewer. Performance evaluation of the wastewater treatment system of unit-1 was carried out and presented below:

Parameter	Influent	Effluent	% Removal
BOD (mg/l)	780	205	74
COD (mg/l)	1639	430	74
TSS (mg/l)	578	95	84
O/G (mg/l)	154	16	90

4.3.2 Solid Waste Generation

The skin, head, feet and tail form part of the carcass. Secondly, pig consumes more concentrated type of food, omnivorous rather than herbivorous, it is provided with a simple stomach, which is small as compared with the ruminant. In addition offals like intestine and stomach are edible. Due to these reasons, the specific solid waste generation kg/ton of live weight killed is much less in comparison to Bovines and Goat/Sheep slaughter houses.

Based on the data collected the solid waste quantity generated per day and the computed specific solid waste generation in kg/head slaughtered and kg/ton live weight killed is shown below:

Unit Nos.	Solid Waste Ton/Day	Specific Solid Waste	
		Kg./Head	Kg./TLWK
1	0.2	1.8	30
2	0.5	2.5	50
3	0.1	2.7	45
4	0.02	2.0	33

The average specific waste generation (kg/head of live weight killed) is calculated as 2.3 kg equivalent to 4% of the live weight of the animal.

Solid waste from Pig slaughter houses is collected by contractors for rendering into fat.

4.3.3 Pollution Abatement Measures

Specific BOD load from Pig slaughter house in European countries is reported to be in the range of 9—12 kg/TLWK compared to about 22 kg/TLWK in India. Waste load reduction can be achieved by:

- Effective handling & recovery of blood which constitute more than 30% of the total organic pollution load.
- Provision of perforated drain pipe in the scalding tub to prevent draining of sludge/solids. The collected sludge should be disposed off as solid waste.
- Segregation and dry handling of intestinal and stomach contents.
- Separation of hairs and solids from eviscerating wastewater by screening and their subsequent reuse as by-product.
- Dry sweeping of processing area, tables and equipment before wet washing.

Specific wastewater generation in Indian Pig slaughter houses is in the range of 5—19 m^3 compared to 1.2—4 m^3 in European countries like F.R.G., indicating tremendous scope for water conservation. Minimisation of water consumption will effectively reduce the size of the treatment facilities required thereby lowering capital and operating costs for on-site treatment. Water consumption can be reduced by:

— Installation of valves to regulate the flow in the wash water line.

— Installation of self closing valves in water hose/pipes to reduce careless water loss.

— Redesign of carcass washing facility i.e. modification of the water spray system.

— Reuse of process water from cleaner area to progressively dirtier areas e.g. carcass wash water can be reused for dehairing operation.

— Dry clean up operations followed by wet washing.

4.4 POULTRY

4.4.1 During the surveys it was observed that only one unit had a wastewater pre-treatment system, all other slaughter houses discharge their wastewater on land without any treatment. This unit is having a chemical coagulation and flotation system providing partial treatment of the slaughtering waste. The wastewater after physico-chemical treatment is used for agricultural purposes. Performance evaluation of the wastewater treatment system of this unit is presented below:

Parameter	Influent*	Effluent	% Removal
BOD (mg/l)	1102	315	71
COD (mg/l)	2410	670	74
TSS (mg/l)	482	130	73
O/G (mg/l)	190	34	82

* combined wastewater from slaughter house and meat processing section.

4.4.2 Solid Waste Generation

Based on the survey carried out, the solid waste quantity and specific solid waste generation kg/head slaughtered and kg/ton live weight killed are presented below:

Unit Nos.	Solid Waste Ton/Day	Specific Solid Waste	
		Kg./Head	Kg./TLWK
1	1.0	0.12	125
2	0.05	0.11	110
3	0.03	0.12	120

The average specific waste generation (kg/head of live weight killed) is calculated as 0.12 kg equivalent to 12% of the live weight of the bird.

Presently the method of disposal of solid waste followed by the slaughter houses is land fill alongwith Municipal garbage.

4.4.3 Pollution Abatement Measures

During the industrial survey feasibility of various in-plant water conservation and pollution abatement measures were assessed and are given as below:

Water conservation areas are:

— Installation of self closing valves in water hose/pipe can reduce the total water consumption upto 50%.

— Feather flume water may be screened for feather recovery and recycled for flume usage for offal carrying flume.

— Recycle of screened chiller overflow water for scald tank makeup water or the feather flume.

— Water conserving nozzles should be used for carcass washing operations, to minimize water consumption.

— Evisceration solids (offals) should be carried away by timed flushing spray rather than by continuous flow.

Pollution load from Poultry slaughtering units can be substantially reduced by effective segregation of blood, feathers and non-edible offals and their subsequent utilization as proteinaceous supplement for animal feed. Some of the pollution abatement measures are mentioned below:

— Organisation of deliveries to co-ordinate with processing capacity in order to reduce pollution load in receiving area.

— Blood constitutes the major source of BOD in all the poultry processing units. It is estimated that potential raw waste load from uncontrolled blood sewering is approximately 7.9 kg BOD per 1000 chicken slaughtered. Proper collection (appoximately 50%) and dry handling of blood will result in about 20% reduction in the waste load.

— To collect sludge at the bottom for disposal as solid waste, a tank drain equipped with screen or perforated riser as mentioned for scald tank in pig slaughtering should be provided. It has reported that waste load from scalding operation ranges from 1.0 to 5.4 kg BOD per 1000 birds slaughtered.

— Dry handling of feathers and offals will reduce pollution load considerably.

— Separation of solids from wastewater stream by screening within the unit and their subsequent reuse as by-product will reduce the organic and solid waste.

4.5 FROZEN MEAT

4.5.1 Except for Unit 1 of large scale category, all other units dispose their untreated wastewater either into the Municipal sewerage system or on land for irrigating. In Unit 1 large category waste water after biological treatment (conventional aerobic treatment) is discharged to Municipal sewer.

4.5.2 Solid Waste Generation

Based on the data collected during the survey, the solid waste quantity (including bones and waste meat) generated per day and the computed specific solid waste generation in ton/ton of frozen meat is shown below:

Category	Unit No.	Solid Waste Ton/Day	Specific Solid Waste Ton/Ton of Product
Large	1	22.0	1.1
	2	30.0	1.0
Medium	1	5.5	1.2
	2	17.5	1.3
Small	1	8.0	1.0
	2	3.0	1.1

The average specific solid waste generation (ton/ton of finished product) is calculated as 1.1 ton. Bones are sold to bone mills for subsequent production of glue, gelatine, tallow etc, and the waste meat and fat trimmings are sold to various agencies for manufacturing chicken feed. Only soiled/moist packing material is disposed off as solid waste into Municipal garbage collection system.

4.5.3 Pollution Abatement Measures

During the industrial survey feasibility of various in-plant water conservation and pollution abatement measures were assessed and are given below:

— Installation of self closing valves in water hose/pipe can reduce the total water consumption upto 20%.

— Reuse/recycle of cooling tower discharge for floor, table and tray washings.

Pollution load from frozen meat units can be reduced by:

— Screening and segregation of solids from wastewater for manufacture of poultry feed.

— Recovery of fatty matter (tallow) as raw material for the chemical/soap industry.

— Dry clean up operations followed by wet washing.

4.6 PROCESSED MEAT

4.6.1 Except for Units 1 & 2 of class-A category, which were studied indepth, all other units dispose their wastewater either into the Municipal sewer system or on land for irrigating without any treatment. Unit 1 is having a chemical coagulation and flocculating system providing partial wastewater treatment. In Unit 2 wastewater after biological treatment (Stabilisation pond system) is discharged onto land for irrigation purposes.

4.6.2 Solid Waste Generation

Based on the data collected during the survey, the solid waste quantity (including bones and waste meat) generated per day and the computed specific waste generation in ton/ton of processed meat is shown below:

Category	Unit No.	Solid Waste Kg./Day	Specific Solid Waste Kg./Ton of Product
Class-A	1	500.0	91.0
	2	600.0	300.0
	3	300.0	300.0
Class-B	1	20.0	67.0
	2	10.0	67.0
Class-C	1	10.0	42.0
	2	6.0	40.0
	3	5.0	50.0

The average specific solid waste generation (kg/ton of finished product) for class-A category 300 kg excluding Unit 1 processing exclusively poultry. For class B & C average specific load is 67 & 44 kg respectively. Solid waste is disposed off into Municipal garbage collection system.

4.6.3 Pollution Abatement Measures

During the industrial survey feasibility of various in-plant water conservation and pollution abatement measures were assessed and are given as below:

— Installation of self closing valves in water hose/pipe can reduce the total water consumption upto 20%.

— Reuse/recycle of defrost and retorting discharge for floor, table and tray washings.

Pollution load from frozen meat can be reduced by:

— Screening and removal of solids from the wastewater for manufacture of animal feed.

— Recovery of fatty matter (tallow) as raw material for the chemical/soap industry.

4.7 SHRIMP PROCESSING

4.7.1 Almost all the units dispose their untreated wastewater either into the Municipal sewerage system or into back waters.

4.7.2 Solid Waste Generation

Based on the data collected during the survey, the solid waste quantity generated per day and the computed specific solid waste generation in ton/ton of finished product is shown below:

Category	Unit No.	Solid Waste Ton/Day	Specific Solid Waste Ton/Ton of Product
Large	1	9.0	0.45
	2	4.0	0.50
Medium	1	0.6	0.50
	2	0.3	0.50
Small	1	0.16	0.53
	2	0.32	0.46

The average specific solid waste generation (ton/ton of finished product) is calculated as 0.49 ton equivalent to 49% of the live weight fish processed. Peels alongwith soiled/moist packing material is disposed off as solid waste into Municipal garbage collection system.

4.7.3 Pollution Abatement Measures

During the industrial survey feasibility of various in-plant water conservation and pollution abatement measures were assessed and are given as below:

— installation of self closing valves in water hose/pipe can reduce the total water consumption upto 20%.

— Reuse/recycle of defrosting discharge for floor, table and tray washings.

Pollution load from frozen shrimp sector can be reduced by:

— Proper screening of wastewater and subsequent reuse of screened material for making fish meal.

— Prevention of disposal of peeled and deveined waste into wastewater stream.

— Proper collection, storage and reuse of peeled shells for preparation of by-product viz. chitin, chitosen etc.

4.8 CEPHALOPODS PROCESSING

4.8.1 Most of the units dispose their untreated wastewater either into the Municipal sewerage system or into back waters.

4.8.2 Solid Waste Generation

Based on the data collected during the survey, the solid waste quantity generated per day and the computed specific solid waste generation in kg/ton of finished product is shown below:

Category	Unit No.	Solid Waste Ton/Day	Specific Solid Waste Kg./Ton of Product
Cephalopods	1	0.65	157
	2	0.60	150
Fresh fish	1	0.90	200
	2	0.50	163

The average specific solid waste generation (kg/ton of finished product) for cephalopods is calculated as 153 kg (equivalent to 15% of the live weight) and 181 kg for fresh fishes (equivalent to 18% of liveweight) respectively. Solid waste alongwith soiled/moist packing material is disposed off into the Municipal garbage collection system.

4.8.3 Pollution Abatement Measures

During the industrial survey the feasibility for various in plant water conservation and pollution abatement measures were assessed and are given as below:

— Installation of self closing valves in water hose/pipe can reduce the total water consumption upto 20%.

— Reuse/recycle of defrosting discharge for floor, table and tray washings.

Pollution load from frozen cephalopod processing sector can be reduced by:

— Proper screening of wastewater and subsequent reuse of screened material for making fish meal.

— Prevention of disposal of ink gland into wastewater stream.

— Proper collection, storage and conversion of viscera, liver, skin, pen and eyes into squid meal.

CHAPTER 5

STANDARDS

SELECTION OF PARAMETER FOR STANDARDS

Wastewater from the slaughter house, meat and seafood processing units is biodegradable in nature. BOD, COD, S.S, O&G and pH are the basic pollutants generated by this sectors. All these basic pollutants are inter-related and their concentration in the wastewater is dependent on the organic matter content (both soluble and suspended portions). Since BOD is a measure of easily biodegradability of the organic matter which is important for the water quality of the recepient. it is more pragmatic to control the effluent quality in terms of BOD. Considering the easily biodegradable nature of the wastewater from this sector, the disposal levels of other parameters will be within the acceptable limits as long as recommended disposal limit of BOD is achieved.

5.1 CATEGORIZATION OF THE UNITS FOR DEVELOPING STANDARDS

Effluent standards for the following three categories of slaughter houses sector are evolved:

Category-A : Large scale slaughter houses slaughtering > 40,000 Bovines and 6,00,000 Goats & Sheeps annually having an average slaughtering capacity of 140 Bovines and 2000 Goats & Sheeps/day.

Category-B : Medium scale slaughter houses slaughtering > 10,000 Bovines and 1,00,000 Goats & Sheeps annually having an average slaughtering capacity of 30 Bovines and 300 Goats & Sheeps/day.

Category-C : Small scale slaughter houses slaughtering > 1,000 Bovines and 15,000 Goats & Sheeps annually having an average slaughtering capacity of 4 Bovines and 50 Goats & Sheeps/day.

The characteristics of wastewater discharged from meat processing Units are as follows:

	Wastewater Characteristics		
Parameters	Large	Medium	Small
Flow, m^3/d	154	21.2	4.0
BOD, mg/l	3364	4875	3990
COD, mg/l	7027	9480	8090
TSS, mg/l	2533	2053	2288
Oil & Grease (mg/l)	155	727	577

Since most of the slaughter houses in India are composite ones i.e. slaughtering Bovines as well as Goats & Sheeps, the wastewater characteristics of both Bovines and Goat & Sheeps have been computed for the purpose of developing standards for category A, B & C of slaughter houses.

Pig and Poultry slaughtering is not done in organised public slaughter houses. Pigs are normally slaughtered in piggery farms whereas Poultry is killed and dressed as per consumer direction by the dealer. However, Class-A pig and poultry processing units have their own slaughter houses, therefore, Pig and Poultry slaughter houses are accounted while evolving standards for class-A meat processing units. No separate standards for Pigs and Poultry slaughter houses are, therefore, required.

5.1.1 Standards for Slaughter House - Large (Category-A)

The daily BOD load from representative large scale (Category-A) slaughter houses is calculated as 518 kg (154 m^3 x 3.364 kg/m^3) equal to a population equivalent of 11.511 (1 PE = 45 gms BOD/day).

Most of the large scale slaughter houses in metropolitan cities are located in very congested areas having space just sufficient to kill and dress animals therefore, indicating that full scale unit level treatment is not feasible. Hence, the slaughter houses having sewer connection and subsequently a terminal wastewater treatment plant should discharge their wastewater after proper screening and removal of free floating oil & grease into the municipal sewer. However, the units without sewer connection should treat their wastewater before disposal.

Best Practicable Treatment System Alternatives:

A schematic flow diagram of this treatment system is shown in Fig 5.1 (a) as alternative—3. This system can achieve a BOD of 30 mg/l. The calculated investment and annual operating cost and the annualised costs for this system are shown in Table 5.1 (A). Since the annualised treatment costs for this wastewater treatment system is 69% of the total annual slaughtering fee collection. This system is economically not feasible and hence not recommended.

Two other technically feasible treatment alternatives were evaluated: Schematic diagram of these are depicted in Figure 5.1(A).

Alternative 1:

Consists of the following units:

— Self cleaning screen

— Anaerobic treatment by anaerobic pond followed by

— Aerobic treatment aerated in an aerated lagoon with 0.2 kg BOD/m^3/d^{-1}, followed by polishing pond.

TABLE 5.1 (A)

Investment, Annual Operating and the Annualised Costs for two stage activated sludge process wastewater treatment (Slaughter House—large)

(Annual Slaughtering Fee = Rs. 17 Lakhs)

All values in Rupees

Particulars	Cost Details for 70 TLWK/D Unit
Investment Cost	
1) Civil	6,60,000
2) Mechanical	10,00,000
3) Elec & Piping	3,32,000
Total with 20% contingencies	19,92,000
Annual Operating Cost	
1) Energy	6,00,000
2) Manpower	66,000
3) Chemicals	74,000
4) O&M Cost	40,000
Total	7,80,000
Operating Cost as % Slaughtering Fees	46.0
Annualised Costs % Slaughtering Fees	69.0

Alternative 2:

Consists of the following units:

— Self cleaning screen

— Anaerobic treatment by anaerobic pond

— Aerobic treatment of the above treated wastewater in a single stage activated sludge process (extended aeration type with F/M ratio 0.25 day^{-1})

The excess sludge produced from the treatment system will be conditioned using Lime & Ferric Chloride and dewatered in a PLate & Frame type Filter Press system.

For supply of oxygen at the activated sludge process, diffused type aeration system is most appropriate compared to surface aeration due to:

— Seasonal variations in slaughtering (e.g. slaughtering is done in 2 shifts/day for 5 months during winter and 1 shift/day for 5 months during summer), requiring high operational flexibility for controlling oxygen supply. Such flexibility is not economically feasible with a surface aeration system.

— Aerosol problems associated with surface aeration, which is not recommended for slaughter houses on hygienic grounds.

However, the aeration system for the aerated lagoon will consist of floating tripoid mounted low speed type flow surface aerator.

With the above considerations, two treatment alternatives have been evaluated for achieving a final treated effluent BOD level of 100 mg/l. The estimated capital investment, annual operating costs and annualised costs for various alternatives providing a final effluent BOD level of 100 mg/l are shown in Table—5.1 (B).

TABLE 5.1 (B)

Investment, Annual Operating Costs and the Annualised Costs for Wastewater Treatment Alternatives (Slaughter Houses—Large)

(Annual Slaughtering Fee = Rs. 17 Lakhs)

All values in Rupees

Particulars		Cost Details for 70 TLWK/D Unit	
		ALT-1	ALT-2
Investment Cost			
1)	Civil	3,00,000	4,50,000
2)	Mechanical	4,12,000	5,54,000
3)	Elec & Piping	82,000	1,00,000
	Total with 20% Contingencies	9,53,000	13,25,000
Annual Operating Cost			
1)	Energy	1,39,000	2,10,000
2)	Manpower	44,000	44,000
3)	Chemicals	—	25,000
4)	O & M Cost	20,000	28,000
	Total	2,03,000	3,07,000
Operating Cost as % Turnover		12.0	18.06
Annualised Costs % Slaughtering Fees		20.0	28.0

The annualised costs of the individual alternatives which achieve a final treated effluent BOD of 100 mg/l have been computed to be below 30% of the annual slaughtering fee, indicating economic viability of the treatment alternatives. Although alternative 1 requires the least overall annualised and annual operating cost, the land requirement is higher than for alternatives 2.

Best Practicable Treatment System for Slaughter Houses—Large Scale (Category-A)

Since the annualised costs for installation of alternative-1 is within the economic viability of the units, this treatment system producing a final treated effluent BOD concentration of 100 mg/l is recommended.

Hence the best practicable treatment scheme will consist of screening followed by anaerobic pond treatment with a subsequent aerobic treatment in a single stage activated sludge process system.

The excess biomass/sludge produced from the activated sludge process should be dewatered using a Filter press system. Installation of a sludge drying bed for dewatering purpose is not recommended because of large area requirement and generation of odour/unhygienic conditions, which is not acceptable in the slaughter house. In addition, cost comparison shows that the investment requirements for a sludge drying bed is equal to that of an effective filter press system.

A treatment system with the above measures will result in the following final treated effluent characteristic:

BOD	—	100 mg/l
TSS	—	100 mg/l
Oil & Grease	—	10 mg/l

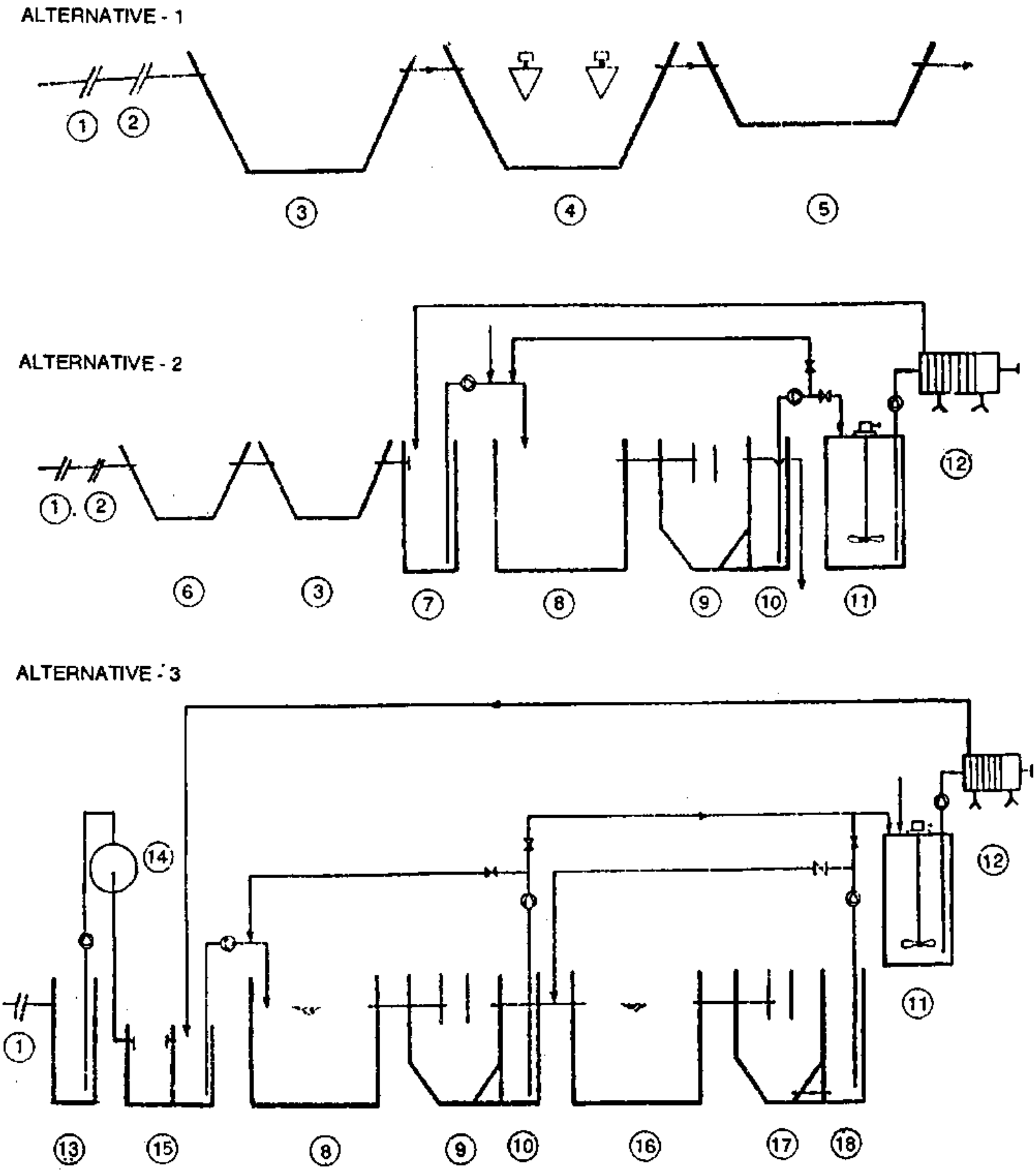
The above figure is adopted as effluent disposal standards for large scale slaughter houses not connected to sewer.

5.1.2 Standards for Slaughter Houses Units (Medium & Small): Category-B & C

The daily BOD load from representative medium and small scale slaughter houses category - B & C is calculated as 103 kg (21.2.m^3 x 4.875 kg/m^3) and 16.0 kg (4.0 m^3 x 3.99 kg/m^3) equal to a population equivalent of 2289 & 355 respectively (1 PE = 45 gms BOD/day).

The medium & small scale slaughter houses are located either in small cities or towns. Most of these slaughter houses are more than 50 years old and do not have the basic facilities like adequate slaughtering floor, proper roofing, sufficient land, power and water supply. In such cases installation of the proposed treatment system to achieve value based standards may not be feasible. Therefore, the effort should be to minimise the pollution generation by providing adequate basic facilities like stockyard, lairage, raceways, sticking area, dressing floor, water supply, effluent disposal etc. required for a slaughter house.

For the slaughter houses (modernised) connected to a sewer system discharge of the wastewater into the sewer should be allowed after proper screening and free floating oil & grease removal. However, the units without sewer connection should treat their wastewater before disposal.



LEGENDS

1 - BAR SCREEN COARSE	10 - SLUDGE SUMP
2 - BAR SCREEN FINE	11 - CONDITIONING TANK
3 - FOCULTATIVE POND	12 - FILTER PRESS
4 - AERATED LAGOON	13 - PUMP SUMP FOR SELF CLEANING SCREEN
5 - POLISHING POND	14 - SELF CLEANING SCREEN
6 - ANAEROBIC LAGOON	15 - OIL & GREASE TRAP
7 - PUMP SUMP	16 - AERATION TANK
8 - AERATION TANK	17 - SEDIHENTATION TANK
9 - SE DIHENTATION TANK	18 - SLUDGE SUMP

TREATMENT ALTERNATIVES SLAUGHTER HOUSE LARGE

FIGURE 5.1. (a) PROCESS FLOW DIAGRAM

Best Practicable Treatment System

Medium and small scale slaughter houses are generally not operated and maintained by municipal corporations and because of non-availability of power, a pond system is the only technically feasible treatment alternatives. Hence the following wastewater treatment system is recommended: installation of a two stage screening system (bar type) followed by anaerobic treatment in an anaerobic pond. The BOD removal efficiency of the anaerobic pond will be approximately 70%. Subsequently the wastewater is further treated in a facultative pond and polishing pond to achieve a final BOD concentration of $\leq$ 500 mg/l.

A treatment system with the above measures will result in the following final treated effluent characteristic:

BOD = 500 mg/l

The above figure is adopted as effluent disposal standards for medium & small scale slaughter houses not connected to sewer.

5.1.3 Summary of Recommended Effluent Disposal Standards

The effluent disposal standards for the slaughter house sector are as follows:

Category		BOD (mg/L)
Connected to Sewer		
—	Large Units (> 70 TLWK/D)	
—	Medium & Small Units 70 TLWK & below	Disposal via screen and oil & grease trap
Not connected to Sewer		
—	Large Units (> 70 TLWK/D)	100
—	Medium & Small Units 70 TLWK/D & below	500

5.1.4 Air Emission Standards

Slaughter Houses do not have process related air emissions. Only in modern slaughter houses air pollution is generated in the form of combustion products from oil fired package boilers. The existing boiler emission standards (prescribed by the Central Pollution Control Board,) are applicable.

5.2 EFFLUENT STANDARDS FOR MEAT PROCESSING INDUSTRIES

Effluent standards for the following six categories of the meat processing sector are evolved:

Frozen Meat

Category-A : Large scale units with a processing capacity of 7500 TPA of meat having an average processing capacity of 30 TDP.

Category-B : Medium scale units with a processing capacity of 3750 TPA of meat having an average processing capacity of 15 TPD.

Category-C : Small scale units with a processing capacity of 1250 TPA of meat having an average processing capacity of 5 TPD.

Processed Meat

Category-D : Class-A meat processing units having their own slaughter house and processing capacity of 500 TPA of processed meat with an average processing capacity of 2 TPD.

Category-E : Class-B meat processing units processing capacity of 65 TPA of processed meat having an average processing capacity of 0.25 TPD.

Category-F : Class-C meat processing units processing capacity of 50 TPA of processed meat having an average processing capacity of 0.20 TPD.

The characteristics of wastewater discharged from meat processing units are as follows:

Wastewater Characteristics

	Frozen Meat			Processed Meat		
Parameters	Large (30 TPD)	Medium (15 TPD)	Small (5 TPD)	Class-A (2 TPD)	Class-B (25 TPD)	Class-C (2 TPD)
Flow, m^3/d	57.0	28.5	9.5	58.2	2.2	1.3
BOD, mg/l	627	627	627	1550	830	2046
COD, mg/l	1449	1449	1449	3522	1812	4936
TSS, mg/l	305	305	305	812	1156	1222
Oil & Grease (mg/l)	123	123	123	90	129	140

5.2.1 Standards for Frozen Meat Processing—Large (Category-A)

The daily BOD load from representative large scale (category A) frozen meat processing units is calculated as 35.8 kg (57 m^3 x 0.627 kg/m^3) equal to a population equivalent of 796 (1 PE = 45 gms BOD/day).

Best Practicable Treatment System Alternatives

In order to arrive at the most economical wastewater treatment system, the following three technically feasible treatment alternatives were evaluated:

Alternative-1:

Consists of the following units:

— Self cleaning screen
— Oil & grease trap followed by flow equalisation tank
— Aerobic treatment of the above treated wastewater in a single stage activated sludge process (extended aeration type with F/M ratio 0.10 day^{-1}).

The excess sludge produced from the treatment system will be conditioned using Lime & Ferric Chloride and dewatered in a Plate & Frame type Filter Press system.

Alternative-2:

Consists of the following units:

— Self cleaning screen
— Oil & grease trap followed by flow equalisation tank
— Two stage aerobic treatment of the above pre-treated wastewater i.e. trickling filter followed by activated sludge process (extended aeration type with F/M ratio 0.20 day^{-1}).

The excess sludge produced from the treatment system will be conditioned using Lime & Ferric Chloride and dewatered in a Plate & Frame type Filter Press system.

Alternative-3:

Consists of the following units:

— Self cleaning screen
— Oil & grease trap followed by flow equalisation tank
— Two stage aerobic treatment of the above pre-treated wastewater i.e. activated sludge process (extended aeration type with F/M ratio 0.20 day^{-1}) followed by trickling filter

The excess sludge produced from the treatment system will be conditioned using Lime & Ferric Chloride and dewatered in a Plate & Frame type Filter Press system.

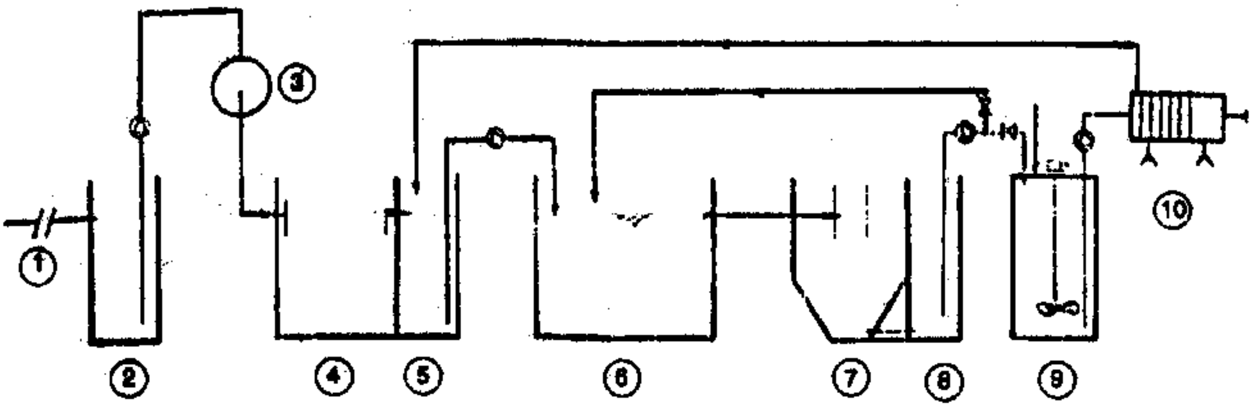
A schematic flow diagram for the above treatment alternatives is shown in Fig. 5.2 (a).

For supply of Oxygen, diffused type aeration system is most appropriate compared to surface aeration due to:

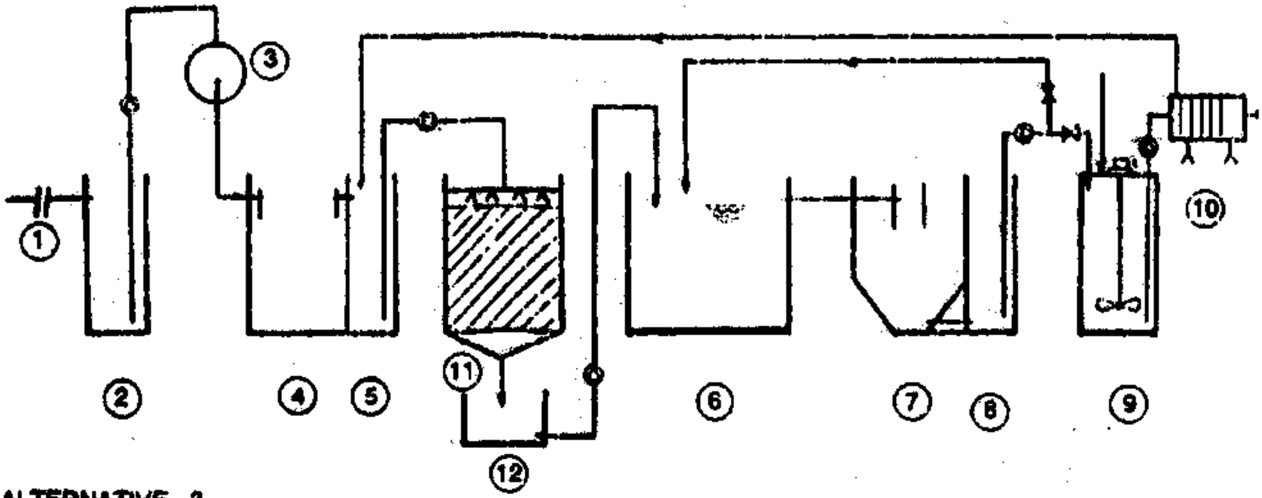
— Seasonal variations in plant operations (e.g. Units operate 2 shifts/day for 3 months and 1 shift/day for 5 months and no processing for 3-4 months), requiring high operational flexibility for controlling Oxygen supply. Such flexibility is not economically feasible with a surface aeration system.
— Aerosol problems associated with surface aeration, which is not recommended for Meat Processing Units on hygienic grounds.

With the above considerations three treatment alternatives are evaluated in respect of COD and effluent BOD achievable. The estimated capital investment and annual operating costs for various alternatives producing a final effluent BOD level of 30 mg/l are shown in Table 5.2 (A).

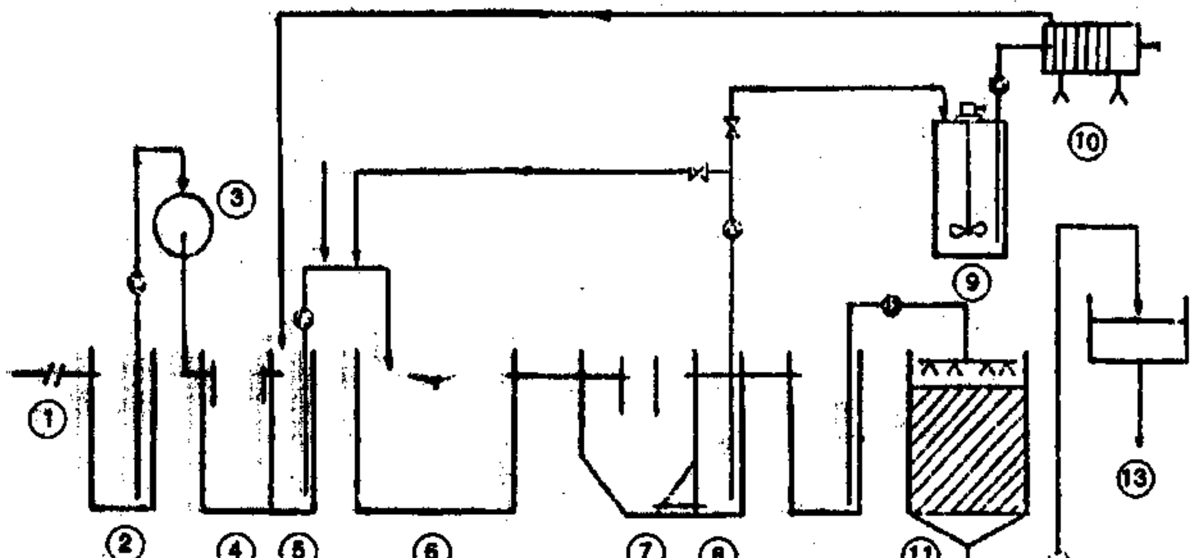
ALTERNATIVE - 1



ALTERNATIVE - 2



ALTERNATIVE - 3



LEGENDS

1 - BAR SCREEN
2 - PUMP SUMP FOR SELF CLEANING SCREEN
3 - SELF CLEANING SCREEN
4 - OIL & GREASE TRAP
5 - FLOW EQUILISATION SUMP
6 - AERATION TANK
7 - SEDIMENTATION TANK
8 - SLUDGE SUMP
9 - SLUDGE CONDITIONING TANK
10 - FILTER PRESS
11 - TRICKLING FILTER
12 - PUMP SUMP
13 - SAND BED FILTER

TREATMENT ALTERNATIVES FROZEN MEAT LARGE

FIGURE 5.2. (a) PROCESS FLOW DIAGRAM

TABLE 5.2 (A)

Investment and Annual Operating Costs for Various Wastewater Treatment Alternatives (Frozen Meat Large)

(Turnover of the Unit = Rs. 12.75 Crores)

All values in Rupees

Particulars		Cost Details for 30 TPD Unit		
		ALT-1	ALT-2	ALT-3
Investment Cost				
1)	Civil	1,94,000	7,53,000	4,00,000
2)	Mechanical	1,96,000	1,90,000	2,28,000
3)	Elec & Piping	40,000	38,000	1,26,000
	Total with 20% contingencies	5,16,000	11,77,000	7,55,000
Total Investment as % Turnover		0.40	0.92	0.60
Annual Operating Cost				
1)	Energy	1,17,000	91,000	99,000
2)	Manpower	22,000	22,000	22,000
3)	Chemicals	2,500	2,000	2,000
4)	O&M Cost	10,500	20,000	20,000
	Total	1,52,000	1,35,000	1,43,000
Operating Cost as % Turnover		0.12	0.11	0.11

The total investment costs of the individual alternatives for achieving a final treated effluent BOD of 30 mg/l has been estimated to be approximately 1% of the annual turnover, indicating economic viability of the treatment alternatives. The annual operating cost for all treatment alternatives are below 0.2% of the annual turnover. Although alternative 2 requires the least overall annual operating cost, the investment cost is highest of all alternatives. The difference in annual operating cost between alternatives 1 & 2 and 3 is only marginal and hence alternatives 2 & 3 requiring high investment are not recommended (The relatively high investment cost for alternative 2 & 3 is due to the trickling filter media cost).

Best Practicable Treatment System for Frozen Meat Processing Units—Large (Category-A)

Since the total investment required for installation of any of the above alternatives is within the economic viability of the units, a treatment system with a final treated effluent BOD concentration of 30 mg/l is recommended.

Among the various alterantives, alterantive-1 is most appropriate for the large category due to:

— Minimum land requirement.

— Overall investment cost is the least for achieving the same degree of BOD removal efficiency.

Hence the best practicable treatment scheme will consist of screening and oil & grease removal followed by biological treatment in a single stage activated sludge process system.

The excess biomass/sludge should be dewatered using a filter press system. Installation of a sludge drying bed for dewatering is not recommended because of large area requirement and generation of odour/unhygienic conditions which is not acceptable the meat processing industry. In addition, cost comparison shows that the investment requirements for a sludge drying bed is equal to that of an effective filter press system.

A treatment system with the above measures will result in the final treated effluent having a BOD concentration of 30 mg/l which is recommended as effluent disposal standard for large scale frozen meat processing Units.

5.2.2 Standards for Frozen Meat Processing Units (Medium & Small): Category-B&C

The daily BOD load from representative frozen meat processing—medium and small scale category - B&C is calculated as 18 kg (28.5 m^3 x 0.627 mg/m^3) and 6.0 kg (9.5 m^3 x 0.627 kg/m^3) equal to a population equivalent of 400 & 133 respectively (1 PE = 45 gms BOD/day).

Best Practicable Treatment System Alternatives

In order to arrive at the most economical wastewater treatment system, the following three technically feasible treatment alternatives were evaluated:

Alternative-1:

Consists of the following units:

— Self cleaning, screen

— Oil & grease trap followed by flow equalisation tank

— Aerobic treatment of the above treated wastewater in a single stage activated sludge process (extended aeration type with F/M ratio 0.10 day^{-1}).

The excess sludge produced from the treatment system will be conditioned using Lime & Ferric Chloride and dewatered in a Plate & Frame type Filter Press systems.

Alternative-2:

Consists of the following units:

— Self cleaning screen

— Oil & grease trap followed by septic tank as pre-treatment

— Aerobic treatment of the above treated wastewater in a single stage activated sludge process (extended aeration type with F/M ratio 0.20 day^{-1}).

The excess sludge produced from the treatment system will be conditioned using Lime & Ferric Chloride and dewatered in a Plate & Frame type Filter Press system.

Alternative-3:

Consists of the following units:

— Self cleaning screen
— Oil & grease trap followed by flow equalisation tank
— Anaerobic treatment in a anaerobic contact filter (ACF)
— Aerobic treatment of the above treated wastewater in a single stage activated sludge process (extended aeration type with F/M ratio 0.15 day^{-1}).

The excess sludge produced from the treatment system will be conditioned using Lime & Ferric Chloride and dewatered in a Plate & Frame type Filter Press system.

A schematic flow diagram of the above treatment alternatives is shown in Fig. 5.2(b).

For supply of oxygen, diffused type aeration system is most appropriate compared to surface aeration due to:

— Seasonal variations in plant operations (e.g. Units operate 2 shifts/day for 3 months and 1 shift/day for 5 months and no processing for 3-4 months), requires high operational flexibility for controlling oxygen supply. Such flexibility is not economically feasible with a surface aeration system.

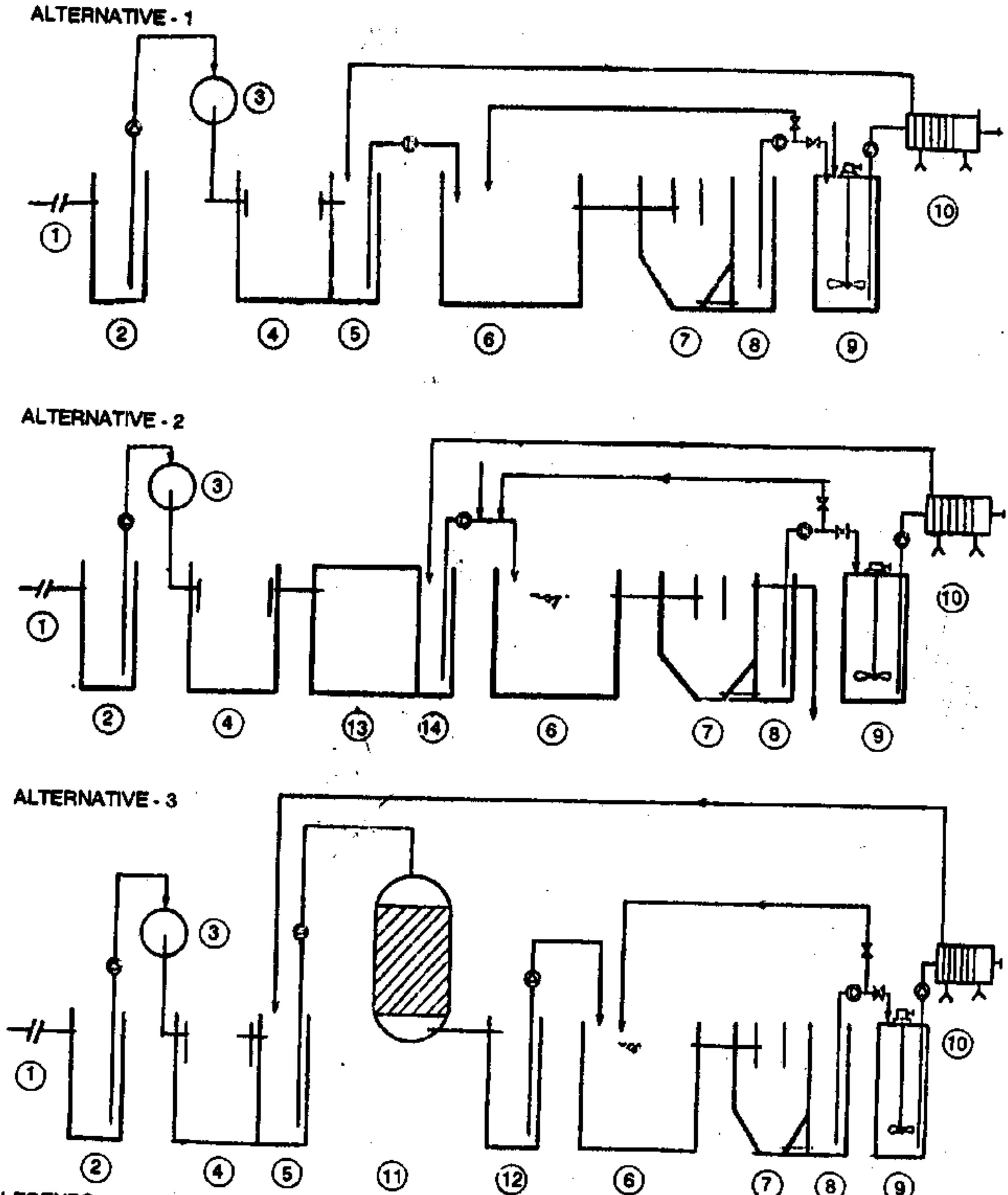
— Aerosol problems associated with surface aeration, which is not recommended for meat processing units on hygienic grounds.

With the above considerations, three treatment alternatives have been evaluated in terms of cost. The estimated capital investment and annual operating costs for various alternatives with final BOD level of 30 mg/l are shown in Table 5.2(B) and (C) respectively.

The total investment cost for the individual alternatives for category B&C has been estimated to be maximum 1.0% of the annual turnover, indicating economic viability of the treatment alternatives. The annual operating costs for all treatment alternatives are below 0.2% of the annual turnover. Lowest investment and overall annual operating costs are required for alternative - 2.

Best Practicable Treatment System for Frozen Meat Processing Units (Category-B&C)

Since the total investment required for installation of any of the above alternatives is within the economic viability of the Units, a treatment system producing a final treated effluent BOD concentration of 30 mg/l is recommended.



LEGENDS

1 - BAR SCREEN
2 - PUMP SUMP FOR SELF CLEANING SCREEN
3 - SELF CLEANING SCREEN
4 - OIL & GREASE TRAP
5 - FLOW EQUILISATION SUMP
6 - AERATION TANK
7 - SEDIHENTATION TANK
8 - SLUDGE SUMP
9 - SLUDGE CONDITIONING TANK
10 - FILTER PRESS
11 - ANAEROBIC CONTACT FILTER
12 - PUMP SUMP FOR AERATION TANK
13 - SEPTIC TANK
14 - PUMP SUMP FOR AERATION TANK

TREATMENT ALTERNATIVES FROZEN MEAT MEDIUM & SMALL

FIGURE 5.2. (b) PROCESS FLOW DIAGRAM

Among the various alternatives, alternative-2 is most appropriate for this category due to:

— Combination of anaerobic treatment in septic tank followed by a single stage activated sludge process assures operational simplicity and requires least maintenance.

— Required investment and annual operating costs are the lowest of all treatment alternatives evaluated for achieving the same degree of BOD removal efficiency.

Hence the best practicable treatment scheme will consist of screening, oil & grease removal, septic tank treatment followed by a single stage activated sludge process.

The excess biomass/sludge should be dewatered using filter press system. Installation of a sludge drying bed for dewatering purposes is not recommended because of large area requirement and generation of odour/unhygienic conditions, which is not acceptable in the meat processing industry. In addition, cost comparison shows that the investment required for a sludge drying bed is equal to that of an effective filter press system.

TABLE 5.2 (B)

Investment and Annual Operating Costs for Various Wastewater Treatment Alternatives (Frozen Meat Medium)

(Turnover of the Unit = Rs. 6.4 Crores)

All values in Rupees

Particulars	Cost Details for 15 TPD Unit		
	ALT-1	ALT-2	ALT-3
Investment Cost			
1) Civil	1,51,000	1,44,000	1,51,000
2) Mechanical	1,56,000	1,39,000	1,51,000
3) Elec & Piping	32,000	28,000	30,000
Total with 20% contingencies	3,70,000	3,49,000	4,04,000
Total Investment as % Turnover	0.58	0.55	0.63
Annual Operating Cost			
1) Energy	65,000	39,000	46,000
2) Manpower	22,000	22,000	22,000
3) Chemicals	1,000	1,000	1,000
4) O&M Cost	7,000	7,000	8,000
Total	95,000	69,000	77,000
Operating cost as % Turnover	0.15	0.11	0.12

TABLE 5.2 (C)

Investment and Annual Operating Costs for Various Wastewater Treatment Alternatives (Frozen Meat Small)

(Turnover of the Unit = Rs. 3.0 Crores)

All values in Rupees

Particulars		Cost Details for 5 TPD Unit	
	ALT-1	ALT-2	ALT-3
Investment Cost			
1) Civil	90,000	94,000	91,000
2) Mechanical	1,43,000	1,32,000	1,44,000
3) Elec & Piping	29,000	26,000	29,000
Total with 20% contingencies	3,15,000	3,03,000	3,17,000
Total Investment as % Turnover	1.05	1.01	1.06
Annual Operating Cost			
1) Energy	58,000	29,500	38,000
2) Manpower	22,000	22,000	22,000
3) Chemicals	1,000	500	1,000
4) O&M Cost	7,000	6,000	7,000
Total	88,000	58,000	68,000
Operating cost as % Turnover	0.29	0.20	0.23

A treatment system with the above measures will result in the final treated effluent having a BOD concentration of 30 mg/l which is recommended as effluent disposal standard for medium and small scale frozen meat processing Units.

5.2.3 Standards for Meat Processing Class-A (Category D)

The daily BOD load from representative pig meat and poultry meat processing units class-A is calculated as 90 kg (58.2 m^3 x 1.55 kg/m^3) and 166 kg (155 m^3 x 1.075 kg m^3) respectively, equal to a population equivalent of 2000 and 3689 respectively (1 PE = 45 gms BOD/day).

Best Practicable Treatment System Alternatives for Pig Meat Processing Units Class-A (Category D)

In order to arrive at the most economical wastewater treatment system, the following three technically feasible treatment alternatives were evaluated:

Alternative-1 :

Consists of the following units:

— Self cleaning screen

— Oil & grease trap followed by flow equalisation tank

— Aerobic treatment of the above treated wastewater in a single stage activated sludge process (extended aeration type with F/M ratio 0.10 day^{-1}).

The excess sludge produced from the treatment system will be conditioned using Lime & Ferric Chloride and dewatered in a Plate & Frame type Filter Press system.

Alternative-2 :

Consists of the following units:

— Self cleaning screen

— Oil & grease trap followed by septic tank as pre-treatment

— Aerobic treatment of the above treated wastewater in a single stage activated sludge process (extended aeration type with F/M ratio 0.10 day^{-1}).

The excess sludge produced from the treatment system will be conditioned using Lime & Ferric Chloride and dewatered in a Plate & Frame type Filter Press system.

Alternative-3 :

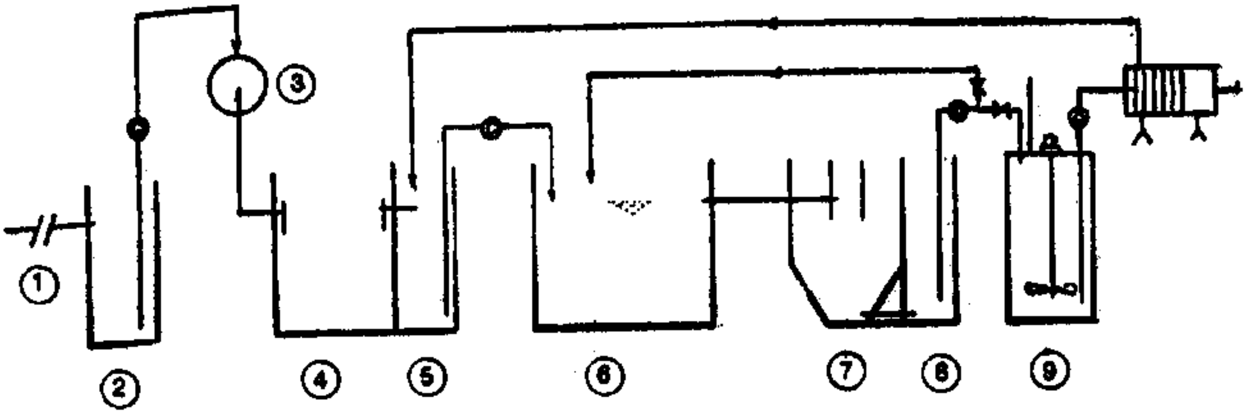
Consists of the following units:

— Self cleaning screen

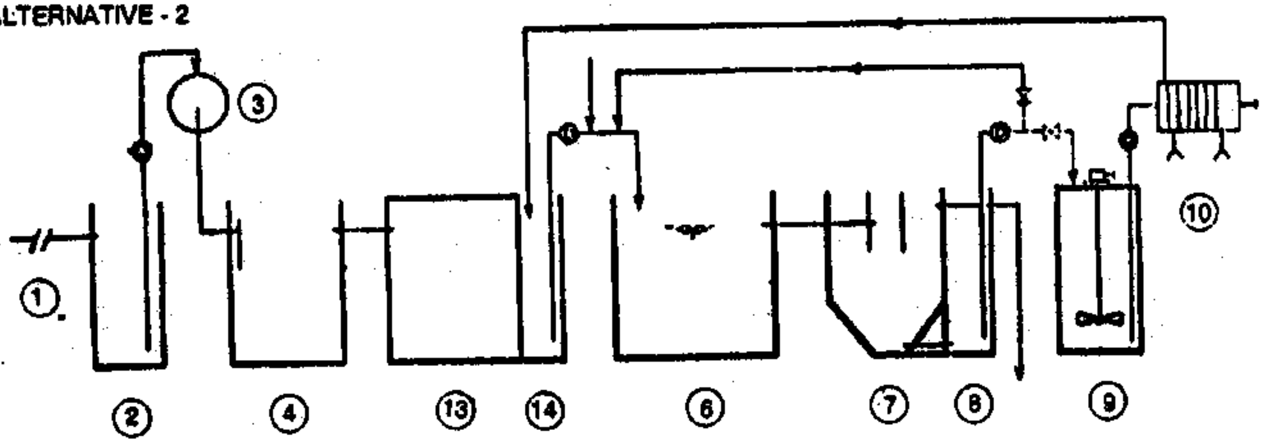
— Oil & grease trap

— Biological treatment in a facultative pond followed by single stage activated sludge process (extended aeration type with F/M ratio 0.15 day^{-1}).

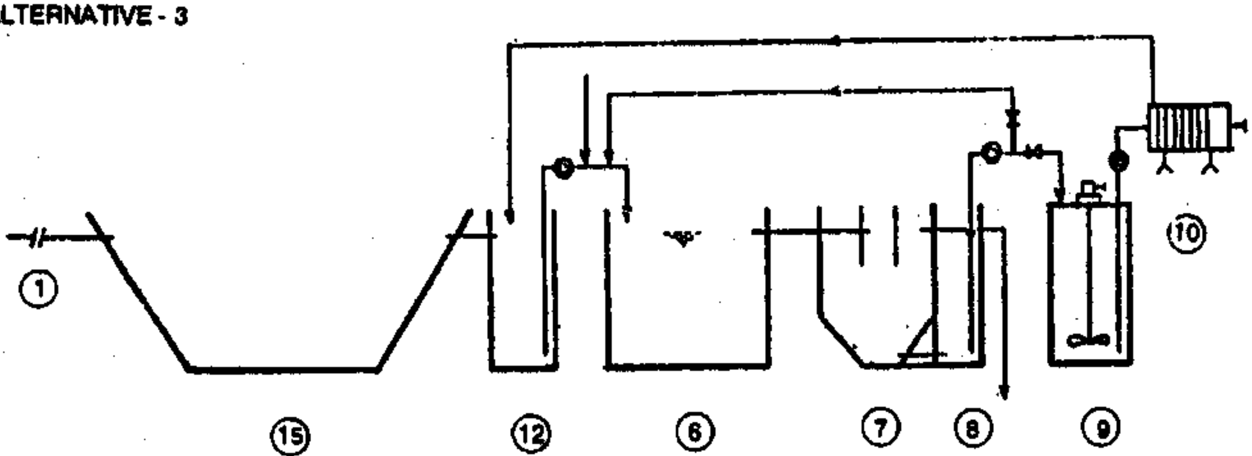
ALTERNATIVE - 1



ALTERNATIVE - 2



ALTERNATIVE - 3



LEGENDS

1 - BAR SCREEN
2 - PUMP SUMP FOR SELF CLEANING SCREEN
3 - SELF CLEANING SCREEN
4 - OIL & GREASE TRAP
5 - FLOW EQUILISATION SUMP
6 - AERATION TANK
7 - SE DIHENTATION TANK
8 - SLUDGE SUMP
9 - SLUDGE CONDITIONING TANK
10 - FILTER PRESS
11 - PUMP SUMP FOR AERATION TANK
12 - SEPTIC TANK
13 - PUMP SUMP FOR AERATION TANK
14 - POCULTATIVE POND

TREATMENT ALTERNATIVES FOR PIG PROCESSED MEAT: CLASS A
FIGURE 5.2. (c) PROCESS FLOW DIAGRAM

The excess sludge produced from the treatment system will be conditioned using Lime & Ferric Chloride and dewatered in a Plate & Frame type Filter Press system.

A schematic flow diagram for the above treatment alternatives is shown in Fig-5.2 (c).

For supply of Oxygen, diffused type aeration system is most appropriate compared to surface aeration due to:

—Seasonal variations in plant operations (e.g. Units Operate 3 shifts/day or 2 shifts/day requiring high operational flexibility for controlling Oxygen supply. Such flexibility is not economically feasible with a surface aeration system.

—Aerosol problems associated with surface aeration, which is not recommended for meat processing Units on hygienic grounds.

With the above considerations, three treatment alternatives have been evaluated for achieving a final treated effluent BOD level of 30 mg/l. The estimated capital investment and annual operating costs for various alternatives produce final BOD level of 30 mg/l are shown in Table 5.2 (D).

The total investment costs of the individual alternatives which will achieve a final treated effluent BOD of 30 mg/l has been estimated to be approximately 2.5% of the annual turnover, indicating economic viability of the treatment alternatives. The annual operating costs for all treatment alternatives are below 0.7% of the annual turnover. Although alternative 2 & 3 require the lowest overall annual operating cost, the investment cost is higher than alternative 1. The difference in annual operating cost between alternative 1 & 2 and 3 is only marginal and hence alternatives 2 & 3 requiring high investment costs and land requirement are not recommended.

Best Practicable Treatment System for Pig Meat Processing Units Category D

Since the total investment required for installation of any of the above alternatives is within the economic viability of the Units, a treatment system with a final treated effluent BOD concentration of 30 mg/l is recommended.

Among the various alternatives, alternative 1 is most appropriate for pig processing due to:

— Overall investment cost is the least for achieving the same degree of BOD removal efficiency.

— Lowest Land requirement.

Hence the best practicable treatment scheme will consist of screening and oil & grease removal as pretreatment followed by biological treatment in a single stage activated sludge process system (extended aeration system).

The excess biomass/sludge should be dewatered using a filter press system. Installation of a sludge drying bed for dewatering purposes is not recommended because of large area requirement and generation of odour/unhygienic conditions, which is not acceptable in the meat processing industry. In addition, cost comparison shows that the investment requirements for a sludge drying bed is equal to that of an effective filter press system.

TABLE 5.2 (D)

Investment and Annual Operating Costs for Various Wastewater Treatment Alternatives (Class-A Pig Meat Processing)

(Turnover of the Unit = Rs. 3.0 Crores)

All values In Rupees

Particulars	Cost Details For 2 TPD Unit ALT-1	ALT-2	ALT-3
Investment Cost			
1) Civil	2,80,000	3,30,000	2,65,000
2) Mechanical	2,40,000	2,21,000	2,66,000
3) Elec & Piping	48,000	45,000	52,000
Total with 20% contingencies	6,82,000	7,15,000	7,00,000
Total Investment as % Turnover	2.3	2.4	2.33
Annual Operating Cost			
1) Energy	1,40,000	1,20,000	1,24,000
2) Manpower	22,000	22,000	22,000
3) Chemicals	12,000	10,000	10,000
4) O & M Cost	14,000	16,000	16,000
Total	1,88,000	1,68,000	1,72,000
Operating Cost as % Turnover	0.63	0.56	0.57

A treatment system with the above measures will result in the final treated effluent having a BOD concentration of 30 mg/l which is recommended as effluent disposal standard for class A pig meat processing Units.

Best Practicable Treatment System Alternatives for Poultry Meat Processing Units Class A (Category D)

In order to arrive at the most economical wastewater treatment system, the following three technically feasible treatment alternatives were evaluated:

Alternative-1 :

Consists of the following units:

— Self cleaning screen

— Oil & grease trap followed by flow equalisation tank

— Aerobic treatment of the above treated wastewater in a single stage activated sludge process (extended aeration type with F/M ratio 0.10 day^{-1}).

The excess sludge produced from the treatment system will be conditioned using Lime & Ferric Chloride and dewatered in a Plate & Frame type Filter Press system.

Alternative-2 :

Consists of the following units:

— Self cleaning screen

— Oil & grease trap

— Biological treatment in a facultative pond followed by single stage activated sludge process (extended aeration type with F/M ratio 0.15 day^{-1}).

The excess sludge produced from the treatment system will be conditioned using Lime & Ferric Chloride and dewatered in a Plate & Frame type Filter Press system.

Alternative-3 :

Consists of the following units:

— Self cleaning screen

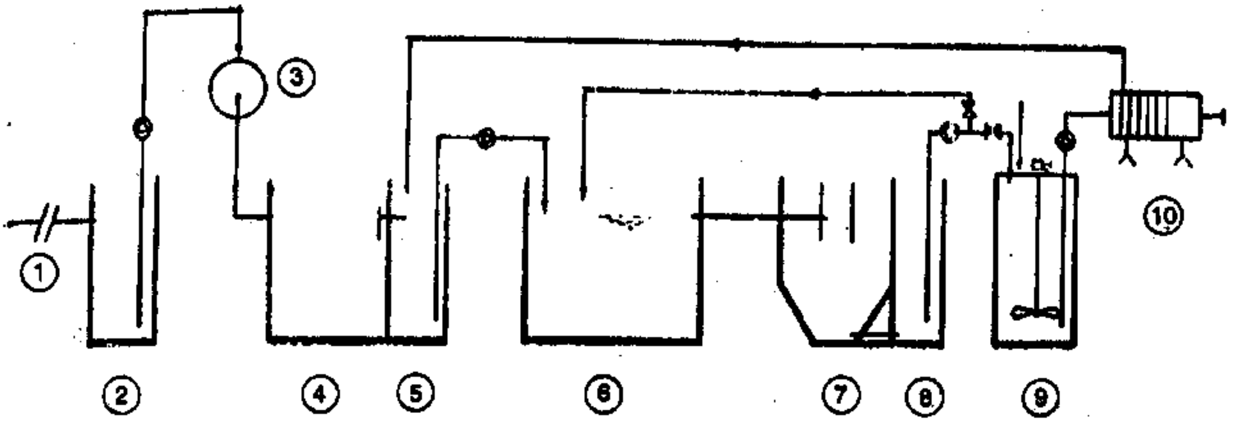
— Oil & grease trap

— Biological treatment in an anaerobic pond followed by aerated lagoon and polishing pond.

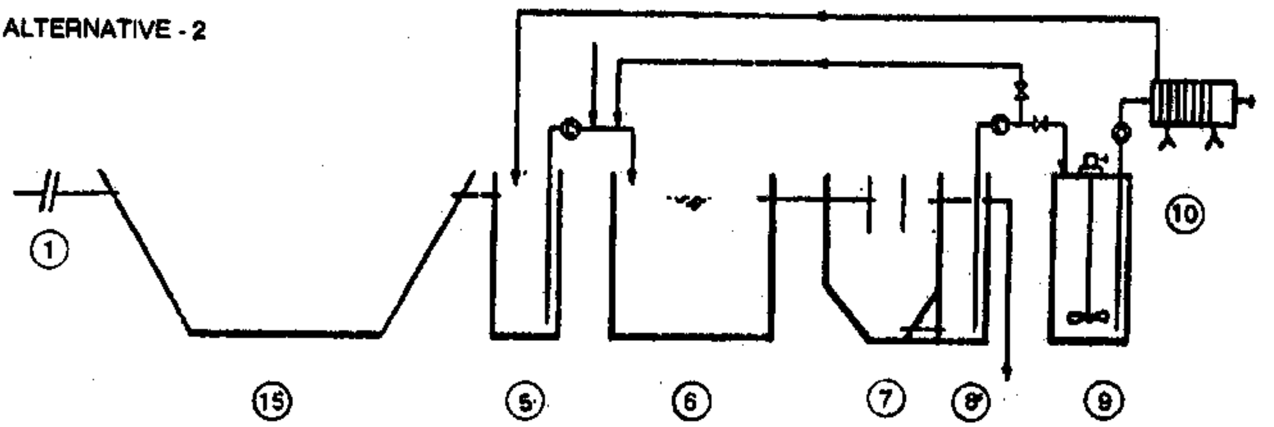
A schematic flow diagram for the above treatment alternatives is shown in Fig-5.2 (d).

For supply of Oxygen in the activated sludge system diffused type aeration system is most appropriate compared to surface aeration due to:

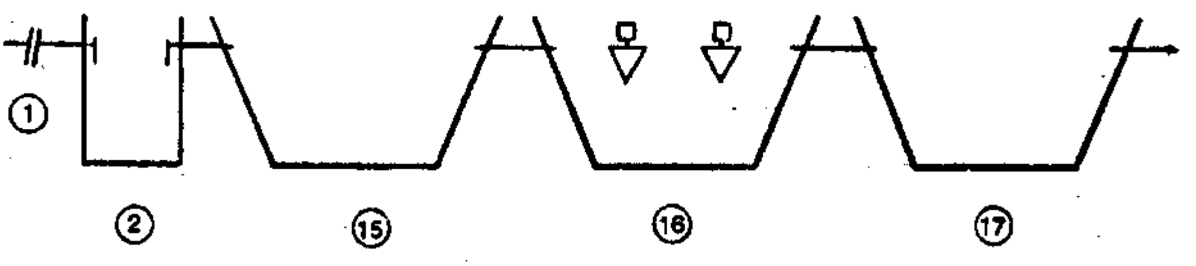
ALTERNATIVE - 1



ALTERNATIVE - 2



ALTERNATIVE - 3



LEGENDS

1 - BAR SCREEN
2 - PUMP SUMP FOR SELF CLEANING SCREEN
3 - SELF CLEANING SCREEN
4 - OIL & GREASE TRAP
5 - FLOW EQUILISATION SUMP
6 - AERATION TANK
7 - SEDIHENTATION TANK
8 - SLUDGE SUMP
9 - SLUDGE CONDITIONING TANK
10 - FILTER PRESS
11 - FOCULTATIVE POND
12 - AERATED LAGOON
13 - POLISHING POND

TREATMENT ALTERNATIVES FOR POULTRY PROCESSED CLASS A
FIGURE 5.2. (d) PROCESS FLOW DIAGRAM

— Seasonal variations in plant operations (e.g. Units Operate 3 shifts/day or 3 shifts/day or 2 shifts/day requiring high operational flexibility for controlling Oxygen supply. Such flexibility is not economically feasible with a surface aeration system.

— Aerosol problems associated with surface aeration, which is not recommended for meat processing units on hygienic grounds.

With the above considerations, three treatment alternatives have been evaluated in respect of cost and achievability of BOD reduction. The estimated capital investment and annual operating costs for various alternatives produce final BOD level of 30 mg/l are shown in Table 5.2 (E).

The total investment costs of the individual alternatives are achieving a final treated effluent BOD of 30 mg/l has been estimated to be approximately 3% of the annual turn over, indicating economic viability of the treatment alternatives. The annual operating costs for all treatment alternatives are below 0.7% of the annual turnover. Although alternative-2 & 3 require the less overall annual operating cost, the investment cost is higher than alternative-1. The difference in annual operating cost between alternative-1 & 2 and 3 is only marginal and hence alternatives-2 & 3 requiring high land requirement are not recommended.

TABLE 5.2 (E)

Investment and Annual Operating Costs for Various Wastewater Treatment Alternatives (Class-A Poultry Meat Processing)

(Turnover of the Unit = Rs. 5.0 Crores)

All values in Rupees

Particulars	Cost Details for 4 TPD Unit		
	ALT-1	ALT-2	ALT-3
Investment Cost			
1) Civil	4,50,000	3,48,000	2,25,000
2) Mechanical	3,30,000	3,63,000	3,33,000
3) Elec & Piping	66,000	60,000	67,000
Total with 20% Contingencies	10,15,500	8,61,000	7,50,000
Total Investment as % Turnover	2.54	2.15	1.90
Annual Operating Cost			
1) Energy	2,00,000	1,48,000	1,40,000
2) Manpower	44,000	44,000	44,000
3) Chemicals	12,000	14,000	20,000
4) O & M Cost	25,000	25,000	25,000
Total	2,81,000	2,31,000	2,29,000
Operating Cost as % Turnover	0.70	0.58	0.57

Best Practicable Treatment System for Poultry Meat Processing Units (Category D)

Since the total investment required for installation of any of the above alternatives is within the economic viability of the Units, a treatment system with a final treated effluent BOD concentration of 30 mg/l is recommended.

Among the various alternatives, alternative-1 is most appropriate for poultry meat processing due to:

- Overall investment cost is the least for achieving the same degree of BOD removal efficiency.
- Lowest land requirement.

Hence the best practicable treatment scheme will consist of screening, oil & grease removal followed by biological treatment in a single stage activated sludge process system (extended aeration system).

The excess biomass/sludge should be dewatered using filter press system. Installation of a sludge drying bed for dewatering purposes is not recommended because of large area requirement and generation of odour/unhygienic conditions, which is not acceptable in the meat processing industry. In addition, cost comparison shows that the investment requirements for a sludge drying bed is equal to that of an effective filter press system.

A treatment system with the above measures will result in the final treated effluent having a BOD concentration of 30 mg/l which is recommended as effluent disposal standard for class-A Poultry meat processing Units.

5.2.4 Standards for Processed Meat Class-B&C (Category-E & F)

The daily BOD load from representative class-B&C meat processing units is as 1.8 kg (2.15 m^3 x 0.83 kg/m^3) and 2.6 kg (1.3 m^3 x 2.04 kg/m^3) respectively, equal to a population equivalent of 40 & 57 respectively (1 PE = 45 gms BOD/day).

Best Practice Treatment System

Because of the low industrial wastewater generation, installation of a simple screen (perforated bucket type) followed by anaerobic treatment in a septic tank system is recommended. The septic tank will achieve a BOD removal efficiency of approximately 50%. For the low wastewater volume, further treatment is technically not feasible. The septic tank should be common for both the industrial and domestic wastewater of the Unit, designed on a hydraulic retention time of 24 hours. However for Units under "shops-and-establishment" category, operating in rented premises with limited area, relaxation may be allowed on a case-by-case basis for direct disposal of screened effluent into the domestic sewer system.

For the reasons mentioned above, it is not recommended to evolve specific effluent standards for Class-B & C Meat Processing Units, but to ensure installation of a screen & septic tank treatment system.

Summary of Recommended Effluent Disposal Standards

The effluent disposal standards for the Meat processing sector are as follows:

Category	Parameter (mg/l)		
	BOD	TSS	Oil & Grease
Frozen Meat			
— Large Units > 7500 TPA	30	50	10
— Medium Units > 3750 TPA and <7500 TPA	30	50	10
— Small Units upto 3750 TPA	30	50	10
Processed Meat			
— Class-A (Pig & Poultry)	30	50	
— Class-B & C	Disposal via screen and septic tank system		

Because of the biological nature of the treatment systems required and the wastewater discharge pattern from the factories, a certain variation in the effluent quality is expected. Therefore, it is recommended to base the effluent standards on a 2 hrs. composite wastewater sample. Wastewater sampling should be done flow proportionate on a 30 minute interval basis for a total period of two hours.

Air Emission Standards

Like slaughter houses, meat processing units do not have process related air emissions. Air pollution is generated only in the form of combustion products from oil fired package boilers. The existing boiler emission standards prescribed by the Central Pollution Control Board, are applicable.

Solid Waste Disposal

Solid waste generated from meat processing activity is basically bones, green & rejected meat, fats and soiled/moist packing material. However, bones being the raw material for manufacture of various valuable products, such as bone meal, crushed bones, ossain, dicalcium phosphate, tallow, bone ash, glue & gelatin etc., they are not considered as waste. Similarly rejected and green meat can be converted into meat cum bone meal or chicken feed. Fat is recovered as by-product during the process and sold as tallow for industrial purpose i.e. soap manufacturing. Therefore, it is recommended that remaining solid waste i.e. soiled/moist packing material should be disposed off alongwith domestic solid waste into Municipal garbage system.

5.3 EFFLUENT STANDARDS FOR SEA FOOD PROCESSING INDUSTRIES

Effluent standards for the following four categories of the Sea Food processing sector are evolved:

Category-A : Large scale units with a processing capacity > 1200 TPA of shrimps and > 400 TPA of cephalopods having an average processing capacity of 15 & 5 TPD of shrimps and cephalopods respectively.

Category-B : Medium scale units with a processing capacity of > 400 TPA each of shrimps and cephalopods having an average processing capacity of 5 TPD.

Category-C : Small scale units with a processing capacity of > 150 TPA each of shrimps and cephalopods having an average processing capacity of 2 TPD.

Category-D : Fresh fish processing units having > 400 TPA processing capacity with an average representative processing capacity of 5 TPD

The characteristics of wastewater discharged from Sea Food Processing Units are as follows:

Parameters	Wastewater Characteristics				
	Shrimps			Cephalopods & Fresh Fish	
	Large (15 TPD)	Medium (5 TPD)	Small (2 TPD)	Cephalopods (5 TPD)	Fresh Fish (5 TPD)
Flow, m^3/d	88.5	29.5	12.0	33.0	13.0
BOD, mg/l	628	628	628	648	432
COD, mg/l	1296	1296	1296	1531	972
TSS, mg/l	333	333	333	292	192
Oil & Grease (mg/l)	140	140	140	60	92

Most of the units depending on the availability of raw material (fishing season) process both shrimps as well as cephalopods. However, fresh fish processing units process exclusively fresh fish.

Since the specific BOD load from cephalopods processing activity is higher compared to shrimp processing, for medium and small scale (category B & C) units, the wastewater characteristic of cephalopods processing will be considered for the purpose of evolving standards. However, for large scale units (category-A) characteristics of shrimp processing will be considered because average processing of cephalopods in category-A is only 5 TPD as against 15 TPD for shrimp processing.

5.3.1 Standards for Shrimp Processing Units—Large Scale (Category-A)

The daily BOD load from representative shrimp processing units—large, category-A is calculated as 54 kg (88.5 m^3 x 0.628 kg/m^3) equal to a population equivalent of 1200 (1 PE=45 gms BOD/day).

Best Practicalble Treatment System Alternatives

In order to arrive at the most economical wastewater treatment system, the following three technically feasible treatment alternatives were evaluated:

Alternative-1 :

Consists of the following units:

— Self cleaning screen

— Oil & grease trap followed by flow equalisation tank

— Aerobic treatment of the above treated wastewater in a single stage activated sludge process (extended aeration type with F/M ratio 0.10 day^{-1}).

The excess sludge produced from the treatment system will be conditioned using Lime & Ferric Chloride and dewatered in a Plate & Frame type Filter Press system.

Alternative-2 :

Consists of the following units:

— Self cleaning screen

— Oil & grease trap followed by flow equalisation tank

— Two stage aerobic treatment of the above pre-treated wastewater i.e. trickling filter followed by activated sludge process (extended aeration type with F/M ratio 0.20 day^{-1}).

The excess sludge produced from the treatment system will be conditioned using Lime & Ferric Chloride and dewatered in a Plate & Frame type Filter Press system.

Alternative-3 :

Consists of the following units:

— Self cleaning screen

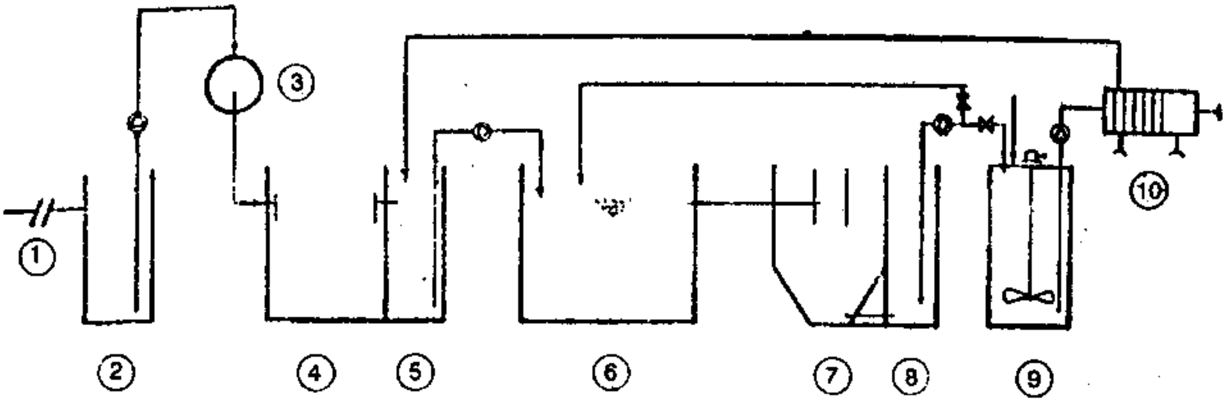
— Oil & grease trap followed by flow equalisation tank

— Two stage aerobic treatment of the above pre-treated wastewater i.e. activated sludge process (extended aeration type with F/M ratio 0.25 day^{-1}) followed by trickling filter.

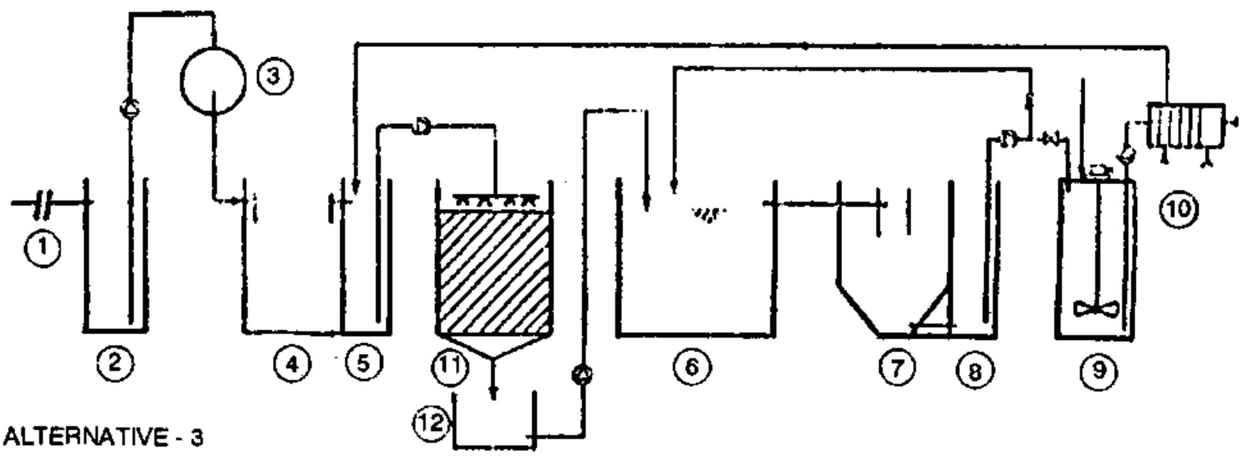
The excess sludge produced from the treatment system will be conditioned using Lime & Ferric Chloride and dewatered in a Plate & Frame type Filter Press system.

A schematic flow diagram for the above treatment alternatives is shown in Fig-5.3 (a).

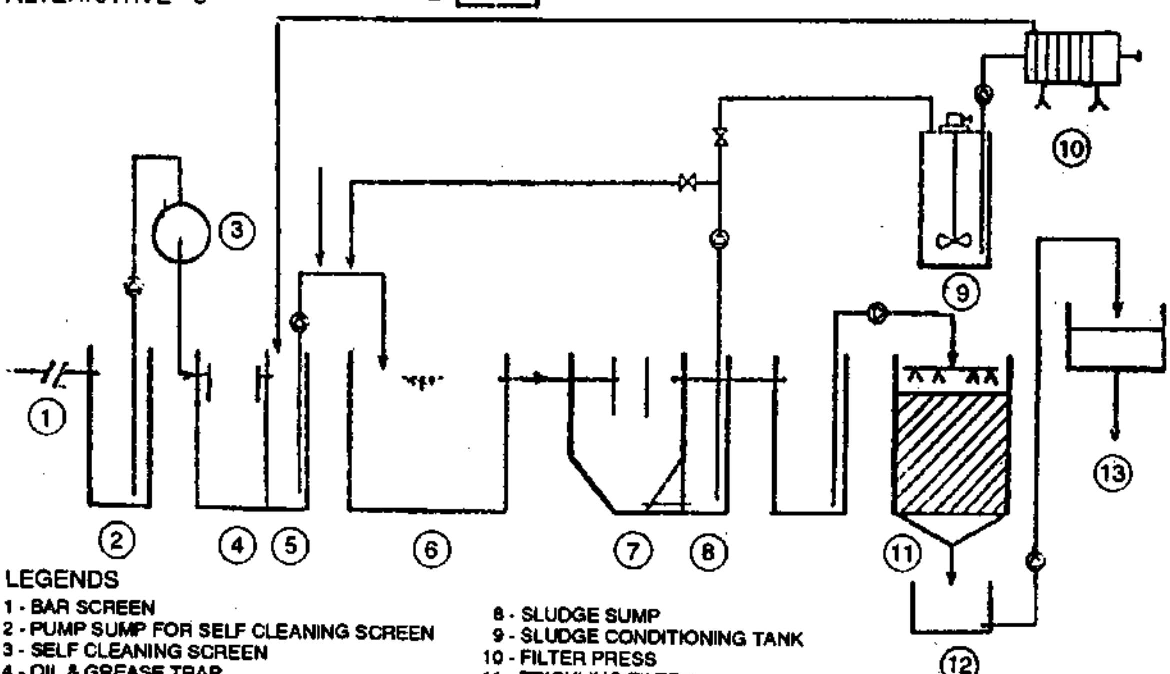
ALTERNATIVE - 1



ALTERNATIVE - 2



ALTERNATIVE - 3



LEGENDS

1 - BAR SCREEN
2 - PUMP SUMP FOR SELF CLEANING SCREEN
3 - SELF CLEANING SCREEN
4 - OIL & GREASE TRAP
5 - FLOW EQUILISATION SUMP
6 - AERATION TANK
7 - SEDIHENTATION TANK
8 - SLUDGE SUMP
9 - SLUDGE CONDITIONING TANK
10 - FILTER PRESS
11 - TRICKLING FILTER
12 - PUMP SUMP
13 - SANO BED FILTER

TREATMENT ALTERNATIVES SHRIMP PROCESSING (LARGE)
FIGURE 5.3. (a) PROCESS FLOW DIAGRAM

For supply of Oxygen, diffused type aeration system is most appropriate compared to surface aeration due to:

— Seasonal variations in plant operations (e.g. Units Operate 2 shifts/day for three months and 1 shift/day for 5 months and no processing for 3-4 months), requiring high operational flexibility for controlling Oxygen supply. Such flexibility is not economically feasible with a surface aeration system.

— Aerosol problems associated with surface aeration, which is not recommended for Sea Food Processing Units on hygienic grounds.

With the above considerations, three treatment alternatives are evaluated with regard to COD and effluent BOD achievable. The estimated capital investment and annual operating costs for various alternatives which will produce final effluent BOD level of 30 mg/l are shown in Table 5.3 (A).

The total investment costs of the individual alternatives for achieving a final treated effluent BOD of 30 mg/l has been estimated to be approximately 1.5% of the annual turnover, indicating economic viability of the treatment alternatives. The annual operating cost for all treatment alternatives are below 0.2% of the annual turnover. Although alternative-2 requires the least overall annual operating cost, the investment cost is highest of all alternatives. The difference in annual operating cost between alternative 1 & 2 and 3 is only marginal and hence alternatives 2 & 3 requiring high investment are not recommended (The relatively high investment cost for alternative 2 & 3 is due to the trickling filter media cost.)

Best Practicable Treatment System for Sea Food Processing Units Category-A

Since the total investment required for installation of any of the above alternatives is within the economic viability of the Units, a treatment system with a final treated effluent BOD concentration of 30 mg/l is recommended.

Among the various alternatives, alternative-1 is most appropriate for the large category due to:

— Minimum land requirement

— Overall investment cost is the least for achieving the same degree of BOD removal efficiency.

Hence the best practicable treatment scheme will consist of screening, oil & grease removal followed by biological treatment in a single stage activated sludge process system.

TABLE 5.3(A)

Investment and Annual Operating Costs for Various Wastewater Treatment Alternatives (SHRIMPS LARGE)

(Turnover of the Unit = Rs. 10.0 Crores)

All Values in Rupees

Particulars	Cost Details for 15 TPD Unit		
	ALT-1	ALT-2	ALT-3
Investment Cost			
1) Civil	2,50,000	8,50,000	5,00,000
2) Mechanical	2,40,000	2,30,000	2,80,000
3) Elec & Piping	50,000	46,000	56,000
Total with 20% Contingencies	6,48,000	13,51,000	10,00,000
Total Investment as % Turnover	0.65	1.35	1.0
Annual Operating Cost			
1) Energy	1,09,000	86,000	97,000
2) Manpower	36,000	36,000	36,000
3) Chemicals	4,000	4,000	4,000
4) O & M Cost	7,000	15,000	10,000
Total	1,56,000	1,41,000	1,47,000
Operating Cost as % Turnover	0.16	0.14	0.15

The excess biomass/sludge should be dewatered using filter press system. Installation of a sludge drying bed for dewatering purposes is not recommended because of large area requirement and generation of odour/unhgienic conditions, which is not acceptable in the sea-food processing industry. In addition, cost comparison shows that the investment requirements for a sludge drying bed is equal to that of an effective filter press system.

A treatment system with the above measures will result in the final treated effluent having a BOD concentration of 30 mg/l which is recommended as effluent disposal standard for large scale shrimp processing Units.

5.3.2 Standards for Sea-food Processing Units (Medium & Small Scale) : Category-B & C (Cephalopod)

The daily BOD load from representative cephalopod processing—medium and small scale category - B & C is calculated as 21 Kg (33 m^3 x 0.648 kg/m^3) & 7.8 kg (12 m^3 x 0.648 kg/m^3) equal to a population equivalent of 467 & 173 respectively (1 PE = 45 gms BOD/day).

Best Practicalble Treatment System Alternatives

In order to arrive at the most economical wastewater treatment system, the following three technically feasible treatment alternatives were evaluated:

Alternative-1:

Consists of the following units:

— Self cleaning screen

— Oil & grease trap followed by flow equalisation tank

— Aerobic treatment of the above treated wastewater in a single stage activated sludge process (extended aeration type with F/M ratio 0.10 day^{-1}).

The excess sludge produced from the treatment system will be conditioned using Lime & Ferric Chloride and dewatered in a Plate & Frame type Filter Press system.

Alternative-2:

Consists of the following units:

— Self cleaning screen

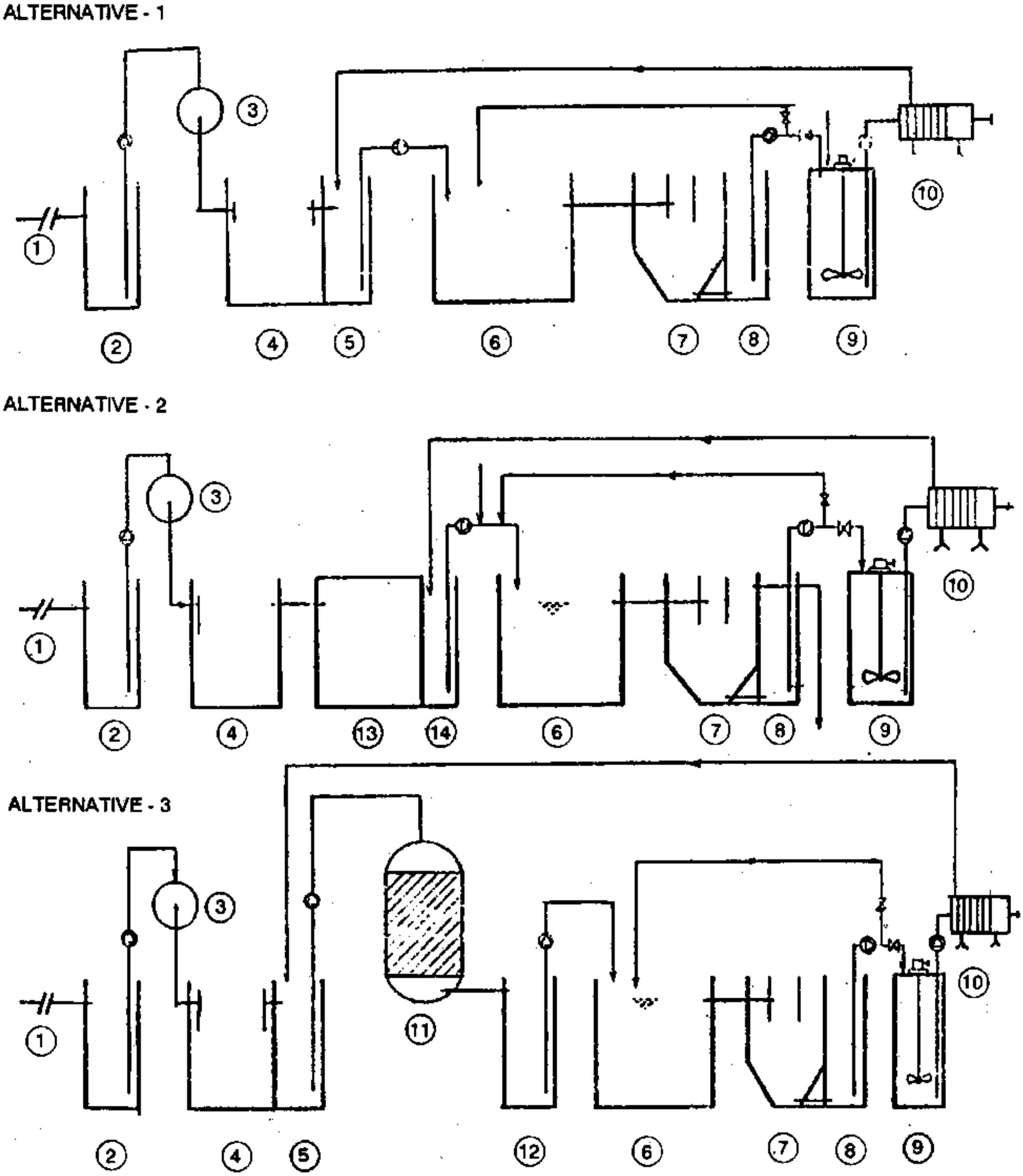
— Oil & grease trap followed by septic tank as pre-treatment

— Aerobic treatment of the above treated wastewater in a single stage activated sludge process (extended aeration type with F/M ratio 0.15 day^{-1}).

The excess sludge produced from the treatment system will be conditioned using Lime & Ferric Chloride and dewatered in a Plate & Frame type Filter Press system.

Alternative-3:

Consists of the following units:



LEGENDS

1 - BAR SCREEN
2 - PUMP SUMP FOR SELF CLEANING SCREEN
3 - SELF CLEANING SCREEN
4 - OIL & GREASE TRAP
5 - FLOW EQUILISATION SUMP
6 - AERATION TANK
7 - SEDIHENTATION TANK
8 - SLUDGE SUMP
9 - SLUDGE CONDITIONING TANK
10 - FILTER PRESS
11 - ANAERBIC CONTACT FILTER
12 - PUMP SUMP FOR AERATION TANK
13 - SEPTIC TANK
14 - PUMP SUMP FOR AERATION TANK

TREATMENT ALTERNATIVES SHRIMP & CEPHALOPODS PROCESSING MEDIUM & SMALL
FIGURE 5.3. (b) PROCESS FLOW DIAGRAM

— Self cleaning screen

— Oil & grease trap followed by flow equalisation tank

— Anaerobic treatment in an anaerobic contact filter (ACF)

— Aerobic treatment of the above treated wastewater in a single stage activated sludge process (extended aeration type with F/M ratio 0.20 day^{-1}).

The excess sludge produced from the treatment system will be conditioned using Lime & Ferric Chloride and dewatered in a Plate & Frame type Filter Press system.

A schematic flow diagram of the above treatment alternatives is shown in Fig. 5.3(b)

For supply of Oxygen, diffused type aeration system is most appropriate compared to surface aeration due to:

— Seasonal variations in plant operations (e.g. Units operate 2 shifts/day for 3 months and 1 shift/day for 5 months and no processing for 3-4 months), requiring high operational flexibility for controlling Oxygen supply. Such flexibility is not economically feasible with surface aeration system.

— Aerosol problems associated with surface aeration, which is not recommended for Sea food processing Units on hygienic grounds.

With the above considerations, three treatment alternatives have been evaluated for achieving a final treatment effluent BOD level of 30 mg/l. The estimated capital investment and annual operating costs for various alternatives with final BOD level of 30 mg/l are shown in Table 5.3 (B) and 5.3 (C).

The total investment cost for the individual alternatives for achieving a final treated effluent BOD of 30 mg/l for category B & C has been estimated to be maximum 2 % of the annual turnover, indicating economic viability of the treatment alternatives. The annual operating cost for all treatment alternatives are below 0.5 % of the annual turnover. Lowest investment and overall annual operating costs are required for alternative-2.

Best Practicable Treatment System for Sea Food Processing Units—Categrory-B & C

Since the total investment required for installation of any of the above alternatives is within the economic viability of the Units, a treatment system producing a final treated effluent BOD concentration of 30 mg/l is recommended.

Among the various alternatives, alternative-2 is most appropriate for this category due to:

— Combination of anaerobic treatment in septic tank followed by a single stage activated sludge process assures operational simplicity and requires least maintenance.

— Required investment and annual operating costs are the lowest of all treatment alternatives evaluated for achieving the same degree of BOD removal efficiency.

Hence the best practicable treatment scheme will consist of screening, oil & grease removal, septic tank treatment followed by a single stage activated sludge process.

The excess biomass/sludge should be dewatered using filter press system. Installation of a sludge drying bed for dewatering purposes is not recommended because of large area requirement and generation of odour/unhygienic conditions, which is not acceptable in the sea food processing industry. In addition, cost comparison shows that the investment required for a sludge drying bed is equal to that of an effective filter press system.

A treatment system with the above measures will result in the final treated effluent having a BOD concentration of 30 mg/l which is recommended as effluent disposal standard for medium and small scale sea food processing units (shrimps & cephalopods).

TABLE 5.3 (B)

Investment and Annual Operating Costs for various Wastewater Treatment Alternatives (Shrimp & Cephalopods Medium)

(Turnover of the Unit = Rs. 4.0 Crores)

All Values in Rupees

Particulars	Cost Details for 5 TPD Unit		
	ALT-1	ALT-2	ALT-3
1) Civil	1,32,000	1,30,000	1,65,000
2) Mechanical	1,92,000	1,54,000	1,72,000
3) Elec & Piping	38,000	31,000	35,000
Total with 20 % Contingencies	4,34,000	3,78,000	4,47,000
Total Investment as % Turnover	1.1	0.95	1.12
Annual Operating Cost			
1) Energy	66,000	39,000	49,000
2) Manpower	22,000	22,000	22,000
3) Chemicals	2,000	1,000	1,000
4) O & M Cost	8,000	6,000	8,000
Total	98,000	68,000	80,000
Operating Cost as % Turnover	0.25	0.17	0.20

TABLE 5.3 (C)

Investment and Annual Operating Cost for various Wastewater Treatment Alternatives (Shrimp & Cephalopods Small)

(Turnover of the Unit = Rs. 1.75 Crores)

All Values in Rupees

Particulars	Cost Details for 2 TPD Unit		
	ALT-1	ALT-2	ALT-3
Investment Cost			
1) Civil	1,02,000	97,000	99,000
2) Mechanical	1,59,000	1,48,000	1,60,000
3) Elec & Piping	31,000	30,000	32,000
Total with 20 % Contingencies	3,50,500	3,30,000	3,50,000
Total Investment as % Turnover	2.0	1.89	2.00
Annual Operating Cost			
1) Energy	52,000	39,000	49,000
2) Manpower	22,000	22,000	22,000
3) Chemicals	2,000	1,000	1,000
4) O & M Cost	7,000	6,000	7,000
Total	83,000	68,000	79,000
Operating Cost as % Turnover	0.48	0.39	0.45

5.3.3 Standards for Fresh Fish Processing Units (Category-D)

The daily BOD load from representative fresh fish processing units, category-D, is calculated as 5.6 kg (13 m^3 x 0.432 kg/m^3) equal to a population equivalent of 125 (1 PE = 45 gms BOD/day).

Best Practicable Treatment System Alternatives

In order to arrive at the most economical wastewater treatment system, the following three technically feasible treatment alternatives were evaluated:

Alternative-1:

Consists of the following units:

— Self cleaning screen

— Oil & grease trap

— Aerobic treatment of the above treated wastewater in a single stage activated sludge process (extended aeration type with F/M ratio of 0.10 day^{-1}).

The excess sludge produced from the treatment system will be conditioned using Lime and Ferric Chloride and subsequently dewatered in a plate & frame type filter press.

Alternative-2:

Consists of the following units:

— Self cleaning screen

— Oil & grease trap followed by flow equalisation tank

— Aerobic treatment of the above pre-treated wastewater in trickling filter with recycling provision followed by a sand bed filter.

Alternative-3:

Consists of the following units:

— Self cleaning screen

— Oil & grease trap followed by septic tank as pre-treatment

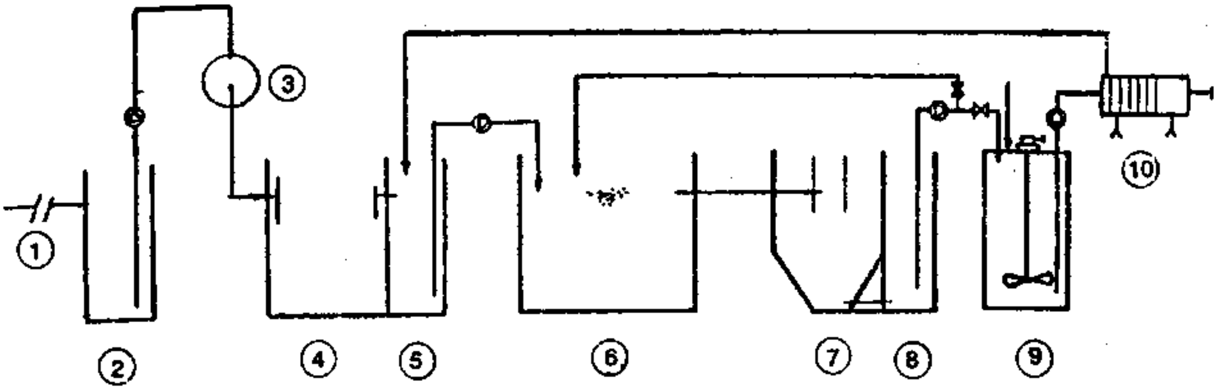
— Aerobic treatment of the above pre-treated wastewater in trickling filter with recycling provision followed by a sand bed filter.

A schematic flow diagram for the above treatment alternatives is shown in Fig 5.3(c).

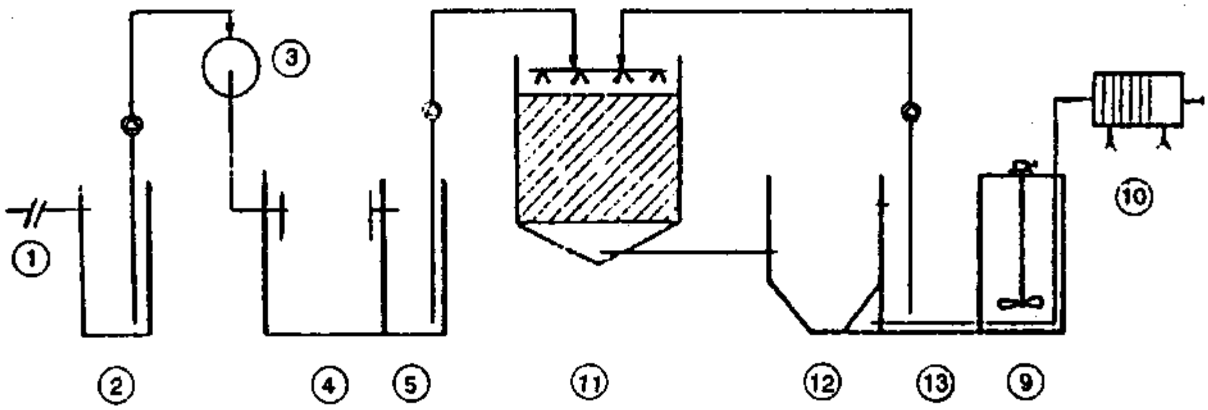
For supply of Oxygen, diffused type aeration system is most appropriate compared to surface aeration due to:

— Seasonal variations in plant operations (e.g. Units operate 2 shifts/day for 3 months and 1 shift/day for 5 months and no processing for 3-4 months), requiring high operational

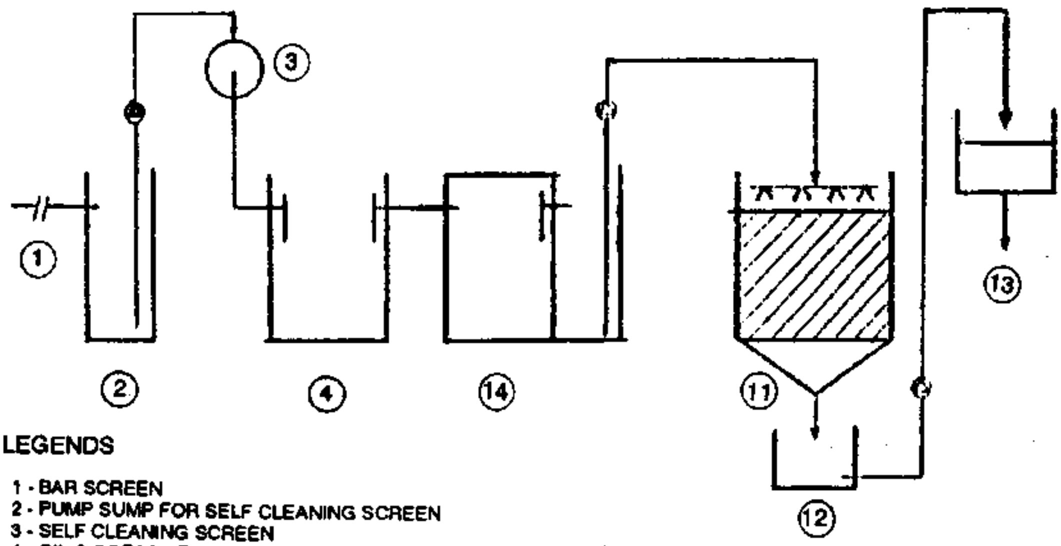
ALTERNATIVE - 1



ALTERNATIVE - 2



ALTERNATIVE - 3



LEGENDS

1 - BAR SCREEN
2 - PUMP SUMP FOR SELF CLEANING SCREEN
3 - SELF CLEANING SCREEN
4 - OIL & GREASE TRAP
5 - FLOW EQUILISATION SUMP
6 - AERATION TANK
7 - SEDIHENTATION TANK
8 - SLUDGE SUMP
9 - SLUDGE CONDITIONING TANK
10 - FILTER PRESS
11 - TRICKLING FILTER
12 - PUMP SUMP FOR RECYCLING TO TRICKLING FILTER
13 - SANO BED FILTER
14 - SEPTIC TANK

TREATMENT ALTERNATIVES FRESH FISH PROCESSING

FIGURE 5.3. (c) PROCESS FLOW DIAGRAM

flexibility for controlling Oxygen supply. Such flexibility is not economically feasible with surface aeration system.

— Aerosol problems associated with surface aeration, which is not recommended for sea food processing units on hygienic grounds.

With the above considerations, three treatment alternatives have been evaluated for achieving a final treated effluent BOD level of 30 mg/l. The estimated capital investment and annual operating costs for various alternatives with final BOD level of 30 mg/l are shown in Table 5.3 (D).

The total investment cost for the individual alternatives for achieving a final treated effluent BOD of 30 mg/l has been estimated to be approximately 2 % of the annual turnover, indicating economic viability of the treatment alternatives. The annual operating cost for all treatment alternatives are below 0.2% of the annual turnover. Although alternative-2 requires the least investment, the overall annual operating cost is highest of all alternatives. The difference in annual operating cost between alternative-1 & 3 is marginal and hence alternative 2 requiring high investment and alternative 3 requiring high annual operating costs are not recommended.

TABLE 5.3 (D)

Investment and Annual Operating Costs for Various Wastewater Treatment Alternatives (Fresh Fish Processing)

(Turnover of the Unit = Rs. 0.75 Crores)

All Values in Rupees

Particulars	Cost Details for 5 TPD Unit		
	ALT-1	ALT-2	ALT-3
Investment Cost			
1) Civil	1,21,000	1,40,000	1,65,000
2) Mechanical	66,000	34,000	34,000
3) Elec & Piping	13,000	7,000	7,000
Total with 20 % Contingencies	2,40,000	2,18,000	2,48,000
Total Investment as % Turnover	3.2	2.90	3.31
Annual Operating Cost			
1) Energy	20,000	26,000	26,000
2) Manpower	22,000	22,000	22,000
3) Chemicals	1,000	1,000	1,000
4) O & M Cost	4,000	4,000	4,000
Total	47,000	53,000	53,000
Operating Cost as % Turnover	0.63	0.71	0.71

Best Practicable Treatment System for Sea-food Processing Units—Catergory-D i.e., Fresh Fish

Since the total investment required for installation of any of the above alternatives is within the economic viability of the Units, a treatment system with a final treated effluent BOD concentration of 30 mg/l is recommended.

Among the various alternatives, alternative-1 is most appropriate for the large category due to overall investment cost is the least for achieving the same degree of BOD removal efficiency.

Hence the best practicable treatment scheme will consist of screening and oil & grease removal followed by treatment in a single stage activated sludge process system (extended aeration type).

The excess biomass/sludge should be dewatered by an effective filter press system.

A treatment system with the above measures will result in the final treated effluent having a BOD concentration of 30 mg/l which is recommended as effluent disposal standard for fresh fish processing units.

5.3.4 Summary of the Recommended Effluent Disposal Standards

The effluent disposal standards for all the categories in the Sea food processing sector is uniform at BOD 30 mg/l & TSS 50 mg/l.

Because of the biological nature of the treatment systems required and the wastewater discharge pattern from the factories, a certain variation in the effluent quality is expected. Therefore, it is recommended to base the effluent standards on a 2 hrs composite wastewater sample. Wastewater sampling should be done flow proportionate on a 30 minute interval basis for a total period of two hours.

5.3.5 Air Emission Standards

Sea-food processing units do not have air emissions either from process or from utilities. However, the odour problem from solid waste storage facilities should be contained by appropriate means.

5.3.6 Solid Waste Disposal

Solid waste generated from Sea-food processing activity consists of shells, peelings, head & tail of shrimps and visceral contents, liver, skin, pen and eyes of cephalopods and fresh fishes. It is recommended that shells and peels should be collected properly for preparation of by-product viz. chitin, chitosen etc. Similarly visceral contents, liver, skin, pen and eyes from cephalopods can be converted into squid meal. Remaining solid waste viz. soiled packing material should be disposed off alongwith domestic waste into Municipal garbage system.

5.4 SUMMARY OF MINIMAL NATIONAL STANDARDS FOR SLAUGHTER HOUSE, MEAT & SEA-FOOD INDUSTRY LIQUID EFFLUENT STANDARDS

Category of Industry	Limit not to exceed, mg/l		
	BOD	TSS	Oil & Grease
Slaughter House			
a) Above 70 TLWK	100*	100	10
b) 70 TLWK & below	500	—	—
Meat Processing			
a) Frozen Meat	30	50	10
b) Raw Meat from Own Slaughter House	30	50	10
c) Raw Meat from other sources	Disposal via Screen and Septic tank.		
Sea Food Industry	30	50	10

* The standard shall be reviewed by 1992 and stringent standards shall be prescribed with respect to BOD.

Note :
1. TLWK—Tonnes Live Weight Killed/day
2. In case of disposal into municipal sewer where sewage is treated, the industries shall install screen and oil & grease separation units.
3. The industries having slaughter house alongwith meat processing units will be considered in meat processing category as far as standards are concerned.

Emission Standards

Stack emissions from boiler house and DG set shall conform to the standards prescribed under Emission Regulations of CPCB

CHAPTER 6

IN-PLANT MEASURES

6.1 REDUCTION OF WATER CONSUMPTION

The observed excessive water use results in the flushing of organic material i.e. proteins and fats, which not only increases the pollution load but also leads to an avoidable loss of valuable by-products. In addition, since the size of the required wastewater treatment system is directly related to the wastewater flow rate and pollution load, investment costs are high. Therefore water conservation will effectively reduce the size, capital & operating costs facilities required to achieve the prescribed effluent standards. Technically feasible in-plant water conservation measures are given below:

— Installation of effective washing systems and self closing valves at water supply lines

High efficiency spray nozzles with quick shot off valve in carcass/bird washing, evisceration line, workers hand washing and all clean up hoses will reduce the water consumption.

— Reuse/recycle of process wastewater from cleaner area to progressively dirtier areas

Resue of carcass wash water and chiller overflow as flumewater used for carrying hair/feathers in pig or chicken slaughter houses to a screen system before final discharge into sewer. Defrost water can be used for all washing purposes USEPA has recommended the reuse of process wastewater for several secondary purposes, except for areas where potable water supply is required.

— Vacuum system for feather/hair removal

Replacement of the feather and hair flow-away flume system by a dry operating vacuum based conveyance system will significantly reduce water consumption.

— Dry clean-up operation

Introduction of a dry cleaning step for all clean-up operations followed by controlled & efficient wet cleaning will reduce water consumption substantially.

6.2 REDUCTION IN POLLUTION LOAD

Reduction in pollution load will reduce the required treatment plant capacity and the operation costs for on-site treatment. In addition, introduction of measures for the reduction in pollution load mostly leads to the recovery of valuable by-products improving the overall profitability of a unit. Technically feasible pollution load reduction measures are given below:

— Segregation and collection of blood for by-product recovery.

Blood, having a BOD concentration in the range of 1,56,500-2,00,000 mg/l, contributes substantially to the BOD load from all types of slaughter houses if discharged to the wastewater. Therefore, proper segregation and collection of blood is strongly recommendead for all slaugher houses. Blood collection/recovery and dry cleaning of the kill area before wash will reduce the BOD load by 42%.

— Collection and separate disposal of stomach and intestine contents.

Discharge of stomach & intestinal contents to the wastewater substaintially increase the TSS and BOD & COD load to the wastewater treatment system. Introduction of dry procedures for the collection of stomach and intestinal contents, therefore, is strongly recommended. The collected solids can be reused by farmers as fertilizer or soil conditioner. A 10% reduction in total wasteload by dry collection of stomach content alone is quite possible.

— Dry offal handling:

Replacement of the flume-water conveyance system by a dry operating technique will avoid wastewater generation from this particular activity and hence reduce the overall pollution load from the unit.

— Separation of hair, feathers and solids from eviscerating wastewater.

Hairs, feathers and other screenable solids should be removed from the wastewater as close to the place of generation/discharge as possible. Wastewater streams containing high content of these solids should be e segregated and pre-treated by a self cleaning screen system prior to combination with the remaining wastewater of the unit.

— Segregation and pre-treatment of wastewater from viscera and intestine washing activities.

Minimisation of water consumption, segregation and effective O/G removal will effectively reduce the pollution load from this activity.

— Installation of an effective self cleaning type screening system at wastewater streams with a high suspended solids content is strongly recommended for all types of the above industries. This will substaintially reduce the overall BOD and COD load to the wastewater treatment plant and avoid choking of sewer lines in cases where only pre-treatment is required prior to sewer discharge.

6.3 BY-PRODUCT RECOVERY

Pollution load from slaughter house, meat and sea food processing units can be substantially reduced by incorporating one or all of the above mentioned techniques. The separated "wastes" can be converted into valuable by-products by the following technically feasible methods.

— Blood should be collected by pharmaceutical companies for manufacturing haemotonic preparations. Alternatively blood plasma could be used in sausage preparations. Blood can also be converted to blood meal which, after mixing and drying with rumen digesta, can be used as animal feed.

— Rumen digesta contains 10-20% proteins, vitamins and essential minerals which, after processing/drying is an ideal animal feed. Alternatively rumen digesta can be used as manure after conposting.

— Rendering: fat should be collected separately and rendered into tallow or lard by using wet or dry rendering processes. Indirect heat is used to melt fat and evaporate moisture from the animal tissue. Tallow and lard is a valuable raw material for several chemical industries.

— **Protein recovery by dissolved air floatation system (DAF):**

Dissolved air floatation is the most widely used and proven method not only for pre-treatment of wastewater but also for subsequently fat and protein recovery for all the above industries. Standard BOD removal efficiencies are between 80-85% for the treatment of wastewater from the above industries. Prior to floatation coagulation and flocculation steps are required which is either achieved by dosage of acid for FDA (Food and Drug Administration approved) polyelectrolytes. The collected float with a solids content of 16-18% consists mainly of proteins and fats. Coagulation of proteins and melting of fats is carried out in the subsequent protein recovery system consisting of a heat exchanger and dryer scheme. The dried product,. with a protein content of approximately 98% is used as animal feed. It is reported that 1.5—.3.0 kg of protein and 0.2-0.3 kg fat can be recovered from one cubic meter of slaughter house wastewater having a BOD concentration of 1000—1400 mg/l. Large scale slaughter houses, meat and fish processing units should consider installation of a DAF based protein recovery system.

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