



# AIT

ASIAN INSTITUTE OF TECHNOLOGY

School of Environment, Resource & Development

ED78.20 Industrial Waste Abatement and Management

# Seafood Processing



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# 1. OVERVIEW OF THE SEAFOOD INDUSTRY

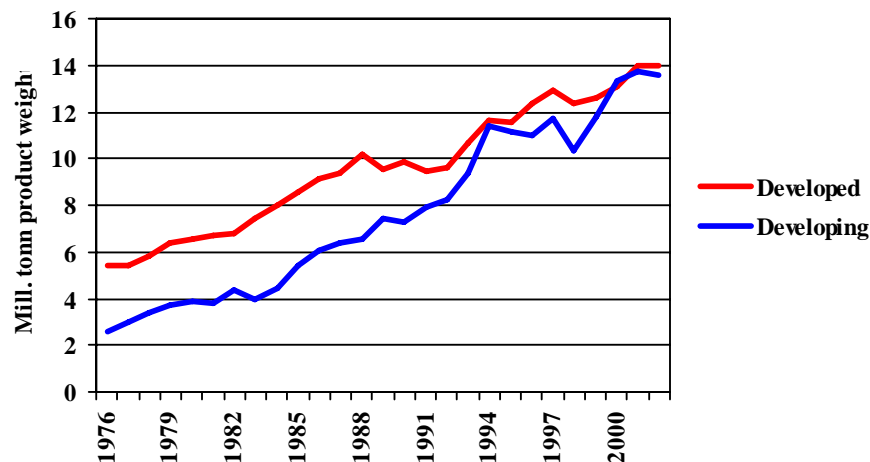
## 1.1 Introduction

The world seafood industry plays a significant role in the economic and social wellbeing of nations, as well as in the feeding of a significant part of the world's population. Fishing and fish farming has emerged as one of the major food processing occupations of mankind. In ancient times, economically and socially backward people were employed in this profession. The advent of modern mechanized fishing vessels has brought vast changes in the attitude of the public fishing and seafood processing. From low income and socially backward communities the profession has shifted to the hands of industrialists and technologists. Today fishing and processing activities provide employment to millions of people around the world.

## 1.2 Global supply and demand

The world's population is expected to increase by 36% in the years 2000 to 2030, from approximately 6.1 billion people to 8.3 billion. It is also expected that the estimated total seafood demand will be 183 million tones by 2030, but the estimated supply will be only 150 to 160 million tones. Thus, there is a sizable gap between demand and supply. However, global capture fisheries will be able to provide only 80-100 million tones of fish annually on a sustainable basis. [Source: Yves Bastien, 2003]

The global seafood market is estimated at US\$ 100 billion per annum. Also, the world demand for seafood increases by 3% each year. The world largest seafood consumption in the world is by Japan, followed by European Union. The top five consumed species are salmon, shrimp, tilapia, catfish and crab (major consumption in China and India). [Source: World Nutrition Forum, September 7<sup>th</sup> - 8<sup>th</sup>, 2006, Vienna, Austria]



**Figure 1:** Global exports of seafood products from developed and developing countries

As shown in Figure 1 above, the contribution of developing countries in the export of seafood products is being increased every year and reached the level of production by developed countries.

The Figure 2 shows that the largest importer of seafood is European Union (EU), followed by Japan.



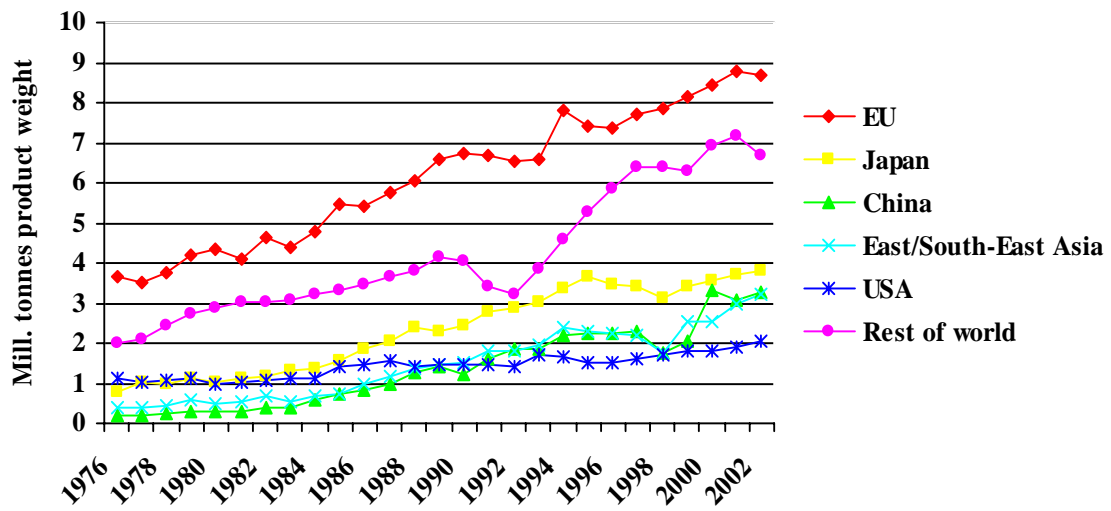


Figure 2: The global seafood importers

## 2. SEAFOOD PRODUCTION PROCESS

### 2.1 Products

There are several product categories from seafood industry, based on raw material type (fresh/frozen) and value-addition (degree of processing and value content). The following figure depicts few seafood product categories in a seafood industry.

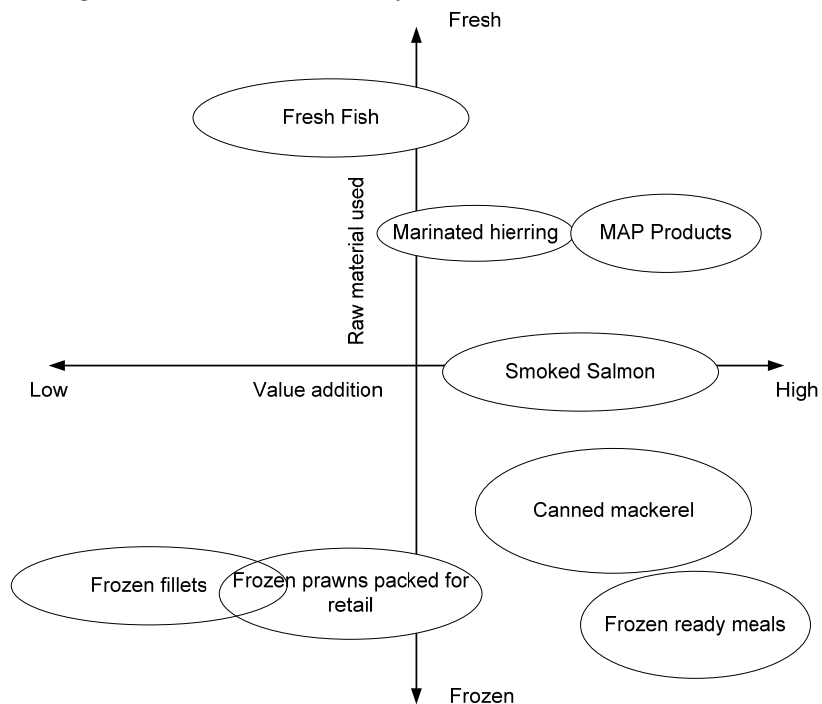


Figure 3: Seafood Products in a seafood industry

Important canned fish products are tuna packed as solid pack, chunks, flakes, grated or shredded in water or oil, sardines or sardine-like fishes in oil, tomato sauce or other types of sauce, pre-smoked



sardines in oil or tomato sauce, kippers (pre-smoked herring), salmon, mackerel, fish paste products and pet food.

**Table 1:** Source and approximate yields of by-products from various fish canning operations

By-product	By-product yield from canning operations		
	Tuna (%)	Sardine (%)	Salmon (%)
Pet food	4-6	-	-
Fish meal	30-35	20-30	30-35
Industrial oil	<5	5	-

## 2.2 Raw Material

### 2.1.1 Fish and other Marine species:

Many types of fish and other marine species are suitable for seafood production and the size of the individual fish varies from that of the smallest sardines to that of the largest tuna species. For some species like tuna and sardines canning is the most common processing method. Other species, suitable for canning are salmon, mackerel, herring, clams, oysters, shrimps, octopus, crab and white fish paste products.

To plan the handling and processing of seafood and to manage problems connected with all operations from transport to processing through storage, it is essential to know the properties of the species involved.

**Table 2:** weight percentage of parts of the common fish species used in canning

Species	Percentage of total weight					ton/m <sup>3</sup>
	Head	Skin & flesh	Bones	Fins	Viscera	
Atlantic herring	12.5	62.2	6.5	1.5	15.0	0.91
Sardines	21.0	58.0	6.5	2.5	9.5	0.85
Atlantic mackerel	22.5	52.0	8.0	1.0	19.5	0.96
Tuna	18.0	64.0	8.0	2.0	8.0	
Pink salmon	16.0	71.0	-	5.0	8.0	0.95

Source: [www.fao.org](http://www.fao.org)

### 2.1.2 Ingredients:

There is wide variety of liquid solutions available that can be added in seafood canning process. Some of them are as listed below:

1. Salt
2. Olive oil
3. Soya bean oil
4. Tomato sauce



Some examples of other ingredients and additives used in the canning process are:

- |                       |                               |
|-----------------------|-------------------------------|
| ✚ Pepper              | ✚ Curry powder                |
| ✚ Cardamom            | ✚ Starch (potatoes flour)     |
| ✚ Ginger              | ✚ Mono Sodium Glutamate (MSG) |
| ✚ Onion               | ✚ Milk                        |
| ✚ Spirit vinegar      | ✚ Sugar                       |
| ✚ Ground mustard seed | ✚ Wine                        |
|                       | ✚ Beer                        |

**Note:** The ingredients should be suitable for human consumption and be free from abnormal taste, flavour and odor.

## **2.2 Packaging Materials**

The most common material used for manufacturing containers for fish products are

- ✚ Tin plate
- ✚ Tin free steel (TFS)
- ✚ Aluminum alloys
- ✚ Enamel coatings
- ✚ Lacquered steel plate
- ✚ Glass jars
- ✚ Retortable pouches

## **2.4 Production Process**

Production process depends on the type of the seafood species, end products, machineries used, etc. In this report Tuna Canning process is described in detail including the process description, material balance, environmental issues and cleaner production opportunities (Refer Table 3).



Water	Electricity		Wastewater	Solid waste	Emission	Noise	Odour
	✓	Frozen Tuna from Storage					
✓		Thawing	✓				
		Eviscerating	✓ Blood	✓			✓
✓	✓	Washing	✓				
✓ Steam	✓	Pre cooking	✓		✓	✓	
✓	✓	Spray Cooling	✓				
		Loin Cleaning		✓			
	✓	Packing in cans				✓	
✓ Preheated Brine		Filling solution	✓ Overflow Brine				
	✓	Seaming		✓ Damaged Cans		✓	
✓		Can Washing	✓				
✓ Steam		Sterilization	✓		✓	✓	
✓		Can cooling	✓				
	✓	Can drying			✓		
		Storage					
		Labeling		✓			
		Loading & Shipment					

Figure 4: Production Process Flow Diagram indicating Inputs & Outputs



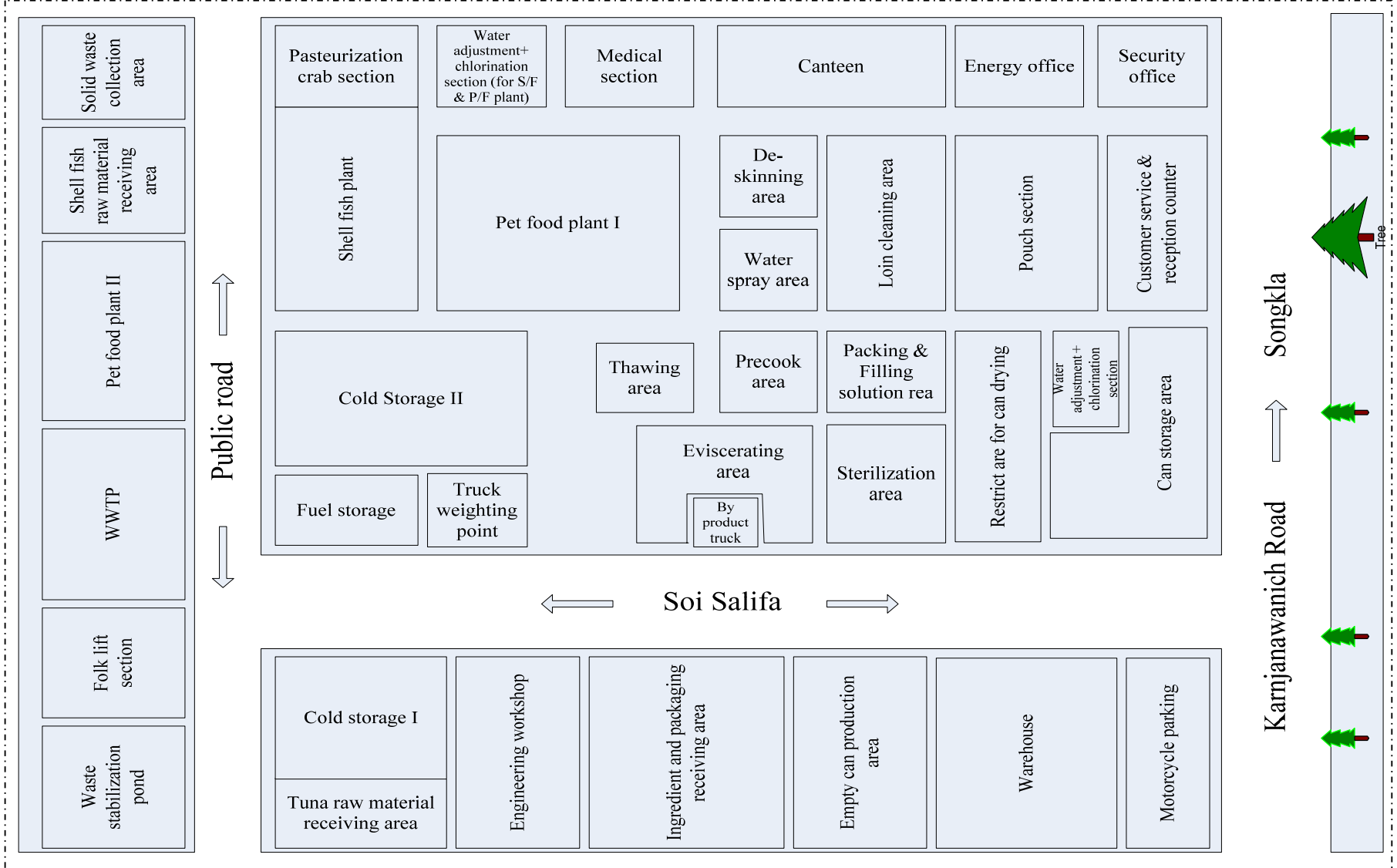


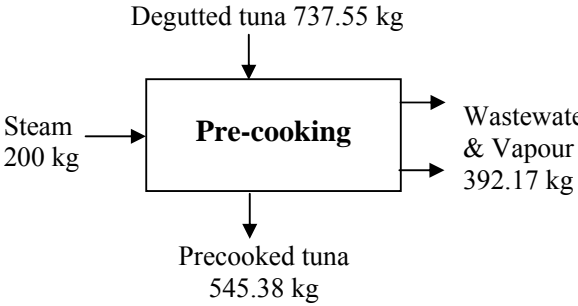
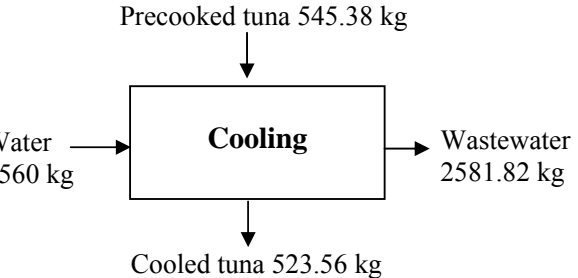
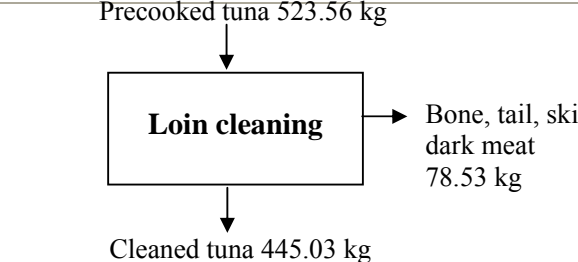
Figure 5: Seafood Processing Plant Layout for Songkla Canning Public Company Ltd.



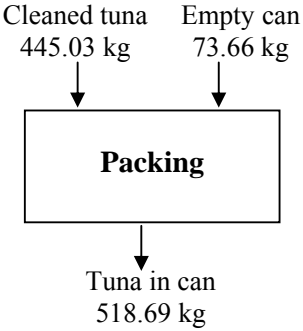
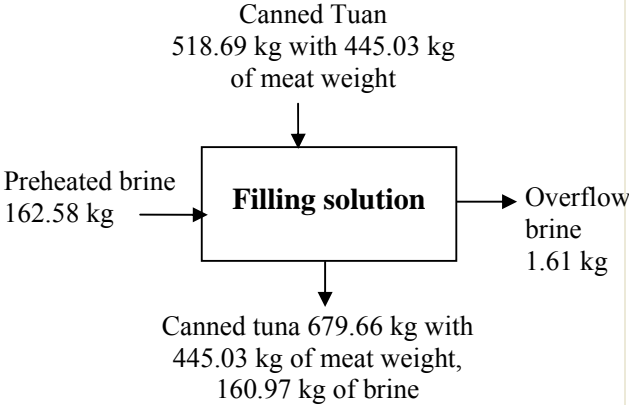
**Table 3:** Production Process of Tuna canning including material balance, environmental issues & cleaner production

Process	Process Description	Material Balance	Environmental Issues	Cleaner Production
<i>Freezing</i>	Frozen Room			<ul style="list-style-type: none"> <li>● Use plastic curtain which has enough thickness to protect cold condition</li> <li>● Do not open or close the door unnecessarily.</li> <li>● Use suitable quantity of ice to freeze the fish.</li> </ul>
<i>Thawing</i>	Frozen tuna is thawed, preferably by means of running water as whirlpool system. Once thawed, the tuna is washed. Loss of weight of tuna during thawing is 0.5-1.0%.	<pre> graph TD     A[Frozen tuna 1000 kg] --&gt; B[Thawing]     C[Water 700 kg] --&gt; B     B --&gt; D[Raw tuna 990 kg]     B --&gt; E[Wastewater 710 kg]           </pre>	<ul style="list-style-type: none"> <li>● High water consumption (depends on the thawing procedure)</li> </ul>	<ul style="list-style-type: none"> <li>● Use air sprayer for water agitation. (Water consumption can be reduced by about 40 %) or</li> <li>● Use moist air method - virtually no water. But energy input of about 70 kW.h/t RM and fewer raw materials is lost.</li> <li>● Maintain conveyors regularly to avoid corrosion.</li> <li>● Reuse the ice</li> </ul>
<i>Eviscerating &amp; washing</i>	The splitting and evisceration procedure is the only butchering operation performed on the tuna while it is in the raw condition and prepare for the first stage cleaning. Loss of weight is approximately 24-27%.	<pre> graph TD     A[Raw tuna 990 kg] --&gt; B[Eviscerating &amp; washing]     C[Water 50 kg] --&gt; B     B --&gt; D[Wastewater 75.2 kg with 25.2 kg blood]     B --&gt; E[Head, viscera, waste 227.25 kg]     B --&gt; F[Degutted tuna 737.55 kg]           </pre>	<ul style="list-style-type: none"> <li>● Wastewater containing organic material such as intestinal remains scales and slime. The degree of contamination depends on cleaning and gutting.</li> </ul>	<ul style="list-style-type: none"> <li>● Use spray nozzle to save water about 50–65%, thus saving about 0.2 m<sup>3</sup>/t RM.</li> <li>● Collect internal organs &amp; other organic matters separately.</li> <li>● The water can be shut off using an automated shut-off system that could save about 1 m<sup>3</sup>/t RM</li> </ul>



<p><b>Precooking</b></p>	<p>The tuna is given a pre-cook by heating at a temperature in range of 102 to 104 °C. This operation is necessary to make it possible to hand pick the light meat from the carcass and also to remove some of the oil from oily fish. The fish is placed in baskets which are placed on racks. The racks of butchered fish are rolled into the cookers which are usually of rectangular cross section and made of reinforced steel plate with a door, or doors, at one or both ends. The pre-cooking is a batch type operation. Loss of weight is approximately 22-26%.</p>	 <pre> graph TD     A[Degutted tuna 737.55 kg] --&gt; B[Pre-cooking]     C[Steam 200 kg] --&gt; B     B --&gt; D[Precooked tuna 545.38 kg]     B --&gt; E[Wastewater &amp; Vapour 392.17 kg]             </pre>	<ul style="list-style-type: none"> <li>● High energy, water consumption for steam production.</li> <li>● Air pollution - Depending on fuel type</li> </ul>	<ul style="list-style-type: none"> <li>● Insulation of retort machine.</li> <li>● Maintain the joint and stream pipe regularly.</li> <li>● Continuous feeding of fish to retort</li> <li>● Use the same size of fish that can help to open the retort only one time.</li> <li>● Use cleaner fuel.</li> </ul>
<p><b>Cooling</b></p>	<p>The precooked fish is sprayed with water thoroughly to cool it to about 45 °C before cleaning. This step help firm the flesh and remove the oil. Loss of weight is approximately 3-5%.</p>	 <pre> graph TD     A[Precooked tuna 545.38 kg] --&gt; B[Cooling]     C[Water 2560 kg] --&gt; B     B --&gt; D[Cooled tuna 523.56 kg]     B --&gt; E[Wastewater 2581.82 kg]             </pre>	<ul style="list-style-type: none"> <li>● High water consumption</li> </ul>	<ul style="list-style-type: none"> <li>● Use warm water from this process to apply heat exchange system in thawing step.</li> <li>● Proper use of spray nozzle from clogging.</li> </ul>
<p><b>Cleaning of fish</b></p>	<p>After the pre-cooking and cooling operations, tuna is individually cleaned. The head is removed and the fish is skinned and split into halves before removing the tail and backbone. The loins are produced by splitting the halves of the fish along the median line. Red meat is then removed from each loin; the blood</p>	 <pre> graph TD     A[Precooked tuna 523.56 kg] --&gt; B[Loin cleaning]     B --&gt; C[Cleaned tuna 445.03 kg]     B --&gt; D[Bone, tail, skin, dark meat 78.53 kg]             </pre>	<ul style="list-style-type: none"> <li>● Organic loading of wastewater generated is relatively high due to contamination with fish head, blood and flesh pieces.</li> </ul>	<ul style="list-style-type: none"> <li>● Train the employees to get the higher yield.</li> <li>● Design a rim in the table to avoid fish residual fall on to floor.</li> </ul>



	<p>and dark meat are scraped away and the loins, edible flakes and waste products are separated; of these portions approximately 15% is flake tuna.</p>			
<p><b>Packing in cans</b></p>	<p>The production of solid packs was formerly a hand-packing operation, but is now carried out by machines. This machine produces a cylinder of tuna loins of uniform density from which can be cut can-sized segments of uniform weight.                  Chunk packs are produced from loins which are cut on a moving belt by means of reciprocating cutter blades. The cut loins are then filled into cans by tuna filler machines.                  Flakes and grated tuna, which is produced from broken loins and flakes, are packed in the same way as chunk packs.</p>	 <pre>                 graph TD                 A[Cleaned tuna 445.03 kg] --&gt; B[Packing]                 C[Empty can 73.66 kg] --&gt; B                 B --&gt; D[Tuna in can 518.69 kg]                 </pre>		
<p><b>Filling Solutions</b></p>	<p>The open cans next pass the line where additives such as salt, vegetables and finally media either water or oil is added. Oil should be added slowly over a sufficient stretch of the line to permit its thorough absorption by the tuna meat. When oil is not added an equivalent amount of water replaces it. The oil temperature is recommended to be 80 °C-90 °C.</p>	 <pre>                 graph TD                 A[Canned Tuna 518.69 kg with 445.03 kg of meat weight] --&gt; B[Filling solution]                 C[Preheated brine 162.58 kg] --&gt; B                 B --&gt; D[Canned tuna 679.66 kg with 445.03 kg of meat weight, 160.97 kg of brine]                 B --&gt; E[Overflow brine 1.61 kg]                 </pre>	<ul style="list-style-type: none"> <li>● Spillage of filling solution.</li> </ul>	<ul style="list-style-type: none"> <li>● Use collector to collect the overflow of brine and reuse it back in the same process.</li> <li>● Adjust oil/saline water flow rate to suit the conveyor speed.</li> </ul>



<p><b>Can Seaming</b></p>	<p>The double seaming method is usually used to seal metal containers. The seam is created in two operations; See Figure 6.</p>	<pre> graph TD     A[Filled can 679.66 kg] --&gt; B[Seaming]     C[Lid 38.11 kg] --&gt; B     B --&gt; D[Seamed can 681.88 kg]     B --&gt; E[Damaged can 35.89 kg]             </pre>	<ul style="list-style-type: none"> <li>• Significant amount of energy is consumed.</li> <li>• Damaged cans create solid waste.</li> </ul>	<ul style="list-style-type: none"> <li>• Maintain seaming machine regularly.</li> <li>• Make sure the continuous can feeding.</li> <li>• Install the baffle to protect steam go out from exhaust box.</li> <li>• Install pressure meter to control the pressure of the seaming machine to be consistent.</li> </ul>
<p><b>Can Washing</b></p>	<p>The sealed cans are transferred by a conveyor through a can washer which cleans the cans in detergent and water before discharging them into retort baskets.</p>	<pre> graph TD     A[Seamed can 681.88 kg] --&gt; B[Can washing]     C[Water 400 kg] --&gt; B     B --&gt; D[Washed can 681.88 kg]     B --&gt; E[Wastewater 400 kg]             </pre>	<ul style="list-style-type: none"> <li>• Considerable amount of water consumption.</li> </ul>	<ul style="list-style-type: none"> <li>• Reuse the water for primary floor cleaning.</li> <li>• Washing operation should be continuous.</li> <li>• Ensure the counter current washing.</li> </ul>
<p><b>Sterilization &amp; can cooling</b></p>	<p>All canned fish products are sterilized at temperatures above 100 °C. Sterilization takes place in retorts, with or without water. The simplest and most common retorts today are horizontal, or vertical, batch retorts. When processing cans in retorts using steam it may be necessary to cool the cans under pressure so that the ends do not peak during cooling. Steam may be used to maintain the pressure</p>	<pre> graph TD     A[Canned Tuna in basket 681.88 kg] --&gt; B[Sterilization &amp; can cooling]     C[Steam 270 kg] --&gt; B     B --&gt; D[Sterilized can 681.88 kg]     B --&gt; E[Condensed wastewater &amp; vapour 270 kg]             </pre>	<ul style="list-style-type: none"> <li>• Energy consumption is the major issue as it causes air pollution.</li> </ul>	<ul style="list-style-type: none"> <li>• Insulation of retort machine.</li> <li>• Reuse cooling water to wash the seamed cans.</li> </ul>



	but compressed air is more usual. The cooling time depends on the processing temperature.			
<b>Can drying</b>	After sterilization and cooling, the cans are stored in a restricted area to dry and prevent corrosion.			<ul style="list-style-type: none"> <li>●Maintain machine regularly</li> </ul>
<b>Storage / Labeling / Loading and shipment</b>	Stacked canned tuna are stored for incubation period. The dry cans are finally labeled by manual or automatic labelers. Good practice is required to handling in this step. Outgoing inspection e.g. packing, quantity and transportation during loading should be provided. And then stuff into shipping containers.			<ul style="list-style-type: none"> <li>●Use proper adhesive to fix the labels.</li> </ul>

**Source:** Water conservation in canned tuna (pet food) plant in Thailand, Munlika Uttamangkabovorn, and Received 11 April 2003; accepted 1 December 2003



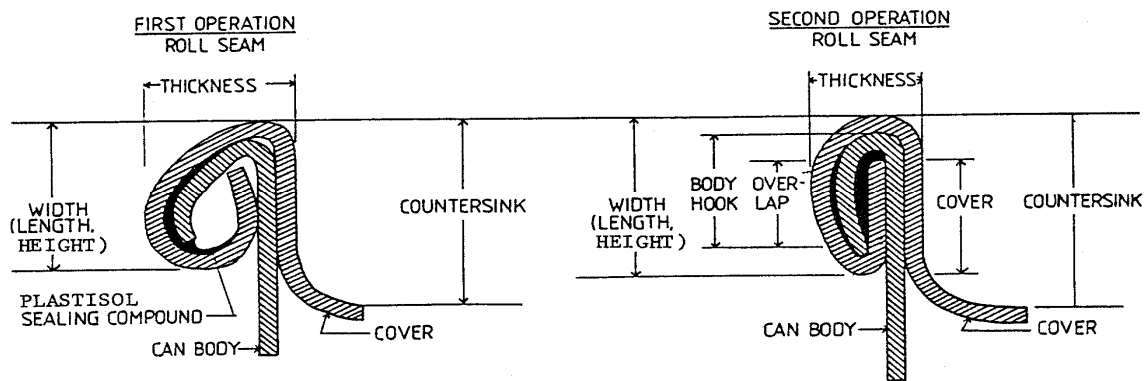


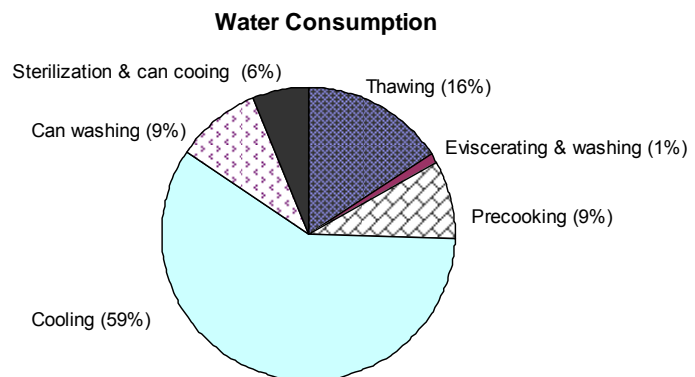
Figure 6: Seaming operation -double seam ([www.fao.org](http://www.fao.org))

### 3. ENVIRONMENTAL ISSUES RELATED TO SEAFOOD PROCESSING

Environmental issues in fish processing industries primarily include the following: Water consumption and wastewater generation, Solid waste generation and by-products production, Emission to air and energy consumption.

#### 3.1 Water Consumption

Most seafood processors have a high baseline water use for cleaning plant and equipment. Therefore, water use per unit product decreases rapidly as production volume increases. Major sources of water consumption include: fish storage and transport; cleaning, freezing and thawing; preparation of brines; equipment sprays; offal transport; cooling water; steam generation; and equipment and floor cleaning.



Water consumption in fish processing operations has traditionally been high to achieve effective sanitation. Several factors affect water use, including: the type of product processed, the scale of the operation, the process used, and the level of water minimization practices in place (Environment Canada, 1994a). General cleaning contributes significantly to total water demand so smaller-scale sites tend to have significantly higher water use per unit of production.

#### 3.2 Energy Consumption

Seafood processing industries consumes large quantities of electrical energy. Most of the power is used for magnetic induction equipment, such as electric motors (compressors for freezers, cold stores, ice-making machines, water pumps, etc.) and lighting that requires magnetic ballasts, air-conditioning [UNEP, 1999]. For fish and fish meal processing energy is required for cooling, cooking, sterilizing, drying, evaporation, can cleaning, fork-lifting. For wastewater treatment



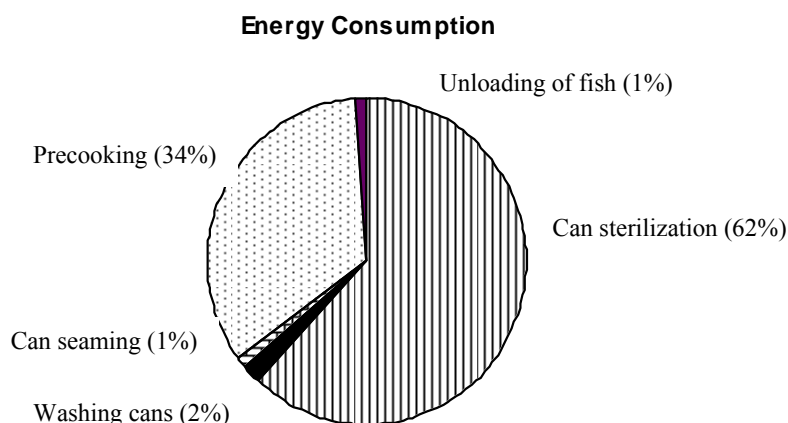
energy is applied for pumping and aerating. Energy consumption depends on various factors like age and scale of plant, the level of automation and the range of products. Processes which involve heating, such as canning and fishmeal production need more energy than other processes (UNEP, 2000).

**Table 4:** Amount of energy consumption per ton of product for canning (calculated from UNEP report)

Process	Energy Consumption (kWh)
1. Unloading of fish	5.7
2. Grading of fish	0.3
3. Nobbing and packing in cans	1.4
4. Precooking of fish to be canned	1.3
Steam: 100 kg	132.4
5. Draining of cans	0.3
6. Can seaming	5.8
7. Washing of cans	7.4
8. Can sterilization	242.1

From the above table and pie-chart, it can be said that for the fish canning process the major energy consumption is for fish precooking and sterilization process. Energy is utilized to produce steam from boilers. The capacity of boiler depends on the steam requirement. Fuel oil is generally used to produce steam in most factories. Besides, LPG and coal are also used.

In addition to fish processing, electricity is consumed for refrigeration, lighting, water and wastewater treatment. A typical value of this kind of energy consumption for a seafood industry located in Vietnam is given in below:



**Table 5:** Electricity Consumption at seafood industry in Vietnam

Area	Number of employee	Working period/day	Capacity	Electricity consumption
6,750 m <sup>2</sup>	700	12-24 hrs.(depend on the market requirement)	200 tons of product/month	Refrigeration: 88% Lighting: 3% Water & wastewater treatment: 9%

Source: Thesis, Trang. AIT, 2005

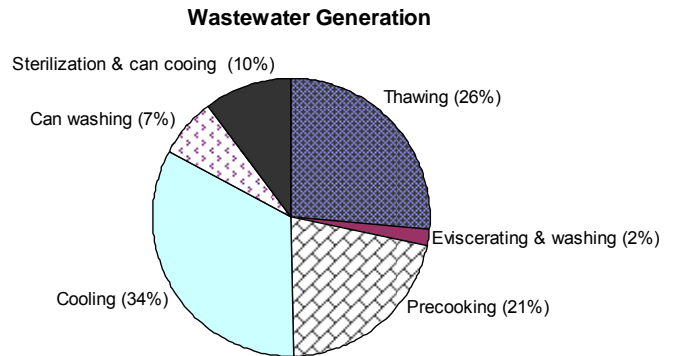


### 3.3 Effluent Discharge

Sources of effluent from fish processing include the handling and storage of raw fish prior to processing, fluming of fish and product around the plant, defrosting, gutting, scaling, portioning and filleting of fish and the washing of fish products.

Effluent streams generated from seafood processing contain high loads of organic matter due to the presence of oils, proteins and suspended solids. They can also contain high levels of phosphates and nitrates.

In canning operations, effluent is also discharged from the draining of cans after pre-cooking, from the spillage of sauces, brines and oil in the can filling process, and from the condensate generated during pre-cooking.



Effluent quality highly depends on the type of fish being processed and type of processing undertaken. Pollution loads generated from the processing of oily fish species are much higher than from white fish species, due to the high oil content and the fact that these species are usually not gutted or cleaned on the fishing vessel.

If the effluent streams described above are discharged without treatment into water bodies, the pollutants they contain can cause eutrophication and oxygen depletion. In addition, fish processing industries have been known to pollute nearby beaches and shores by releasing wastewater containing oils. Since oil floats on water, it can end up on the surrounding coastline. Refer Table 8 for Wastewater characteristics of various species

### 3.4 Emission to Air

**Point-Source Emission:** These emissions are exhausted into a vent or stack and emitted through a single point source to the atmosphere. The major air pollution sources in a typical seafood industry are from combustion sources like boiler and generators for electric power. Boiler is used for steam supply during pre-cooking and sterilization process. The examples of fuels used in the boilers are electricity, fuel oil, coal and LPG. [UNEP, 1999] The Table 6 highlights common air emissions and their sources from seafood processing.

**Odor:** Odor is often the most significant form of air pollution in fish processing. Major sources include storage sites for processing waste, cooking by-products during fish meal production, fish drying processes, and odor emitted during filling and emptying of bulk tanks and silos. Fish quality may deteriorate under the anaerobic conditions found in onboard storage on fishing processing facilities. This deterioration causes the formation of odorous compounds such as ammonia, mercaptans, and hydrogen sulphide gas [National Pollutant Inventory. June, 1999].



**Table 6:** Common Air Emissions from Seafood Processing (Source: Queensland Department of Environment and Heritage, 1998.)

Sources	Emission
Cooking	Volatile Organic Compound (VOC)
Fried dryer	VOC, particulate matter(PM <sub>10</sub> )
Pre-cooking & Sterilization	VOC, CO, NO <sub>x</sub> , SO <sub>2</sub> , CO <sub>2</sub>
Refrigeration	NH <sub>3</sub>
Disinfection/cleaning	Cl <sub>2</sub>

**Table 7:** Typical emission from boilers using different fuels (Source: Design of Air Pollution Control system by Dr. N. T. Kim Oanh)

	PM	SO <sub>2</sub>	CO	HC	NO <sub>2</sub>
LPG-F	0.2 [g/L]	0.5[g/L]	0.23[g/L]	0.084[g/L]	1.35[g/L]
Coal	12.5 (g/kg)	12 (g/kg)	1 (g/kg)	0.5 (g/kg)	7.5 (g/kg)
Fuel oil	2.75 (g/l)	10 (g/l)	0.5 (g/l)	0.35 (g/l)	9.6 (g/l)

**Table 8:** Wastewater characteristics of various species (Source: Rapid Inventory techniques in environmental pollution- part 1 by Alexander P. Economopoulos)

Parameters	Units	Blue Crab		Shrimp			Tuna	Catfish	Salmon		Sardine
		Conventional	Mechanized	Breaded	Canned	Frozen			Mechanical	Hand	
Wastewater	m <sup>3</sup> /t	1.2	38	116	52	115	25	24	18.5	4	8.7
BOD <sub>5</sub>	kg/t	5.2	22.5	84	82	120	13.4	7.3	50.8	2.1	9.2
Total Nitrogen	kg/t	1	3.7	5.9	9.5	10	2.1	0.65			
Oil, fats & grease	kg/t	0.25	5.6	20	31	29	7.4	4.7	6.5	1.5	1.7
Total suspended solids	kg/t	0.74	12	93	43	220	10.4	9.4	20.3	1.2	5.4



### **3.5 Noise Pollution**

Noise is not a significant problem in seafood industries. Noise may be generated during cutting, pre-cooking, filling and weighing the can, can seaming and sterilization. The noise measurements at any sources in the process do not exceed the standard of Maximum Sound Level (140 dB) [Ministry of Interior, 1976], but they have more value than Equivalent Continuous Sound Level 24 hours.

**Table 9:** Sources of noise pollution

Source	Causes of noise	Emission, dB
Pre-cooking	Steam blow out from vent	80-85
Filling & weighing the can	Collision of cans	92-93
Can seaming	Seamer operating to seam the can	86-87
Sterilization	Venting process, steam is continuously blowing out through the hole	90-95

### **3.6 Solid waste generation**

Solid waste is mainly in the form of organic wastes generated in the production processes. It consists of fish shells and heads from the seafood processing. The majority of captured species are ground fish and it is estimated that only 25-50% of the raw material is utilized for primary products. The remaining 50-75% of the raw material is considered processing waste and is utilized for low-valued products or disposed. Seafood processing activities generate potentially large quantities of organic waste and by-products from inedible fish parts and endoskeleton shell parts from the crustacean peeling process. The waste generation depends on the species and the process. If coal is used as a fuel in the boiler, ash will be generated depends on the ash content of the coal. Generally, 80% of the ash becomes fly ash and the remaining 20% will be bottom ash.

**Table 10:** Source and quantities of solid waste (Source: M.T. MORRISSEY, Astoria Seafood laboratory, Oregon State University, 2001)

Process	Waste generation (kg/t)
Eviscerating	240
Cleaning	400
Seaming	50
<b>Total</b>	
Organic	640
Inorganic	50

## **4. WASTE TREATMENT PRACTICES**

### **4.1 Wastewater treatment**

Seafood processing facilities typically employ a combination of primary and secondary wastewater treatments, depending on the degree to which organic materials are collected separately or mixed into the effluent stream. Wastewater from seafood processing facilities



typically has a very high organic and nitrogen load which can be effectively treated in aerobic or anaerobic systems, including lagoons. However, care should be taken to reduce odors including those from extended biological and/or chemical phosphorus removal.

**Table 11:** Effluent standard for wastewater of different countries

Parameters	Units	Germany*	Thailand	Sri Lanka	Bangladesh
pH	pH	5.5 - 9	5.5-9	6 – 8.5	6 - 9
BOD <sub>5</sub>	mg/L	25	20	100	50
COD	mg/L	110	120	250	250
Nitrogen	mg/L	25 (NH <sub>4</sub> – N) & 25 (TKN)	100	50 (NH <sub>4</sub> – N)	10 (TN)
Total Phosphorous	mg/L	2	--	--	5
Oil, fats & grease	mg/L	--	5	20	10
Total suspended solids	mg/L	--	50	150	50
Total Dissolved Solids	mg/L	--	3000 -5000	--	--
Temperature	°C	--	<40	<45	--

\* Specially for Seafood Industry

#### 4.1.1 Pre treatment:

The pre treatment of the seafood processing wastewater generally includes screen, grit chamber, oil & grease remover or flotation unit & equalization tank.

- ✚ Screening is used to remove large objects, such as stones or sticks, which could clog lines or block tank inlets. This is one of the treatments most commonly used by food processing plants as it quickly reduces the amount of solids being discharged. Removal rates may vary from 40 to 75 %.
- ✚ Grit chamber is used to slow down the flow to allow grit to fall out from the effluent wastewater. The grits are removed to prevent abrasion of mechanical parts of equipments, deposits in pipelines and in the digesters. The removal efficiency varies between 75 – 95%.
- ✚ Fisheries wastewaters contain variable amounts of oil and grease which depend on the process used, the species processed, and the operational procedure. The main objective of this unit operation is to protect downstream treatment processes such as biological process and air diffusers from blocking.
- ✚ Generally the industrial wastewater has high fluctuation in flow depends on the production cycle of the industry. Therefore, equalization tank is used to equalize the flow & concentration wastewater. The secondary usage of this unit operation is to do pH adjustment and nutrient addition.

#### 4.1.2 Primary treatment:

Primary Sedimentation is used to remove suspended solids present in the wastewaters. In fisheries wastewaters these include fish scales, portions of fish muscle and offal, and the relative proportions varying with the particular process being used. If the BOD<sub>5</sub> of the seafood processing wastewater is nearly 1000mg/L we can use this unit operation to reduce the suspended solid &



BOD<sub>5</sub> loads in the aerobic biological process followed. Treatment efficiency of the primary sedimentation tank is 40 – 60 % suspended solids removal and 30 % BOD removal.

#### 4.1.3 Secondary treatment:

The secondary treatment of seafood processing wastewater is basically a biological treatment as wastewater contains high load of organic matters and high nutrient contents.

There are two basic biological processes namely, aerobic and anaerobic. These two processes have wide varieties of options available such as activated sludge process, up flow anaerobic sludge blanket process, anaerobic lagoons, etc.

The treatment efficiency of the secondary treatment is 90 % suspended solids removal and 90 % BOD removal.

#### 4.1.4 Sludge treatment & Disposal:

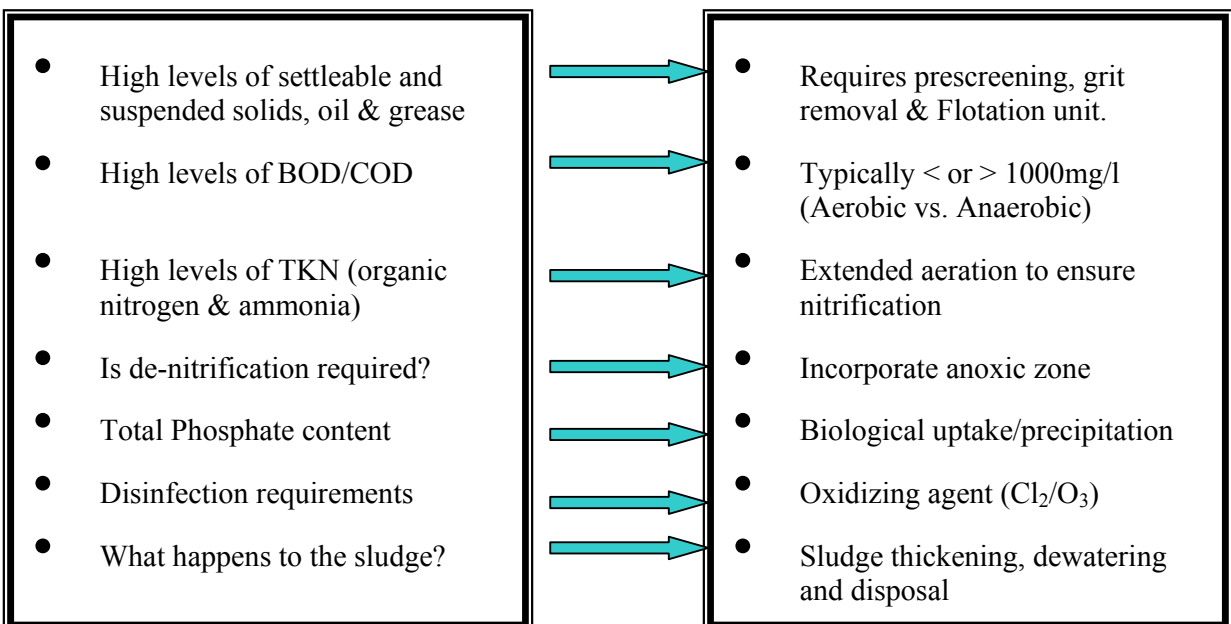
Sludge treatment includes, sludge thickening, sludge digestion & sludge dewatering and finally safe disposal of the treated sludge. Since the sludge from fish processing plants are highly biodegradable, the treatment and disposal is easy.

#### 4.1.5 Treatment Selection criteria & check list:

Selection of wastewater treatment technique depends on several factors such as

- ✚ Wastewater characteristics
- ✚ Process techniques available
- ✚ Land availability
- ✚ Human skills
- ✚ Location of wastewater discharge & effluent standards
- ✚ Investment cost and O & M cost

#### *Checklist for deciding the type of wastewater treatment option:*



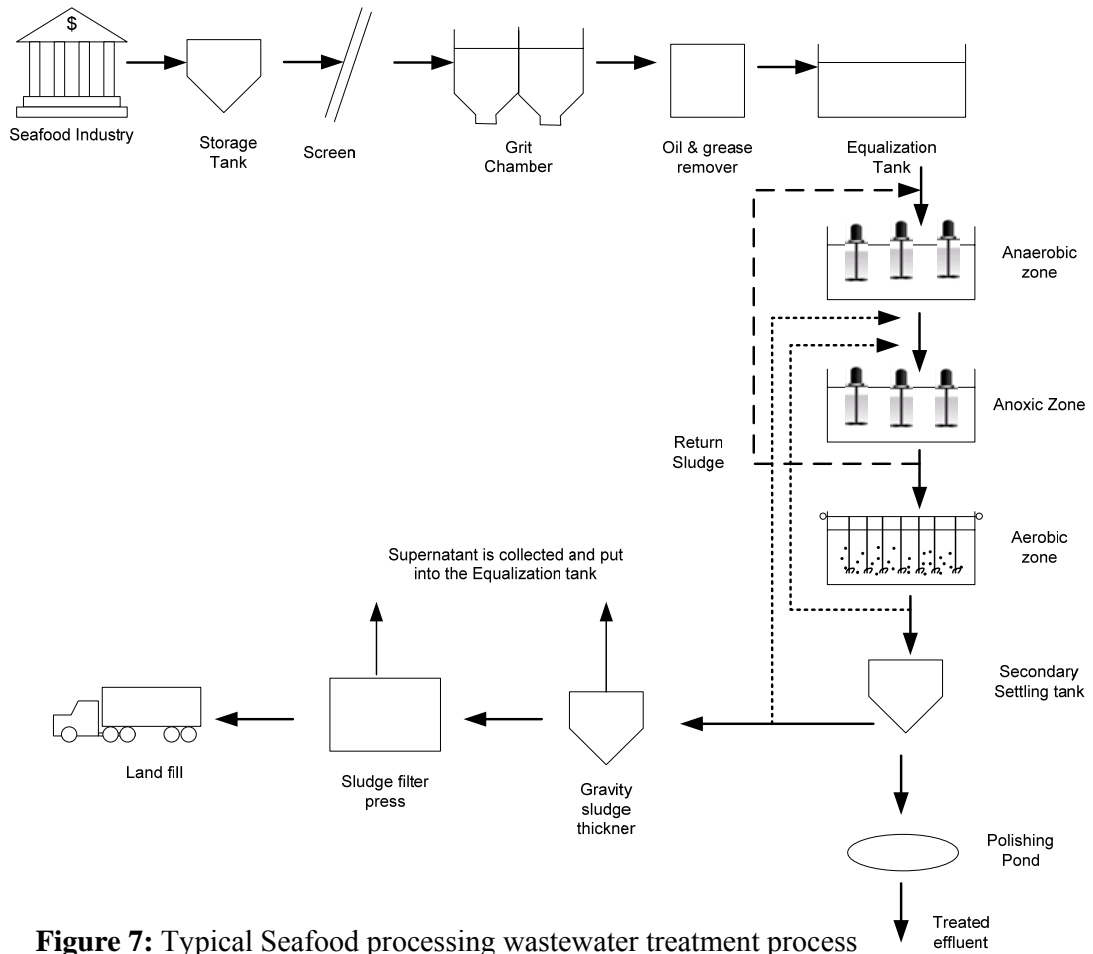


Figure 7: Typical Seafood processing wastewater treatment process

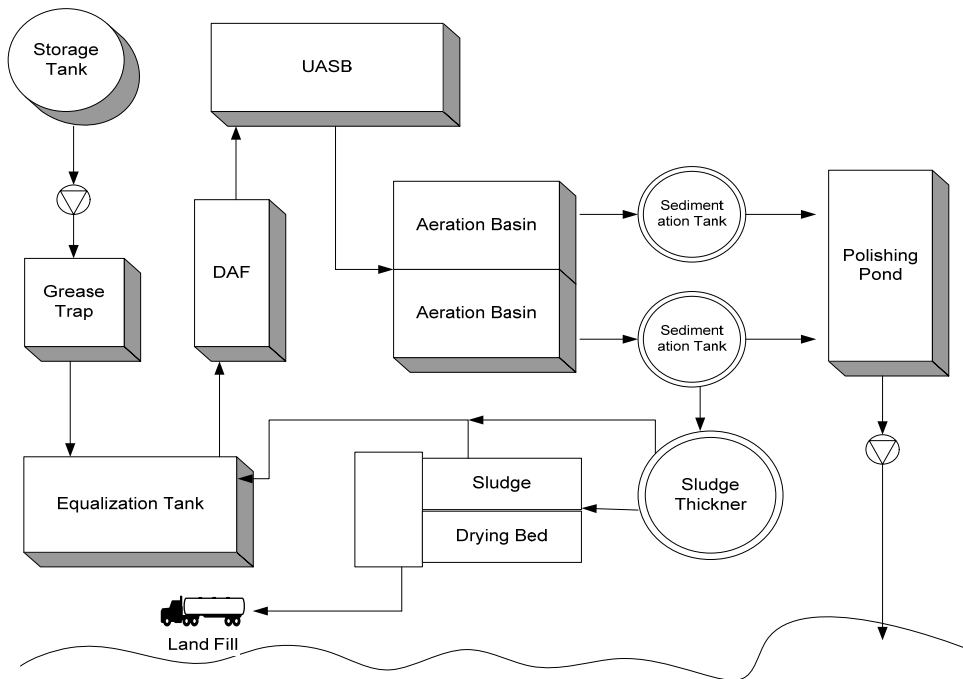


Figure 8: Wastewater Treatment Plant in Songkla Canning Public Company Ltd.



### **4.2 Air emission control**

Venturi scrubbers can remove both dust and gaseous pollutants. This device has the highest particle collection efficiencies (excluding Electrostatic Precipitator). Caustic soda is used for the sprayer. This solution can remove the gaseous pollutants. Cyclone with demister is established following the scrubber. Removal efficiency is shown below.

**Table 12:** Air emission control Efficiency of Venturi Scrubber (**Source:** Design of Air Pollution Control Systems by Dr. N. T. Kim Oanh)

Pollutant	Type	Efficiency
Gaseous	SO <sub>2</sub> , NO <sub>2</sub> , HC	30-60%
PM	PM <sub>10</sub>	90-99%

### **4.3 Odor pollution control**

The following recommended measures can be undertaken to prevent the generation of odor emissions:

- ✚ Avoid processing batches of raw material that are of considerably lower than average quality; this will reduce the odor components;
- ✚ Reduce the stock of raw materials, waste, and by-products and store this stock for short periods of time only in a cold, closed, well-ventilated place;
- ✚ Seal by-products in covered, leak-proof containers;
- ✚ Keep all working and storage areas clean and remove waste products immediately from the production line;
- ✚ Empty and clean fat traps on a regular basis;
- ✚ Cover all transfer systems, wastewater canals, and wastewater treatment facilities to reduce the escape of foul odors.

### **4.4 Solid waste management:**

Fish waste is a rich source of essential amino acids and others. Thus all inedible fish waste should be utilized rather than disposed. Options for using fish wastes are listed below;

1. Extract biochemical and other pharmaceuticals
2. Extract color additives
3. Produce gelatin from skin and bones
4. Use solid waste in fishmeal and oil production
5. Use solid waste in silage production
6. Use solid waste in compost production
7. Use solid waste directly as fertilizer
8. Use solid waste for fish bait or chum
9. Use solid waste for animal feed

For example, A New Zealand fish processor decided to look for an alternative to landfill for disposal of its fish wastes. After considerable research, the company installed a fish bio- digester. Using anaerobic digestion, the plant now produces two useful by-products: methane and fertilizer. Methane (biogas) is used to heat the digester and to supplement the energy requirements of the plant. Sales of the by-products of what previously was waste are US\$9000 per month. Energy savings



amount to US\$4000 per year and annual disposal charges of US\$12,500 have been saved. The overall payback period is estimated at 6 years. (Source: UNEP Report, 1999)

## **5. CLEANER PRODUCTION & TRENDS IN TECHNOLOGY IMPROVEMENT**

Fish processing typically consumes large quantities of water and energy and discharges significant quantities of organic material, both as effluent and as solid waste. However, there is very little use of hazardous substances. (Source: UNEP Report, 1999)

### ***Cleaner production tips for housekeeping***

- ✚ Keep work areas tidy and uncluttered to avoid accidents.
- ✚ Maintain good inventory control of raw ingredients.
- ✚ Ensure that employees are aware of the environmental aspects of the company's operations and their personal responsibilities.
- ✚ Train staff in good cleaning practices.
- ✚ Schedule maintenance activities on a regular basis to avoid inefficiencies and breakdowns.
- ✚ Identify and mark all valves and equipment settings to reduce the risk that they will be set incorrectly by inexperienced staff.
- ✚ Improve start-up and shut-down procedures.
- ✚ Segregate waste for reuse and recycling.
- ✚ Install drip pans or trays to collect drips and spills.

### ***Cleaner production tips for water saving***

- ✚ Install fixtures that restrict or control the flow of water for manual cleaning processes.
- ✚ Reuse relatively clean wastewaters for other applications.
- ✚ Use compressed air instead of water where appropriate.
- ✚ Install meters on high use equipment to monitor consumption.
- ✚ Use closed circuit cooling systems.
- ✚ Pre-soak floors and equipment to loose dirt before the final clean.
- ✚ Report and fix leaks promptly.

### ***Cleaner production tips for reducing effluent loads***

- ✚ Sweep up solid materials for use as a by-product, instead of washing them down the drain.
- ✚ Clean dressed fish with vacuum hoses and collect the blood and offal in an offal hopper rather than the effluent system.
- ✚ Fit drains with screens and/or traps to prevent solid materials from entering the effluent system.
- ✚ Use dry cleaning techniques where possible, by scraping equipment before cleaning, pre-cleaning with air guns and cleaning floor spills with squeegees.

### ***Cleaner production tips for energy saving***

- ✚ Implement switch-off programs and install sensors to turn off or power down lights and equipment when not in use;
- ✚ Improve insulation on heating or cooling systems and pipe work;
- ✚ Favour more efficient equipment;
- ✚ Improve maintenance to optimize energy efficiency of equipment;



- ✚ Maintain optimal combustion efficiencies on steam and hot water boilers;
- ✚ Eliminate steam leaks;
- ✚ Capture low-grade energy to use elsewhere in the operation.

**Table 13:** Typical Performance of Seafood processing and Target in Thailand

Parameter	Typical Performance	Target
Power consumption (kWh/ton of fish)	22 – 279	36.7
Furnace oil grade B (L/ton of fish)	71 – 174	174
Water consumption (m <sup>3</sup> /ton of fish)	9 – 16	8.5
Yield (%)	40 – 53	41.9
BOD loading (kg/ton of fish)	8 - 29	7.5

**Source:** Department of Industrial Works. (2005). Industrial Sector codes of practice for pollution prevention (cleaner technology) for canned fish industry, Ministry of Industry, Thailand



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