CHAPTER 3 WASTE AUDIT

3.1 Introduction

Waste audit is the first step towards reducing waste and overcoming pollution problems (http://www.great-white-north.com, 2010). It is a detailed analysis of a company's processes and wastes aimed at minimizing, or even eliminating, discharges from unit processes. Waste audit was conducted at Kapar Coconut Industry Sdn. Bhd., where different types of coconut-based products were being processed such as spray dried coconut milk powder and low fat desiccated coconut.

In order to be more effective, a waste audit was done through precise methods under the company's appointed personnel. A proficient waste audit included the following:

A) a definition of sources, quantities, and types of waste being generated;
B) a compilation of information on unit processes, products, raw materials, water usage, and waste generation;
C) highlighted process efficiencies and inefficiencies;
D) identified areas of wastage, loss, and waste problems;
E) the identification of set targets for waste reduction;
F) the development of cost-effective waste management strategies; and,
G) Information to increase employee knowledge on production processes and concern for waste reduction.

3.2 Waste Audit Procedure

Waste audit was carried out according to a waste reduction manual ("Waste Audit Manual," 2001) which was published for the purpose of achieving zero waste generation in New Zealand in the following order:

1. Specification of audit scope,
2. Collection of general background information on the company,
3. Determination and quantification of the generated waste; and,
4. Managing and analysing the data for waste audit report.

3.2.1 Specification of Audit Scope

The audit scope is an important step for conducting waste audit in the plant. The scope of the audit was determined to identify the sources of the waste generation and which require detailed investigation and proper waste minimization system.

3.2.2 Collection of General Background Information

Sufficient background information was collected from the company by following the waste audit manual. This included a process flow diagram of manufacturing process, waste material produced and cost of the current waste management method.

3.2.3 Determination and Quantification of the Generated Waste

The characterization and quantification of the wastes was determined by categorizing every waste stream based on the process flow diagram. Also, sufficient data was collected for the storage, rate of generation of the materials, and the volume of generated waste.

3.2.4 Managing and Analysing the Data for Waste Audit Report

The study involved observing, measuring, and recording process-related data, collecting and analysing waste samples and conducting interviews with key plant personnel. Determination and quantification of the waste stream was done in order to follow feasible and proper waste minimization plan. A week was utilized to observe all the processes in the production plant. Areas covered included major sites, paring station, production site, packing site, storage (weighing house), and administration site. The wastes were weighed and separated to quantify the rate of waste generation and the type of wastes. The results will show the ratio of waste generation and waste types.

3.3 Waste Audit Result

3.3.1 Audit Scope

The waste audit only focused on selected sites, namely the paring station, production site, packing site, storage, and administration site. This was based on the need to observe the company protocol. The press station (separating milk from coconut) and desiccated coconut (DC) station were the major points of waste auditing within the production site. The

administration site comprised of production, marketing, quality assurance (QA), human resource management (HR) and general.

3.3.2 Collection of General Background Information

Some background information was available as shown in Table 3.1 which was prepared in controlled documents by the company based on their operating procedure to comply with the local, and some specific countries, standards where the products are exported to.

Table 3.1: Available Background Information from the Company.

Background information	Availability
Process flow diagram	√
Operating manuals and process description	*
Material safety data sheet	√
Product and raw material inventory records	*
Waste transport and disposal records	*
Product, utility and raw material cost	*

Note: 1. Available information = √

2. Information available but not revealed by the facility= *

3.3.3 Determination and Quantification of the Generated Waste

Paring Station

The waste types generated during the process operation were closely related to the type of the raw materials being utilized. The raw coconut (kernel) was delivered to the company (by trucks) from different sources, either from the coconut plantation which also belongs to the same company or imports from Indonesia. The raw coconut was loaded in an open area and a separation process was used to select mature and non-rotten coconuts manually by 6 workers who work 6-8 hours/day and 6 days/week. The coconut will be further processed through deshelling and paring to remove the coconut husk as shown in Figure 3.1.

Coconut shell is sold for charcoal production while coconut husk is either dried and squeezed for production of coconut oil or fibre used as animal feeds (chickens and ducks). Sometimes raw coconuts break during coconut loading into the paring station. These broken coconuts often sent to copra house and used for the production of coconut oil. Prior to loading of the deshelled coconut onto the truck, the coconut is washed. This generates wastewater which is sent to the wastewater treatment plant (WTP).

Process operation	Waste generated
Receiving the raw coconut	Broken raw coconut, coconut water
Selection of coconut (mature & non rotten)	Cracked coconut, used gloves
Deshelling of coconut	Coconut shell, broken knife, used gloves
Pare into kernel	Coconut husk, used gloves, scraped equipment, coconut water
Washing	wastewater
Conveying	Wastewater, raw coconut waste

Figure 3.1: Waste Generated Inside Paring Station.

Production Site

After the white kernel was prepared from the paring station and weighed, it is conveyed to a chlorination tank (5-10ppm) in order to clean and remove foreign particles. Outsourced kernels provided by external suppliers were sent to the visual inspection area for selection. The company's productions were either in the form of flakes or powder. The products are

Coconut Milk Powder (CMP) and Desiccated Coconut (DC). The main types of wastes that are generated in a very low proportion within the production site are wastewater, spilled milk during the mixing process and flow down of desiccated coconut during pressing process as indicated in Figure 3.2. Waste generation during production is very low due to the strict monitoring by the supervisor, automated processing and regular checks on the pipelines and screw conveyor.

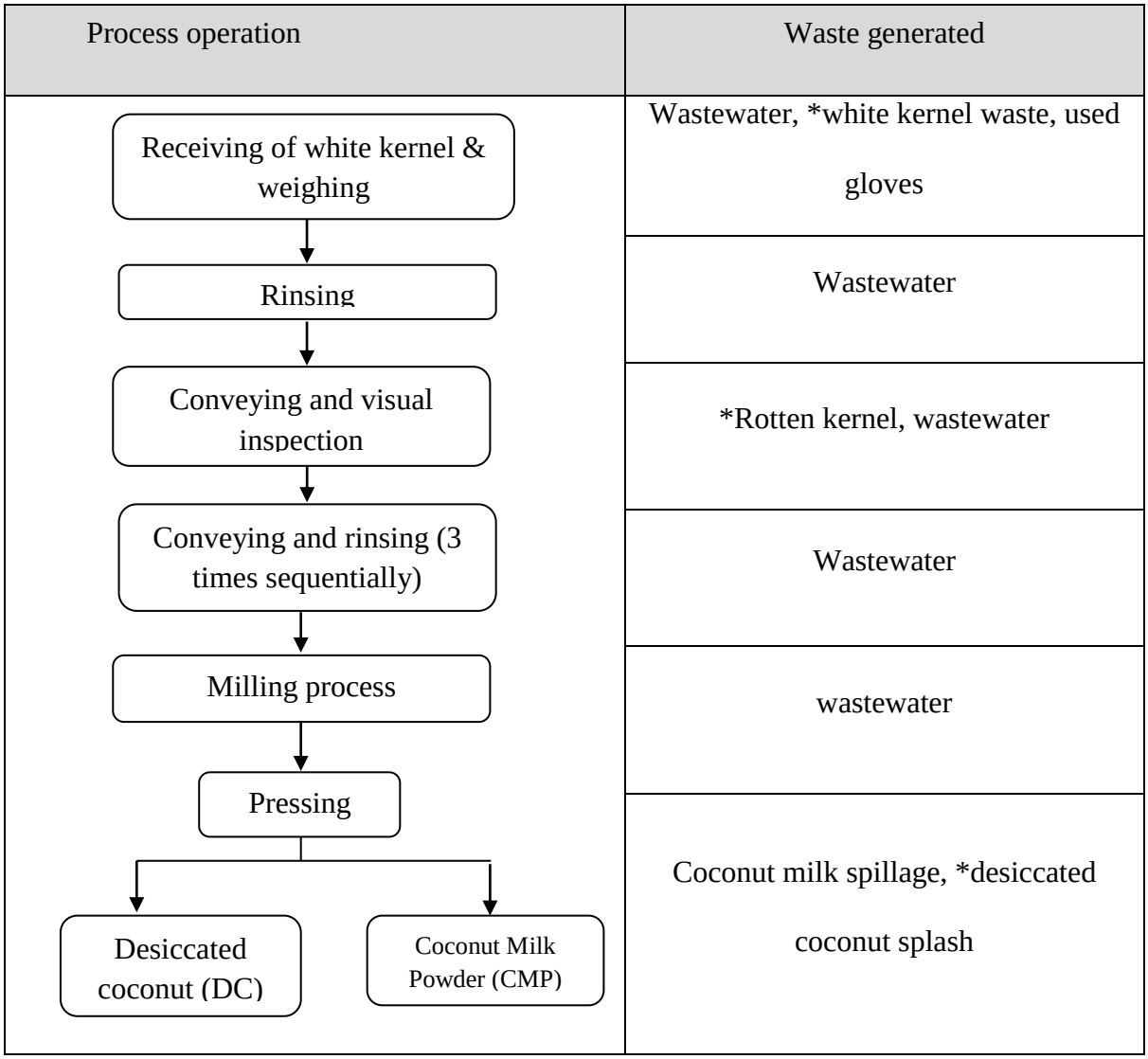

Figure 3.2: Waste Generation from Process Operation (Production Site)

Note: *= reused inside the facility.

- Process Operation of Coconut Milk Powder (CMP)

The white kernel goes through the pressing process and milk is separated from the coconut fiber before being pumped to the milk collection tank as indicated in Figure 3.3. Wastes such as nylon boxes, used gloves, masks, bouffant caps and textiles mostly are thrown away. During pasteurization process, hot water (90-95^{O}C) is used to increase the temperature of the milk to 70-72 ^{O}C in order to kill bacteria and protozoa and make the products safe for drinking. But in all steps, from milk extraction through pasteurization and packing, human contact is minimal.

After pasteurization, the milk will be cooled immediately with cold water before being pumped into pre-heating tank by hot water. Furthermore, the milk will go through three different mixing tanks. The milk is mixed in the first tank with Maltodextrin (modified starch) and Sodium Casseinate (from cow's milk), which are food grade ingredients. Subsequent mixing is done in other tanks. Then, the milk is pumped to the homogenization stage which is accomplished by mixing specified mass of harvested milk to create homogenized milk, and forced at high pressure through small holes or nozzles to a spray dryer tank. Sometimes the milk overlaps the spray dryer chamber and spills in to the drain.

Process operation (CMP)	Waste generated
Milk collection tank 1	Coconut milk spillage, wastewater
Pumping	Coconut milk spillage, wastewater
Filtration	Textile filter, *fiber remain
Milk collection tank 2	Coconut milk spillage, wastewater
Pumping	Coconut milk spillage, wastewater
Pressure filtration	*Fiber remain
Pumping and pasteurization process	Wastewater
Rapid cooling (cold water) and storage	Wastewater, Coconut milk spillage
First mixing tank (milk with Maltodextrin and Sodium Casseinate)	Wastewater, Coconut milk spillage, Maltodextrin and Sodium Casseinate spillage.
Second and third mixing tanks (stirring tank)	Wastewater, Coconut milk spillage

Figure 3.3: Waste Generation from Process Operation of Coconut Milk Powder. (Cont'd…)

Note: *= reused inside the facility

Process operation (CMP)	Waste generated
Homogenization	Wastewater, rages
Spray drying	CMP spillage
Cooling	CMP spillage
Sieving	CMP spillage
Filling (plastic line)	CMP spillage, plastic bags, used gloves, Bouffant Caps
Weight adjustment and sealing	CMP spillage, sealing tape, plastic bag, used gloves, Bouffant Caps
Packaging (cartoning)	Plastic waste, cardboard boxes, wooden pallet
Temporary storage	cardboard boxes, plastic bags, Plastic-film, used gloves, Bouffant Caps, spillage ink, tape, CMP spillage
Final storage	cardboard boxes, CMP spillage, steel pallet

Figure 3.3: Waste Generation from Process Operation of Coconut Milk Powder. (Cont'd…).

- Process Operation of Desiccated Coconut (DC)

After separation of milk fiber, the fiber was conveyed to two dryer chambers for 5-10 minutes at 90-100 ^{O}C. The dried coconut (desiccated coconut) will be cooled and sieved before packaging. The main wastes through this process are desiccated coconut spill and wastewater as shown in Figure 3.4. But these wastes are minimal since the entire process is mostly automated.

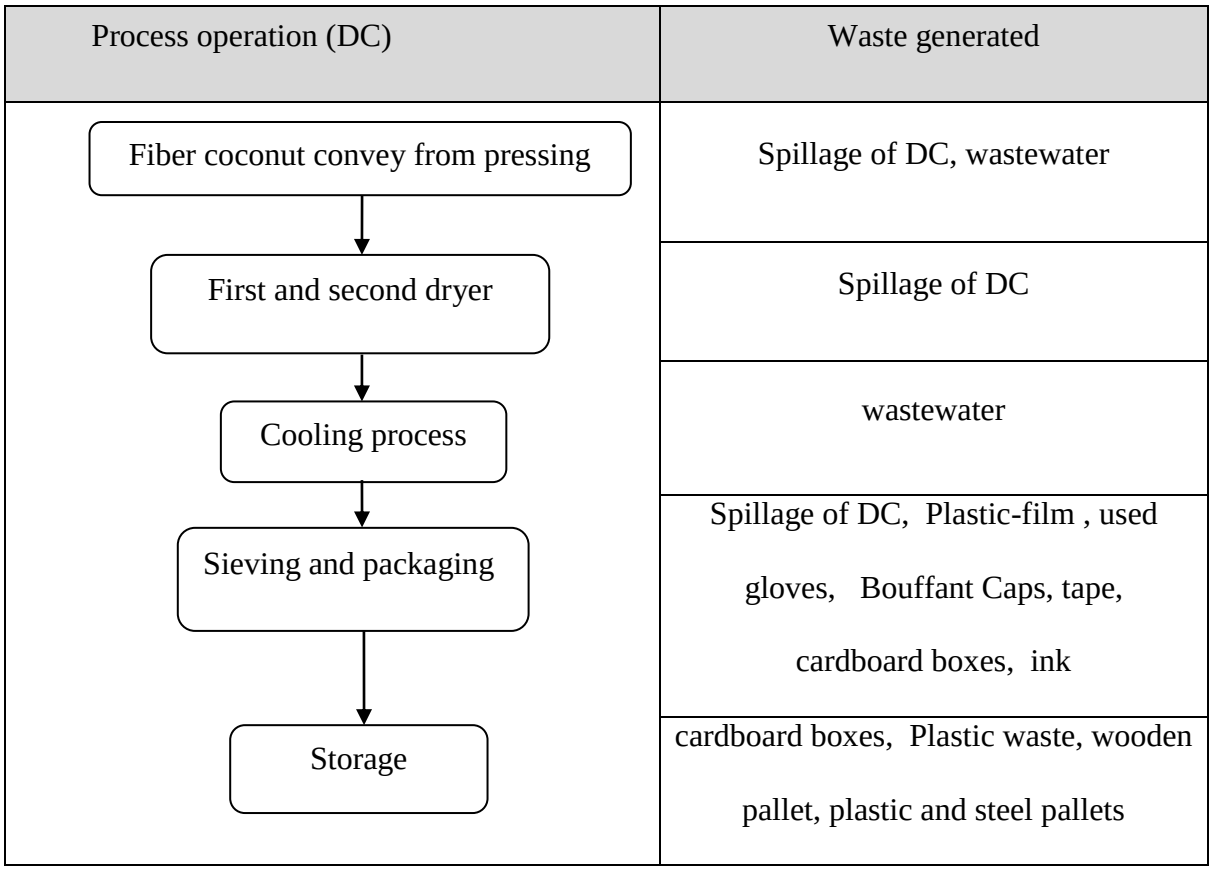

Figure 3.4: Waste Generation from Process Operation of Desiccated Coconut.

- Shredded Coconut (SC)

White kernel is selected manually from the chlorination tank and conveyed to an automated shredder. The product is weighed manually (400 g per box), tightly sealed and stored inside the cooling room at -18 ^{O}C. The main wastes from this stage are wastewater and white kernel waste as shown in Figure 3.5. In addition, the kernel and skin waste from the selection process are sent to some other companies for coconut oil extraction with a different quality for the local market.

Process operation (SC)	Waste generated
Selecting white kernel manually inside chlorination tank	Kernel waste, wastewater, coconut skin, used gloves, Bouffant Caps, mask
Shredding white kernel	Shredded coconut waste
Weighing	Spillage of SC
Sealing	Plastic-film , used gloves, Bouffant Caps, mask
Storage	cardboard boxes, Plastic-film, wooden pallet, plastic bags

Figure 3.5: Waste Generation from Process Operation of Shredded Coconut.

Packaging Process

Packaging takes place after the products are ready in the form of powder or flakes. During the packaging process, different types of waste are generated such as plastic-film, cardboard box, ink, plastic bags, used gloves, bouffant caps and used tape as shown in Figure 3.6. Furthermore, different carton sizes are used for packaging based on customer and markets order which ranges from 8 to 15 kg and the process is done automatically. However, placing the packets inside the carton is done manually.

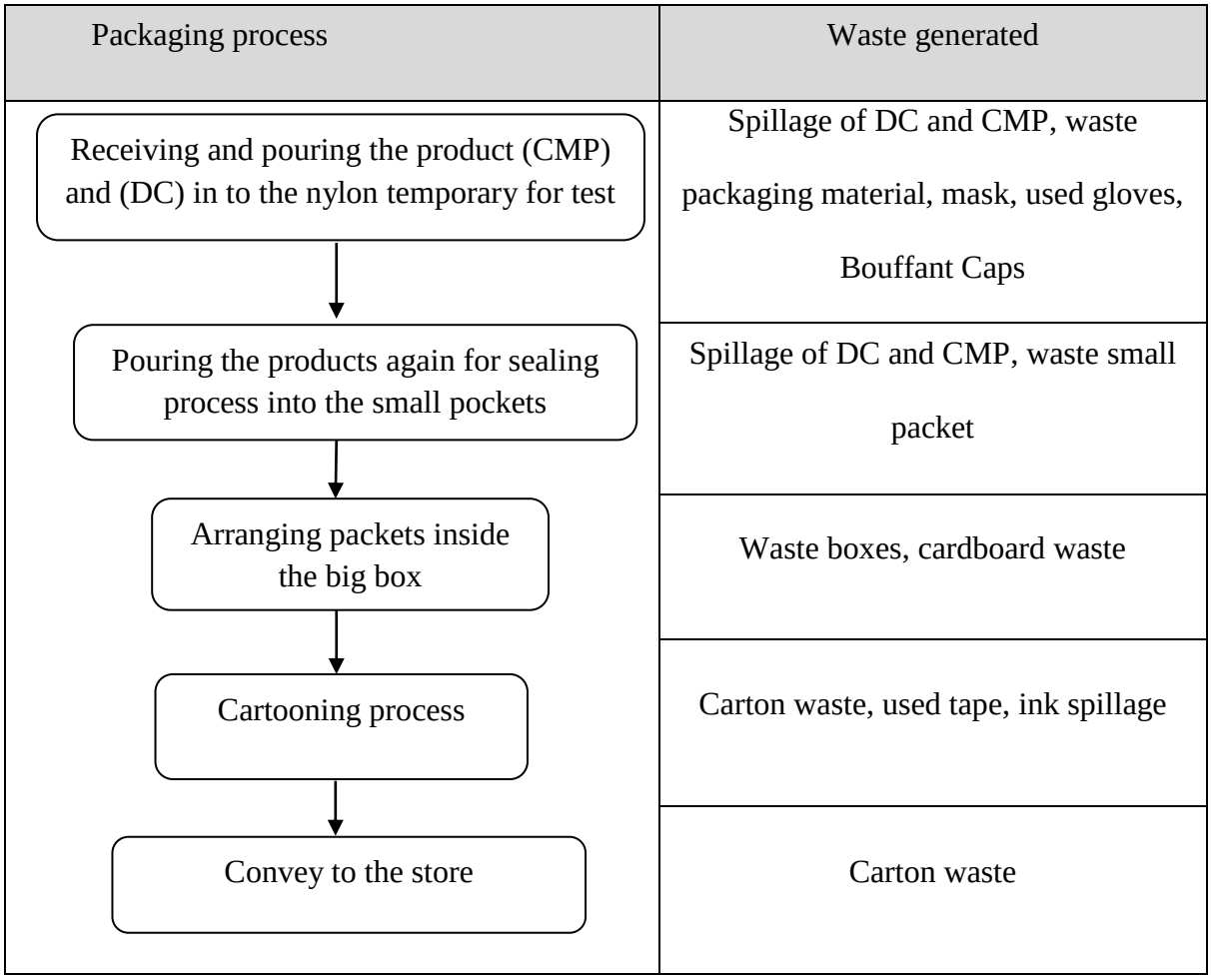

Figure 3.6: Waste Generation from Packaging Process.

Storage Process:

The last section of the company's production operation is storage, where the final product after the packaging process will be kept for a limited period under the controlled environment in terms of temperature and moisture. There are 4 different storage points; one of them stores the products (CMP and DC) temporarily prior to final packaging in order to allow for testing of compliance with local and international standards required (quality control). Another one stores chlorination powder and soda for washing the spray dryer, CIP for washing inner part of the transforming pipes once a week, and liquid soap and detergent for washing the production site's floor. These materials are stored in plastic drums, small containers and nylon boxes. A third storage point keeps Maltodextrin (modified starch) and Sodium Casseinate (from cow's milk), which later is added to the CMP during first mixing process. The last storage point keeps the final product that will be transported to the customers and the products are kept on steel, plastic and wooden pallets. Wastes generated inside these storage sites include spilled chloride, spilled Maltodextrin and Sodium Casseinate, broken drums, used cartons, used nylons, wooden, steel and plastic pallets and wastewater.

Administration Office:

Administration office comprises of five different sections namely; Human Resource management (HR), production management, marketing, general manager and Quality Assurance (QA). The main types of wastes in all these sections are waste paper, plastic bags, tissue paper, used stationary, ink and food containers. The amount of generated waste is very low and is deposited to the waste container before dispose in a landfill. The wastes

are generated daily, during office hours from 9:00 a.m. to 5:30 p.m. Wastes from the administration office were often in dry form, collected for one week (Monday to Friday) and kept in black plastic bags. In addition, the wastes were segregated and weighed to quantify and specify the types of the waste.

- Human Resource Management (HR):

This section is responsible for conducting training for new staff. Training is either via the services of internal or external experts in order to ensure familiarity with the work environment. Furthermore, the details of all departments' staff will be registered under this segment for salary payment, insurance and others as shown in Table 3.2.

Table 3.2: Waste Generation from Human Resource Management Section.

Activity	Waste generated
Conduct training	Used stationary, waste paper
Document and report preparation	Waste paper, stationary waste
Washing the office	Wastewater, used rags and sponge
Photocopying	Waste paper, used printer cartridge

- Production Manager:

The company's production manager is responsible for providing overall management of the success and ongoing production operations, which include controlling the site scheduling, documentation and equipment maintenance as shown in Table 3.3. Moreover,

production manager's job is also to come up with some methods to make the production process more efficient and make the right decisions on time.

Table 3.3: Waste Generation from Production Manager Section.

Activity	Waste generated
Conducting regular meeting with the staff	Waste paper used stationary, food container, tissue paper.
Documentation	stationary waste, cover paper waste
Washing the office	Wastewater, used rags and sponge

- Marketing Section:

This section deals with the distribution of the final product into the consumer market. Therefore, it undertakes fixing the daily prices of the shipping (including day of delivery), currency-market and monitoring the available space of storage to receive new raw materials. The section also takes care of contracts with customers as shown in Table 3.4.

Table 3.4: Waste Generation from Marketing Section.

Activity	Waste generated
Preparing of contracts between the company and customers	Stationary waste, paper waste
Documentation	Waste paper
Photocopying	Waste paper, used printer cartridge

- General Manager:

The company's general manager section is responsible for monitoring all production sites and departments, especially the marketing section (production schedule). The office also checks the quantity of the raw materials to be utilized and generates monthly reports from every department as shown in Table 3.5. The manager also has the responsibility to make decisions in running in the company.

Table 3.5: Waste Generation from General Manager Section.

Activity	Waste generated
Conduct meeting with supervisors	Stationary waste, paper waste
Documentation	Waste paper
Photocopying	Waste paper, used printer cartridge

- Quality Assurance:

Under this section, the products are checked for physical and microbial parameters like flavor, density, number of bacteria, etc. and for every 40 cartons one sample is taken for quality testing. Furthermore, the pipelines which transfer the milk and water are checked regularly. The waste in this section was used paper and stationary generated from documentation and photocopying.

Laboratory Section:

This section conducts biological and chemical tests on raw materials and products before final packaging. The reports from this section are verified by the quality assurance section and then have it compared with test analysis from an external laboratory. Biological analysis is done twice a week while the chemical analysis is conducted once a week. The main wastes in the laboratory were Petri dish, used gloves, bouffant caps, mask, coconut waste from testing, plastic bags and waste paper.

Boiler Operation Unit:

Hot water and the steam for heating and drying the milk and making milk powder were generated at the spray dryer chamber. Sometimes other materials, such as paper waste from offices and broken wooden pallets from the storage are also fed to the boiler. The boiler emits white smog since it is equipped with scrubber to purify the emitted air from different pollutants. The waste generated is in solid form which is dumped into the landfill by another contractor.

3.3.4 Quantification of Generated Waste at the Selected Sites

Waste quantification was carried out at the facility to specify the current generation rate at each site, which included the paring station, production site, packing unit, storage and administration section. The average of waste generated weekly is shown in Table 3.6.

Table 3.6: Waste Generated Weekly by the Selected Locations.

Material type	Source location				
	Paring station	Production site	Packing	storage	Administration office
Coconut shell	3456 kg	-	-	-	-
Coconut husk	540 kg	2.3 kg	-	-	-
White kernel	3.5 kg#	4.2 kg#	-	-	-
Ordinary paper	-	0.2 kg	0.4 kg	0.5 kg	1.3 kg
Corrugated cardboard and carton	-	-	1.4 kg*	20 kg*	0.6 kg*
Nylon bags	-	0.9 kg	32.5 kg	5.5 kg	0.3 kg
Coconut Milk Powder	-	0.8 kg	21.2 kg	1.4 kg	-
Wood (including pallet)	-	320 kg (at boiler section)#	-	1 unit (pallet)#	-
Stationary (pen, etc)	-	1 unit	1 unit	1 unit	2 unit
Petri dish	-	5.5 kg (at laboratory section)#	-	-	-
Plastic items	1 unit (basket)	1 unit (dust bin)	-	1 unit (plastic pallet)	-

Note: #= items will be recycled inside the facility
*= items will be recycled outside the facility

The summary of the main types of waste generated by each section of the company is shown in Table 3.7.

Table 3.7: Summary of the Waste Generated at Various Site in the Company.

Waste generated (type of waste)	Main area of waste generation (which department)	Method of temporary storage (in drum or container)
Spent used gloves, masks, Bouffant Caps, rags, and boots.	Production site, packaging and laboratory section	In appropriate containers
Used paper	office	In appropriate containers
Acid, detergent and milk protein	Storage unit	In appropriate drums and nylon boxes
Wood (broken pallet)	Storage unit	Wood-yard
Scrap metal (steel pallet)	Storage unit	Scrap-yard
Corrugated cardboard and carton	Packaging unit	In steel containers
Plastic bags and nylon box	Packaging and storage units	In appropriate containers

The main types of waste generated by the company is coconut shell and coconut husk and is sold to be further processed by other company to make charcoal from the coconut shell and coconut oil from coconut husk after drying. The coconut shell is sold for RM80/tonne and coconut husk for RM 450/tonne. Other types of waste such as waste paper, cartons and wooden pallets, mostly is used as feed materials for steam generation at the boiler operation unit. As a result of conducting waste audit process, types and quantity of coconut waste (organic waste) were identified in order to choose the best method for waste management at coconut-based industry.