Malaysian Journal of Science **20**: 1-7 (2001)

A case study of waste auditing in an oleochemical plant

S.H. Fauziah and **P. Agamuthu**

Institute of Postgraduate Studies, University of Malaya, 50603 Kuala Lumpur

ABSTRACT This paper describes the results of a waste audit conducted in a leading manufacturer of basic oleochemical products in Malaysia. The two principal wastes generated by the facility are wastewater sludge and glycerol residue, with a daily production of 3.0 tonnes and 1.0 tonne, respectively. Besides glycerol residue, which is classified as scheduled waste, the process operations also generated 1.17 tonnes/day of other hazardous wastes including spent chemicals and contaminated items. Currently, 65% of the total solid waste generated by the plant is recycled and reutilized within the premises. The administrative center alone contributed as much as 21.17 kg/day of waste paper and 1.71 kg/day of plastic waste. Results from the waste audit indicated that the percentage of recycling could be increased with the implementation of cleaner technology to almost 75% of the total waste generated by reutilizing more identified items within the facilities. Besides the reduction in waste generation, the cost of purchasing the reutilized items would also decrease, as well as the cost of waste disposal.

ABSTRAK Kertas ini membincangkan hasil keputusan pengauditan sisa yang telah dijalankan di salah sebuah pengeluar produk oleokimia yang utama di Malaysia. Dua jenis sisa utama yang dikeluarkan oleh kilang ini ialah enap cemar dari pusat rawatan sisa air dan sisa gliserol, dengan pengeluaran harian masing-masing sebanyak 3.0 metrik ton dan 1.0 metrik ton. Di samping sisa gliserol yang diklasifikasikan sebagai sisa berbahaya, proses operasi ini juga menghasilkan 1.17 ton metrik sisa berbahaya dalam sehari, termasuk sisa bahan kimia dan bahan-bahan tercemar. Sehingga kini, 65% daripada jumlah sisa pepejal yang dikeluarkan oleh kilang tersebut dikitar-semula dan guna-semula di dalam premis tersebut. Pusat pentadbirannya sahaja telah menyumbangkan 21.17 kg sisa kertas dan 1.71 kg sisa plastik dalam sehari. Keputusan yang diperolehi daripada pengauditan sisa ini menunjukkan bahawa kadar kitar-semula dapat ditingkatkan dengan implementasi teknologi bersih, sehingga 65% daripada jumlah total sisa yang dijana, dengan program guna-semula item-item tertentu di dalam kilang tersebut. Selain daripada pengurangan dalam penjanaan sisa, perbelanjaan untuk membeli item-item yang digunapakai semula akan turut berkurangan, di samping perbelanjaan kos pembuangan sisa.

(waste audit, oleochemical)

INTRODUCTION

Waste Generation

Increment in waste generation rate to 0.76 kg/person/day in 1995 [1] caused an alarming response in the society. In 1998, 15,268 tonnes/day of waste were generated [2], resulting in increased environmental pollution. The production of industrial waste in 1993 in Kuala Lumpur area alone, reached up to 253.4 tonnes/day [3]. Agriculture-based industries, which are becoming more and more important influenced the economy positively but also concurrently contributed towards pollution with the contribution of 3.5 % of the water pollution of the country in 1997 [4]. In Malaysia, the waste generated normally are categorized into three major group, which include solid waste handled by the municipality or assigned private companies, wastewater managed by Indah Water Konsortium, and scheduled waste that should be disposed in Kualiti Alam. The annual generation of these wastes differ every year with the establishment of new industrial facilities and the new development in industrial technologies as indicated in the Table 1 [5],[6],[7],[8]. There are various of method for waste disposal, which include storing or exporting to foreign company,

individual treatment within the plant through various methods, and sending off to sanitary landfills.

Oleochemical Industry

The availability of abundant raw materials has turned the palm oil industry towards increased production of oleochemical products. Due to the fact that the raw material of this industry is from renewable sources such as castor oil, palm oil and tallow, the production of oleochemical products is increasing. The size of the global oleochemical industry can be indicated by the capacity of its production in 1990, which exceeded 1.7 million tonnes per annum (tpa) [9]. The first oleochemical plant in Malaysia was set up in 1982 [10] and with the establishment of five more plants in 1996, the country managed to produce 165,000 tonnes of fatty acids [11]. In recent years, additional plants have been set up and constructed to produce more sophisticated oleochemicals including esters and fatty alcohols. In 1997, there were 16 plants, which produced 968,000 metric tons of basic oleochemicals, enabling Malaysia to be the world's third largest oleochemicals producer with the contribution of nearly 20% of the 115 million tonnes [12].

Cognis Oleochemical (M) Sdn. Bhd.

Cognis Oleochemical (M) Sdn. Bhd. which was previously known as Henkel Oleochemical (M) Sdn. Bhd. is one of the leading manufacturers of oleochemical products including caprylic-capric acids, fatty acid methylesters, distilled palm kernel fatty acids, fractionated fatty acid methylesters, fractionated fatty acids, saturated fatty alcohols and glycerine. The glycerine produced is classified as P11 EUR, with a purity of 99.5% to 99.8% and is exported to more than 40 countries.

Cleaner Production Technology

Cleaner Technology is generally a technology, which avoids generating pollutants in the production process. Unlike 'clean-up' technology that focuses on waste handling and disposal and usually reduces environmental damage but increases production costs, cleaner technology frequently cut cost and reduces occupational risk, reduces wastage of raw materials and energy, and reduces toxic emission of waste. Cleaner technology applies to the production of goods and services with an integrated, preventive environmental strategy to increase efficiency of the industrial growth as well as maintaining environmental sustainability.

Due to the rapid development in the industrial sector in Malaysia, the oleochemical industry faces problems of limited labour force, higher labour cost, and strict environmental protection regulations set by the DOE. Realising that the compliance of regulations is important to remain competitive in the oleochemical sector, industries try to improve production with implementation of Cleaner Technology in the production line, while researching for alternative solutions for waste treatment and disposal [13]. Cleaner Technology is generally a technology, which avoids generating pollutants in the production process, which frequently cuts cost and reduced occupational risks, reduced wastage of raw materials and energy, and reduced toxic emission of waste [1]. The Global Environmental Outlook (GEO-1) Report indicates a significant progress by the industrial and developing countries towards the betterment of the environment where legal frameworks, economic instruments, environmentally sound technologies, and cleaner production processes have been improved and implemented.

Waste Audit

The most significant steps in achieving waste minimization goals require the auditing of waste generated by the team [13,14,15]. It involves the investigation of each operation that produced waste to resolve the process of the waste being generated, the distinctive characters, the management and the costs involved. These auditing steps contribute information in the evaluation towards waste minimization goals and recognized the options of minimizing it. In addition to it, the auditing steps also allow identification of waste stream that requires the most attention based on the composition, quantity, disposal costs, degree of risk, minimization possibility, recyclable and status of compliance [16].

METHODOLOGY

The waste audit was conducted by determining the audit scope, which is essential in order to carry out waste auditing in a plant allowing the identification of specific points and routes that

require more intensive and detailed investigation. Collection of background information was carried out using a waste audit protocol/worksheet according to the worksheets recommended by the USEPA Waste Audit Guidelines [17].

The waste audit worksheets were used to collect essential background information in the plant including the information on input materials, waste material produced and the process flowchart, production figure and utilities consumption. It was carried out by distinguishing and characterizing input materials, product and waste stream; categorizing every waste stream according to production process flow diagram and compiling data on input and production materials including those categorized as hazardous components. Data on the material handling, storage, and the rate of generation of the materials were also compiled together with the quantitative data on the waste streams including volume and generation rate. Data obtained, which were collected within a month, was evaluated to prepare a waste audit report. The auditing process was conducted daily for a month to ensure the data obtained are the representatives data for the whole year.

The study also included the inspection of the process line from raw materials arrival and storage to the transporting of final product, production line through observation and interviews with operators, and meeting with management staffs, to obtain a better understanding of the possible sources of waste generation.

Identification and quantification of the existing potential waste stream was conducted to explore possible waste minimization from the waste stream based on the observation of the flow process [18] at four representative sites. Weight of waste generated was taken to quantify the rate of waste generation. The results are presented in terms of waste types and waste generation rates.

RESULTS AND DISCUSSION

Waste generated in the main operation plant was related to the activities and type of material being used in the process. Some of the materials in the list of inputs were identified as hazardous while others were non-hazardous wastes. Waste generated in the operation plant is shown in Table 2.

Waste generated in the Quality Control (QC) was closely related to the QC activities and Quality Assurance (QA) activities, and the type of the material being used in the process. Most of the waste generated by the QC department was in the form of liquid, generated continuously due to continuous QC analysis of product samples. Some of chemicals used in the activities were hazardous including acids, solvents, reagents, and various chemical additives, while the others were non-hazardous as indicated in Figure 1.

The waste generated at the administration buildings was closely related to the activities, mainly documentation and administration works. Most of the wastes generated from here were non-hazardous, usually are papers and stationeries as indicated in Table 3.

The wastes generated through the administration activities were in dry form and were segregated accordingly to the type of waste before being collected by the appointed contractors for recycling and disposing purposes. The income from selling the recyclables covered the cost of service of the contractors. Waste from the cafeteria was generally mixed waste with high percentage of organic component, which was non-hazardous as shown in Table 4, and was sent to landfill for disposal. The wastes generated at the facility were quantified to observe the generation rate of each selected sites. The monthly generated waste in term of weight is shown in Table 5.

Basically, the cost of disposing bulk of the waste generated by the company was very minimal due to the arrangement between the administration and the waste disposal contractor. However, the disposal cost of major waste i.e. wastewater sludge into municipal landfills and glycerol residue to sanitary landfill in Kualiti Alam were high, as much as RM 150/tonne and RM 793.24/tonne, respectively.

From the waste audit conducted, there are various options for waste reduction and reutilization. Reduction of waste can be conducted by replacing appropriate items with

materials, which can be reused and last for a longer period. For an example, disposable gloves and paper towels used in every activity can be replaced with rubber gloves and cotton towels, which can be washed and used again. This is to minimize the generation of disposable items to the smallest quantity possible to reduce waste generation and reduce the utilization of natural resources. Waste reduction also can be carried out by maintaining good housekeeping to avoid excessive waste generation during cleaning process; conducting regular machinery maintenance to prevent breakdown, and reduce inefficiency in production; preparing good plan to increase and maintain efficiency, prevent spillage of product and chemicals; and utilizing recycled items such as one-sided paper to print draft documents and internal circulars. Waste reutilization can be implemented to handle wastewater sludge, which mainly consisted of organic matter (80%) through composting to avoid the disposal of the resource to landfills. Since the company has the policy of not revealing the cost of purchasing of the items and materials used in the facilities, the precise reduction in cost from the cleaner technology program cannot be revealed.

By implementing cleaner technology, where composting technique can be applied to the wastewater sludge, the disposal cost of this waste could be reduced significantly. The estimated cost reduced with the implementation of the program is RM 162,000 annually, which include the cost of transporting and disposing wastewater sludge to municipal landfills.

Table 1. Percentage of Scheduled Waste Generation in Malaysia.

Types of Waste	1994	1996	1998	2000
Mineral Sludge	31.8 %	13.21	13.27 %	20.60 %
Catalyst	0.2 %	0.34	0.06 %	0.77 %
Containers	0.4 %	0.04	0.16 %	0.33 %
Oil and hydrocarbon	2.5 %	1.97	17.58 %	10.11 %
Others	65.1 %	84.4 %	68.93 %	68.19 %
Total (Million tonne)	**417, 413**	**632, 521.31**	**398, 518**	**344, 550.34**

Table 2. Waste Generated from The Main Operation Plant.

Activity	Waste Generated
Plant cleaning	- water, product waste #, waste packaging.
Pastillation process	- off-spec production accumulation #, dust, spent lube oil*, scrap metal (spoilt parts).
Packaging	- waste packaging material (paper, poly-ethylene bags, shrink wrap) damaged wooden pallets.
Palletizing	- dust, waste materials (shrink wrapper, label, paper), damaged wooden pallet.
Remelting/reworking off-spec product	- spillage of non-conformance product liquid*, solid waste *, paper.
Blending reaction	- dust, raw material waste #, drums #, used bags, filter bags, spillage of raw material #, scrap equipment, damaged personal protection equipment *.
Pumping	- spillage of product and raw material #, scrap equipment.
Pipelines, vessel and pastillator cleaning	- water, used bags and drums, mixed and unknown products or rejects #.
Rebagging	- packing material waste *, bags, plastic, shrink wrapper, waste from sewing material.

Note : * = disposed as scheduled waste,
= residue is collected to be reused

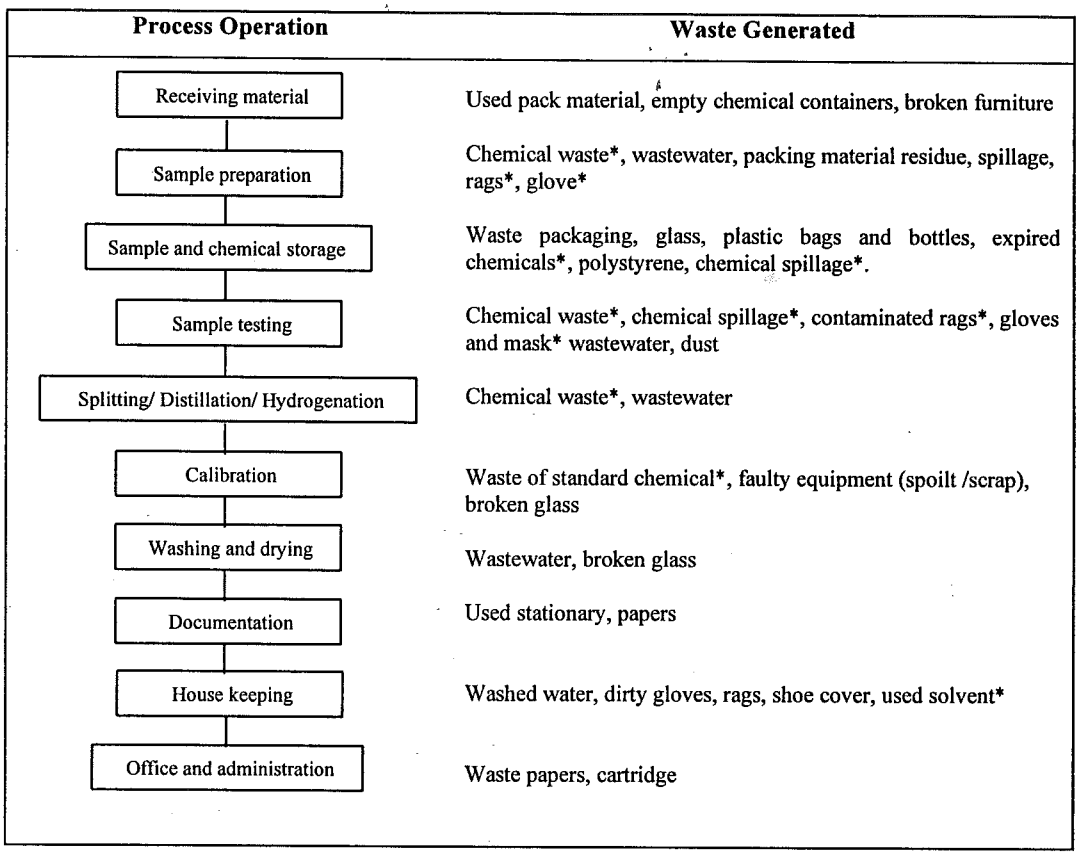

Figure 1. Process Flow in The Quality Control and The Waste Generated.

Note: * = disposed as scheduled waste,
= residue is collected to be reused.

Table 3. Types of Waste Generated by Administration Activities.

Activity	Waste Generated
Reports preparation	Waste paper, waste stationary
Medicine requesting	Bandage, plastic, expired medicine*, used packaging materials
Document Stamping	Waste paper, ink
Paper shredding	Waste paper
Photocopying	Waste toner, waste paper
Conduct Training	Used stationary, food containers
Washing	Wastewater, used sponge, brush, rubber glove, apron, food waste.
Cooking and food preparation	LPG leakage, food containers, cooking oil, food waste.
Pest controlling	Pesticide spillage*
Document typing	Waste cartridge
Storing	Waste paper, waste box, cabinet scrap
Cheque preparation	Waste stationary/cheques

Note: * = disposed as scheduled waste

Table 4. Types of Waste Generated from The Activities in The Cafeteria.

Activity	Waste Generated
Kitchen cleaning	Plastics, papers, food residues.
Delivery of raw goods from supplier	Plastic bags, papers
Checking, unpacking and storing purchased goods	Spoilt goods, expired food, paper, plastic, glass, metal, organic materials
Cleaning, preparing and cooking of food	Organic materials from food preparation, water, glass, metal, plastic, paper.
Serving food	Organic waste, leftover, plastic cover, plastic bags.
Cleaning dishes, kitchen utensils and cooking tools	Organic waste, leftover, plastic straw.
Housekeeping	Dirty cotton rags, mops, spilled food waste

Table 5. Weight of Waste for Disposal Generated Monthly by The Selected Locations.

Material type	Source Location			
	Operation Plant	Quality Control Dept	Cafeteria	Administration
Corrugated cardboard	6.0 kg	12.86 kg	-	-
Beverage cans	-	-	9 units	-
Ordinary paper	*250 kg	*67.48 kg	*9 kg	*633.5 kg
Paper bags	150 units	-	-	-
Boxes	-	2 units #	6 units	29 units
Garbage	15 kg	46.97 kg	214. 5 kg	28.4 kg
Scheduled waste	35 tonnes	83.7 kg	-	-
Batteries	-	4 units	-	20 units
Textile	*700 kg	*2.6 kg	0.1 kg	9.614 kg
Metal drums	172 units #	1 unit #	-	-
Steel items	-	-	*135 kg	*15.4 kg
Plastic items	0.8 kg	1.3 kg #	87 kg	51.2 kg
Poly-ethylene bags	16 units	4 units	-	8 units
Wood (including pallet)	300 units (pallet)	-	-	133 kg
Reaction tank filter bags	10 units	-	-	-
Stationary (pens, etc)	2 units	3 units	-	22 units
Empty cartridges	-	1 unit	-	9 units
Carbon/ stencil ribbons	-	-	-	5.7 kg
Glass items	-	*32.5 kg	*5.1 kg	*5.5 kg
Organic waste	-	-	312.6 kg	28 kg

Note: * - items recycled outside the facility
- items reused within the facility

CONCLUSION

The identification of the waste streams in the activities in the plant will allow the planning of a suitable waste minimization program, which not only would benefit the owner of the plants through cost reduction but would also reduce the generation of waste.

Acknowledgements We wish to thank Cognis Oleochemical (M) Sdn. Bhd. for allowing us to conduct the research in their manufacturing facility. The project was funded by a PJP grant from the University of Malaya.

REFERENCES

1. Agamuthu, P. (2001). *Solid Waste: Principles and Management*, University Malaya Press, Kuala Lumpur. 395 pp.
2. Ministry of Housing and Local Government (1999) *Annual Report-Section 4- Local Government Technical Section, Local Government Division,* Ministry of Housing and Local Government.
3. Engineering Advancement Association of Japan. (1993) *Preliminary Feasibility Study Report on Solid Waste Disposal Management in Malaysia/Kuala Lumpur.*
4. Department of Environment, Ministry of Science, Technology and the Environment, Malaysia. (1998). *Malaysia Environmental Quality Report 1997*, Machentar Printers Sdn Bhd. Kuala Lumpur.
5. Department of Environment, Ministry of Science, Technology and the Environment, Malaysia. (1995). *Malaysia Environmental Quality Report 1994*, Harian (Zulfadzli) Sdn. Bhd. Kuala Lumpur.
6. Department of Environment, Ministry of Science, Technology and the Environment, Malaysia. (1997). *Malaysia Environmental Quality Report 1996*, Malindo Printers Sdn. Bhd. Kuala Lumpur.
7. Department of Environment, Ministry of Science, Technology and the Environment, Malaysia. (1999). *Malaysia Environmental Quality Report 1998*, Maskha Sdn Bhd. Kuala Lumpur.
8. Department of Environment, Ministry of Science, Technology and the Environment, Malaysia. (2000). *Malaysia Environmental Quality Report 1999*, Maskha Printers Sdn Bhd. Kuala Lumpur.
9. Speed, R.M. (1990). *1989 PORIM International Palm Oil Development Conference*, Palm Oil Research Institute of Malaysia, Kuala Lumpur. 232 pp.
10. Ahmad, I. and Mohamed Jaafar, A. (1993). *Selected Readings on Palm Oil and Its Uses. Palm Oil Research Institute of Malaysia (*PORIM*)*, Ministry of Primary Industry, Malaysia. 231 pp.
11. Zafarizal, A. A. H. (1997). *Palm Oil Development.* **26**: 13.
12. Palm Oil Research Institute of Malaysia. (1997). *Palm Oil Link.* 1/97(8): 14.
13. Sastry, C.A., M.A. Hashim and P. Agamuthu (1995). *Waste Treatment Plants.* John Wiley & Sons and Narosa Publishing House, New Delhi. 435 pp.
14. Shen, T.T. (1995). *Industrial Pollution Prevention.* Springer-Verlag, Berlin. 371. pp.
15. Environmental Protection Agency (1990). *Pollution Prevention Directive.* USEPA, Washington D.C., USA. 13 May 1990.
16. Haas, C.N. (1995). *Hazardous and Industrial Waste Treatment*, Englewood Cliffs, Prentice Hall, New Jersey. 363 pp.
17. USEPA (1990) *Waste Audit Guidelines*, **277**: 27.
18. Ciambrone, D.F. (1995). *Waste Minimization as a Strategic Weapon*, Lewis Publishers, United States of America. 395 pp.