Hazardous waste management: current status and future strategies in Malaysia

Article *in* International Journal of Environmental Engineering · January 2010

DOI: 10.1504/IJEE.2010.029825

6 authors, including:

Zulkifli abdul rashid

37 PUBLICATIONS **535** CITATIONS

SEE PROFILE

Azil Bahari Alias

Universiti Teknologi MARA

63 PUBLICATIONS **884** CITATIONS

SEE PROFILE

Mohanad El-Harbawi

King Saud University

82 PUBLICATIONS **1,245** CITATIONS

SEE PROFILE

Norazah abd rahman

Universiti Teknologi MARA

99 PUBLICATIONS **1,265** CITATIONS

SEE PROFILE

Hazardous waste management: current status and future strategies in Malaysia

Zulkifli Abdul Rashid, Azil Bahari Alias and Mohd Jindra Aris

Faculty of Chemical Engineering,
University of Technology MARA,
40450 Shah Alam Selangor, Malaysia
E-mail: zulmas06@yahoo.com.my
E-mail: azil5539@yahoo.com
E-mail: astrojin@yahoo.com

Mohanad El-Harbawi*

Department of Chemical Engineering,
University of Technology Petronas,
31750, Tronoh, Perak, Malaysia
E-mail: mohanad_elharbawi@petronas.com.my
*Corresponding author

Norazah Abdul Rahman and Ayub Md. Som

Faculty of Chemical Engineering,
University of Technology MARA,
40450 Shah Alam Selangor, Malaysia
E-mail: noraz695@salam.uitm.edu.my
E-mail: ayub522@salam.uitm.edu.my

Abstract: Although Malaysia is a model for economic success amongst Southeast Asian countries with its impressive development over the last 36 years, it has not been without its detrimental effects on the natural environment. The most apparent effect is the drastic increase in the generation of hazardous wastes. This paper highlights Malaysia's current status in hazardous waste management and the potential major difficulties. The principles, objectives and the remedial plans for hazardous waste control are also explained in detail and have been stipulated in the environmental policies as issued by the Department of Natural Resources and Environmental Ministry, Malaysia.

Keywords: hazardous waste; current status; future action plan; Malaysia.

Reference to this paper should be made as follows: Rashid, Z.A., Alias, A.B., Aris, M.J., El-Harbawi, M., Rahman, N.A. and Som, A.M. (2010) 'Hazardous waste management: current status and future strategies in Malaysia', *Int. J. Environmental Engineering*, Vol. 2, Nos. 1/2/3, pp.139–158.

Biographical notes: Zulkifli Abdul Rashid, MSc (Environmental Engineering), is a Lecturer in the Faculty of Chemical Engineering, University of Technology MARA (UiTM), Malaysia. His research interests are in the areas of hazardous waste management, industrial wastewater and air pollution design and treatment, river rehabilitation, GIS technology, resource recycling and pollution prevention. He has published papers in several conferences, proceedings and specialised journals He had 10 years hands-on experience in the field of environmental engineering and management.

Azil Bahari Alias, MSc (Energy and Environment), is a Lecturer in the Faculty of Chemical Engineering, University of Technology MARA Malaysia (UITM), Shah Alam. His research interests are in the areas of combustion, coal and combustion technology and also renewable energy. He has published more than 20 papers in several conferences, proceedings and specialised journals.

Mohammad Jindra Aris, MSc Eng (Chemical Process and Bioprocess System Engineering) is a Senior Lecturer with the Faculty of Chemical Engineering, University of Technology MARA Malaysia (UITM), Shah Alam. His research interests include issues related to numerical method analysis, mathematical modelling, bioreactor design engineering, transport phenomena and environmental decision support system analysis.

Mohanad El-Harbawi is a Lecturer with the Faculty of Chemical Engineering, University of Technology Petronas (UTP), Tronoh, Perak Malaysia. His research interests are in the areas of safety and loss prevention, software development, risk assessment, air pollution, GIS and modelling and simulation. He has published papers in several conferences, proceedings and specialised journals.

Norazah Abdul Rahman is an Associate Professor and a deputy dean with Faculty of Chemical Engineering at the University of Technology MARA Malaysia (UITM), Shah Alam, Malaysia. Her fields of interest include drying, particle and non-destructive technology and crystallisation process.

Ayub Md. Som is an Associate Professor with the Faculty of Chemical Engineering at the University of Technology MARA Malaysia (UITM), Shah Alam, Malaysia. His fields of interest include environmental decision support system and expert system technology, industrial wastewater treatment and hazardous waste management.

1 Introduction

Malaysia today is an example for economic success, attaining a rapid economic growth rate in Southeast Asia. The country continues to take big strides towards becoming an industrialised nation by the year 2020. With the current trends of rapid population growth and industrialisation, wastes and pollutants are released faster than the earth can absorb them, such that maintaining a sustainable environment is becoming a challenging task. Thus, the environmental issues we encounter today are increasingly complex and require more integrated solutions. Integrated strategies offer solutions that address more than one

problem in a holistic approach. For example, waste is conventionally defined as something unwanted and has no economic value. However, there is a new approach of looking waste stream nowadays. Instead of seeing used materials as waste with a need of disposal, used materials are seen as valuable resources. Waste can be a source of living for many people, in many ways. This include business activities such as recycling and composting of waste materials, generating energy from waste, as well as converting waste to other useful resources such as proposing to use red gypsum waste, copper slag, silica sludge and spent catalyst generated from other industries as substitutes of raw materials for the manufacturing of Portland cement. It is anticipated that the use of above waste can substitute about 2–5% of the principal raw materials and lower the overall cost of cement production. It is reported that one of the cement industries in Negeri Sembilan, Malaysia used with an estimated quantity of 10,100 metric tonnes of the above waste per month (DOE, 2005; EIA, 2006). Currently, the approach of waste disposal through landfill creates continuous environmental issues, which does not provide a sustainable solution as more land is required to cater the increase in waste generation and finally outpacing the lifespan of current landfills capacity. The disposal activities require high cost and pose major problems such as odour, leachate, air pollution and surface water and groundwater contaminations. As of late, one of the many issues that have become highly important is the problem of managing the hazardous wastes. The traditional management tools alone, such as regulatory control, are not enough under the present circumstances. New innovative means and measures need to be devised by which these complex environmental problems can be dealt with effectively in the future.

2 Overview of the current status of hazardous waste management in Malaysia

2.1 Industry and economic growth development

Malaysia has established a diverse and quickly growing manufacturing sector that plays an increasing role in the Malaysian economy. The development of the manufacturing industry in Malaysia has boosted the economic growth of the country. In 1996, it is reported by the Ministry of Finance that the industrial sector contributed RM 45.2 billion to Malaysia's Gross Domestic Product (GDP), accounting for 34.6% of overall GDP, with 13.3% growth over the previous year (Ministry of Finance Malaysia, 1996). The industrial sector initially consisted of oil refining, machinery assembly and light industries (including foodstuff processing and textile manufacturing). However, Malaysian manufacturing sector was boosted in the 1970s and 1980s by the extensive growth of the electric assembly and electronics sectors. Malaysia became an important producer of radios, television sets, stereo equipment and other related products. In the 1980s, the Malaysian government launched its national automobile project, the locally produced Proton car (in cooperation with Mitsubishi of Japan), and in the late 1980s, it started exporting the Proton to the international market. In the 1990s, there was further growth in the manufacturing sector, especially in export-oriented electronics production, including semiconductors, silicon wafers and other items.

The industrial sector was anticipated to contribute 37.2% of overall GDP in the year 2000 (Malaysia, 1991). However, during the economic recession from 1997 to 1998, growth in the manufacturing industry decreased by 13.4%. The performance of the manufacturing industry has been geared up, and its growth increased by 13.5% in 1999 and 21% in 2000. This has led to a GDP contribution of 33.4% in the year 2000 (Malaysia, 2001). With equipped policies and strategies established by the federal and state governments, the manufacturing industry expanded significantly. Infrastructure and utilities have been developed to support industrial development, and their capacity has increased each time when there was a need for an increase in the number of new industries. The services sector, which provides financial, transportation and other services, was established to ensure that industrial development targets were met and sustained. The number of factories in Malaysia is increasing every year, and production is escalating in tandem with market demand. Industry focus is always on the number and volume of products, but industrial waste production during the extraction of resources, production processes and use by consumers has been never placed in the overall manufacturing design. In 2005, the Department of Statistics Malaysia has reported that there were more than 28,257 manufacturing factories in Malaysia (Department of Statistics, 2005). This number is almost 1.5 times higher than the number of factories in 2001 – there were 19,184 manufacturing factories in Malaysia.

Rapid economic growth and stability brought economic prosperity to a large proportion of the population, especially in urban areas. The population of Malaysia was estimated as 21,793,000 in July 2000. It has almost doubled since the 1960s. The estimated population growth rate is 2.01% and if the current trend remains unchanged, the population could reach 31 million by 2020. The population is very unevenly distributed, with almost 81%, or 17.5 million, living in Peninsular Malaysia, and 19%, or 4.2 million, living in East Malaysia. The population density is about 129 people per square kilometre (334 people per square mile) in Peninsular Malaysia and about 20 people per square kilometre (52 people per square mile) in East Malaysia (Malaysia, 2001).

2.2 Hazardous waste in Malaysia perspective

Generally, the control of airborne and waterborne toxic residuals does not address the major issues of the large quantities of hazardous materials that are being left over after the production (and recycling) process is completed, and which must then be disposed of. This is the problem of hazardous waste. Hazardous waste consists of a diverse set of materials in the form of solid, liquid and semi-solid. In legal terms, the Department of Environment (DOE) Malaysia, which is under the Ministry of Natural Resources and Environment, have the authority to define what is considered as hazardous waste or, from the disposal operation point of view, which have been classified as scheduled waste.

Under Environmental Quality Act (EQA) 1974, waste is defined as

> "any matter prescribed to be scheduled waste or any matter whether in a solid, semi-solid or liquid form of a vapour, which is emitted, discharged or deposited in the environment in such volume, composition or manner as to cause pollution."

This definition is appreciably different from that which is widely used internationally. In the European Union (EU) and many other countries, waste is defined as any material, which the holder discards or intends to discard. The Basel Convention definition is similar but uses the term 'dispose of' instead of 'discard'. In Malaysia, therefore, a material only becomes waste at the point at which it is emitted, discharged or deposited and then only it causes pollution.

Hazardous waste means waste, which contains one or more properties that pose risks and danger to health or the environment. On serious note, this term has considerable legal impact on industries in determining how the waste is regulated and managed until its final disposal. Hazardous waste regulations compliance depends on the regulatory definition of hazardous waste. To determine if waste is hazardous, it must first meet the regulatory definition of a 'solid waste'. The US Environmental Protection Agency (USEPA) describes a solid waste as "any solid, liquid or contained gases material that you no longer use, and is recycled, thrown away or stored until you have enough of it to treat or dispose". If waste meets the definition of solid waste, it will then be considered to be hazardous waste if it is included in one of the four lists of hazardous wastes found in the US Federal Resource Conservation and Recovery (RCRA) regulations (i.e., listed wastes) or in the list of Malaysian's First Schedule of the Environmental Quality (Scheduled Wastes) Regulations, 2005 or it exhibits one of the four defined hazardous waste characteristics of ignitability, corrosivity, reactivity or toxicity. In USA, a waste is classified as a listed waste of RCRA regulations if it has been shown to be harmful to health and the environment and when it has not been properly managed. The regulation lists over 400 hazardous wastes (40 CFR Part 261) in four Federal lists (Deninison, 1993). In Malaysia, a hazardous waste is classified as scheduled waste if it is included in the 77 categories of hazardous wastes listed in the First Schedule of the Environmental Quality (Scheduled Wastes) Regulations, 2005.

2.3 Trends in hazardous waste distribution characteristics and production in Malaysia

Hazardous waste generation is not spread evenly over the states of Malaysia. As presented in Table 1 for the year 2004, the largest quantities of hazardous waste were produced in Penang, Selangor, Johor and Perak in 2004 where most of the industries were mainly located on the west coast of Malaysia. At the other end of the scale, Wilayah Persekutuan Labuan, Perlis and Kelantan produced relatively small amounts of hazardous waste (Keng, 2006).

On the basis of the notification received by the Department of Environment during the 1995–2004 periods, there was a marked increase in the generation of toxic and hazardous waste in 1996 due to the large number of waste that has been accumulated over the years as Kualiti Alam (first Integrated Waste Management Centre in Malaysia)

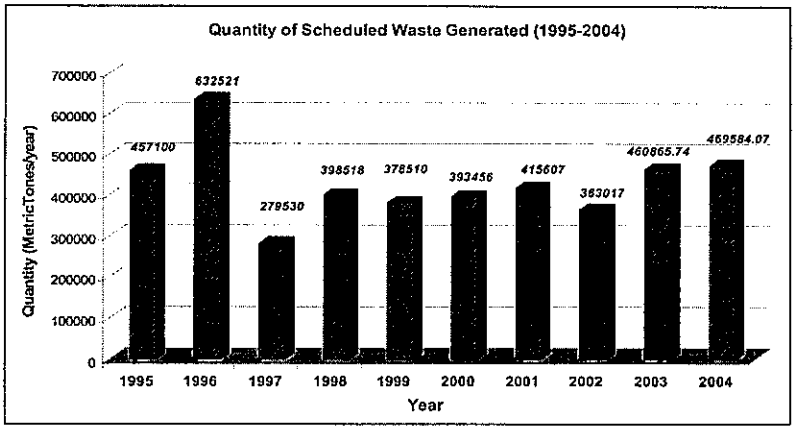
was not established prior to 1995 and due to rapid industrialisation as presented in Figure 1. The highest quantity of scheduled wastes generated was in 1996, with a total of 632,521 tonnes (EPU, 2002). After 1996, the quantity of scheduled waste had drastically decreased to an average of 370,593 tonnes per year (DOE, 2003, 2005; EPU, 2002; Keng, 2006). In 2004, 469,584.07 tonnes of scheduled waste had been generated as compared with 460,865.74 tonnes in 2003 by 5139 of waste generators. There is a 1.9% increase of scheduled waste even though the number of waste generators is the same for both years 2003 and 2004. This is due to the remaining waste accumulated and not delivered for disposal over the previous years. A total of 363,017 tonnes of scheduled waste were generated by 4079 waste generators in 2002, which is 21% less compared with that in 2003. Heavy metal sludge, mineral sludge, metal dross, slag and clinker waste made up the main categories of waste produced in Malaysia, which is about 49–55%, followed by the oil and hydrocarbon waste (about 23–25%) and the other waste, that is, photographic waste, paint waste, lacquer and ink waste, spent catalyst and acid and alkali waste (about 20–28%) (DOE, 2003, 2005). Of the total scheduled waste generated, it was estimated that 55–58% of the waste will be recycled at the off-site local Scheduled Waste Recovery Facilities (SWRF), with only 65–90% of the recycle waste being reused at the SWRF process plant as product and 10–35% as waste residue (DOE, 2003, 2005; EIA, 2004).

Table 1 Scheduled waste generated in Malaysia in the year of 2004

State	*Quantity*
Johor	44,483.60
Kedah	33,892.22
Kelantan	962.54
Melaka	13,317.55
Negeri Sembilan	3,798.98
Penang	89,549.34
Pahang	18,580.95
Perak	68,459.14
Perlis	646.59
Selangor	61,933.11
Terengganu	58,961.95
Sabah	33,767.98
Sarawak	36,501.87
W. Persekutuan Kuala Lumpur	4,277.37
W. Persekutuan Labuan	450.82
Total	*469,584.07*

Source: Keng (2006)

Figure 1 Quantity of scheduled waste generated in Malaysia (1995–2004) (see online version for colours)



2.4 Brief issues in handling current hazardous waste management

Table 2 shows the results of hazardous waste quantities managed by the first Integrated Waste Centre in Malaysia between 1998 and 2004. The greatest proportion was disposed of in the landfill. Hazardous waste was disposed of through incineration process to treat organic waste such as mineral oil waste, waste solvents, pesticide waste and waste containing halogens and sulphur (Abdul Rashid et al., 2007). On the basis of DOEM (Department of Environment Malaysia) annual report 2004, about 58.01% of hazardous waste is subject to some type of recovery (recycling) operation, and about 6.7% is burned in integrated waste management centre incinerator, and about 2.73% is burned at local off-site clinical waste incinerators (Pantai Medivest Sdn Bhd). Currently, about 22% of the hazardous waste is transported to off-site disposal facilities, and 11–12% is disposed for onsite treatment, that is, at the site of the industrial plant where it was manufactured or used (DOE, 2005).

Table 2 Hazardous waste quantities managed since 1998 to October 2004, by various technologies

Year	*Hold*	*Incineration*	*Landfill*	*PCT*	*Solidification*	*Total*
1998	0.00	14,071.00	25,281.00	99.00	15,878.00	55,329.00
1999	0.00	25,953.00	28,158.00	610.00	15,778.00	70,479.00
2000	0.00	29,028.00	33,629.00	1992.10	19,681.00	84,330.10
2001	0.00	30,533.86	29,758.73	1585.15	16,338.00	78,216.10
2002	27.76	34,976.64	35,222.97	2648.95	14,639.92	87,516.23
2003	0.43	32,777.86	35,150.97	3479.31	13,259.99	84,668.56
2004	267.40	22,982.54	31,059.04	4736.09	11,862.68	70,907.75
Total	*295.59*	*190,802.90*	*218,259.71*	*15150.59*	*107,437.96*	*352,846.50*

Generation of hazardous wastes must be controlled to protect public health and the environment. We have learnt from the experience of developed countries such as the USA, Japan, UK that the environmental problems associated with illegal and indiscriminate disposal of hazardous waste are detrimental to the environment and require costly clean-up measures. For example, in the USA, in 1920, Love's land was sold in public auction to the City of Niagara Falls, who began using the undeveloped area as a landfill for chemical waste disposal, and later the US Army allegedly began using the site as well, burying waste from its experiments in chemical warfare. From 1942 to 1952, Hooker Chemical and Plastics Corporation buried about 22,000 tonnes of toxic waste in the area. The incident resulted in more than 900 families being forced to leave their homes so that the site could be cleaned up, and in the company spending USD 98 million and USD 129 million as incurred by the state of New York and federal government, respectively. USEPA scientists found 82 toxic chemicals in air, water and soil samples near the dumps, and numerous toxic chemicals, which are carcinogenic being discarded at Love Canal for the past 30 years, thus triggering several health problems, including miscarriages, leukaemia and birth defects among the area's residents (Lagrega et al., 2001).

Realising the potential danger posed by improper management of toxic and hazardous wastes, the Government of Malaysia has extended many efforts since 1979 to identify possible options and necessary measures. Overview on the past and current policy in hazardous waste management indicates that the Federal policy has been directed towards several types of problems:

- defining, identifying, classifying and quantifying the various types of toxic and hazardous wastes generated
- developing a system to manage the storage, transportation and disposal of past and current hazardous wastes
- developing a set of standards for treatment, storage, recovery of waste and disposal of waste facilities
- establishing a permit system for the approval of hazardous waste landfills, incinerators, recovery facilities and integrated waste management centre.

2.5 Regulations, standards and policy systems for the management of hazardous waste

At present, the control of most hazardous wastes in Malaysia is governed by the Environmental Quality Act 1974. The definition of scheduled wastes varies from one country to another. At the international level it is called toxic and hazardous waste. In Malaysia, the Environmental Quality (Scheduled Wastes) Regulations 2005 (amendment 1989) defines scheduled wastes as any waste falling within the categories of waste listed in the first schedule, which comprises 77 Scheduled Waste code categories in the Environmental Quality Act 1974 (DOE, 2005; Mohd and Khalid, 2006). The US Resources Conservation and Recovery Act of 1976 (RCRA) considers wastes toxic or hazardous if they significantly contribute to an increase in mortality or an increase in serious irreversible, or incapacitating reversible illness: or pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, disposed off, or otherwise managed (DOE, 2005; Goh, 1990;

Lagrega et al., 2001; Mohd and Khalid, 2006). The first schedule of these scheduled waste regulations 2005 defines and rescheduled 107 categories of hazardous wastes listed in the first scheduled of the EQR (SW) 1989 to 77 categories of schedule waste code (77 SW) from which was also known as toxic and hazardous wastes, covering all except radioactive wastes which are controlled by the Atomic Energy licensing Act, 1984. The regulations cover the management of the potentially toxic and hazardous wastes based on the 'cradle to grave' approach where the generation, storage, transportation, treatment and disposal are regulated. Table 3 shows the regulations focused on the following key provisions.

Table 3 Key provisions focus on scheduled waste regulation 2005

1	Control of the generation of waste by a notification system
2	Avoidance or minimisation of waste generation
3	Safe storage of wastes
4	Licensing of scheduled waste facilities
5	Treatment and disposal of waste at prescribed premises
6	Implementation of the manifest system for tracking and controlling movement of wastes

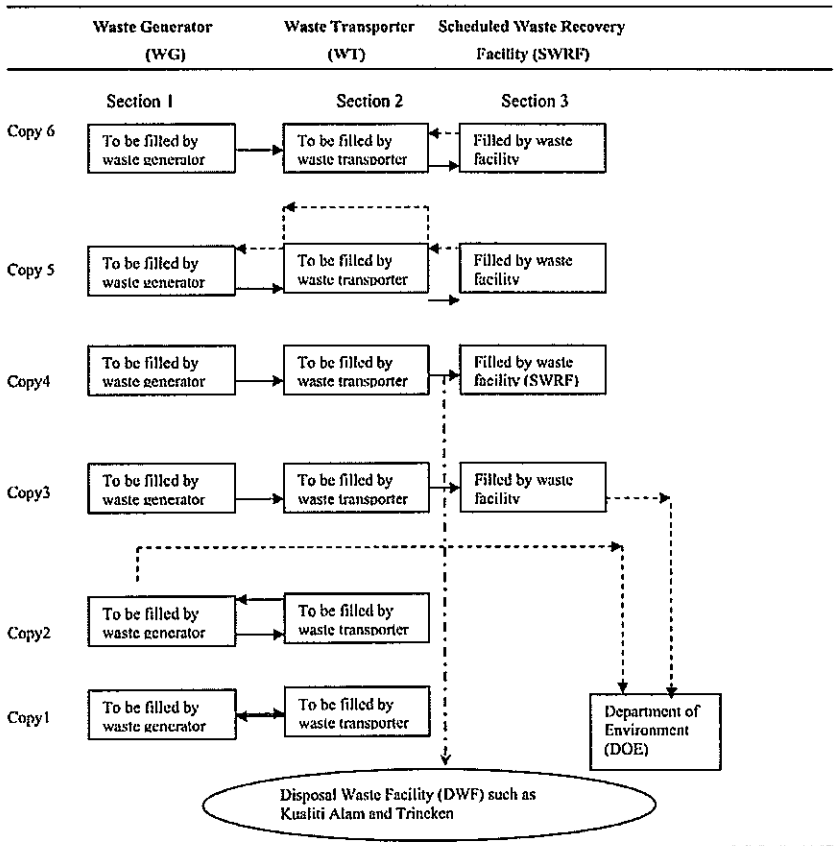
As presented in Table 3, this act requires waste generators to notify the Department of Environment, whilst the treatment and disposal of scheduled wastes can only be carried out at a licensed facility. The movement of wastes from the point of generation to the treatment facility is tracked by the use of consignment notes. Figure 2 shows the legal route of toxic waste movement according to Environmental Quality (Scheduled Waste Treatment and Disposals) Regulation 2005.

As presented in Figure 2, based on the Environmental Quality (Scheduled Waste Treatment and Disposals) Regulation 2005, for the transportation of a scheduled waste to the prescribed premises such as Kualiti Alam's or Trineken's final disposal facility, the regulations require the waste generator to fill out a prescribed consignment note in six copies, stating the characteristics of the waste and its handling precautions, and to hand it to a DOE-approved contractor. The waste generator, contractor, final disposal facility and DOE each receive a copy of the consignment note, and one copy will be returned to the waste generator as a proof for the final disposal being carried out.

According to the Environmental Quality (Scheduled Wastes) Regulations 2005, it was revealed that no description regarding the permissible limits in terms of discharge volume or concentration of contaminants. For instance, the regulations did not state the parameters involved, and its limit quantity and concentration, which may cause harm to human, health and environment. This means that even if a factory generates a very small amount of scheduled wastes, the final disposal in accordance to the laws and regulations is still required. The regulations stipulate that the scheduled wastes can only be finally disposed of at 'prescribed premises' approved by the Director General of the DOE. Other provisions under the regulations state that if a scheduled waste is newly generated, the waste generator is obliged to notify the Director General of the DOE within one month. Further, if a new type of scheduled waste is generated or is likely to be generated, say as a result of alteration to a manufacturing process, the waste generator must promptly notify the category and quantity of the waste generated. In addition, the provisions state that the waste generator is obligated to endeavour to reduce the amount

of scheduled wastes generated by using the most practical method, and is responsible for storage and transportation to prescribed premises.

Figure 2 Scheduled waste notification process (legal routes of disposal) based on Environmental Quality (Scheduled Waste) Regulation 2005



Consignment notes		WG	WT	SWRF	DOE	Total
2 phases	WG →WT	1 copy			1 copy	2 copies
3 phases complete	WT→SWRF→DOE	1 copy	1 copy	1 copy	1 copy	4 copies
	Sub-total	2 copies	1 copy	1 copies	2 copy	6 copies
		SWRF	DWFT	DWF	DOE	
2 phases	SWRF→DWFT	1 copy			1 copy	2 copies
3 phases complete	SWRF→DWFT→DWF	1 copy	1 copy	1 copy	1 copy	4 copies
	Sub-total WG→SWRF→DWF→DOE	4 copies	2 copies	2 copies	4 copies	
$N^{WG \to DOE}$ (if more than 1 WG)		n(4)	n(2)	n(2)	n(4)	

The major change in the 2005 Regulation is that scheduled wastes are now categorised based on the type of waste rather than on the source or origin of the wastes. New provisions instituted include the special management of waste, limits for the amount and duration of waste storage, recovery of scheduled wastes, conduct of training for persons handling scheduled wastes and improvement in the labelling requirements.

Table 4 shows the scheduled wastes regulation 2005 newly categorised under five groups.

Table 4 Scheduled wastes regulation 2005 new category

1	Metal and metal-bearing wastes
2	Wastes containing principally inorganic constituents, which may contain metals or organic materials
3	Wastes containing principally organic constituents, which may contain metals and inorganic materials
4	Wastes, which may contain either inorganic or organic constituents
5	Other wastes

Four types of wastes in the 1989 Regulations were deleted and ten new waste categories were included in the new Regulations. The deleted wastes were effluents from rubber factory, effluents from textile factory, leachate from landfills and slag from iron and steel industry, whilst those added were galvanic sludge, leaching residue from zinc processing, electrical and electronic wastes, wastes gypsum, waste of organic phosphorous compound, wastes containing dioxin or furans, discarded chemicals, obsolete laboratory chemicals, wastes containing peroxides and residues from treatment of scheduled wastes. In 2005, for the first time, scheduled wastes generated are not allowed to be stored for more than 180 days after generation provided the quantity of scheduled wastes accumulated on site that shall not exceed 20 tonnes.

In general, it can be summarised that currently there are five sets of regulations and orders that can be implemented in managing the scheduled wastes in Malaysia. The regulations cover the management of the potentially toxic and hazardous wastes from their sources through to treatment and disposal under a 'cradle to grave' approach. Legislation regarding scheduled wastes as enacted in 2005 (amendment 1989) in Environmental Quality Acts (EQR) 1974 is basically set forth in three regulations and orders: Environmental Quality (Scheduled Wastes) Regulations 2005, Environmental Quality (Scheduled Wastes Treatment and Disposal Facilities) Order 1989, Environmental Impact Assessment 1987 and Environmental Quality (Scheduled Wastes Treatment and Disposal Facilities) Regulations 1989, and two procedures under Customs Act 1967 were enacted and enforced in 1993. These regulations are the Customs (prohibition of exports) 1993 and the Customs (prohibition of imports) 1993. Under these regulations, specify that any export and import of toxic and hazardous waste out of or into Malaysia must obtain prior written consent from the Director-General of Environmental Department. According to the Basel Convention on the Control of Transboundary Movement of Hazardous Wastes in 1993, the basic prerequisites for scheduled wastes export is for resource recovery, and that the exporter should have the approval of the appropriate government authorities in the destination country.

3 Main problems of hazardous waste management in Malaysia

Experience gained through the administration of the scheduled wastes regulations indicate that the hazardous waste management in the country has, to a great extent, met the primary goals of the Environmental Quality Acts 1974. However, there are still issues

that confront the authorities in dealing with the management of scheduled wastes. These include illegal dumping, increasing request to recover/reuse wastes and new and emerging issues of contaminated land.

3.1 Illegal dumping of scheduled wastes

Generally, there seems to be an increase in the number of illegal dumping cases detected by the Department in the last five years, which is from three cases in 2001 to 31 cases in 2005. The types of wastes dumped were mainly waste paint, mineral oil and dross. These activities were mostly carried out in secluded areas to avoid detection. There were also factories that buried their wastes within their premises. This does not mean that we can treat this issue lightly because these wastes can contaminate groundwater and nearby rivers as well as affect public health. Table 5 shows, of large-scale cases of illegal dumping (import and export) of scheduled waste in and around Malaysia (Abdul Rashid et al., 2007).

Table 5 Large-scale cases on illegal dumping (import and export) of scheduled waste in Malaysia 1996–2006

Date of discovery, location	*Quantity*	*Dumped waste*	*Significant impact/causes effect/action to be taken*
January 2005, found at an unauthorised site at Sungai Kandis in Klang, Selangor	15,000 drums	sludge and oil waste	Waste disposal contractor Carbon World Industries is alleged to have stored the waste for some eight years. The court case is pending
2004, at Simpang Renggam, Johor	More than 1000 jumbo bags were found at abandoned bricks warehouse	Metal Hydroxide sludge from Taiwan illegally import and storage at Simpang Renggam	Bad portray about Malaysia as new illegal graves destination. Toxic substances contained of heavy metals such as zinc, lead, chromium and cadmium
23 June 2006, at an illegal dumping site in Labis, Johor and two other spots: Km 9.75 Jalan Labis and Km 15 Jalan Yong Peng Jln Haji Musa	Estimated 5000 tonnes of aluminium dross were buried at the Kg Sungai Gatom and 3000 tonnes at the two other sites	Aluminium dross. The substance is a scheduled toxic waste, reacts when exposed to rain to release poisonous ammonia gases	Nearly 700 peoples evacuated DOE engages Kualiti Alam to clean up the three sites, an estimated cost of about *RM 8 millions and another RM2 millions for waste treatment.* DOE's 'cradle to grave tracking' system of hazardous wastes used in manufacturing is obviously not working
May 2000, Port Klang	Forwarding agency submitted documentation for the two containers by declaring waste as zinc scrap without licenses	Dross material used in metal galvanising. Waste origin was from Seri Kembangan	Case has been investigated by Customs and Excise department, DOE Reason – foreign firms offered RM 4000 per tonnes of material dross, while local recycling factories offered only RM1, 200 tonnes

It was reported in Table 6 that there is an average of 97 cases of illegal toxic waste disposals in the last five years (2001–2006) (Malaysia, 2001). Nevertheless, since 1989 none of the guilty parties was given a jail sentence and Environmental Quality (Scheduled Waste Regulations) 1989, requires them to pay one-third of the maximum fine of RM 500,000. Furthermore, only 40 cases of illegal hazardous waste dumping have been successfully brought to court under Section 34(B) EQA 1974 as shown in Table 7, and the rest of the culprits were not traced (Keng, 2006; Abdul Rashid et al., 2007).

Table 6 Cases of illegal dumping of hazardous waste during 2001–2006

State	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*Total*
Johor	1		1	4	2	1	9
Kedah		1	2	1	2		6
Kelantan		1		1			2
Melaka		1	1		3		5
Negeri Sembilan				1			1
Pahang		1		2	2		5
Perak			1	1	3		4
Perlis							0
Pulau Pinang	1	1	1	3	1		7
Sabah				1	1		2
Sarawak					1		1
Selangor	1	4	7	25	15	2	54
Terengganu			1	1	1		3
Kuala Lumpur							
W.P Labuan							
Total	*3*	*9*	*14*	*40*	*31*		*93*

Table 7 Cases of illegal dumping of hazardous waste brought to court under Section 34(B) Environmental Quality Acts 1974 (2001–2006)

State	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*Total*
Johor	4		3				7
Kedah				3			3
Kelantan					1		1
Melaka		1	1				2
Negeri Sembilan						1	1
Pahang							
Perak							
Perlis							0
Pulau Pinang				1			1
Sabah							0
Sarawak							0

Table 7 Cases of illegal dumping of hazardous waste brought to court under section 34(B) Environmental Quality Acts 1974 (2001–2006) (continued)

State	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*Total*
Selangor	4	4	3	8	4		23
Terengganu				1	1		2
Kuala Lumpur							
W.P Labuan							
Total	*8*	*5*	*7*	*13*	*6*	*1*	*40*

Abdul Rashid et al. (2007) studied the chronology of cases of illegal dumping of scheduled waste in Malaysia with respect to the causes of the illegal dumping tragedy and its impact to the economic and environmental aspects. Their results indicated the causes that contributed to the illegal dumping in the current dumping process (Figure 3).

Figure 3 Illegal routes of disposal based on Environmental Quality (Scheduled Waste) Regulation 2005

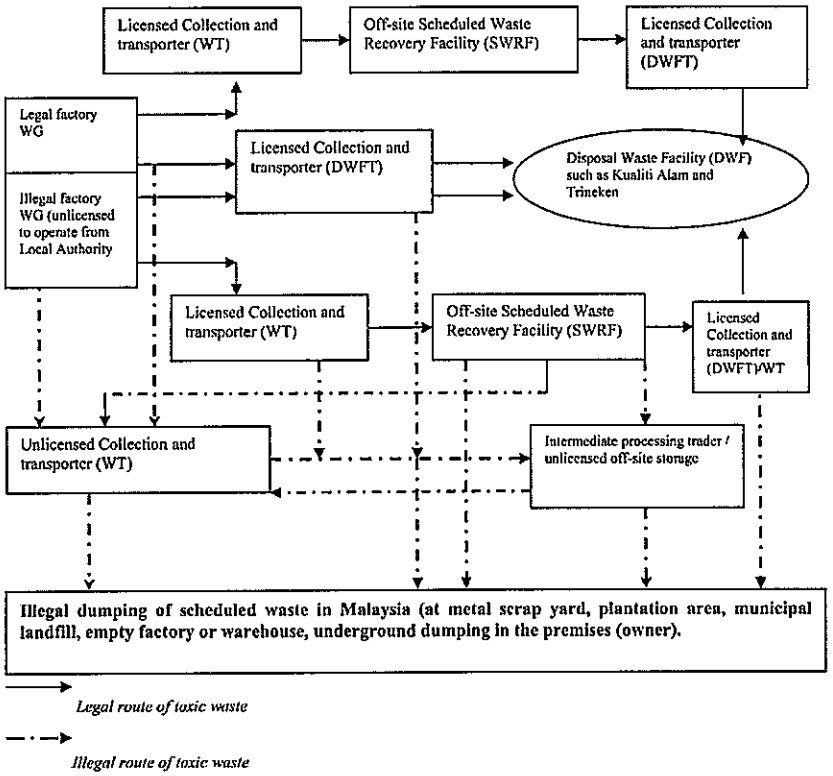


Figure 3 shows that the illegal dumping of the toxic waste were contributed by the illegal factories and unlicensed transporter at illegal dumpsite with or without permission from the landowner. Even worse, there are even illegal dumping done by the licensed

recyclers, recovery facilities and licensed transporter from legal factories. There are cases whereby legal transporters distribute the toxic material to illegal transporters to be taken to illegal dumpsite.

3.2 Status of spent batteries and electronic waste (E-waste)

With an increase in the numbers of batteries being generated, the output, types and quantity of spent batteries have also increased. Spent batteries are listed under the first schedule of scheduled waste regulation, which includes batteries containing mercury, lead, nickel and cadmium. The main sources of spent batteries are, from various electric devices and appliances in daily use at homes, hotels, offices, traffic vehicle power supplies, communication equipment and waste produced by battery manufacturers.

Electrical and electronic wastes or the so-called E-waste has become a serious environmental and health challenge for two major reasons:

- It is potentially hazardous because the waste from electrical and electronic assemblies contain components such as accumulators, mercury switches, glass from cathode-ray tube contaminated with radiation and other activated glass or polychlorinated biphenyl capacitors or those that were contaminated with cadmium, mercury, lead, nickel, chromium, lithium, silver, manganese or polychlorinated biphenyl.
- It is being generated at an alarming rate. It is estimated that in the USA, by 2007 there would be more than 700 million obsolete computers. European studies indicate that E-waste is increasing at the rate of 3–5% per annum. Other than computers, the use of mobile phones is also growing exponentially. From 16 million users in 1991, it has grown to 1.3 billion globally in 2003. In Malaysia, there are 10 million mobile phone subscribers (DOE, 2005). This growth has created additional wastes and it is a challenge to ensure waste emanating from this source does not end up in the landfills, thus releasing toxic substances to the environment. Computer waste contains heavy metal such as lead, chromium and mercury that can be hazardous to human health and the environment if not managed properly. Therefore, the regulators should be vigilant against dumping of used computers or mobile phones in the guise of refurbishment and recycling.

4 Strategies and future focus on hazardous waste in Malaysia

The purpose of waste management is to improve public health, protection of the living environment and conservation of natural resources.

4.1 Strengthen the hazardous waste management policy

To achieve a programme of environmentally sound hazardous waste management, it is necessary to design an action plan that takes the whole hazardous waste management process into account. An overall policy system and a national framework of law have been established in Malaysia to complete the regulation system for waste management, and to enhance its enforcement. Technological and economic policies, as well as standard and technical guidelines, are not well developed, so it is necessary to complete the

creation of a system of technical and economic policies and related regulations. These mainly include the technological policies for pollution control of hazardous wastes, an environmental tax mechanism on products containing hazardous substances, a recovery system by producers and the establishment of policies that will eventually eliminate harmful products altogether.

4.2 Enforcement

Environmental legislations are only as good as their enforcement. The laws are difficult to be implemented and enforced if the current shortage of manpower is not remedied (Jamaluddin, 1993). More officers should be recruited which could be pulled by offering more competitive renumeration package to attract potential applicants. The effectiveness of enforcement work by the relevant agency could be improved by organising enforcement team by involving police, local councils and other enforcement authorities to aid DOE in monitoring illegal dumping.

To strengthen the administrative management of hazardous waste, cooperation between governmental departments must be strong. It is also necessary to strengthen the functioning of the government enforcement of waste management policies, to increase their number of manpower, to improve the quality of management centres for hazardous wastes and to establish effective monitoring mechanisms to ensure efficient supervision of producers and their behaviour (i.e., whether or not their actions take the environment into consideration).

4.3 Recovery/reuse of wastes

All over the world, it is understood that the conservation of natural resources is essential. It must be confirmed that the waste management does not form an obstacle for the accomplishment of the higher ranked target and the conservation of natural resources. Malaysia upholds practices and promotes resource conservation. Therefore, any waste that could be utilised should be reprocessed into useful products. To increase hazardous waste recovery rates and improve disposal technologies, several new activities must be set in place. Furthermore, a reduction in the hazardous waste volume can be accomplished by recycling, recovery or reuse of the hazardous waste.

4.4 Contaminated land

Contaminated land can be described as "land containing substances that when present in sufficient concentrations, may cause harm to human, animals and the environment". In Malaysia, although the EQA provided powers to DOE to prohibit pollution of any soil or surface of any land, it has not gone further to specify the acceptable conditions for the deposition of wastes into this segment or element of the environment. Potential contaminated land can be found in places such as motor workshops, petrol stations, fuel oil depots, railway yards, bus depots, landfills, industrial sites and sites with underground storage tanks. These places generate spent diesel, lube oil, other hydrocarbons, solvents and grease, which if not properly managed, could end-up polluting the soil and groundwater through leakage and seepage. There are also contaminated sites that remain hidden or unknown such as municipal landfill and refuse dumping sites that have been abandoned in the past. The complex characteristics of industrial waste have diverse

impacts on the environment and human health. The metal and chemical content have different effects on the environment and human health. Waste in landfill will contaminate groundwater, while landfills located near river will contaminate surface water, and will later affect drinking water quality. Case related to those issues has emerged. The Star newspaper in 2002 reported that 80 metric tonnes of aluminium oxide from an aluminium factory had been buried, which contaminated the soil as well as emitting ammonia gas after reacting with rainwater (The Star, 2002). Currently, there are 171 landfills in Malaysia, and a total of 60 landfills were closed in 2001 with little or no post closure control. Furthermore, 95% of these landfills were not sanitary or secured landfills, and hence could cause severe environmental impact if proper and closer procedures were not implemented. In 2006, it is reported that 16 landfills were closed owing to locations near to water intake points (Agamuthu, 2006).

Assessment of soil contamination at industrial premises is still ad hoc and has yet to provide any significant profile on the status of soil quality. This is carried out on some of the sites where illegal dumping of hazardous waste has occurred. Realising the importance of dealing with contaminated land, the special programme has to be created to look into these issues seriously. There is a need to develop criteria and standards for contaminated soil in Malaysia. Prior to any formulation of clearer policies and legal limits for soil, it is imperative that a compilation of contaminated soil status should be initiated and a set of soil pollution guidelines should be drawn up to assist both public and private sectors in managing this problem.

4.5 Counter measures

Illegal dumping of scheduled wastes remains a challenge. From 2001 to 2006, 93 cases of illegal dumping were detected but only 39 cases were prosecuted (Malaysia, 2001). This is due to the lack of evidence and the nature of the crime. Various measures have been instituted to tackle this environmental crime. These include setting up of an intelligence unit to gather information from individuals and groups to detect and prevent environmental crimes. Although, four years ago DOE started an electronic reporting system called Scheduled Waste Information System (E-SWIS) and E-consignment that involves less paperwork and quicker tracking of waste movements; its effectiveness is unproven. The system failed to discern and comprehend the material in-flow and out-flow of such complex successive scheduled wastes recoveries and recycles, within the closed-loop recycling and recovering system.

Therefore, advance support tools are required that can effectively monitor and control illegal dumping of toxic waste such as satellite monitoring systems, which can play a role in detecting any environmental pollution. The investigation techniques of the agency to identify the waste fingerprint are not up-to-date. Therefore, research and development of analytical environmental forensic methods for hazardous waste fingerprinting to recognise the culprit factory can be considered for the future.

Audits on waste generators, recyclers and disposal facilities should be carried out in a systematic and regular manner. Special training should be provided to the officers to enable them to conduct their audit and investigation tasks more effectively. Programmes to develop national criteria and standards for hazardous waste characteristics prior to formulation of dedicated legislation should be undertaken. International experiences from other countries could provide useful guidance and reference to Malaysia in the implementation of the programmes.

4.6 Disposal of hazardous waste

Most of the problems of illegal dumping reported in Malaysia were due to the problem of indiscriminate toxic waste disposal, which encouraged the mushrooming of recycling companies to operate illegally. Last year in 2006, DOE reported that one registered or licensed recycler had 20 illegal recycling traders (NST, 2006; DOE, 2005). The negative attitudes of several multinational companies in adopting double standards in the disposal of waste in the country, and that of the waste generators in cutting costs for waste disposal, which are too expensive, also contributed to the illegal dumping of waste. The growing number of licensed recyclers has triggered a price war, to the disposal waste facility like Kualiti Alam. For instance, the waste generators have to pay RM 2500–RM 3750 per tonne to Kualiti Alam to dispose their waste, but if they send their waste to recyclers companies they will only pay RM 300 per tonne to the recyclers. In addition, the waste code to be sent to the recyclers is limited. Out of 77 waste codes listed at the Environmental Quality (Scheduled Waste) Regulations 2005, only 15 waste codes are allowed to be sent to the waste recyclers. The 15 waste codes are SW102, SW103, SW104, SW110, SW202, SW 204, SW305, SW306, SW307, SW310, SW311, SW319, SW410, SW423 and SW427 (Abdul Rashid et al., 2007; DOE, 2005), which were mainly electronic waste, batteries waste, waste catalyst, metal sludge (majority), oil and hydrocarbon waste, mineral sludge, photographic waste, phenolic resin waste and any material, which was contaminated by scheduled waste. Therefore, to maximise waste generators' profits, the waste is dumped illegally. Katsuya and Kuniko (2006) presented that social factors such as the cost from waste treatment, waste disposal were high related to the incidence of illegal dumping. In Malaysia, due to inadequate and highly expensive legal scheduled waste treatment, industries have to store, pre-treat or export their wastes as the storage capacity is slowly exhausted. The situation will soon worsen as cases of illegal dumping of toxic wastes at unused land or secluded areas are rampantly carried out by irresponsible contractors. Therefore, the government of Malaysia through the ministry of natural resources and environment should look upon the issue of how to moderate the disposal cost of treatment and also review the present cost for waste recovery.

5 Conclusions

The Environmental Quality (Scheduled Wastes) Regulations 1989 have served its purpose in providing the essential regulatory framework on scheduled waste management in Malaysia despite the constraints faced in administering the various provisions in the regulations. Strengthening the whole hazardous waste management process will require the improvement of the management of transportation, treatment and recovery of hazardous waste, developing data registration, improving data management system, establishing information systems for the decision-making process, and to improve the tracking of wastes, enhancing registration authenticity through penalties, training staff at local environmental bureaus and developing an information system for the decision-making process for any issues dealing with waste management.

Waste disposal will not become cheaper. Hence, it is prudent for industries to engage in waste minimisation. This could be done through changing the process or the raw material used. If this is not possible, wastes should be reused or recovered. Industries

should embark on the use of cleaner technology to eliminate or reduce waste generation. In addition, by implementing the cleaner technology, industries are able to reduce hazardous emissions and save money for waste treatment and disposal.

Acknowledgement

The authors like to thank the Institute of Research, Development and Research (IRDC), University of Technology MARA Malaysia and Department of Environment Malaysia for their guidance and support.

References

Abdul Rashid, Z., Alias, A.B., Aris, M.J., El-Harbawi, M., Rahman, N.A. and Som, A.M. (2007) 'Illegal dumping of hazardous waste in Malaysia: assessing based on implementation and compliance of environmental quality act (1974) and the regulations', *Proceedings of 3rd International World Engineering Congress, FIECC 2007*, Penang, Malaysia, pp.191–201.

Agamuthu, P. (2006) *Post Closure of Landfill: Issues and Policy*, Waste Management and Research, SAGE Publications, Vol. 24, p.503.

Deninison, M.S. (1993) *RCRA Regulatory Compliance Guide*, Noyes Publications, New Jersey, USA, pp.25–30.

Department of Statistics (2005) *Annual Survey of Manufacturing Industries in Malaysia*, Kuala Lumpur.

DOE (2003) *Malaysia Environmental Quality Report 2002*, Publication Section, Strategic Communications Division, Department of Environment, Putrajaya.

DOE (2005) *Malaysia Environmental Quality Report 2004*, Publication Section, Strategic Communications Division, Department of Environment, Putrajaya.

EIA (2004) *Proposed Metal Hydroxide Sludge Recycling Facility for Producing Coagulant Poly Aluminum Chloride*, Koshin Analytical Limited and Golden Ecosystem Sdn. Bhd. Detailed Report submitted for Department of Environment, Senawang Industrial Estate, Negeri Sembilan, Malaysia.

EIA (2006) *Proposed for Waste Recycling in Cement Making*, Negeri Sembilan Cement Industries Sdn Bhd., Detailed Report submitted for Department of Environment, Bahau Industrial Estate.

EPU (2002) *Economic Planning Unit*, Chapter 19 Environment and Sustainable Resources Management, http: //www.epu.jpm.my/new%20

Goh, K.S. (1990) *Toxic and Hazardous Waste Management in Malaysia; Policies and Strategies*, ENSEARCH, Kuala Lumpur.

Jamaluddin, M.J. (1993) 'Issues on environmental management through legislative measures in Malaysia', *Journal of Social Sciences and Humanities*, UKM, Bangi, Vol. 42, pp.181–204.

Katsuya, K. and Kuniko, U. (2006) 'Restoration and recovery technologies for illegal dumping of waste pollution, sciences and technology trends', *Quarterly Review*, Vol. 3, No. 2, pp.42–58.

Keng, L.H. (2006) 'Scheduled waste management: regulations 2005', *Waste Management Conference and Exhibition*, ENSEARCH, Nikko Hotel, Kuala Lumpur, 13–15 November, pp.1–7.

Lagrega, M.D., Phillip, L. and Evans, B.J.C. (2001) *Hazardous Waste Management*, 2nd ed., McGraw-Hill, USA.

Malaysia (1991) *Second Outline Perspective Plan 1991–2000*, National Printers, Kuala Lumpur, Malaysia.

Malaysia (2001) *Eighth Malaysia Plan 2001–2005*, Economic Planning Unit, Prime Ministers Department, Putrajaya, Malaysia.

Ministry of Finance Malaysia (1996) *Economic Report 1995/96*, National Printers, Malaysia.

Mohd, R.S. and Khalid, M.A. (2006) *Hazardous Waste Management with Reference to the Environmental Quality Act, 1974*, University Publication Centre UPENA, UiTM, Malaysia.

NST (2006) *Jail Sentence for Illegal Dumping*, www.doe.gov.my/index

The Star (2002) *More Waste May Be Buried at Warehouse*, Bernard, S., 23 March.