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Overview of Hazardous Waste Management Status in Malaysia

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Abstract

This chapter reviews the status of hazardous waste management in Malaysia. It highlights the sources of the hazardous waste, government policies on waste generation and management, the involvement of the stakeholders, and the various management procedures adopted in Malaysia. Currently, the manufacturing sector is the major contributor in hazardous waste generated in Malaysia. Other sectors that contribute include household, agriculture, medical, and other industrial sectors. Malaysian government's resolve on human health protection and safeguarding the environment prompted various acts, regulations, and orders such as the popular Environmental Quality Act (EQA) 1974. The regulations made pursuant to the Environmental Quality Act have continuously improved to address the issues on the definition and classifications of hazardous waste and the management process in Malaysia. The management of hazardous waste in Malaysia is effectively growing as a result of continuous review of the regulations and enforcement of the acts. The stakeholders in the industries have also been active in keeping to the EQA regulations to keep the environment safe as much as possible.

Keywords: hazardous waste generation, health effect of hazardous waste, hazardous waste management, Malaysia Government policies, stakeholders involvement

1. Introduction

Malaysia is one of the fast growing nations in the global economy. Malaysian economy ranked 24th in the global competitive index of 2013 [1] and has grown to occupy the 18th position in the 2015 global competitive index ranking [2]. Economic growth comes with some burden on

the environment which includes waste generation, greenhouse gas emission from energy systems, deforestation, etc. The continued increase in waste generation in Malaysia has been associated with the growing population and the growing economy. These factors create high demand for goods and services by the growing classes of people with an aim to meeting their varying lifestyles, while the environment bears the consequence of the increasing waste generation [3]. The quantity of municipal solid waste generated in Malaysia was analyzed in 2010 by Agamuthu [4] with a projection of 30,000 tons/day of waste generation by 2020; in a review by Aja and Al-Kayiem [5], it was found that in 2013, the waste generation in Malaysia was 33,000 tons/day which exceeded the projection cited earlier. In a recent review by Fazeli et al. [6] on waste to energy, it was noted that the growing economy of Malaysia contributes to the environment burden levied by high energy consumption and high volume waste generation. Wastes generated in Malaysia are categorized based on level of potential hazard. According to the Department of Environment, waste is defined as “any substance prescribed to be scheduled waste or any matter whether in a solid, semi-solid, or liquid form, or in the form of a gas or vapor, which is emitted, discharged, or deposited in the environment in such volume, composition, or manner as to cause pollution” [7]. Scheduled wastes are the categories of waste listed in the First Schedule of the Environmental Quality (Scheduled Wastes) Regulations 2005 [8, 9]. Some categories of the scheduled waste are classified as environmental hazardous waste due to the toxic and hazardous nature of such wastes.

Environmentally hazardous substance (EHS), under the Malaysian Environmental Quality Act (EQA) 1974, is defined as “any natural or artificial substances including any raw material, whether in a solid, semi-solid, or liquid form, or in the form of gas or vapor, or in a mixture of at least two of these substances, or any living organism intended for any environmental protection, conservation, and control activity, which can cause pollution” [10–12]. There are currently 3839 items in the EHS reference list [13] and in a situation where a potentially hazardous material is not on the list, such substances are classified using the globally harmonized system (GHS) classification scheme and assigned a hazard category as implemented by the Department of Occupational Safety and Health, Malaysia [10].

There are currently 77 categories defined in the First Scheduled Waste of the Environmental Quality in Malaysia as EHS, which are classified into five groups as detailed in **Table 1**. The hazardous wastes in the five groups are from different sources such as industrial sector, agricultural sector, health sector, and households. Industrial waste poses potential serious hazard to the environment as most industrial processes employ chemical or chemically produced materials. In agriculture, hazardous wastes are generated through the use of pesticides [14], herbicides and even the use of inorganic fertilizer which has fluoride as by-product of phosphate fertilizer production [15, 16]. The use of organic manure also constitutes a hazard in agriculture by the dissolution of manure nitrate into ground water. This causes health hazards in most developing countries where there is no access to treated water and ground water is used as alternate source [17, 18]. Medical wastes include hospital disposables contaminated with blood and tissues, used pharmaceutical products, expired and used drugs, chemical wastes, radioactive isotopes used for diagnosis and treatment, etc. which require careful disposal [19–21]. In homes, several hazardous wastes are generated in meeting the

desired lifestyle of the people. Such wastes include caustic cleaner, toxic paints, flammable solvents, pesticides, expired/unused drugs, mercury, etc. [22, 23].

SW1:	Metal and metal-bearing wastes
SW 101	Waste containing arsenic or its compound
SW 102	Waste of lead acid batteries in whole or crushed form
SW 103	Waste of batteries containing cadmium and nickel or mercury or lithium
SW 104	Dust, slag, dross, or ash containing arsenic, mercury, lead, cadmium, chromium, nickel, copper, vanadium, beryllium, antimony, tellurium, thallium or selenium excluding slag from iron and steel factory
SW 105	Galvanic sludge
SW 106	Residues from recovery of acid pickling liquor
SW 107	Slags from copper processing for further processing or refining containing arsenic, lead, or cadmium
SW 108	Leaching residues from zinc processing in dust and sludge form
SW 109	Waste containing mercury or its compound
SW 110	Waste from electrical and electronic assemblies containing components such as accumulators, mercury-switches, glass from cathode-ray tubes and other activated glass or polychlorinated biphenyl-capacitors, or contaminated with cadmium, mercury, lead, nickel, chromium, copper, lithium, silver, manganese, or polychlorinated biphenyl
SW 2:	Wastes containing principally inorganic constituents which may contain metals and organic materials
SW 201	Asbestos wastes in sludge dust or fiber forms
SW 202	Waste catalysts
SW 203	Immobilized scheduled wastes including chemically fixed, encapsulated, solidified, or stabilized sludge
SW 204	Sludge containing one or several metals including chromium, copper, nickel, zinc, lead, cadmium, aluminum, tin, vanadium, and beryllium
SW 205	Waste gypsum arising from chemical industry or power plant
SW 206	Spent inorganic acids
SW 207	Sludge containing fluoride
SW3:	Wastes containing principally organic constituents which may contain metals and inorganic materials
SW 301	Spent organic acids with pH less or equal to 2 which are corrosive or hazardous
SW 302	Flux waste containing mixture of organic acids, solvents, or compounds of ammonium chloride
SW 303	Adhesive or glue waste containing organic solvents excluding solid polymeric materials
SW 304	Press cake from pretreatment of glycerol soap lye
SW 305	Spent lubricating oil
SW 306	Spent hydraulic oil
SW 307	Spent mineral oil–water emulsion
SW 308	Oil tanker sludge

SW 309	Oil–water mixture such as ballast water
SW 310	Sludge from mineral oil storage tank
SW 311	Waste oil or oily sludge
SW 312	Oily residue from automotive workshop, service station, oil, or grease interceptor
SW 313	Oil contaminated earth from re-refining of used lubricating oil
SW 314	Oil or sludge from oil refinery plant maintenance operation
SW 315	Tar or tarry residues from oil refinery or petrochemical plant
SW 316	Acid sludge
SW 317	Spent organometallic compounds including tetraethyl lead, tetramethyl lead, and organotin compounds
SW 318	Waste, substances, and articles containing or contaminated with polychlorinated biphenyls (PCB) or polychlorinated triphenyls (PCT)
SW 319	Waste of phenols or phenol compounds including chlorophenol in the form of liquids or sludge
SW 320	Waste containing formaldehyde
SW 321	Rubber or latex wastes or sludge containing organic solvents or heavy metals
SW 322	Waste of non-halogenated organic solvents
SW 323	Waste of halogenated organic solvents
SW 324	Waste of halogenated or unhalogenated non-aqueous distillation residues arising from organic solvents recovery process
SW 325	Uncured resin waste containing organic solvents or heavy metals including epoxy resin and phenolic resin
SW 326	Waste of organic phosphorus compound
SW 327	Waste of thermal fluids (heat transfer) such as ethylene glycol
SW 4:	Wastes which may contain either inorganic or organic constituents
SW401	Spent alkalis containing heavy metals
SW402	Spent alkalis with pH more or equal to 11.5 which are corrosive or hazardous
SW403	Discarded drugs containing psychotropic substances or containing substances that are toxic, harmful, carcinogenic, mutagenic, or teratogenic
SW404	Pathogenic wastes, clinical wastes, or quarantined materials
SW405	Waste arising from the preparation and production of pharmaceutical product
SW406	Clinker, slag, and ashes from scheduled wastes incinerator
SW407	Waste containing dioxins or furans
SW408	Contaminated soil, debris, or matter resulting from cleaning-up of a spill of chemical, mineral oil, or scheduled wastes
SW409	Disposed containers, bags, or equipment contaminated with chemicals, pesticides, mineral oil, or scheduled wastes
SW410	Rags, plastics, papers, or filters contaminated with scheduled wastes

SW411	Spent activated carbon excluding carbon from the treatment of potable water and processes of the food industry and vitamin production
SW412	Sludge containing cyanide
SW413	Spent salt containing cyanide
SW414	Spent aqueous alkaline solution containing cyanide
SW415	Spent quenching oils containing cyanides
SW416	Sludge of inks, paints, pigments, lacquer, dye, or varnish
SW417	Waste of inks, paints, pigments, lacquer, dye, or varnish
SW418	Discarded or off-specification inks, paints, pigments, lacquer, dye, or varnish products containing organic solvent
SW419	Spent di-isocyanates and residues of isocyanate compounds excluding solid polymeric material from foam manufacturing process
SW420	Leachate from scheduled waste landfill
SW421	A mixture of scheduled wastes
SW422	A mixture of scheduled and non-scheduled wastes
SW423	Spent processing solution, discarded photographic chemicals, or discarded photographic wastes
SW424	Spent oxidizing agent
SW425	Wastes from the production, formulation, trade, or use of pesticides, herbicides, or biocides
SW426	Off-specification products from the production, formulation, trade, or use of pesticides, herbicides, or biocides
SW427	Mineral sludge including calcium hydroxide sludge, phosphate sludge, calcium sulfite sludge, and carbonates sludge
SW428	Wastes from wood preserving operation using inorganic salts containing copper, chromium, or arsenic of fluoride compounds or using compound containing chlorinated phenol or creosote
SW429	Chemicals that are discarded or off-specification
SW430	Obsolete laboratory chemicals
SW431	Waste from manufacturing or processing or use of explosives
SW432	Waste containing, consisting of or contaminated with, peroxides
SW 5:	Other wastes
SW 501	Any residues from treatment or recovery of scheduled wastes

Table 1. The 77 categories of first scheduled waste in the five grouping [7].

Malaysian government is set to ensure that industrial processes meet her environmental protection rules and regulations. It is a resolve demonstrated in a demand that chemicals must be produced and used such that risks and significant adverse effects are minimized on the environment and human health. The process involves cross-sector commitment of all stakeholders to coordinate approaches and common principles in the adoption and strength-

ening of good practices for a safe and ecologically sustainable chemicals management regime [8, 24].

2. Hazardous waste generation in Malaysia

The manufacturing sector in Malaysia was the first identified generators of toxic and hazardous waste. The hazardous waste problems were very much noticeable between the 1970s and 1980s; this is connected to the boom in the manufacturing sector between 1966 and 1988. The manufacturing sector in 1966 contributed 11% to the nation's gross domestic product (GDP), 24% in 1988 [25], and 24.6% in 2010 [26], while in 2012, the manufacturing sector contributed 24.2% to the Malaysian GDP [27]. The volume of hazardous waste generated from the Malaysia industrial sector in 1987 was about 400,000 tons, yet there was no institutional mechanism for managing the wastes [25]. In 2008, the hazardous waste generated was 1304902.74 metric tons [28, 29], while in 2011, it grew to 1622031.52 metric tons [29]. The hazardous waste generation for 2008 and 2011 is reported in **Tables 2** and **3**, respectively, showing the waste categories as presented in **Table 1**.

No	Waste category	Waste code	2008 waste generation	
			MT/Year	Percentage
1	Dross/slag/clinker/ash	SW 104, 107, 406	208319.53	15.96
2	Gypsum	SW 205	366771.99	28.11
3	Mineral sludge	SW 427	107122.05	8.21
4	Heavy metal sludge	SW 204, 105, 108	91730.67	7.03
5	E-waste	SW 110	102808.53	7.88
6	Oil and hydrocarbon	SW 305, 306, 307, 308, 309, 310, 311, 312, 314, 315, 415	129701.99	9.94
7	Clinical/pharmaceutical	SW 404, 403, 405	26967.95	2.07
8	Batteries	SW 102, 103	34283.59	2.63
9	Acid and alkaline	SW 206, 401, 414	38179.66	2.93
10	Used container/oil filter	SW 409	38876.05	2.98
11	Spent solvent	SW 322, 323	38062.81	2.92
12	Contaminated paper and plastic	SW 410	17270.40	1.32
13	Ink and paint sludge	SW 416, 417, 418	18695.75	1.43
14	Residue	SW 501	13544.07	1.04
15	Rubber sludge	SW 321	15512.02	1.19
16	Mixed wastes	SW 422, 421	33928.70	2.60
17	Pheno1/adhesive/resin	SW 325, 319, 303	6184.99	0.47
18	Catalyst	SW 202	5225.53	0.40
19	Others	NA	6627.73	0.51

No	Waste category	Waste code	2008 waste generation	
			MT/Year	Percentage
20	Arsenic	SW 101	–	–
21	Chemical waste	SW 430, 429	1169.75	0.09
22	Contaminated land/soil	SW 408	1324.77	0.10
23	Photographic waste	SW 423	418.77	0.03
24	Contaminated active Carbon	SW 411	934.42	0.07
25	Pesticide	SW 426	12.26	0.00
26	Mercury	SW 109	469.31	0.04
27	Asbestos	SW 201	668.94	0.05
28	Thermal fluids	SW 327	–	–
29	Sludge contain cyanide	SW 412	84.78	0.01
30	Peroxide agent	SW 432	5.73	0.00
Total			1304902.74	100.00

Table 2. Hazardous waste generation by category for year 2008 [28, 29].

No	Waste category	Waste code	2011 Waste generation	
			MT/Year	Percentage
1	Dross/slag/clinker/ash	SW 104, 107, 406	370789.09	22.86
2	Gypsum	SW 205	278139.00	17.15
3	Mineral sludge	SW 427	207445.01	12.79
4	Heavy metal sludge	SW 204, 105, 108	173837.06	10.72
5	E-waste	SW 110	152722.04	9.42
6	Oil and hydrocarbon	SW 305, 306, 307, 308, 309, 310, 311, 312, 314, 315, 415	133260.91	8.22
7	Clinical/pharmaceutical	SW 404, 403, 405	44674.52	2.75
8	Batteries	SW 102, 103	41246.65	2.54
9	Acid and alkaline	SW 206, 401, 414	38152.48	2.35
10	Used container/oil filter	SW 409	36706.83	2.26
11	Spent solvent	SW 322, 323	30976.89	1.91
12	Contaminated paper and plastic	SW 410	23332.03	1.44
13	Ink and paint sludge	SW 416, 417, 418	19224.56	1.19
14	Residue	SW 501	18118.39	1.12

No	Waste category	Waste code	2011 Waste generation	
			MT/Year	Percentage
15	Rubber sludge	SW 321	16130.66	0.99
16	Mixed wastes	SW 422, 421	10708.41	0.66
17	Pheno1/adhesive/resin	SW 325, 319, 303	7904.42	0.49
18	Catalyst	SW 202	6229.05	0.38
19	Others	NA	5505.33	0.34
20	Arsenic	SW 101	2131.57	0.13
21	Chemical waste	SW 430, 429	1327.61	0.08
22	Contaminated land/soil	SW 408	1072.87	0.07
23	Photographic waste	SW 423	587.63	0.04
24	Contaminated active carbon	SW 411	510.03	0.03
25	Pesticide	SW 426	487.10	0.03
26	Mercury	SW 109	434.18	0.03
27	Asbestos	SW 201	194.11	0.01
28	Thermal fluids	SW 327	178.00	0.01
29	Sludge contain cyanide	SW 412	5.09	0.00
30	Peroxide agent	SW 432	–	–
Total			1622031.52	100.00

Table 3. Hazardous waste generation by category for year 2011 [29].

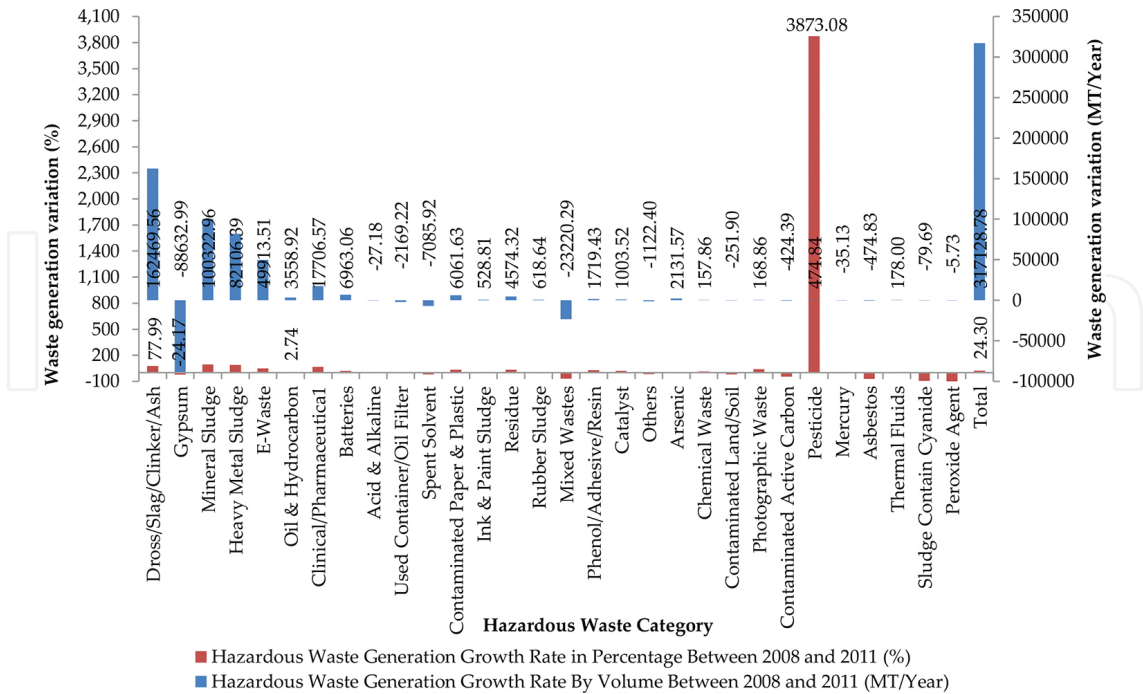


Figure 1. Analysis of the hazardous waste generation growth rate between 2008 and 2011.

The highest volume of hazardous waste generated in 2008 was from gypsum with a total volume of 366771.99 metric tons, while in 2011, Dross/Slag/Clinker/Ash was the highest with 370789.09 metric tons of hazardous waste. Pesticide showed the highest percentage growth which is connected to the rapidly growing agricultural status of Malaysia, most especially the oil palm. In 2008, the hazardous waste generated from pesticides was 12.26 metric tons which drastically shot up to 487.1 metric tons in 2011, showing an increase of 474.84 metric tons in three years translating to 3873% increase waste generation compared to the waste generated in 2008. An analysis of the variation in the hazardous waste generation between 2008 and 2011 by categories is analyzed in **Figure 1**. It was found that even though oil and hydrocarbon was a strong industry in Malaysia, the change in the waste generation was (3558.92) lower than the change in clinical and pharmaceutical waste which increased by 17706.57 metric tons between 2008 and 2011. Similar observation can be made from the figure for other waste categories such as mineral sludge, batteries, and heavy metal sludge. There was no reference on the reason for the change, but it can be attributed to the sound safety and environmental regulations in the oil and gas industries championed by PETRONAS in Malaysia [30].

3. Malaysian hazardous waste management strategy

The core objective of pollution control and waste management was centered on human health protection and environmental cleanliness [31]. The Environmental Quality Act (EQA) of 1974 is the foundation of almost all the environmental protection and waste management policies in Malaysia. The EQA was enacted in 1974 and came into force in 1975 and has since been amended in 1976, 1985, and 1996 to meet the changing technologies and meet international standards. Hazardous waste management during the boom in the manufacturing sectors was unsuccessful because no regulation was in place till 1989; thus, there were no comprehensive hazardous waste management facilities in Malaysia. Industrial wastes were disposal freely into refuse disposal sites [25] which were unsuitable as destinations for hazardous waste without proper treatment. The improper disposals led to poor air quality near the disposal sites, contamination of ground water, and surface water bodies by chemical and biological agents from the waste dumps/disposal sites causing adverse effects on human health and the environment [32]. To protect the environment and the health of the citizens, the Sixth Malaysia Plan 1991–1995 clearly defined the policy statement for full integration of environmental concerns into all development processes of the nation with direct focus on sustainable development [33, 34]. As the adverse effects became known, industries began to treat, recycle, and reuse some of their waste materials [35]. The Malaysia Government also stepped up programs to render all scheduled waste harmless by enacting policies for scheduled wastes to be treated at the waste generation point or at specially designed treatment plants following the National Policy on the Environment. This policy, launched in 2002, is aimed at harmonizing economic development goals in line with environmental imperatives following the dictates of the Eight Malaysia Plan [36]. The enforcement of the regulations with some tax rebates to promote compliance and penalties for non-compliance made the industries become active players in waste reduction and recycling [37].

4. Malaysian hazardous waste management legislation and policy

In the Environment Quality Act, 1974 as amended, legislation on hazardous waste management has the main objective of controlling/regulating waste generation and improving waste management process and procedure in Malaysia. The legislation describes waste management process from generation, storage, handling, treatment, and final disposal. The EQA, 1974 is the primary legislation upon which other subsidiary environmental legislations and policies are built. Other environment regulations are also in place for the management of hazardous wastes as shown below:

- Environmental Quality (prescribed activities) (environmental impact assessment) Order 1987: This order is established following the dictates of EQA 1974, section 34A. The article 18a of the order is centered on waste treatment and disposal of toxic and hazardous waste outlining the developmental plan and procedure for sustainable management of hazardous waste. The plans and procedures are stipulated for the construction of incineration plants, off-site recovery plants, off-site waste water treatment plants, secure landfill sites, and off-site waste storage facilities [38].
- Environmental Quality (scheduled wastes) Regulations, 1989: This document contains regulations specifically for the management of scheduled waste from generation to final disposal. It classifies the most common hazardous scheduled wastes generated in Malaysia and defines a case of incompatible scheduled waste which is a condition, where a non-hazardous waste can be treated as hazardous waste. These regulations have been replaced by Environmental Quality (scheduled wastes) Regulations, 2005.
- Environmental Quality (prescribed premises) (scheduled wastes treatment and disposal facilities) Order, 1989: The order prescribed the premises occupation or use a holder of a license issued will cover. The premise occupation include off-site storage facilities, off-site treatment facilities, off-site recovery facilities, scheduled waste incinerators, land treatment facilities, and secure landfills.
- Environmental Quality (prescribed premises) (scheduled waste treatment and disposal facilities) Regulations, 1989: These regulations support the order 1989 and set procedure for licensing for prescribed premises (scheduled waste treatment and disposal facilities).

In compliance with the Basel Convention on control of transboundary hazardous waste, import and export orders were formulated under the Malaysian Customs Act, 1967 which prohibits importation or exportation of hazardous wastes unless with prior written approval from the Director General of the Department of Environment. The two orders are as follows:

- Custom (Prohibition of Export) Order (Amendment) (No. 2) 1993 now replaced with Custom (Prohibition of Export) Order 1998.
- Custom (Prohibition of Import) Order (Amendment) (No. 2) 1993 now replace with Custom (Prohibition of Import) Order 1998.

The Department of Environment of Malaysia does not encourage the import of hazardous waste into the country. Waste generators are allowed to export waste for recycling, recov-

ery, or treatment with prior written approval from the importing state to discourage abuse of other nations' rights. On importation of used electrical and electronics equipment, Malaysia does allow such importations, provided the products are not older than three years from manufacturing date following the guideline policies for the classification of used electrical and electronic equipment in Malaysia 2008, revised 2010 [39].

5. Scheduled waste management facilities

The waste management facilities used by the various waste management operators in Malaysia depend on the waste that the operators handle. Below is the current hazardous waste management facilities used in Malaysia.

- Scheduled/hazardous waste transport facilities.
- Off-site waste storage and waste transfer stations/facilities.
- Secure landfill—for final disposal of stabilized wastes.
- Scheduled waste incineration plant which can be on-site or off-site activities depending on the type of waste and volume generation.
- Clinical waste incineration—specifically for the management of clinical and pharmaceutical wastes.
- Off-site physio-chemical waste treatment facilities for waste stabilization or solidification for final landfilling.
- Centralized waste treatment facility (e.g., electroplating park).
- Resource recovery—this involves the recovery of reusable materials from hazardous waste such as oily wastes, metal dross/metal hydroxide, and catalyst.
- Land treatment—treatment of contaminated land.
- Waste water/sewage treatment facilities.

To establish any of the facilities, the operator needs to apply for a license through the office of the Director General of the Department of Environment. The licensing process is well detailed in Part III of the EQA, 1974 as amended. The process involves the following four stages:

- i. Environmental impact assessment (EIA)—proposes site inspection to access suitability for the operation against environmental pollution following the developmental plan of Malaysia.
- ii. Processing of the written permission—Provision of all qualifying document for the operator to prove capability to run the operation in conformity with the EQA, 1974 and other environmental regulations.
- iii. Pre-licensing inspection.

iv. Processing of the operating license.

5.1. Classification hazardous waste management facilities

A hazardous waste facility is any of the government-approved waste management facility that observes ethical practices and sustainable development. The facilities include contiguous land, waste storage facility, waste recovery facility, recycling facility, incinerator, and secure landfill [40]. A hazardous waste facility can function independently depending on the type of hazardous waste that it handles or may require a combination of technologies as in the case of commercial facility processing different types of wastes. The different facilities available in Malaysia for hazardous waste management include the following:

- **Waste recovery/recycling facilities:** This type of facility is used to recover material for reuse and is saleable for economic benefits. Examples of recoverable products are typically solvents, oils, acids, or metals etc.
- **Treatment facilities:** The use of treatment facilities is mainly for materials that require changes in the physical or chemical characteristic before disposal. This process uses thermal, physical, biological, or chemical methods to reduce the potential harm in the waste before disposal.
- **Land disposal facilities:** This is the final destination of stabilized waste that need no further usage before being permanently buried below soil surface.
- **Fully integrated facility:** This is one major commercial facilities operator for the management of Hazardous waste in Malaysia Kualiti Alam Sdn Bhd which operates fully integrated facility.

5.2. Exclusive right to Kualiti Alam Sdn. Bhd

In the mid-1960s through 1980, Malaysia experienced rapid economic growth in the manufacturing sector which triggered the generation of hazardous wastes in Malaysia and the associated negative effects on the environment [25]. The Malaysian government recognized the growing problem of hazardous waste generation in the country and worked out general waste management strategies to cater for her waste generations. The growing concern on hazardous waste generation led to a survey by a Danish consultancy corporation, which findings helped in drafting regulations on hazardous waste management in 1984. Further surveys on hazardous waste generation and the effect on the environment were conducted by the Department of Environmental (DOE) in 1985 [25]. After several surveys and review of reports of findings on the growing problems of hazardous waste, the Malaysian Government issued the first formal legislation on hazardous waste in 1989. The legislation was supported with the development of a national scheduled waste program aimed at developing an integrated scheduled waste management system which was given to two private companies to design. In 1995, one of the companies, Kualiti Alam Sdn. Bhd, a consortium of Malaysian and Danish companies was given approval to establish integrated scheduled waste plant and was granted the exclusive right operate the plant for 15 years. Kualiti Alam Sdn Bhd was given

the responsibilities for waste collection, transportation, treatment, and final disposal of hazardous waste [41, 42].

5.3. Integrated scheduled waste management system

The integrated scheduled waste management system of Kualiti Alam Sdn Bhd is a centralized integrated waste management center (WMC) developed to use a combination of multiple technologies in the treatment and final disposal of different types of scheduled wastes. The waste management center initially has four integrated treatment facilities comprising incineration plant, physio-chemical treatment plant, solidification plant, and secure landfill but currently includes another facility for clinical waste treatment as shown in **Figure 2**. The facility treats all the categories of scheduled wastes except radioactive waste, pathological waste, and explosive waste.

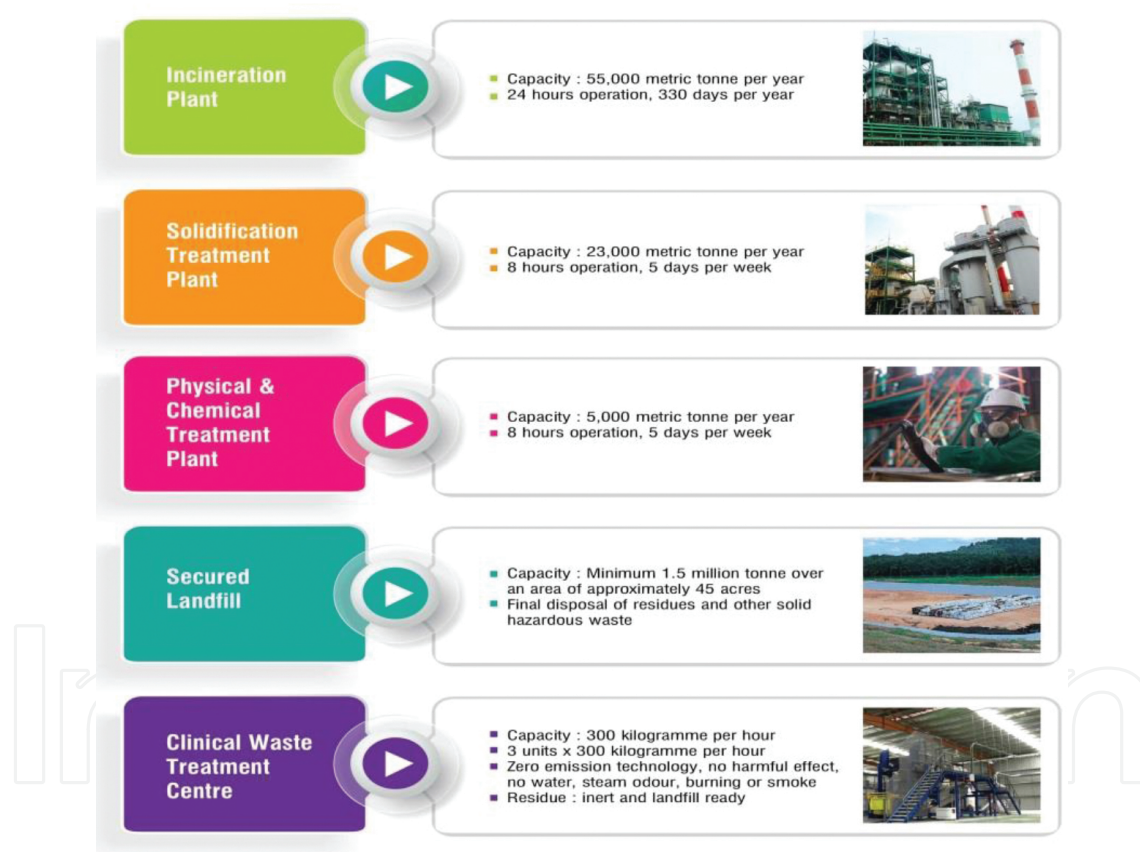


Figure 2. Kualiti Alam end-to-end facilities of the waste management center.

5.3.1. Incineration

Kualiti Alam Sdn Bhd treats about 120,000 metric tons of Malaysia's industrial wastes per year [43]. Industrial wastes are categorized following the organic carbon content where wastes that contain organic carbon level above 10% are disposed only by incineration. Kualiti Alam Sdn

Bhd incineration plant design incorporates a rotary kiln, secondary combustion chamber, and flue gas-cleaning system. The incinerator, as shown in **Figure 3** operates at high temperature, thus volatily destroys all the hazardous scheduled waste channeled to it including polychlorinated biphenyls PCBs contaminated wastes. The ash produced at Kualiti Alam incineration process is around 14,000 metric tons of bottom ash which are disposed to secured landfills lined with impermeable layers [43]. A full landfill will be covered to protect it from rainwater and to minimize seepage using low-density polyethylene liner, but this covering process is not 100% effective. A recent study investigated a sustainable method of managing the ash and found nearness of the ash composition to cement [43].



Figure 3. Kualiti Alam incineration facility.

5.3.2. Stabilization/solidification and physical and chemical treatment facilities

Hazardous waste solidification plant of Kualiti Alam stabilizes neutral inorganic waste and reduces hazardous substances mobility. The system traps contaminants within their host medium and bind them into solid matrix [44]. The facility has a capacity of 15,000 MT/year. Physical and chemical methods are often used in combination with solidification, to separate or transform hazardous substances to less harmful materials. Inorganic wastes are reduced to neutral pH values and other management method like stabilization will be employed.

5.3.3. Secured landfills

The secured landfill is the final destination of stabilized or reduced waste. Incineration by-products like slags, fly ash, and flue gas cleaning products with other residues do undergo solidification and finally deposited in the secure landfill. The landfill is constructed with some monitoring sensors as shown in **Figure 4**. The monitoring system is a specific requirement from the department of environment to prevent ground contaminations.

5.4. Inspection of hazardous waste management facilities

Inspections of waste management facilities are carried out by the Department of Environment, which is a part of the procedural standards for the licensing of waste management facilities or license renewal for operators. The inspections include inspection of schedule of compliance

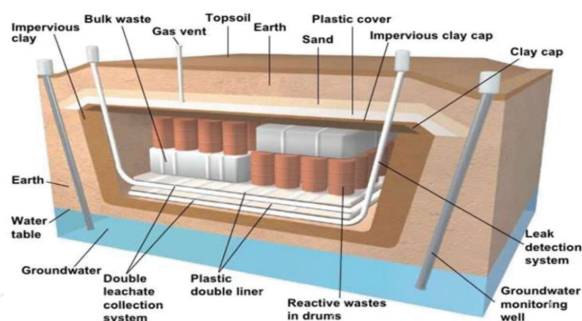


Figure 4. Secured landfill.

for written permission and pre-license inspection. A routine annual inspection for operating facility which requires license renewal is one of the major inspections. This routine inspection helps the Department of Environment to monitor and keep updated record of the various operating facilities. There is also an unscheduled inspection when there is sign or report of operator contravening the regulation of the EQA 1974 and other acts. Hazardous waste management facility inspections from pre-licensing period to operations depend on the type of facility the operator applied for.

Scheduled hazardous wastes	Recovery	PCT	Solidification	Incineration	Secured landfill
Inorganic waste					
Reactive agent, acidic substances and alkalis	√	√			
Metallic solids/heavy metals	√	√	√		
Metallic solution/sludge of heavy metals	√	√	√		
Inorganic sludge		√	√		
Inert inorganic waste					√
Organic waste					
Organic solvents	√			√	
Organic oil contaminates	√			√	
Agro-pesticides/herbicides				√	
Chlorinated hydrocarbons				√	
Resins, organic sludge, and paints	√			√	

Table 4. Waste treatment options for some hazardous waste categories.

5.5. Scheduled hazardous wastes treatment and disposal methods

There are several treatment methods available for hazardous waste management. The waste management methods considered by government are waste reduction (most sustainable procedure), recover/reuse, physio-chemical treatment (PCT), thermal treatment/incineration,

solidification, and biological methods. Some waste treatment options used in the management of scheduled wastes are analyzed in **Table 4**.

6. Conclusion

The focus in this chapter has been the status of hazardous waste management in Malaysia. As highlighted, industrial waste is the major source of hazardous waste in Malaysia, and the nations' approach to hazardous waste management is very well designed and in line with the nation's development plan. The management process is designed such that only licensed operators can handle and treat hazardous waste. Close monitoring of the industries is enforced and sanctions swiftly imposed on erring operators to help keep everyone in line. There is still much to do in the management of agro-hazardous waste as most of the wastes are associated with fertilizer and pesticides usage. The oil/hydrocarbon industry was found to be more conscious following the growth in the waste generated between 2008 and 2011. Clinical waste, which is high-potent hazardous substance, is growing so much and the regulators should pay more attention to that sector and devise more stringent rules on its management. Zero waste generation (reduction) concept is the most sustainable option for Malaysia and can only be achieved if rules are set for waste generators to pay higher fees per kilogram of waste generated.

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