

# SOLID AND HAZARDOUS WASTE MANAGEMENT

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**Abstract:**

The textbook "Solid and Hazardous Waste Management" provides fundamental knowledge on managing solid and hazardous waste. It is designed for students pursuing a Bachelor of Civil Engineering Technology (Environment) at UTHM. Chapter 1 present an overview of solid waste management. It introduces students to solid waste, including its types, sources, composition, and properties. Chapter 2 covers an overview of hazardous waste management. This includes an introduction to hazardous waste, its definitions, characteristics, and categories. This chapter also addresses on clinical waste and E-waste. Chapter 3 explores legislation on solid and hazardous waste in Malaysia. This chapter outlines the history of solid waste management in Malaysia, the Malaysia plan and national policy, as well as legislation related to both solid and hazardous waste. Chapter 4 focuses on the concept of waste separation and 3R. The topics include waste separation at the source, the hierarchy of ISWM, reduce, reuse, recycle as well as the recycling of materials found in municipal solid waste. Chapter 5 explains on the generation rates, storage, and collection of waste. It provides an overview of the solid waste management process, including waste generation and collection practices. Chapter 6 discusses the transfer and transport of waste. This chapter addresses the need for transfer stations, types of transfer stations and collection vehicles, along with the transportation of hazardous waste. Chapter 7 presents treatment technologies for solid and hazardous waste. This chapter discusses different methods available for treating the waste. Chapter 8 elucidates on waste disposal strategies of both solid and hazardous waste.

**Keywords:** Solid Waste Management, Hazardous Waste, Waste Legislation, 3R Concept & Waste Treatment Technologies

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Mimi Suliza Muhamad



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# PREFACE

The textbook “Solid and Hazardous Waste Management” provides fundamental knowledge on managing solid and hazardous waste. It is designed for students pursuing a Bachelor of Civil Engineering Technology (Environment) at UTHM. Chapter 1 present an overview of solid waste management. It introduces students to solid waste, including its types, sources, composition, and properties. Chapter 2 covers an overview of hazardous waste management. This includes an introduction to hazardous waste, its definitions, characteristics, and categories. This chapter also addresses on clinical waste and E-waste. Chapter 3 explores legislation on solid and hazardous waste in Malaysia. This chapter outlines the history of solid waste management in Malaysia, the Malaysia plan and national policy, as well as legislation related to both solid and hazardous waste. Chapter 4 focuses on the concept of waste separation and 3R. The topics include waste separation at the source, the hierarchy of ISWM, reduce, reuse, recycle as well as the recycling of materials found in municipal solid waste. Chapter 5 explains on the generation rates, storage, and collection of waste. It provides an overview of the solid waste management process, including waste generation and collection practices. Chapter 6 discusses the transfer and transport of waste. This chapter addresses the need for transfer stations, types of transfer stations and collection vehicles, along with the transportation of hazardous waste. Chapter 7 presents treatment technologies for solid and hazardous waste. This chapter discusses different methods available for treating the waste. Chapter 8 elucidates on waste disposal strategies of both solid and hazardous waste.

# CHAPTER 1

## OVERVIEW OF SOLID WASTE MANAGEMENT

### 1.1 INTRODUCTION TO SOLID WASTE

Solid waste is waste material generated by human activities that are typically solid, rather than liquid or gaseous, and are discarded as unwanted or useless. The emphasis here is on municipal solid waste (MSW), distinguishing it from agricultural, mining, and industrial wastes. Integrated Solid Waste Management (ISWM) refers to the comprehensive approach of handling all aspects of waste management in society. In the Middle Ages, waste disposed of in the streets led to the proliferation of rats and the associated fleas that transmitted the plague. About 22 human diseases have been associated with improper solid waste disposal. Solid waste also has great potential to pollute air, soil, and water. MSW can cause many potential negative effects. It can promote the breeding of microorganisms that cause diseases. MSW can also attract and support disease vectors such as rodents and insects that carry and transmit disease-causing microorganisms. MSW generate noxious odors and degrade aesthetic quality of the environment. MSW also takes up significant space that could be utilized for other purposes. Moreover, MSW cause general pollution of the environment.

The best way to reduce solid waste is to prevent it from being generated in the first place. Other methods include reducing raw material consumption and increasing the recovery rate of waste materials. In addition, technological advancement can increase the use of recycled materials. Solid waste management is the control of all wastes generated by human and animal activities that are normally solid and disposed of as useless and unwanted. Storage is the management of waste until it is placed in a container. Collection is the gathering of solid waste and recyclable materials before being transported to empty the collection vehicle which accounts for 50% or more of the total cost. Processing of separated household waste versus commingled waste (all together) is a big issue. Processing involves various methods, including physical techniques like shredding and screening, the removal of bulky materials, and chemical and biological processes such as incineration

# CHAPTER 2

## OVERVIEW OF HAZARD WASTE MANAGEMENT

### 2.1 INTRODUCTION TO HAZARDOUS WASTE

A waste is considered as hazardous if meet any of the following conditions:

- i. Exhibiting any of four characteristics of hazardous waste which are ignitability, corrosivity, reactivity or toxicity.
- ii. Listed as hazardous in one of the four tables in Resource Conservation and Recovery Act (RCRA) regulations; Hazardous Waste from Nonspecific Sources (F Code), Hazardous Waste from Specific Sources (K Code), Acute Hazardous Waste (P Code) or Toxic Waste (U Code).
- iii. The waste consists of a mixture of both listed hazardous and non-hazardous materials.
- iv. It is declared as hazardous by the waste generator.

Table 2.1 shows the EU listing of properties that render a compound or waste hazardous. Carcinogenic is any substance or agent that have the potential to cause cancer. Teratogenic are substances that may cause birth defects via a toxic effect on an embryo or fetus which include thalidomide, mercury, alcohol, and lead. Mutagenic is a physical (radiation) or chemical agent (cigarette, preservatives, personal care products) that permanently changes genetic material, usually DNA, in an organism and thus increases the frequency of mutations above the natural background level. Ecotoxic is harmful effects on animals, plants or the environment caused by natural or manmade substances.

# CHAPTER 3

## LEGISLATION ON SOLID AND HAZARDOUS WASTE IN MALAYSIA

### 3.1 SOLID WASTE MANAGEMENT HISTORY IN MALAYSIA

The tremendous increased of solid waste generation daily is a major challenge for people and government in evaluating the national legislation and international policy framework for effective control and enforcement in dealing with waste management. Figure 3.1 shows the timeline of solid waste management history in Malaysia. The local authorities (local government/state government) provide solid waste management services to small contractors.

In 1997 government had given interim privatisation to concession companies for solid waste management. The solid waste management responsibility of 48 local authorities has been privatized to 2 concession companies which is Alam Flora for the Central Region and Southern Waste for the Southern Region while the North was under interim regime for a year.

In 2007, act 672 was passed by parliament. The act was enacted to regulate the management of controlled solid waste and public cleansing for the purpose of maintaining proper sanitation and for related purpose. The Solid Waste and Public Cleansing Management Act 2007 (Act 672) is the guiding framework for the solid waste concessionaires to provide their services.

In 2011, act 672 was enforced where federal government took over solid waste management from several state governments which give their executive powers. Full privatisation was given to concession companies including in the Central (Selangor, Pahang, Terengganu, Kelantan, Kuala Lumpur, and Putrajaya) and Southern Region (Negri Sembilan, Malacca, Johor) while the North (Perlis, Kedah, Penang, Perak) was under interim regime for a year. Full privatisation of the service was also the way forward of the government commitment to reduce greenhouse gas emissions 40% by 2020.

# CHAPTER 4

## THE CONCEPT OF WASTE SEPARATION AND 3R

### 4.1 WASTE SEPARATION AT SOURCE

Separation of MSW can occur at the household or industry level, at transfer stations, or at the final disposal site where mechanical sorting is feasible. When separation is performed at the source, it reduces the need for costly and complex manual or mechanical sorting processes. Source separation also yields the cleanest and most well-defined waste fractions, which are more suitable for subsequent recycling or reuse.

Separation of MSW that are desirably separated at source are; food waste (household separation), paper and cardboard (household separation), plastic (household separation), ferrous metals (household separation), glass and non ferrous metal (community drop-off centres), bulky waste, yard waste, hazardous house hold waste (drop off centres).

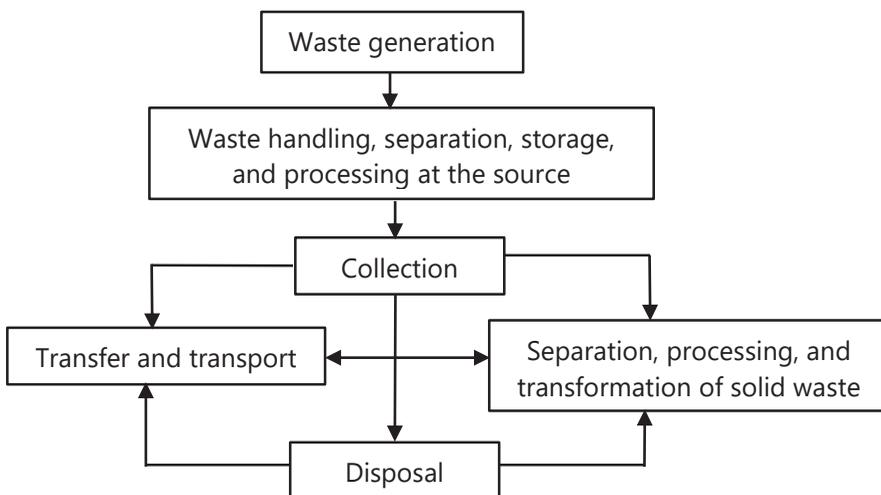
The purpose of unit operations for separation and processing is to alter the physical characteristics of materials to facilitate the removal of desired components. This process also aims to eliminate specific components or contaminants and prepare the material for subsequent uses. Screening is a unit operation that separates mixtures of materials into two or more size fractions using screen surfaces. The goal is to remove oversized and undersized materials, as well as to separate materials into different fractions, such as light (combustible, paper), heavy, and (non-combustible, glass). Figure 4.1 shows the screening devices that include vibrating screens, rotary screens, and disc screens.

# CHAPTER 5

## GENERATION RATES, STORAGE AND COLLECTION OF WASTE

### 5.1 OVERVIEW OF SOLID WASTE MANAGEMENT PROCESS

The management of solid waste comprises several steps that start with the waste generation. The generated waste by residential, commercial or industrial is stored in a trash bin as commingled waste or source separated waste. Then the waste will be collected by the waste management company to be transfer and transport for separation, processing, and transformation of the solid waste before it can be disposed to the landfill. Figure 5.1 shows the overview process of solid waste management. The knowledge of solid wastes generation, separation for recycling and collection for further processing or disposal is of fundamental importance to all aspects of solid waste management.



**Figure 5.1:** Overview of solid waste management process

# CHAPTER 6

## TRANSFER AND TRANSPORT OF WASTE

### 6.1 TRANSFER AND TRANSPORT

Transfer and transport refer to the means, facilities used to transfer of wastes from one location to another, usually more distant location. Contents of relatively small collection vehicles are transferred to larger vehicles that are used to transport the waste over extended distances either to MRFs or to disposal sites. A Materials Recovery Facility (MRF) is where recyclable materials that are collected from households are sorted into different types (e.g. plastics, cardboard, paper, metal) using a mixture of manual and automated methods. When the materials have been sorted, they are sent to reprocesses and manufacturers where they are used to create new products. Material Recovery/Transfer Facilities (MR/TFs) represent a forward-looking approach to waste management. These facilities may encompass various functions, including drop-off center, materials separation, composting, bioconversion, production of refuse-derived fuel (RDF), as well as transfer and transport facility.

### 6.2 NEEDS FOR A TRANSFER STATION

Transfer station is needed for several reasons as follows:

- i. Transfer and Transport operations become a necessity when haul distances to available processing centers or disposal sites increase so that direct hauling is no longer economically feasible.
- ii. They also become a necessity when processing centers or disposal sites are sited in remote locations and cannot be reached directly by highway.
- iii. Transfer and transport operations are also integrated with MRFs to transport recovered materials to markets or waste-to-energy facilities, as well as to transport materials to landfills.

# CHAPTER 7

## SOLID AND HAZARDOUS WASTE TREATMENT

### 7.1 WASTE TREATMENT TECHNOLOGIES

Waste that cannot be recovered and poses risk to human health or environment must be managed by treatment prior to disposal. The available waste treatment technologies include physical treatment, chemical treatment, physical-chemical treatment, stabilization-solidification, biological treatment, and thermal treatment.

#### 7.1.1 Physical Treatment

Physical treatment involves altering the physical properties of waste, such as its size, shape, density, or state (i.e., gas, liquid, solid), without changing its chemical composition. The primary goals of physical treatment are to concentrate, solidify, or reduce the volume of the waste. Common physical processes include flotation, sedimentation, centrifugation, encapsulation, and filtration. Figure 7.1 shows the physical process of floatation, sedimentation, centrifugation, and encapsulation.

Flotation is a solid-liquid separation process that utilizes up-current injection of air bubbles. By exploiting the attractive forces between suspended solids and water particles, along with the surface tension and pressure of the air flow, the air bubbles attach to the solid particles and carry them to the surface where the solid particles can be removed.

Sedimentation is a gravity-driven process where suspended solids are allowed to settle at the bottom of a tank containing still or slowly flowing liquid. The accumulated solids can then be collected and removed from the bottom of the tank.

Centrifugation is a separation process that distinguishes between lightweight and heavy particles through centrifugal force. This force is generated by rotating either the entire vessel, known as a "centrifuge," or just the fluid inside, "hydrocyclone."

# CHAPTER 8

## SOLID AND HAZARDOUS WASTE DISPOSAL

### 8.1 WASTE DISPOSAL STRATEGIES

Waste that has been treated or waste that has no value and needs disposal can be managed through methods such as landfills, surface impoundments, or deep well injection. A landfill is a site designated for the disposal of waste materials through burial, representing one of the oldest methods of waste disposal. In this process, waste is directly deposited into mining voids or borrow pits, where it is then compacted and covered with soil. Gases produced by decomposing waste materials are often burned to generate power. Special landfills with stringent regulations are used for hazardous waste to ensure safe containment. Additionally, surface impoundments, which are ponds lined with plastic and clay, are utilized for liquid hazardous waste. In these impoundments, the liquid waste evaporates, leaving behind a solid residue. Deep well injection involves pumping hazardous waste deep underground into porous and stable rock formations, away from aquifers, to prevent contamination of groundwater.

#### 8.1.1 Landfill

There are two main type of landfills which is sanitary landfill and secured landfill. Sanitary landfill is a land disposal site employing an engineered method of disposing of solid wastes in a manner that minimizes environmental hazards by spreading the solid wastes to the smallest practical volume and applying and compacting cover material at the end of operation of each day. A clay liner is used to isolate the trash from the environment. The waste is isolated from the environment until it is safe. It is considered safe when it has completely degraded biologically, chemically, and physically. Sanitary landfills use technology to contain the waste and prevent the leaching out of potentially hazardous substances. The advantages and disadvantages of sanitary landfill is shown in Table 8.1. The method of landfilling can be divided into three which are:

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