# AN ASSESSMENT

# OF

# MUNICIPAL SOLID WASTE MANAGEMENT PRACTICES

# IN PULAU KETAM, MALAYSIA

**CAO XIANG**

**FACULTY OF ENGINEERING**

**UNIVERSITY OF MALAYA**

**KUALA LUMPUR**

**2016**

# AN ASSESSMENT OF MUNICIPAL SOLID WASTE MANAGEMENT PRACTICES IN PULAU KETAM MALAYSIA

**CAO XIANG**

**RESEARCH REPORT SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF ENGINEERING (SAFETY, HEALTH AND ENVIRONMENT)**

**FACULTY OF ENGINEERING**
**UNIVERSITY OF MALAYA**
**KUALA LUMPUR**

**2016**

**UNIVERSITY OF MALAYA**

# ORIGINAL LITERARY WORK DECLARATION

Name of Candidate: **CAO XIANG**

Registration/Matric No: **KGJ140056**

Name of Degree: **Master of Engineering (Safety, Health and Environment)**

**An Investigation of Municipal Solid Waste Management in Pulau Ketam, Malaysia**

Field of Study: **Solid Waste Management**

I do solemnly and sincerely declare that:

(1) I am the sole author/writer of this Work;
(2) This Work is original;
(3) Any use of any work in which copyright exists was done by way of fair dealing and for permitted purposes and any excerpt or extract from, or reference to or reproduction of any copyright work has been disclosed expressly and sufficiently and the title of the Work and its authorship have been acknowledged in this Work;
(4) I do not have any actual knowledge nor do I ought reasonably to know that the making of this work constitutes an infringement of any copyright work;
(5) I hereby assign all and every right in the copyright to this Work to the University of Malaya ("UM"), who henceforth shall be owner of the copyright in this Work and that any reproduction or use in any form or by any means whatsoever is prohibited without the written consent of UM having been first had and obtained;
(6) I am fully aware that if in the course of making this Work I have infringed any copyright whether intentionally or otherwise, I may be subject to legal action or any other action as may be determined by UM.

Candidate's Signature Date:

Subscribed and solemnly declared before,

Witness's Signature Date:

Name:

Designation:

# ABSTRACT

As a mangrove island, Pulau Ketam is rich in natural resources and attracts quite a number of visitors. Fishing and tourism are the main economic sources on this island. Therefore, municipal solid waste management in Pulau Ketam is becoming increasingly important. Presently, the total population is approximately 6 to 7 thousand on this island. Among them about 4 thousand residents are living in Pulau Ketam village, which is the study area. Through interviews, questionnaire, observation and document analysis, the information on current MSWM practices in Pulau Ketam was gathered. After 16 years of MSWM practice, the situation of management MSW has been changed. The solid waste collection company has placed dustbins on this island. However, open dumping on the island still exists. Throughout this study, an assessment has been done on the current status of MSWM practices in Pulau Ketam. This assessment has identified the issues of MSWM system, and subsequently proposed suggestions to overcome the issues. The major issues on this island are included: lack of infrastructures for MSWM system, weak awareness of islanders, and non-implementation government management policy. By analyzing and comparing with effective MSWM systems in Asia, especially Kamikatsu, appropriate sustainable solutions are proposed. The analysis proved that MSWM system cannot succeed without the understanding and commitment from the residents. Therefore, to overcome the issues, the committee of Pulau Ketam should set a program to increase islanders' awareness of MSWM system, add the infrastructures of MSWM reasonable, and enforce the management of MSW recycling and disposal. Although achieving a successful MSWM system in Pulau Ketam has a long way to go, the islanders are certainly in a positive mindset to support any policy change towards cleaner home.

***Key words:*** Solid waste, MSW management, MSWM practice, Pulau Ketam

# ABSTRAK

Sebagai sebuah pulau bakau, Pulau Ketam kaya dengan pelbagai sumber semulajadi. Kini, kebanyakan pelawat tertarik dengan makanan laut di atas pulau ini. Walaubagaimanapun, selepas 16 tahun MSWM dilaksanakan, lambakan terbuka masih wujud di atas pulau. Sistem Pengurusan Sisa Pepejal Perbandaran (MSWM) yang berkesan mampu meningkatkan keadaan alam sekitar di atas pulau, serta menggalakkan perkembangan pelancongan. Kajian ini menyiasat keadaan semasa MSWM di Pulau Ketam. Melalui analisa dokumen, temuduga, pemerhatian, dan soal selidik, maklumat semasa MSWM di Pulau Ketam dapat diperoleh. Situasi MSWM adalah lebih baik daripada sebelum. Tetapi, ia boleh menjadi lebih baik. Beberapa masalah utama telah dikenal pasti. Isu utama di atas pulau ini adalah infrastuktur untuk MSWM, kesedaran penghuni pulau, dan dasar pengurusan kerajaan. Dengan menganalisa dan membandingkan sistem-sistem MWSM yang berkesan di Asia, penyelesaian mampan yang sesuai dicadangkan untuk pelaksanaan mampan MSWM di Pulau Ketam. Analisa membuktikan system MSWM tidak dapat dijayakan tanpa pemahaman dan komitmen daripada penghuni pulau. Walaupun untuk mencapai MSWM yang mampan di Pulau Ketam masih memerlukan jalan yang jauh, penghuni pulau sepastinya menpunyai minda positif untuk menyokong sebarang perubahan dasar terhadap persekitaran bersih.

***Kata kunci:*** Sisa pepejal, MSWM, Pulau Ketam

# ACKNOWLEDGEMENTS

I would like to express my deepest appreciation to all those who provided me the possibility to complete this report. A special gratitude I give to my supervisor, Dr. Jegalakshimi, whose guidance and encouragement, helped me to complete my report.

Furthermore, I would like to acknowledge the residents in Pulau Ketam who willing to share their experiences and information in order to gain better understanding and knowledge to complete this project.

I am also grateful to my classmates and friends for their friendship and gave suggestions about my project.

Last but not least, many thanks go to my family: my parents for supporting me spiritually throughout writing this report and my life in general.

# TABLES OF CONTENTS

# LIST OF FIGURES

# LIST OF TABLES

# LIST OF SYMBOLS AND ABBREVIATIONS

**MSW:** Municipal Solid Waste

**MSWM:** Municipal Solid Waste Management

**IWM:** Integrated Waste Management

**C2C/C2G:** Cradle-to-Grave

**CAD:** Controlled Anaerobic Digestion

**CRC:** Centralized Refuse-Chute System

**3R:** Reduce, Reuse, and Recycle

**LCA:** Life Cycle Assessment

**GDP:** Gross Domestic Product

**ABC Plan:** Action Plan for a Beautiful and Clean Malaysia

**OPP3:** The Third Outline Perspective Plan

**NRP:** The National Recycling Program

**ICM:** Integrated Coastal Management Program

**NGO:** Non-Governmental Organization

**DONSWM:** Department of National Solid Waste Management

**SWPCMC:** Solid Waste and Public Cleansing Management Corporation

# CHAPTER 1: INTRODUCTION

## 1.1 Overview

Municipal solid waste (MSW) has been a major problem in all the countries, especially in developing countries. In these countries, due to industrialization and improving living standards, the generation of MSW is increasing rapidly. However, they only have limited resources and technologies for MSW treatment and disposal, and also lack of enforcement for relevant regulations in municipal solid waste management (MSWM), especially on safety disposal and recycling (Chen, Geng, & Fujita, 2010).

Besides, MSW can harm human health in many ways, and also pollute the environment, including atmosphere, hydrosphere, and pedosphere. Moreover, the ecological balance is destroyed at an alarming rate. However, if MSW could be treated in a right way, they will be a part of the resource for human society and reduce the environmental burden.

Hence, to manage MSW, and find a way which can save the resource, reduce waste, and achieve development, become critical. Therefore, sustainable development has been proposed in 1987, to protect the environment while implementing development (Jalil, 2010). Nowadays, sustainable management of MSW become an area of growing concern in Malaysia islands, due to the inefficient collection and unacceptable disposal of MSW already caused serious marine pollution, and harmed the marine system. (Pariatamby & Periaiah, 2010).

In 2009, more than 23,000 tonnes of waste were produced per day in Malaysia. This quantity increases every year and illustrates a linear increase. As the population growth and economic development, the amount of MSW is expected to 30,000 tonnes in the year 2020. Unfortunately, less than 5% of the MSW is recycled at present (Kumar et al., 2009).

Solid wastes have become one of the main environmental problems in Malaysia. There are several reasons for this condition. First one is that the documents of MSW composition and generation rates are not enough and out of date. The second one is inefficient storage and collection systems. Then, residents drop the MSW and hazardous waste together, as there is no solid waste segregation. Next one is the inefficient utilization of disposal site space. Last, the government management for MSW is not enough so MSW is discarded, indiscriminately (Global Environment Centre, 2016; Kumar et al., 2009).

In Malaysia, landfilling is the only way used for MSW disposal, and most of these landfill sites are uncovered, which can raise the risk of environmental and social issues (Saheri, Aghajani, Basri, Mahmod, & Begum, 2011; Yunus & Kadir, 2006). Landfills can deal with approximately 98% of the total MSW. For this method, the main problem is difficult to extend the service life of the landfill. Due to land scarcity, Malaysia, with rapid development, will need a better and more efficient strategy for MSW, urgently (Manaf, Samah, & Zukki, 2009).

Actually, the Malaysia government has made efforts to increase the efficiency of landfill sites. According to Action Plan 1988, there are 4 levels for improvement (Huri bin Zulkifli, 1993):

Level 1: Controlled dumping

Level 2: Sanitary landfill with daily cover

Level 3: Sanitary landfill with leachate circulation

Level 4: Sanitary landfill with leachate treatment

Additionally, more than 50% of MSW budget is spent for waste collection system at present, but only 76% of total wastes were collected. The government lacks financial aid and technical for MSWM.

Therefore, Malaysian government made a new structure, whereby MSWM was privatized in 1996. Under the Ministry of Housing and Government, Department of National Solid Waste Management (DONSWM) and Solid Waste and Public Cleansing Management Corporation (SWPCMC) have been set up. DONSWM becomes a regulatory body, then SWPCMC conducts operations. According to (Manaf et al., 2009), "the corporation would take over the role of managing MSW from local authorities and watch over the concessionaires. However, local authorities would continue to monitor cleanliness in areas under their jurisdiction". Now, there are 3 solid waste concessionaires that have their own operation zones, they are Southern Waste Management for southern regions; Alam Flora Sdn Bhd for central regions; and Idaman Bersih Sdn Bhd for northern regions (Manaf et al., 2009).

The MSW situation of islands in Malaysia, under the new structure of MSWM, also began to change. Pulau Ketam is one of them. According to the research "Solid waste management in Pulau Ketam - Alam Flora's experience", this island used to be a "foul stench island", as it without any cleaning program or MSWM over 100 years (Yaacob, 2004). Garbage is still dropped indiscriminately onto the ground as well as into the sea.

But, things have been changed in October 1999. Alam Flora's proposal about MSWM has been approved by the Selangor government, and then they gave the company the responsibility. According to the report, there has been improved in the MSWM area, since 2000. Now, the islanders on Pulau Ketam are trying to create a new culture of MSWM instead of "throw away culture" (LUAS/SWMA and Port Klang Project Management Office, 2006; Yaacob, 2004).

Since the MSWM began on this island, Alam Flora organized some public talks, community cleaning to grow environmental awareness and to encourage proper MSW disposal among locals. Besides that, dustbins with wheels are now found in the village. The collected MSW will be shipped to Klang 4 times per week, then the rubbish will be

treated by landfilling. Although these measures already helped Pulau Ketam to change its reputation, dumping MSW still happens because there are not enough dustbins.

"It is difficult getting people to stop throwing things into the sea. Their families have been doing this for over 100 years", said Mr. Chia Mong Chun, the Pulau Ketam village head. Furthermore, increasing the number of dustbins will need more workers to push them to the jetty.

### 1.2 Problem Statement

Disposing MSW from Pulau Ketam costed RM1,000 per ton because of transportation fee, but for those in mainland only needed RM150 (Li, 2005). Currently, economic development makes the amount of MSW is increasing. Hence, the price for shipping MSW from Pulau Ketam to Klang does not decrease. Shipping the waste to the mainland cannot be a long-term solution for Pulau Ketam, especially if the number of waste increasing significantly, the shipments would be more expensive.

The incinerator is a choice for MSW disposal, but this method needs efficient gas-cleaning systems. Currently, there are some islands using incinerator, namely Tioman, Langkawi, Pangkor, and Labuan. However, the result is not well, due to technical problems. On these islands, the incinerators almost like burners. Composting can be another choice, as the composition of MSW is typically 50% organic. Particularly, the villagers can dispose of organic wastes individually through household composting bins (Li, 2005).

Nowadays, although the facilities are limited, most villagers are willing to separate their waste. Hence, there is a little recycling on this island. More or less, the number of MSW on Pulau Ketam could be reduced, which is benefit for shipping and landfilling.

Clearly that the MSW situation in Pulau Ketam has changed, since 2000. An awareness program conducted by Alam Flora was enacted in this year. But, it is not enough. On this

islands, MSWM needs a more complicated and more effective method to implement better development (Li, 2005).

In the past 16 years, the company for MSWM on the island has been changed from Alam Flora to Umi Kasmah Enterprise. Most islanders agree that solid waste management is necessary. However, the problem of solid waste disposal still exists in Pulau Ketam. This study will focus on the current situation of MSWM in Pulau Ketam. The ecosystems in this island are easy to be affected by human activities and unsustainable development because this is a mangrove island (LUAS/SWMA and Port Klang Project Management Office, 2006). Hence, it is important to manage MSW in a sustainable way, in this island. This project will identify what are the issues of current MSWM system in Pulau Ketam, as well as propose viable suggestions to overcome these issues.

### 1.3 Aim and Objectives of Study

This study aims to implement sustainable MSWM in Pulau Ketam, by analyzing the current situation of MSWM system, and proposing sustainable solutions on the island.

The objectives of the study are:

a. To analyze the current issues of municipal solid waste management in Pulau Ketam,
b. To compare the existing municipal solid waste management system practices with other islands in Asia,
c. To suggest solutions in overcoming municipal solid waste management issues in Pulau Ketam.

### 1.4 Scope of Study

This research will focus on how to manage MSW in a sustainable way, in Pulau Ketam. The MSWM in Pulau Ketam is compared to other Asian islands, such as Hong Kong, Singapore, and Japan. Among them, MSWM in Japan is the major experience that can

help Pulau Ketam to manage MSW in an efficient sustainable way. Finally, some improvement suggestions for MSWM in a sustainable way are proposed in the report.

### 1.5 Organization of Thesis

This report shows the issues of the MSWM system in Pulau Ketam, by analyzing current MSWM situation. Then, after comparing with the cases in other Asian islands, some sustainable solutions are suggested to improve MSWM system on this island.

The organization of this thesis is as follows.

Chapter 2 is literature review part. This part introduces the information of MSW and lists the methods of MSWM. Then, the MSWM situation in Malaysia and Pulau Ketam both were mentioned in detail. The last section in Chapter 2 is focusing on reviewing other MSWM examples in Asian islands, including Hong Kong, Singapore, and Japan.

Chapter 3 is the methodology of this study. This part describes how the study proceed. It is linked back to chapter 2 to explain the academic basis of research, and the methods for gathering information.

In Chapter 4, the results and discussion part, illustrates the current problems of MSWM in Pulau Ketam, and discusses the reasons which lead to these issues. And also, in discussion part, the relevant solutions are provided, respectively.

Chapter 5 is conclusion and recommendation part. This part expounds a comprehensive summary of findings. Then, the brief, clear, precise recommendations are proposed.

# CHAPTER 2: LITERATURE REVIEW

## 2.1 Introduction

MSWM is one of the most popular research topics in the world. This topic includes the information of MSW and management system. The concepts of MSW are including definition, sources, category, characteristics, and composition. The management system basically consists of collection and storage, transportation, disposal, as well as policies. To design an MSWM system needs considering the generation, policies, economic condition and social factors in the different area.

As this study is an investigation of MSWM in Pulau Ketam, the literature review is focusing on the information of MSW, the current situation of MSWM system in Malaysia, and the brief cases in Hong Kong, Singapore, and Japan. In addition, this literature review will not include concepts of hazardous waste, nor MSWM in East Malaysia. The MSWM system in Pulau Ketam will only focus on residence zone.

The literature review findings will contribute to identify the problems of MSWM in Pulau Ketam. And also, the solutions which can improve the MSWM system in a sustainable way will be proposed.

## 2.2 Municipal Solid Waste

Municipal Solid Waste (MSW), typically referred to as rubbish or garbage, involves day-to-day items we used and then discarded, such as yard waste, product packaging, clothing, various bottles, food wastes, paper, e-waste, batteries, furniture, and so on. This kind of originates from our living place and any workplace (USEPA, 2016).

### 2.2.1 Source and Category of Municipal Solid Waste

MSW sources can be identified as living garbage which including residential, commercial activities; industrial and mining solid waste which including

industrial, mining, construction, manufacturing, treatment facilities; and other solid wastes, like agricultural, breeding, forestry, etc. (Tchobanoglous, 2009). These sources can be typically list as Table 2.1.

**Table 2.1:** General Sources of Municipal Solid Wastes (Tchobanoglous, 2009)

| Source | Classification | Facility/Activity/Location | Waste |
|---|---|---|---|
| **Living Garbage** | Residential | Families, Dwellings, Apartments, etc. | Food wastes, papers, plastics, yard wastes, glasses, cans, metals, electronics, batteries, oil, household hazardous wastes, old tires, etc. |
| | Commercial services | Stores, restaurants, markets, office buildings, hotels, motels, print shops, service stations and auto repair shops | Paper, cardboard, plastics, wood, food wastes, glass, metal wastes, ashes, hazardous wastes, etc. |
| | Institutional | Schools, hospitals, governmental centers, etc. | |
| **Industrial and Mining Solid Wastes** | Industrial (treated & untreated) | Demolition, manufacturing, chemical and power plants, construction wastes, etc. | Papers, plastics, woods, glass, metal wastes, ashes, steel, concrete, hazardous wastes, etc. |
| **Other Solid Wastes** | Treatment facilities | Street cleaning, landscaping, parks, beaches, other recreational areas wastewater, industrial treatment processes, etc. | Special wastes, rubbish, street sweepings, tree trimmings, treatment plant wastes, sludge, and other materials, etc. |
| | Construction | Build process, demolition process | woods, glass, metal wastes, ashes, steel, concrete, hazardous wastes, etc. |
| | Agricultural, breeding, forestry | Field, row crops, orchards, dairies, feedlots, zoos, etc. | Spoiled food wastes, agricultural wastes, rubbish, animal wastes, hazardous wastes |

### 2.2.2 Characteristics of Municipal Solid Waste

Composition, quantity, and specific weight are important characteristics of solid wastes (Tchobanoglous, 2009).

a) Composition, including food waste, paper products, plastics, metals, glass,

and ceramics, etc., each of them should be studied and weighed. The composition of MSW is affected by people's habits, education, and economic status, commercial and industrial types, location, and so on.

b) Quantity, the number of solid wastes generated and collected by one person/day. According to Franklin Associates (in 1999, yearly updates), "the amount of municipal solid waste collected is estimated to be 6lb/people/day, among them, about 3.5lb is living garbage and this figure will increase yearly, in the USA". To expect the quantity of MSW can help for making MSWM system, especially in preliminary planning and feasibility assessment.

c) Specific Weight (unit weight), a weight per unit volume of a material, and also affect the systems of transportation, as well as the land area of disposal. This figure is affected by a set of conditions, including the number of solid waste containers, containers' size and type, water content, collection cars, and stations to transfer.

### 2.2.3 Composition of Municipal Solid Waste

Normally, solid wastes including all solid wastes caused by society, and those from medical, radioactive, industrial activities, agricultural producing, water treatment systems (sewage sludge), or other treatment systems are defined as hazardous wastes (Ven Te Chow, 1997). However, the definition of MSW will not include hazardous waste.

The composition of municipal solid waste (MSW) changes significantly with time and countries. In countries that have a developed waste recycling system, the waste stream mainly consists of intractable wastes like unrecyclable packing materials and plastic. Those without developed recycling system, solid waste usually includes yard wastes, food waste, plastic and packaging materials, and

others from residential, commercial, institutional, and industrial sources (Herbert, 2007).

As an example, the composition of MSW in Kuala Lumpur, in the year 2004, is shown in Table 2.2.

**Table 2.2:** Composition of MSW in KL (Kathirvale, Yunus, Sopian, & Samsuddin, 2004)

| Source | High-income % | Medium-income % | Low-income % | Commercial % | Institutional % |
|---|---|---|---|---|---|
| **Food** | 30.84 | 38.42 | 54.04 | 41.48 | 22.36 |
| **Mixed paper** | 9.75 | 7.22 | 6.37 | 8.92 | 11.27 |
| **Corrugated paper** | 1.37 | 1.75 | 1.53 | 2.19 | 1.12 |
| **Newsprint** | 6.05 | 7.76 | 3.72 | 7.13 | 4.31 |
| **High-grade paper** | 0 | 1.02 | 0 | 0.35 | 0 |
| **Plastic** | 26.21 | 20.04 | 11.66 | 17.18 | 19.50 |
| **Diapers** | 6.49 | 7.58 | 5.83 | 3.80 | 1.69 |
| **Rubber** | 0.48 | 1.78 | 1.46 | 0.80 | 2.07 |
| **Textile** | 1.43 | 3.55 | 5.47 | 1.91 | 4.65 |
| **Wood** | 5.83 | 1.39 | 0.86 | 0.96 | 9.84 |
| **Yard waste** | 6.12 | 1.12 | 2.03 | 5.75 | 0.87 |
| **Glass** | 2.75 | 4.09 | 1.30 | 4.72 | 0.62 |
| **Aluminum** | 0.34 | 0.08 | 0.39 | 0.25 | 0.04 |
| **Ferrous** | 1.93 | 3.05 | 2.25 | 2.47 | 3.75 |
| **Non-ferrous** | 0.17 | 0 | 0.18 | 0.55 | 1.55 |
| **Hazards** | 0.22 | 0.18 | 0 | 0.29 | 0.06 |
| **Fine** | 0 | 0.71 | 2.66 | 0 | 0.39 |
| **Others** | 0.02 | 0.27 | 0.25 | 1.26 | 16.02 |
| **Total** | 100 | 100 | 100 | 100 | 100 |

## 2.3 Municipal Solid Waste Management (MSWM)

Management of MSW is a complicated procedure. An MSWM system needs a lot of technologies and theories to support. These are including source reduction, on-site handling and storage, collection, transportation, and disposal (Tchobanoglous, 2009).

To protect the human health is the first target of MSWM. MSWM also aims to improve environmental quality, to supply support for economic productivity, and finally to implement sustainable development. In order to reach these goals, the local government must cooperate with related sectors to establish sustainable MSWM systems. Although

compared with industrialized countries, the quantity of MSW generated in developing countries is lower, the MSWM still remains inadequate (Henry, Yongsheng, & Jun, 2006). Operating the MSWM system needs proper policies, infrastructures, maintenance, and upgrade. Moreover, with the speeding up of urbanization process, the MSWM becomes more and more expensive and complex (Mor, Ravindra, De Visscher, Dahiya, & Chandra, 2006; Sharholy, Ahmad, Mahmood, & Trivedi, 2008).

### 2.3.1 Solid Waste Collection and Storage

#### 2.3.1.1 Collection

In MSWM, the way of collection depends on the disposal method. As the first step of MSWM system, the collection systems must be designed carefully because the cost of collection will take a large proportion of the total cost of MSWM system. A collection service of MSW needs to based on the community program. Typically, MSW collection is used for mixed waste and source-separated wastes. In addition, there are other collection services be provided for special waste, such as annual or semi-annual collections for e-waste, tires, oils, yard wastes, glass, plastic bottles, and so on.

The plan of collection frequency depends on the quantity of MSW per year, the local environment, and economic conditions, and also the municipal responsibility. Usually, in business areas or places with warm weather, the collection will be once a week. Moreover, most cities also set the programs for the household hazardous waste collection, normally every three months (Tchobanoglous, 2009).

#### 2.3.1.2 Storage

Storage of MSW actually is lacking in most of the cities. The dustbins are not performed waste segregation, and then the waste is disposed at a public place. Storage dustbins can be classified into 2 kinds, movable and fixed. The movable

bins are easy to transport, but they lack durability. On the contrary, the fixed bins are more sustained but fixed positions (Nema, 2004)

### 2.3.2 Transfer of MSW

The transportation of MSW is needed, to implement the requirements of health, safety, and environmental (Hagerty, Pavoni, & Heer, 1973). The collected MSW from the dustbins, collection points, and storage stations will be transported to disposal sites by carrier vehicles. The distances to disposal sites would decide the size of collection vehicles. For example, if it is a long distance to disposal sites, the MSW in small collection vehicles would be transferred to a larger one. It is also critical to scheme the timetable between the collection areas and the final disposal area.

According to the transport vehicles using the method, the transfer stations can be classified into 3 types (Tchobanoglous, 2009):

1) Direct Discharge: normally used in the small communities. The wastes in the collection vehicles are emptied directly into the transport vehicle, then transport them to the final disposal area.
2) Storage Discharge: useful for the large communities. Firstly, the wastes are emptied into the storage area by auxiliary equipment. Then will be transferred to the final disposal sites.
3) Combined with storage and direct Discharge: in some transfer station, both methods are used to serve a broad range of users.

### 2.3.3 Disposal methods

#### 2.3.3.1 Sanitary Land Filling

Landfilling can be considered as one of the major methods of MSW disposal in the world, due to the less cost and more simple operation. In principle, reuse or

recycling the waste will be better than landfilling, but landfilling will not increase the unacceptable impacts to the environment, or hazards to health.

As the increasing number of MSW generation, landfilling need a large area of land. Therefore, it cannot be used in all countries, especially those short of land resources. For example, in North America, most of MSW, currently produced, will be landfilled. However, some European countries, such as Germany, Denmark, are using incinerators for handling a large number of MSW, and the ash from the process will be used for building roads or similar purposes (Hjelmar, 1996).

#### 2.3.3.2 Incineration

The process of incineration is quite different in countries, as different environmental and economic factors. This method usually can be used in countries which don't have enough space for landfilling, such as Japan, Switzerland, France, Germany, etc. Some of them already passed the laws to prohibit future landfilling of combustible waste (Butz, 1997). Therefore, incineration will become increasingly important. This way can reduce almost 90% of the amount of MSW, and it allows to recover lots of the energy through the process. But, combustion and air pollution control residues are produced, these products subsequently were utilized or landfilled (Hjelmar, 1996).

Incineration normally is used in developed countries, because to design and built an incinerator needs a lot of technologies and funding. The humidity and temperature also are the problems faced by the process. If cannot meet the technical requirements of incineration, the disposal process would become burning, and produced a large number of hazardous substances which can cause secondary pollution.

#### 2.3.3.3 Biological Treatment

Biological treatment can be divided into two categories, one is composting, another one is controlled anaerobic digestion (CAD). Among, CAD needs a high level of technical knowledge. Therefore, in developing countries, they would not choose CAD for MSW disposal (The World Bank, 2012). As Malaysia is a developing country, CAD will not be described in detail.

#### 2.3.3.4 Composting

Composting can be used with a low demand of technology, and quite economic. As food waste is the most component of MSW, composting has been used in lots of cities (Otten, 2001). This method aims to change organic solid wastes into products with low-cost, and these products can be applied in agriculture. The conditions about economic and environment, both can affect the use of composting, for instances, the capacity of landfilling, costs of landfilling and transportation, and the government policies. In addition, using composting can decrease the use of commercial fertilizers (Hargreaves, Adl, & Warman, 2008).

## 2.4 Sustainable Methods of MSWM

Although, in different countries, the strategies and definitions of waste management are substantially different, it's also a critical issue of obtaining certain goals and objectives. The methods of waste management cannot be totally same because they cannot deal with all potential wastes in a sustainable way by the individual. Hence, methods must also vary appropriately to make certain that these circumstances can be successfully achieved. Solid waste management systems need to remain flexible as the changing economic, environmental and social conditions. In many cases, MSWM can be carried out by a lot of processes, lots of them usually are related. For this reason, it is better to design integral waste managing systems than the alternative and competing options (Staniskis, 2005).

A particular framework can help engineers solve the issues of MSWM, in an efficient

way, and improving the existing designs (McBride, 1995). It provides: flexible frame and analysis for quantitative and qualitative information in different scopes; clearly structures to identify major goals; logical consider options related to probability and results; clearly communicate with key ideas (Scharfe, 2010).

### 2.4.1 Integrated Waste Management

According to UNEP, Integrated waste management (IWM), has been known as "a frame of reference for designing and implementing new waste management systems and for analyzing and optimizing existing systems" (UNEP, 2009). This concept means to manage MSW by using appropriate technologies and management programs to reduce the number of MSW or achieve other goals (McDougall, White, Franke, & Hindle, 2008; UNEP-IETC, 1996).

In addition, IWM is comprised of some systems and functions. Therefore, to manage MSW in a sustainable way cannot use the individual method to disposal MSW. IWM systems are used in different places, but still, have some common characteristics. Firstly, to use a comprehensive way to analysis the total environmental problems and economic costs of the program, and to use a range of collection and treatment facilities to produce less waste. Secondly, to handling all materials in the solid waste rather than only focus on specific materials. Next, be environmentally friendly, like reducing the pollutant emission, and economically. Last but not least, increasing public corporation and ensuring workers can understand their job in the waste management (McDougall et al., 2008).

### 2.4.2 Minimization of Wastes

Waste minimization is different with reducing waste, but it will be implemented by reducing waste. To reduce the generated MSW can be implemented in many

ways, the most effective way to reduce waste is controlling the sources (Bandyopadhyay, 2015).

Therefore, 3R (reduce, reuse, and recycle) was proposed by W. M. S. Russell and R. L. Burch, in 1959. This concept has become a guide which is widely used in sustainable MSWM (Tudor, Robinson, Riley, Guilbert, & Barr, 2011). It can help to implement minimization of wastes, at the same time, it can help to maintain public health, to protect the environment better, and to implement resource conservation & recovery (Memon, 2010).

Waste minimization means to redesign goods or to change the pattern of products' life cycle to prevent the waste generation and minimize the hazardous wastes (Cheremisinoff, 2003). It will save the use of resources in the manufacturing processes for producing new products; reduce the amount of waste generated from product disposal; decrease the costs of waste disposal (Chiu, 2010). In addition, in many cases, the wastes can be recycled and become useful new materials, such as glass, papers, etc. By the way, to recycle the products can reduce the usage of new material, waste generation, and the disposal costs (Memon, 2010).

### 2.4.3 Zero Waste

Zero waste means that managing wastes and designing approaches to prevent waste generation, it focuses on through a series of recycling, reuse methods, such as reconstruction production and distribution systems, to decrease waste and, moreover, do not produce waste (Spiegelman, 2006). As limited conditions (technology, costs, etc.), it's hard to eliminate waste completely, but zero waste, as a guide, provides principles for eliminating waste (Snow & Dickinson, 2001). In other words, zero waste is focusing on eliminating waste at the beginning. This concept needs heavy supports from government and industries. And it won't be

possible without great efforts and actions from industry and government (Connett & Sheehan, 2001). Industries will control the design of product and packaging, processes of manufacturing, and the selections of material (Townend, 2010). Meanwhile, governments need to provide policy and funding for developing and adopting IMW strategies that aim to eliminate waste rather than manage it (Snow & Dickinson, 2001).

### 2.4.4 Cradle-to-Grave

Cradle-to-Grave (also known as Cradle to Cradle, C2C) is an approach used to describe the flow of materials from raw resources to wastes which require disposal. C2C focuses on industrial systems design which means material flow in a closed loop cycle, and waste goods can be recycled and reused.

Perfectly, C2C, like the biological metabolism of an ecosystem, aim to design a metabolism of the process which is a closed-loop system with resources traveling in cycles of producing, using, recovering and remanufacturing. It means that the system can be designed to use available wastes and to imitate the natural processes in biological systems (McDonough & Braungart, 2010).

### 2.4.5 Life-Cycle Assessment (LCA)

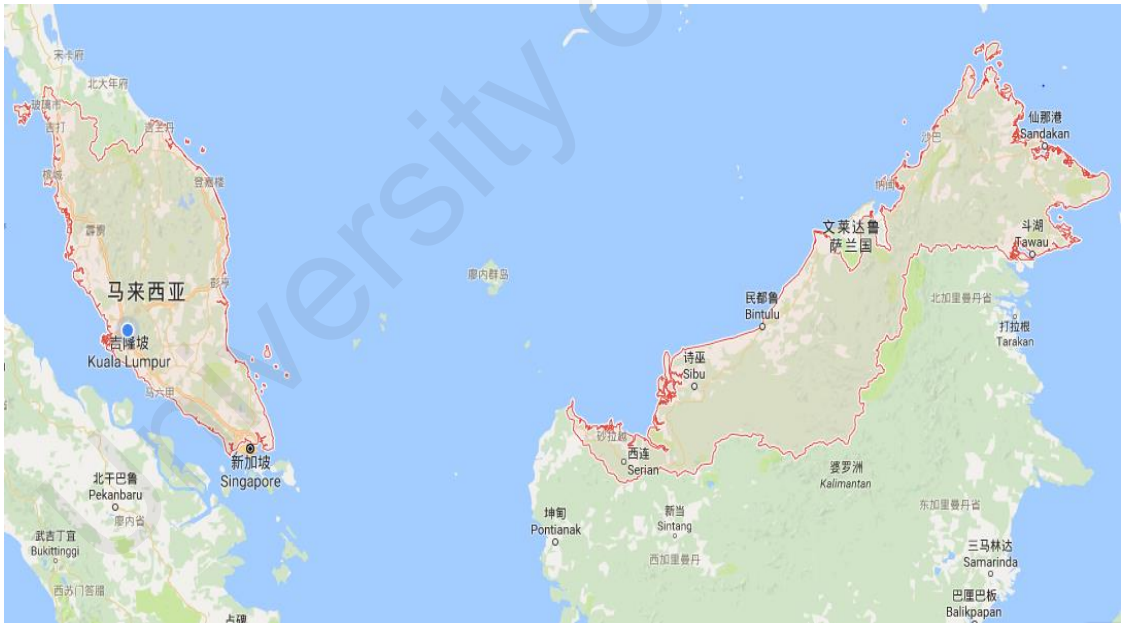
According to USEPA document Life Cycle Assessment: principles and practice, LCA is used to evaluate environmental impacts of products, processes or service, such as C2C (Curran, 2006). In order to solve issues that cannot be conducted by other environmental management tools, such as statutory environmental impact assessment, LCA is necessary. LCA can be described by 4 associated phases, they are goal and scope definition, Inventory analysis, impact assessment, and interpretation.

In many types of research, LCA has been used as an effective environmental

management tool. For instance, LCA can be used to reduce the VOC content of paint in the paint industry. It also can be used to decrease the environmental burdens caused by the used automotive batteries. Moreover, LCA can assess different conditions of municipal wastewater treatment, as well as inspects the potential risk to the environment and human health (Özeler, Yetiş, & Demirer, 2006).

## 2.5 Current Situation of MSWM in Malaysia

Malaysia as a tropical country which located in the Southeast Asia has 329,847 km2 land, figure 2.1 shows Peninsular Malaysia and East Malaysia in google maps. This country is surrounded by Thailand, Singapore, Indonesia, and the Philippines. The climate in Malaysia is warm and humid all the year, the temperature and humidity range from 21℃ to32℃ and 80% to 90% respectively (Manaf et al., 2009).




Source from google maps

**Figure 2.1:** Peninsular Malaysia and East Malaysia

### 2.5.1 Policies in Malaysia

According to Section 72 of the Local Government Act 1976, MSWM in Malaysia is under the responsibility of the local authority. Based on this act, public clean

services for both urban and semi-urban communities will be provided by the local authority. Also, the local authority must handle of all the collected waste in a sanitary way. There are another 3 related policies, list as the Site, Drainage and Building 1974, Local Government Act 1976, as well as Town and Country Planning 1976. The penalties are tight, for whom did the illegal dumping, storage, or treatment is subject to a fine of between RM 10,000 and RM 100,000 and a jail sentence of up to five years.

In addition, by the implementation of Solid Waste and Public Cleansing Act 2007, the road of MSWM privatization is paved. The sources of managed MSW in this Act are including public areas, commercial centers, construction places, industrial zones, households, and so on. In addition, the act clearly mentioned that MSWM services need to include separation, collection, storage, transportation, processing, recycling, and disposal (Manaf et al., 2009).

Also, it is worth mentioning that the Action Plan for a Beautiful and Clean Malaysia (ABC Plan) was enacted in 1988, with the aim to make a consolidated MSWM system by 2020. And this system needs to be accepted by environment and society, in Malaysia. However, this was not an official plan, has not been implemented. Even, the recycling program, which is introduced in ABC Plan, was not formulated until 1993. Then, Vision 2020 for Malaysia was declared in 1990, it said that Malaysia will become a fully developed country by the year 2020, as well as pursue environmentally sustainable development.

Under Vision 2020, in the second decade, the development focused on reducing the energy, materials, pollution and waste intensity of urban and industrial activities. The Third Outline Perspective Plan (OPP3) has been set up during this period, from 2001 to 2010. In OPP3, it introduced the policy of IWM, highlighted

the issues of waste reduction, reuse and recycling (3R) (Abas & Wee, 2014a; Moh & Abd Manaf, 2014).

Malaysia has provided a mechanism for effective policy implementation to promote sustainable MSWM. However, there is a common problem that the result of the adoption of the policies is not equal. For instance, the Solid Waste Management and Public Cleansing Act (Act 672) has brought great changes in solid waste management in Malaysia. However, the implementation of policy on solid waste management looks like feeble and doubtful which not goes like its planning (Abas & Wee, 2014a).

Actually, to promote the effectiveness of MSWM policy, the legislation should involve the role of producers, customers, management and whoever that will generate the solid waste. Moreover, for the environmental problem caused by ineffective MSWM, the producers and customers are both have a responsibility to deal with. It is not possible that to implement a successful MSWM program without good governance. And good governance needs all related parts, such as NGOs, private sectors, committees and local authorities, cooperation with each other (Abas & Wee, 2014b).

### 2.5.2 MSW Generation

For an MSWM system, it is very important to get the data about the quantity of MSW generation (Tchobanoglous, Theisen, & Vigil, 1993). The studies about this figure usually based on the quantity of collected waste and landfilling disposal. The demographic factors and processing facilities can both affect the rate of MSW generation. In table 2.3, the relationship between the demographic factor and MSW generation in Peninsular Malaysia is shown (Manaf et al., 2009).

**Table 2.3:** Waste generation in Peninsular Malaysia (tons/year), from Ministry of Housing and Local Government 2003 statistics (Manaf et al., 2009)

| States | Population (2000) | Waste generated (2000) | Population (2001) | Waste generated (2001) | Population (2002) | Waste generated (2002) |
|---|---|---|---|---|---|---|
| **Kuala Lumpur** | 1400,000 | 2520 | 1435,000 | 2635 | 1470,875 | 2755 |
| **Selangor** | 3325,261 | 2826 | 3408,393 | 2955 | 3493,602 | 3090 |
| **Johor** | 2252,882 | 1915 | 2309,204 | 2002 | 2366,934 | 2093 |
| **Kedah** | 1557,259 | 1324 | 1596,190 | 1384 | 1636,095 | 1447 |
| **Kelantan** | 1216,769 | 1034 | 1247,188 | 1081 | 1278,368 | 1131 |
| **Penang** | 1279,470 | 1088 | 1311,457 | 1137 | 1344,243 | 1189 |
| **Perak** | 1126,000 | 1527 | 1841,489 | 1597 | 1887,527 | 1669 |
| **Pahang** | 1126,000 | 957 | 1154,150 | 1001 | 1183,004 | 1046 |
| **N. Sembilan** | 890,597 | 757 | 912,862 | 791 | 935,683 | 827 |
| **Melaka** | 605,361 | 515 | 620,495 | 538 | 636,007 | 562 |
| **Perlis** | 230,000 | 196 | 235,750 | 204 | 241,644 | 214 |
| **Terengganu** | 1038,436 | 883 | 1064,397 | 923 | 1091,007 | 965 |

In Malaysia, as the growth of population, the generation of MSW also illustrates an increase. The average amount of MSW generated in Malaysia was 0.5~0.8 kg/person/day, in the year 2003. Furthermore, in major cities, such as Kuala Lumpur, this figure reached to 1.7 kg/person/day (Kathirvale et al., 2004). As table 2.4 shows, the MSW generation of major cities in Malaysia illustrated an increase from the year 1970 to 2006

**Table 2.4:** Generation of MSW in major urban areas in Peninsular Malaysia from 1970 to 2006 (Periathamby, Hamid, & Khidzir, 2009)

| Urban center | Solid waste generated (tons/day) | | | | | |
|---|---|---|---|---|---|---|
| | **1970** | **1980** | **1990** | **2002** | **2006** | **1970** |
| **Kuala Lumpur** | 98.9 | 310.5 | 586.8 | 2754 | 3100 | 98.9 |
| **Johor Bahru (Johor)** | 41.1 | 99.6 | 174.8 | 215 | 242 | 41.1 |
| **Ipoh (Perak)** | 22.5 | 82.7 | 162.2 | 208 | 234 | 22.5 |
| **Georgetown (Pulau Pinang)** | 53.4 | 83 | 137.2 | 221 | 249 | 53.4 |
| **Klang (Selangor)** | 18 | 65 | 122.8 | 478 | 538 | 18 |
| **Kuala Terengganu (Terengganu)** | 8.7 | 61.8 | 121 | 137 | 154 | 8.7 |
| **Kota Bharu (Kelantan)** | 9.1 | 56.5 | 102.9 | 129.5 | 146 | 9.1 |
| **Kuantan (Pahang)** | 7.1 | 45.2 | 85.3 | 174 | 196 | 7.1 |
| **Seremban (Negeri Sembilan)** | 13.4 | 45.1 | 85.2 | 165 | 186 | 13.4 |
| **Melaka** | 14.4 | 29.1 | 46.8 | 562 | 632 | 14.4 |

To design an MSW disposal system, the characteristics of MSW components are also important.

According to a conference proceeding, in most Asian countries, most of MSW consists of plastics, food waste, agriculture waste, yard waste, paper, rubber/leather, glass and textiles, metal, and so on (Visvanathan, Tubtimthai, & Kuruparan, 2004; Zamali, Lazim, & Osman, 2009). Table 2.5 shows the different data about the MSW composition in Malaysia, from1975 to 2005.

**Table 2.5:** Composition of MSW (percentage of wet weight) in Malaysia from 1975 to 2005 (Periathamby et al., 2009)

| Waste composition | 1975 | 1980 | 1985 | 1990 | 1995 | 2000 | 2005 |
|---|---|---|---|---|---|---|---|
| **Organic** | 63.7 | 54.4 | 48.3 | 48.4 | 45.7 | 43.2 | 44.8 |
| **Paper** | 7 | 8 | 23.6 | 8.9 | 9 | 23.7 | 16 |
| **Wood** | 6.5 | 1.8 | NA | NA | NA | 0.7 | 6.7 |
| **Metal** | 6.4 | 2.2 | 5.9 | 4.6 | 5.1 | 4.2 | 3.3 |
| **Plastic** | 2.5 | 0.4 | 9.4 | 3 | 3.9 | 11.3 | 15 |
| **Glass** | 2.5 | 0.4 | 4 | 3 | 3.9 | 3.2 | 3 |
| **Textiles** | 1.3 | 2.2 | NA | NA | 2.1 | 1.5 | 2.8 |
| **Others** | 0.9 | 0.3 | 8.8 | 32.1 | 4.3 | 12.3 | 8.4 |

*NA: not available*

Based on these data, the main component of MSW is the organic waste. According to (Samah et al., 2013), in Selangor state, the organic waste accounts for approximately a half of the total MSW, at 46%. The plastics and paper share similar percentages of the total MSW, at 15% and 14%, respectively (Samah et al., 2013; Sh, Simon, & Agamuthu, 1970).

### 2.5.3 Disposal System of MSW in Malaysia

#### 2.5.3.1 Landfilling

Currently, landfilling is the main method used for the MSW disposal in Malaysia. Shown in table 2.6, in Malaysia, landfilling is the major way for MSW disposal. However, most of the landfill sites are not for sanitary landfilling, they are open

dumping areas. These are serious threats to the environment and human health in Malaysia (Saheri et al., 2011; Yunus & Kadir, 2006).

**Table 2.6:** MSW Disposal Methods in Malaysia (Periathamby et al., 2009)

| Treatment | Percentage of waste disposal (%) | | |
|---|---|---|---|
| | **2002** | **2006** | **2020 (Target)** |
| **Recycling** | 5 | 5.5 | 22 |
| **Composting** | 0 | 1 | 8 |
| **Incineration** | 0 | 0 | 16.8 |
| **Inert landfill** | 0 | 3.2 | 9.1 |
| **Sanitary landfill** | 5 | 30.9 | 44.1 |
| **Other disposal sites** | 90 | 59.4 | 0 |
| **Total** | 100 | 100 | 100 |

As Table 2.7 shows, in the year 2001, there were totally 155 disposal sites under the responsibility of local authorities, their sizes were ranging from 8 to 60 hectares. The size of disposal sites is depending on the amount of disposing MSW and the location (M. Hassan, Awang, Afroz, & Mohamed, 2001; Wan & Kadir, 2001). Most of them the capacity already overloaded.

**Table 2.7:** Types and number of disposal site in Malaysia, 2001 (Wan & Kadir, 2001)

| State | Open dumping | Controlled dumping | Sanitary landfill | Total |
|---|---|---|---|---|
| **Perak** | 15 | 11 | 4 | 30 |
| **Johor** | 12 | 14 | 1 | 27 |
| **Kelantan** | 12 | 2 | 0 | 14 |
| **Kedah** | 9 | 5 | 1 | 15 |
| **Negeri Sembilan** | 8 | 6 | 0 | 14 |
| **Pahang** | 7 | 5 | 3 | 15 |
| **Selangor** | 5 | 15 | 0 | 20 |
| **Melaka** | 2 | 3 | 0 | 5 |
| **Terengganu** | 2 | 8 | 1 | 11 |
| **Pulau Pinang** | 1 | 1 | 1 | 3 |
| **Perlis** | 0 | 1 | 0 | 1 |
| **Total** | 73 | 71 | 11 | 155 |

Recently, using landfilling for MSW disposal has become more and more difficult. Most existing sites for landfilling are filling up at an alarming rate. In addition, as the scarcity of land resource and the increasing land prices, to build a new landfill site is also becoming more difficult, especially in urban areas (Manaf et al., 2009).

#### 2.5.3.2 Recycling

To dispose of MSW mainly depends on the landfilling in Malaysia, and recycling is another efficient way which can reduce the number of MSW for landfilling. Malaysia has the potential to achieve the goal that the rate of recycling achieved 22% in 2020, but now the progress of recycling has to change to implement this goal.

Before implementing a successful recycling program, Malaysia still needs a long period to solve the main obstacles in existing system (M. N. Hassan, Rahman, Chong, Zakaria, & Awang, 2000; Zamali et al., 2009).

The recycling program in Malaysia was started in 1993. In this 'Reuse Program', there were 23 local authorities participated. Unfortunately, it failed because this program did not promote any serious awareness program, and the management level just made less commitment. In 2000, the government launched the National Recycling Program (NRP), and at this time, there were 95 local authorities participated in this program. The goal of this program is clear that to reduce the generation of MSW by 3R (Reduce, Reuse, and Recycle) approach. The aim of this program is reducing the MSW generation rate at least 22% by 2020. However, because of missing technology, infrastructure and people's attitude towards the environment, the current percentage of recycling is 5% (Jamallulail, 2014).

#### 2.5.3.3 Incineration

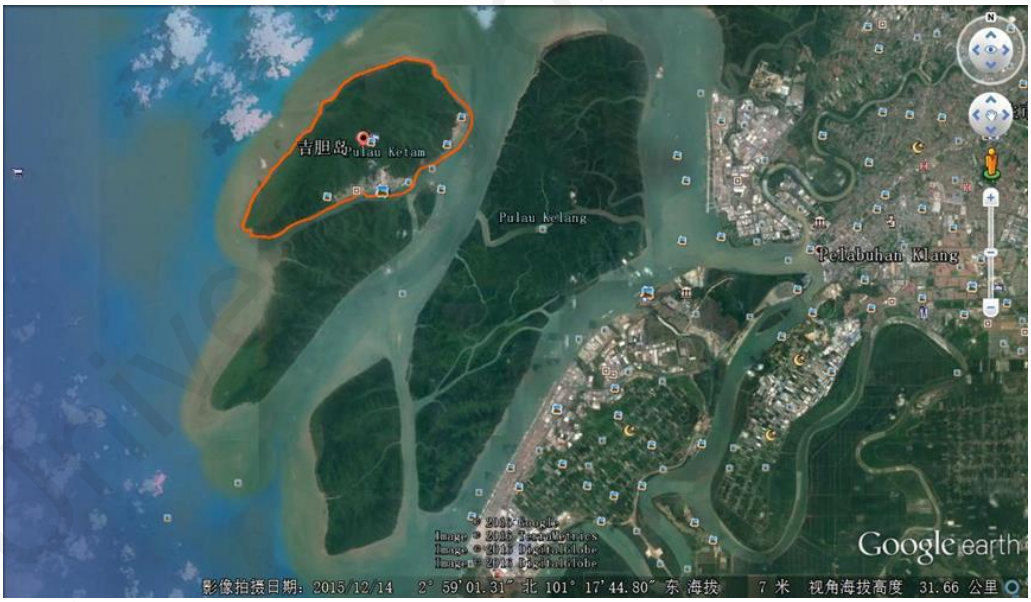
Malaysia has used the technique of incineration for a while, especially in hazardous waste disposal. Furthermore, in some islands also use this method, such

as Labuan, Tioman, Pangkor, and Langkawi. Also, to build the gasification and liquidation ash incinerator plant has been planned in the government program. Broga, Semenyih was the place chosen for constructing this plant. Then, this plant can be used to dispose the MSW from Klang Valley. However, this project had been terminated because the residents in Broga brought forward their complaints to the court (Manaf et al., 2009).

## 2.6 Review of Pulau Ketam

### 2.6.1 Background Information

Pulau Ketam, as figure 2.2 shows, is a mangrove-covered island in Malaysia which surrounded by mud flat area. It has 30 nautical miles distance from Port Klang, and the total area of this island is about 22.921 $km^2$ (LUAS/SWMA and Port Klang Project Management Office, 2006).



Source from google earth

**Figure 2.2:** Pulau Ketam Area on Google map

Basically, there are two villages, as residence zone, on this island, namely Pulau Ketam village and Sungai Lima village. As figure 2.3 shows, they are separated by forest, and there is no road to link them. To date, the population of Pulau Ketam

is approximately 6 to 7 thousand, the maximum part is Chinese, at 95%. Then, 4% are Malay and 1% Indian ("Pulau Ketam," 2016). In this study, the study area is Pulau Ketam village, shown in figure 2.4

Source from google earth

**Figure 2.3:** Residence Zone of Pulau Ketam

Source from google earth

**Figure 2.4:** Study Area on Pulau Ketam

As a mangrove island, Pulau Ketam is rich in natural resources. This is an important habitat for flora and fauna, such as birds, mammals, fish, and so on. Also, the mangrove is an important area for buffering against erosion.

Therefore, the local authority put this island under the Integrated Coastal

Management (ICM) program, then the degraded mangrove of Pulau Ketam will be replanted, and the area will be a forest reserve. The ecosystem function in this island will be enhanced. Hence, it will promote the ecosystem restoration and eco-tourism in Pulau Ketam (LUAS/SWMA and Port Klang Project Management Office, 2006).

Currently, this island has become a tourist spot. The major economic activity on the island is fishing. A lot of tourists come here for seafood, such as crabs, fishes, and prawns.

### 2.6.2 History of MSWM in Pulau Ketam

In Pulau Ketam, the history of dumping into the sea can be traced back to the 1870s, the time for the first fisherman arrived. Until 1999, the Selangor state government gave the responsibility to Alam Flora to manage solid waste in Pulau Ketam (Li, 2005; Yaacob, 2004). The waste volumes on the island have changed little over the years and now average 34 tonnes per month. Weekends see the amount growing 1.5 times higher than weekdays, said by Mr. Mohd Zin Mohd Sharif, assistant manager (operations) at Alam Flora Klang (Li, 2005).

According to “Solid waste management in Pulau Ketam - Alam Flora's experience”, Alam Flora introduced and managed MSW, meanwhile, changed the islanders’ mind, during the initial period. As a result, the residents already changed their attitudes to accept and practice the MSWM. This change can be attributed to a systematic solid waste service. Nowadays, the culture for the conservation of natural resources has instead of the "throw away culture" on this island, and the cleaner environment is conducive to the development of ecological tourism (Yaacob, 2004).

Alam Flora provided a basic MSWM program which changed the condition of

MSWM in Pulau Ketam as well as increased the islanders' awareness on MSW. Based on a news report in 2005, the company placed 70 proper dustbins with wheels at central locations in the village. Then, shipping MSW to Klang 4 times a week. They also provide low prices for recyclable waste collected by workers, so that workers can sell the items to the company. Alam Flora also organized some public events, like public talk, to increase residents' awareness on MSW (Li, 2005).

On the other hand, as a part of the ICM program, the staffs from the Klang Municipal Council and Selangor Waters Management Authority (SWMA), promoted a series of visits to Pulau Ketam. They made some dialogues and consultative sessions with islanders. Through their activities, they found that dumping MSW still exists. But, in the MSWM area, the condition of the environment has been improved since 2000. The report from staffs also shows that the introduction of an environmental awareness program has got the response from the local community. And they started these programs from school education. The areas of these programs covered multi-factional functions of mangrove ecosystem, biodiversity of flora and fauna, sewage disposals, the hygiene and sanitary issues, 3R approach, and so on (LUAS/SWMA and Port Klang Project Management Office, 2006).

### 2.6.3 Issue for MSWM in Pulau Ketam

As the housing area on the island consists of "floating houses" perched on wooden stilts 1 to 10metres above sea level. The main roads are narrow concrete pavements. The old rickety wooden plank bridges can still be seen, in the residential areas ("Pulau Ketam," 2016). So, there are no cars, nor garbage trucks. Workers have to push the dustbins to the jetty, along the rickety walkways. And

workers have to work fast as the boat can only stay during high tide (Li, 2005). Hence, it is difficult to increase the number of dustbins. This makes the collection of MSW in Pulau Ketam more difficult. The price for the collection and shipment are high, which means to handle MSW in Pulau Ketam is more expensive than that on the mainland.

## 2.7 Brief Cases of MSWM in Asian Countries' Islands

Currently, to reorient MSWM system toward sustainability is a global target. Asian countries are heavily influenced by this change. However, countries have a different attitude towards sustainability, due to the different economic status.

The quantity of MSW generation also has a relationship with the economic status. Table 2.8 shows the relationship between the composition, waste generation rates and GDP for some Asian countries. In developing economies with lower GDP, waste generation rates are also lower (Shekdar, 2009).

**Table 2.8:** Information on GDP (per capita), waste quantity and composition for some Asian countries (Shekdar, 2009)

| Country | GDP estimated for 2007 (USD) | Waste quantity (kg/capita/day) | Composition (% wet weight basis) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Biodegradable | Paper | Plastic | Glass | Metal | Textile leather | others |
| **Japan** | 33,010 | 1.1 | 26 | 46 | 9 | 7 | 8 | – | 12 |
| **Singapore** | 31,165 | 1.1 | 44.4 | 28.3 | 11.8 | 4.1 | 4.8 | – | 6.6 |
| **South Korea** | 23,331 | 1 | 25 | 26 | 7 | 4 | 9 | 29 | – |
| **China** | 8854 | 0.8 | 35.8 | 3.7 | 3.8 | 2 | 0.3 | – | 47.5 |
| Hong Kong, **China** | 37,385 | 2.25 | 38 | 26 | 19 | 3 | 2 | 3 | 9 |
| **Malaysia** | 12,702 | 05–0.8 | 40 | 15 | 15 | 4 | 3 | 3 | 20 |
| **Thailand** | 9426 | 1.1 | 48.6 | 14.6 | 13.9 | 5.1 | 3.6 | – | 14.2 |
| **Philippines** | 5409 | 0.3–0.7 | 41.6 | 19.5 | 13.8 | 2.5 | 4.8 | – | 17.9 |
| **Indonesia** | 5096 | 0.8–1 | 74 | 10 | 8 | 2 | 2 | 2 | 2 |
| **Sri Lanka** | 5047 | 0.2–0.9 | 76.4 | 10.6 | 5.7 | 1.3 | 1.3 | – | 4.7 |
| **India** | 3794 | 0.3–0.6 | 42 | 6 | 4 | 2 | 2 | 4 | 40 |
| **Vietnam** | 3502 | 0.55 | 58 | 4 | 5.6 | 1.6 | 1.5 | 1.8 | 27.5 |
| **Lao PDR** | 2260 | 0.7 | 54.3 | 3.3 | 7.8 | 8.5 | 3.8 | – | 22.5 |
| **Nepal** | 1760 | 0.2–0.5 | 80 | 7 | 2.5 | 3 | 0.5 | – | 7 |

With obvious economic growth, Japan, Singapore also South Korea have been rapidly boosting their MSWM systems. MSWM in these countries has a common, ultimate goal that to eliminate landfills from their systems. Their MSWM systems are very stable and supported by a lot of legal measures and national funding.

Currently, for conforming to the global trend of development, the MSWM system is ready to contribute towards a sustainable society consistent with relevant legislation. In table 2.9, time-line and national programs have been launched in Taiwan, South Korea, and Japan (Shekdar, 2009).

**Table 2.9:** Solid waste programs in the developed economies in Asia (Shekdar, 2009)

| Country | National program | Plan period | Waste generation | Recycling rate | Solid waste disposal |
|---|---|---|---|---|---|
| **Taiwan** | Complete recycling for zero waste | Initiated in 2003 | – | 154 tons be recycled in 2007,199 tons in 2011 and 316 tons by 2020 | No waste be landfilled in 2020 |
| **South Korea** | Firm establishment of a sustainable and resource-circulating socioeconomic foundation | 2002–2010 | Reduction by 12% | Increase by 53% | Reduction by 22% |
| **Japan** | Establishing a sound material society | 2000–2010 | Reduction by 20% | Increase by 40% | Reduction by 50% |

### 2.7.1 Hong Kong, China

In the year 2005, Hong Kong generated 6 million tonnes of solid waste. Among them, 43% was recovered, and others were handled by landfilling. Then, to prolong the service life of existing landfills becomes a problem which needs to be solved. Now, the MSW in Hong Kong mostly disposed by thermal treatment (Shekdar, 2009). In fact, Hong Kong is facing a controversial debate. To prolong the service life of landfills, or to use the advanced incineration facility, this is a question of solving the MSW disposal issue. However, the Hong Kong Special

Administrative Region Government is also taking efforts to reduce the carbon intensity (Woon & Lo, 2013).

In 2010, the recycling rate in Hong Kong has achieved 52%, but approximately 9,000 tonnes of unrecoverable MSW were still discarded in the landfills daily (HKEPA, 2010). Currently, Hong Kong only relies on landfilling for MSW disposal. However, Hong Kong is facing a serious problem that shortage of land for MSW disposal sites. The current strategic landfilling site, named West New Territories will be exhausted in 2018 (HKEB, 2013).

To solve this problem, a policy framework for MSWM was made by the Hong Kong Environment Protection Department (HKEPD). In this framework, the approaches for increasing the rate of MSW reduction, and extending the quantity of disposal MSW are applied. Although there are a lot of controversies, the HKEPD has proposed to implement landfill extension (LFE) and Integrated Waste Management Facility (IWMF), with the advanced incineration facility (AIF) (Woon & Lo, 2013).

### 2.7.2 Singapore

In Singapore, the legislation to handling MSW is the *Environmental Pollution Control Act* (EPCA). It was made in 1999. This act is a consolidation of existing legislation on the control of solid waste, water and air (Bai & Sutanto, 2002; Zhang, Keat, & Gersberg, 2010). In 2000, the National Environmental Agency (NEA) formulated a series of strategies and programs for MSWM in Singapore. They are including the recycling program for MSW, and to promote recycling in schools and community areas. Then, 3P (public, private and public, government) initiatives and a lot of programs for increasing public awareness are also introduced (Shekdar, 2009; Teo, 2007).

There are 2 collection methods have been adopted in Singapore. One of them is a direct collection, which the waste is directly collected from individual households, such as private residences. This way is consuming time, and need a lot of workers. Another one is an indirect collection. This is including two types. The first one is used in the old building, like a high-rise apartment. In these buildings, the containers are filled with an extensive quantity of MSW.

The second one is centralized refuse-chute (CRC) system, there is a central garbage container in the apartment, and the MSW is discharged directly through common hoppers located in individual flats. Then, the collection trucks will transport these MSW. To use the CRC system can effectively control the leakage and smell in a time of collection and transportation process. Moreover, this system has extremely increased the collection efficiency of MSW (Zhang et al., 2010). The daily MSWM system starts with a network of collection vehicles, then through the mechanical compactors, transfer stations and container trucks. At last, the processed MSW will be sent to sanitary landfills or incineration plants (Foo, 1997).

In 2001, the National Recycling Programme (NRP) was established by NEA. Under this program, recycling bins have been positioned at public area. And also, 4,100 sets of centralized recycling depositories have been positioned in public areas. As a result, the rate of recycling rose from 40% to 49%, and MSW generation was reduced by 8%, in 2005. Then, the targets of "Towards Zero Landfill" and "Towards Zero Waste" had been formulated by the NEA (Teo, 2007).

### 2.7.3 Japan

According to (Shekdar, 2009), the MSWM systems in Japan may be the best. By

enhancing the awareness and participation of society, developing the relative technology, and publishing new legal approaches, the MSWM system is being improved in this country.

At the beginning, the MSWM aims to sustain the standards of public health. As the economic development, this system needs to face lots of problems. For examples, energy recovery became the major focus, during the 1970s. Recycling was legally mandated in the systems, in the 1990s. Then, in 2000, basic laws for MSWM were formulated to improve a recycling-focused society for sustainable development. Currently, citizens put the MSWM as a shared responsibility. They separate the waste into recyclables, non-combustibles, and combustibles. Then, they deposit the sorted waste fractions at the collection centers (Shekdar, 2009). Moreover, municipalities are responsible for the source-separated collection. They collect metal, glass, waste paper, cans, etc. as recyclable materials. After separating MSW at the source, they will be transported proper recycling facilities. The bulky waste, such as furniture or home electric appliances, contains recyclable material will be crushed before recycling. Last, the manufacturers will help with material recycling.

Nowadays, incineration is advanced in Japan. This disposal method can achieve the 98% volume reduction with the use of plasma arc technology for ash processing. In 2005, MSWM system handling about 53 million tons of solid waste, among them 13% was landfilled, 68% underwent intermediate processing, mostly by incineration, and 19% was recycled. However, this disposal method for MSW is very costly (Terazono, Yoshida, Yang, Moriguchi, & Sakai, 2004). In addition, there is a big challenge about MSWM in Japan. As the opposition of public, shortage of available land, it is always difficult to obtain land for MSW disposal. This directly leads to illegal dumping become the very significant and serious

problem (Shekdar, 2009; Terazono et al., 2004). Therefore, MSWM in Japan is a crucial project with the target to implement "Zero Waste".

### 2.7.4 Conclusions

MSWM in these cases have some common features. There is no doubt that both of them faced a shortage of land resources. To reduce the discharge of MSW, and to improve the recovery rate of MSW has become the focus of attention.

Hence, in these cases, the government formulates sufficient plan to manage MSW. The reliable data, such as MSW generation, composition, recycling rate, and so on, are collected on a regular basis. Then, these data will be used in MSWM design and system operations. Similarly, lots of literature is available on various aspects of MSWM. They also established facilities for technical training. An important key point is using proper equipment to decrease the number of labors because of the increasing costs in the service industries. The processes of MSWM, such as collection, transportation, processing and disposal, technologies are established very well. And there is a plenty of funds to support the MSWM system. Furthermore, the citizens are performing their responsibilities with high awareness. Last, they have realistic prospects of the managing authorities which made serious attempts to increase the rate of recycling, to decrease the burden of landfills, and to achieve sustainable development (Shekdar, 2009).

## 2.8 Literature Review Summary

As a mangrove island, the ecosystem in Pulau Ketam is very fragile. Recently, the main economic sources of this island are fishing and tourism. Therefore, an efficient MSWM system can protect the environment on the island, and promote the development of tourism. Due to the geographical location of this island is far from the mainland (about

30min by boat), the population flow on this island is small. Moreover, there is no industrial or manufacturing on this island. These provide the conditions to set up this island as the pilot area for practicing a comprehensive and advanced MSWM system.

At the beginning, the MSWM system in Pulau Ketam aimed to improve the living environment quality. However, the result of this management system is not good enough, due to the high price of MSW disposal and the low efficiency collecting system. To improve MSWM system in Pulau Ketam, the issues of this system should be identified first. Then, based on the experience which from the efficiency management systems in Asian cases, the options can be provided to overcome the issues. Although the economic development condition in Malaysia is different to that in Hong Kong, Japan and Singapore, the MSWM system practices in these cases still provide models to Pulau Ketam.

In addition, the most successful MSWM system in Japan has been practiced in Kamikatsu. The MSWM system in Pulau Ketam will be compared with this Japanese town's system.

# CHAPTER 3: METHODOLOGY

## 3.1 Introduction

This chapter will discuss the methodology used in the research. As an investigation report, this part will explain who to find and analyze the problems of the current MSWM system in Pulau Ketam. And also, it will provide reasons for the proposed solutions.

## 3.2 Research Design

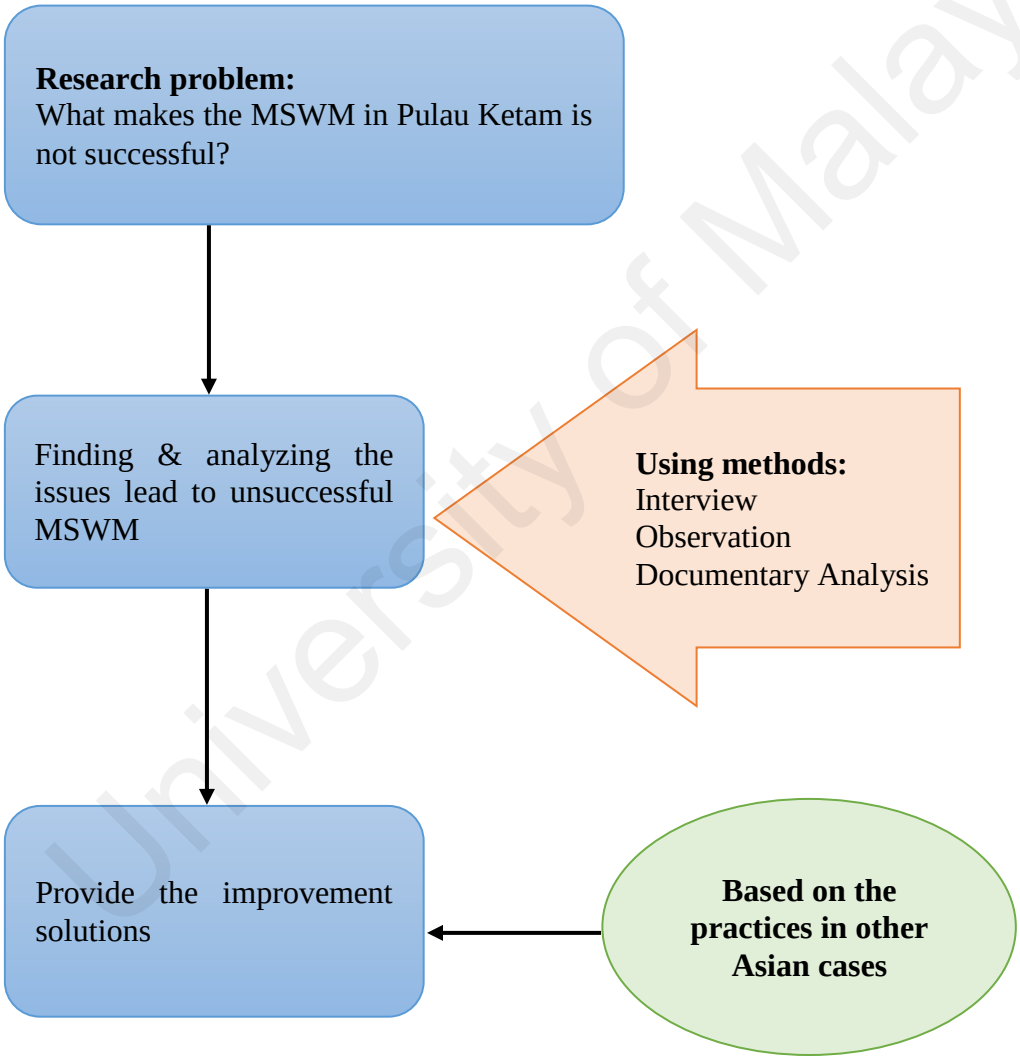



**Figure 3.1:** A Sketch for Research Design

As figure 3.1 shows, this study needs to analyze and find the issues in the current MSWM system, in Pulau Ketam, Selangor. For this purpose, the Pulau Ketam village was chosen as the study area. The problems of the MSWM system on this island were identified through interview, observation, questionnaire, and document analysis of previous studies and on-line information.

In addition, literature review part summed up the common features of MSWM systems in other islands, especially Hong Kong, Singapore, and Japan. By comparing the MSWM in Pulau Ketam and in these areas, the sustainable solutions have been proposed.

## 3.3 Information Collection

### 3.3.1 Document Analysis (Secondary Data)

Before conducting the research, the relative information has to be collected and analyzed. They can be collected from journals, reports, databases, and internet webs. The document analysis was displayed in the literature review part.

The basic information of MSWM should include source, category, characteristics and composition of MSW, and management methods for MSW. Additionally, the history, existing management system and policies for MSW in Malaysia also need be analyzed. Moreover, the basic data about Pulau Ketam also need to be collected, before visiting it. These data should include geographic and traffic information, as well as the history of MSWM on this island. Finally, the MSWM in the other Asian countries' islands/places was also collected on-line. As brief cases, MSWM on these places would be the examples for Pulau Ketam, and provide the sustainable solutions to improve the management system on this island.

In addition to mention is all the data in this report is secondary data, due to the limited time and fund. These data exist in the previous research, such as relevant books, journals, etc. And also, they can be found from other sources on the internet,

including news, government websites, and so on.

### 3.3.2 Interview

By visiting this island, the study area which is the residential zone of the Pulau Ketam village can be identified. As the interview time was a workday, 10 islanders were interviewed. They were school students, business operators, restaurant and hotel workers. In addition, the questions in interview part are different to the questionnaire. The interview questions are including the location of MSWM infrastructures, their attitude to manage MSW, the reason for dumping trash, as well as residents' comment of the local authority, solid waste company and NGO. Through interviews can get detailed information about MSWM in Pulau Ketam. The waste management company has been changed from Alam Flora to Umi Kasmah Enterprise. This company still shipping MSW to Klang four times per week. Moreover, parts of islanders will salvage floating waste twice per month when spring tide. There is an NGO, named Tzu-Chi, on the island, they also do some recycling. Then, the islanders will support to improve the MSWM system, meanwhile, some of them complained about the number of dustbins was not enough.

In order to get more detailed information, the emails for requesting an interview and some detail data were sent. Unfortunately, neither Umi Kasmah Enterprise nor Tzu-Chi replied email. Due to the time for this research is limited, these requests had to be cancelled.

### 3.3.3 Observation

Table 3.1 shows the observation ways, used in this study.

**Table 3.1:** Observation Ways

| Number | Methods | Remarks |
|---|---|---|
| **1** | Visually | Rented a bicycle, and observed the surroundings in Pulau Ketam. |
| **2** | Walk Through | Some area cannot reach by bicycle. |
| **3** | Photograph | Recorded the situation of MSWM system practices, included shipping boat, dustbins, recycling points, inert waste landfill site. |

Through observation, there is some phenomenon and the behavior of residents was recorded. The restaurants and hotels, especially near the jetty, dispose their MSW into dustbins nearby. However, some residents those far from the dustbins normally put the MSW outside their house and dispose of MSW once 2 or 3 days. Then, the dogs and crows get chances to make the trash out for finding foods, the trash usually drops onto the ground. Even, there are some people still dump MSW into the sea. In addition, there are some recycling points provided by Tzu-Chi. Although these points are very simple, there is still recycling something, such as plastic bottles, cans. Also, the landfill for inert waste in this island was visited, without management, this place can be described as a mess.

### 3.3.4 Questionnaire

At the same time, questionnaires also need to be done about the islanders' attitude of MSWM. The questions were about the major waste, facilities, the situations of this island, and islanders' judgment and ideas. However, because English popularity is not high on the island, the English questionnaire to fill out rate is quite low. For this reason, the questionnaires were changed into bilingual (Chinese/English), in APPENDIX A.

The major result of questionnaire survey is that most residents in Pulau Ketam did not realize the importance for MSWM, especially elderly people. The islanders support the MSWM in mind, but they lack activities. Most of them blame that sea

dumping still existing to a shortage of dustbins. In view of the perspective of an observer, however, the lack of the awareness (MSW cause a series of problems to the environment and human health) is the fundamental reason.

### 3.4 Ethical Statement

In this research, the participants will take part voluntarily and are informed of the research aim and objectives. All personal details of participants are kept in privacy being be stored separately from the findings and will not be disclosed within the dissertation. The research is not for commercial use.

### 3.5 Safety Precondition

As this study needs to travel to Pulau Ketam by KTM and ship, there are some safety conditions should be noticed.

1. Leave itinerary with friends and supervisor
2. Map out directions
3. Cellphone and charging treasure
4. Stay on main roads
5. Beware of surroundings
6. Should not go to danger area

# CHAPTER 4: RESULTS AND DISCUSSION

## 4.1 General Municipal Solid Waste Management History in Pulau Ketam

The MSWM in Pulau Ketam started in 1999. The Selangor state government contracted waste management company Alam Flora and gave the company the responsibility to manage MSW on the island (LUAS/SWMA and Port Klang Project Management Office, 2006). During the initial period, Alam Flora made a program for introducing and managing the MSW as well as changing the idea of locals. Recently, through a new round of bidding, the company Umi Kasmah Enterprise has taken over this job. By carrying out the systematic MSWM service, the residents' attitudes towards acceptance and practice of sustainable solid waste management changed (Yaacob, 2004). However, the situation of MSWM in Pulau Ketam still appalling.

## 4.2 Current Issues in Pulau Ketam

### 4.2.1 Incomplete Collection System

This mangrove island is a mudflat, and lack of available land resources for landfilling, and there is no incineration nor composting to disposal MSW. In addition, this island has no roads, all the structures which stand on stilts, are linked by a narrow, twisting network of wooden walkways.

Therefore, to collect the MSW on this island is not easy. There was no garbage truck to collect MSW. All the dustbins, as figure 4.1 shows, were pushed by workers to the jetty.

**Figure 4.1:** Dustbin Provided by Waste Collection Company

According to the investigation on Pulau Ketam, the MSW collection system was shown as below:

**Table 4.1:** MSW Collection System on Pulau Ketam

| **Collectors** | | **Time** | **Kind of MSW** |
|---|---|---|---|
| **Company** | Umi Kasmah Enterprise | 4 times per week (Monday, Wednesday, Friday, Sunday) | Mixed in dustbins |
| **NGO** | Tzu-Chi | Once a week (Monday 6:00pm~9:00pm) | Recyclable (i.e. plastic bottles) |
| **The Village Committee** | Residents | Twice a month (when high tide) | Floating trash |

The MSW, collected by Umi Kasmah Enterprise, is shipped to Klang for landfilling. One of the cargo ships used for MSW transportation has been shown in figure 4.2. However, as the amounts of MSW increases, the number of shipments increases and disposal becomes costly. Shipping all the waste to landfilling was not the best way for disposal MSW of Pulau Ketam.

**Figure 4.2:** Cargo Ship for MSW Used by Waste Collection Company

Tzu-Chi, an NGO from Taiwan, has been doing recycling in Malaysia, since 1997. They also set recycling points in Pulau Ketam, as the one shown in figure 4.3 shows. Residents would throw recyclable MSW here, then Tzu-Chi would do the recycling processes.


**Figure 4.3:** Recycling Point of NGO

### 4.2.2 Defective Storage System

In fact, open dumping is very common in developing countries. The characters of open dumping include: low regulations, low or none planning, low control, and

consequently dumping sites are also low engineered (Lindell, 2012). Open dumping also exists in Pulau Ketam.

As figure 4.4 shows, there is an inert waste landfill on this island, built by government. According to a news from SELANGORKINI, this landfill site completed in December last year (Selangorkini, 2015). This site only accepts inert waste, including construction waste, woods, iron products, plastics, and paper.


On stone tablets: Tapak pelupusan Sisa Lengai Pulau Ketam

**Figure 4.4:** Inert Waste landfill, Pulau Ketam

However, this inert waste landfill has become an uncovered temporary dumping area without proper management. Islanders just throw all the rubbish there. As seen in the figure 4.5, food waste is also thrown into this site. The MSW in this dumping area was mixed and exposed to the sun and rain, which means that was a potential hazard to the environment.


On the right side, there is a signboard, writing "TEMPAT PEMBUANGAN SAMPAH SEMENTARA".

**Figure 4.5:** Temporary Disposal Sites

### 4.2.3 Lack of Awareness

With the cooperation of other agencies, the local community, and the Klang Municipal Council were setting the program to increase islanders' environmental awareness (LUAS/SWMA and Port Klang Project Management Office, 2006). Over the past ten years, there were organized public talks, environmental awareness education, and community clean-ups, to encourage resident taking part in MSW disposal (Li, 2005).

As there was no MSWM system, nor cleaning service for more than 100 years, it is not easy to change the habits of residents (Yaacob, 2004). Although these measures have changed the condition of MSWM in Pulau Ketam, the residents in Pulau Ketam still lack of awareness about MSW. Not all islanders are clear about the reasons for doing MSWM and did not realize the problems caused by dumping waste. Moreover, dustbins on this island are not enough, some islanders did not want to walk a long distance for handling their waste. As figure 4.6 shown, rubbish is still thrown under the wooden bridges in the village. During high tide, the spaces under the wooden bridges are covered by sea water. The rubbish eventually ends

up into the sea.

**Figure 4.6:** Trash Dumping on The Island

The residents doing business on the island, such as shop, restaurant and hotel operators, are supporting proper MSW disposal. But, those living further inland do not care about this problem. Some of them are accustomed to staying with junk because they are not aware of the hazard caused MSW. For example, the fishermen did not know dumping will eventually harm the marine environment which supports the island's thriving fisheries and fish farms (Li, 2005).

In addition, the local government lack of management on MSW. Although the Malaysian government has lots of policies for MSWM and also makes penalty to whom commits an offense against the regulations, these policies are just on papers without enforcement.

### 4.2.4 Incomplete Recycling Process

Even if it was just a rough classification, this island still has a little recycling process.

On one hand, Tzu-Chi, an NGO from Taiwan, will collect recycling waste every Monday. Their recycling list is including plastics, glass bottles, aluminum cans, iron products, hardware, electric appliance, papers, and clothes. Then, the recyclable waste collected by Tzu-Chi will be transported to one of their recycling centers in Klang. After classifying these wastes, these renewable resources will correspond respectively to the recycling companies. However, some islanders would put other rubbish into these points, said by Johnson Cha who's running a hotel on the island.

On the other hand, some villagers were collecting and separating recycled waste, then resell those valuable to recycling companies, privately. Normally, they collected the waste, like electrical appliances and hardware, by paying some money to the owner. Then, split these wastes into different components by themselves, then resell the material with a higher price to other companies.

As figure 4.7 shown, this is a private recycling point was filled with waste in Pulau Ketam. Unfortunately, this private recycling stop cannot classify MSW very well and recycling of species also has limitations. Firstly, the islanders who were doing private recycling only collected the waste which can be resold. In addition, they didn't have specialized knowledge to manage these wastes. In this recycling stop, recyclable wastes were piled up randomly.

**Figure 4.7:** Private Recycling Point

### 4.3 Compare with Kamikatsu, Japanese Town

As Japan already has a very mature system of MSWM, it provides a complete model for Malaysia. In Japan, MSWM in Kamikatsu is the most successful.

Kamikatsu is a small Japanese town. The population of this town is only over 1,700. There is a mission in here that to become the first 'zero-waste' community in Japan by 2020. According to the local report in 2015, around 80% of its trash has been recycled, reused, or composted, with the last 20% going to be landfilling (Phil Green, 2016). In 2000, for protecting the eco-environment in the village, this town closed two incinerators, has terminated the incineration treatment for years (Palmisani, 2016). Correspondingly, the division of the garbage collection category increased from 19 to 34. Later, in order to further reduce the discharge of wastes, this small town which has attached great importance of MSW problem, was refined the collection category from 34 to 44 (Poon, 2015).

This town has no garbage trucks. Therefore, every resident has to bring their waste to the recycling center by themselves, every Tuesday and Friday morning. And this journey will

spend average 15min. Before that, they also need to wash and sort their waste. At the recycling center, there is a worker oversees the sorting process, and to ensure waste goes into the right bins. Some used items will be resold or repurposed into accessories, toys, and clothing.

After Kamikatsu get rid of the habit of dumping trash into an open fire for fear of endangering both the environment and the population, the committee of this town declared its zero-waste ambition in 2003 (Onishi, 2005).

For this ambitious goal, Kamikatsu has gotten international attention, but this is not the only town that is making recycling progress, said by Neil Seldman, co-founder, and president of the Institute for Local Self-Reliance. "Berkeley, California, which is several hundred thousand people, is close to 80%; San Francisco reports 70%; and there are several cities in the U.S. that are over 70%," he said. "In Italy, they do it similarly to Kamikatsu where they have many different separations and drop off." For the most part, he adds, the efforts are led by NGOs (Poon, 2015).

The features of MSWM in Kamikatsu and Pulau Ketam are compared in table 4.2.

**Table 4.2:** MSWM Features in Kamikatsu and Pulau Ketam

| **Items** | | **Kamikatsu** | **Pulau Ketam** |
|---|---|---|---|
| **Small population** | | 1,700 | 6,000 |
| **Collectors** | | Each resident | Workers & volunteers |
| **Collection time** | | Twice a week | Four times a week |
| **Garbage trucks** | | No | No |
| **Transportation** | | Each resident | Shipment |
| **MSW Disposal** | **Landfilling** | Transfer MSW to another place for landfilling | |
| | **Incinerator** | No | No |
| | **Composting** | For food waste | No |

The information in this table shows both Kamikatsu and Pulau Ketam are transferring their MSM to another place for landfilling, and there is no garbage truck for MSW collected in these two places. The residents in Kamikatsu do MSW collection, classification, transportation and composting by themselves. In contrast, the public

participation of MSWM in Pulau Ketam is not enough. MSWM system in Kamikatsu could be a good example for Pulau Ketam.

## 4.4 Suggestions Measures for Pulau Ketam

### 4.4.1 Increase the facilities for MSW

Currently, the dustbins with wheels are used on the island. However, the number of dustbins on the island is not enough. Therefore, most of the islanders have to walk a long distance for throwing their waste into the dustbin. Some of them just put the garbage outside the door, then the dogs and crows can have chances to put the garbage everywhere for searching food. In addition, as workers have to push the dustbins to the jetty along the narrow walkways, more dustbins would require more workers (Li, 2005).

To alleviate the situation of dumping, improving the collection system will be necessary. The first thing needs to do, is to increase the MSW disposal facilities, especially dustbins, on this island. Replacing the old-style dustbins to smaller classification recycling bins is one choice for this island. As figure 4.8 shown, dustbins used in Pulau Ketam (picture a) can be changed into smaller bins, such as dustbins in China (picture b) or in Japan (picture c). Dustins in China and Japan can simply classify garbage before transportation process. And the number of dustbin placement points can be increased because of their smaller size. Increasing the number of dustbins means the distance of throw trash for islanders can be shortened. In addition, the number of dustbins should base on the dwelling area, every 20 ~50 meters need to place a trash bins.


**Figure 4.8:** Comparing Dustbins

Another thing for solving this problem is using small carts to collect MSW. As figure 4.9 shown, waste collection cart (a) or (b) can be used for waste collection, then workers transporting these carts to jetty instead of pushing the dustbins one by one. The number of waste collection carts will be based on the number of dustbins, normally, 1 cart can collect MSW from 3~5 dustbins.


**Figure 4.9:** Carts for Waste Collection

After simply classifying, these collected MSW can be transported separately. The unrecyclable waste can be shipped to Klang for landfilling. And the recyclable waste, after further processing, will become renewable resources. Therefore, the amount of rubbish for landfilling could be decreased, which means the cost of

landfilling would be reduced and the service life of landfill sites could be increased.

### 4.4.2 Storage Area

The inert waste landfill on the island cannot be used for disposal the daily household waste. However, this area has been a temporary dumpsite for islanders. The government and the local committee did not provide corresponding management measures.

To solve this issue, the government should enforce the relevant regulations, and manage the waste in this landfill. In addition, this area can be changed to be a temporary storage for MSW.

The new concept of temporary storage will promote the optimization of waste recycling. Temporary Storages have been defined by Nanne K. HOEKSTRA and Hans GROOT, as "environmentally and structurally safe storage places that already permit present in situ recovery of materials and energy from waste streams and allow easy future access to resources whenever needed." (Hoekstra & Groot, 2013). In this theory, waste materials are potential resources which mean these resources will not be handled by landfilling or incineration anymore. Moreover, this concept allows for realizing recycling with a time delay and also promotes recovery of valuable materials from old or abandoned landfill sites. At the same time, using temporary storage can carry off the environmental threats caused by landfilling. Temporary storage is a bridge connected present to future. It provides a place for waste storage, the MSW that cannot be recycled or reused with present technology, can be stored in this place waiting to be recovered in the future (Hoekstra & Groot, 2013).

### 4.4.3 Use the appropriate disposal technic

To set a landfill site needs to consider topography situation, Geotechnical conditions and the engineering, geological conditions (Carey & Carty, 2000). As Pulau Ketam is actually a mudflat, the geographical conditions of this island are not suitable for construction of the sanitary landfill.

In fact, incineration was considered in 1995, but it could cost a lot. On this island where lacks of land, the incinerator is an option, but the gas-cleaning system is one problem which cannot be ignored. Furthermore, the high moisture, as much as 70%, and low calorific, below 5,000 megajoules per kg, which means the waste in the incinerator is unable to keep burning themselves after fired. So, to ensure complete combustion, auxiliary fuel such as diesel will be needed. The high cost of fuel is another one reason why incinerators are hardly used (Li, 2005).

Due to the most kind of MSW on this island is food waste, various plastic products, and glass, among them organic rate nearly take 50%, composting is another option for disposal MSW (Li, 2005). Composting is the microbial degradation of the organic solid material. It yields the stabilized end-product compost. Various MSWM objectives can be achieved through composting, including sanitation, mass and bulk reduction, and resource recovery. Besides, compost can bring economic benefits in certain specialized practices, such as hotbed gardening, and as an edible fungus cultivation matrix. For these purposes, compost derived from MSW can take the place of the traditional horse manure preparation. Moreover, compost can be an economical soil amendment, used for high-value crops, especially flowers and vegetables (Finstein & Morris, 1975).

If central composting cannot be implemented, the islanders could use household composting bins to dispose their organic waste individually, shown in figure 4.10. For instance, in Kamikatsu, residents use small home composting systems for

handling kitchen waste. With the help of government subsidies, 98% of households in Kamikatsu are using this system to dispose of their organic waste. Therefore, there is no need for an industrial composting facility (Phil Green, 2016).

**Figure 4.10:** Composting Bins

### 4.4.4 Increase the Awareness of Islanders

Actually, not all islanders would prefer to separate their MSW. To solve this issue, the awareness program needs to be strengthened, as most islanders did not realize the consequences of environmental pollution caused by MSW.

Increasing awareness of residents is a major step for MSWM. Enough propaganda will be necessary, islanders need to understand the impacts caused by MSW; the practice for 3R approach; the safe way for MSW disposal; and their legal responsibilities for MSW. These knowledge and skills gained from environmental education could help in changing human behavior to the environment (Timlett & Williams, 2009).

In addition, the awareness education about environmental problems and solutions for students still needs to strengthen. Students are more active to participate in

environmental protection plans and activities. They may also share new information with their families, community, and other adults. This will bring some positive impact on MSWM practices (Desa, Yusooff, & Kadir, 2012).

Last but not least, the government needs to make efforts that mean the policy and regulation are required, especially the implementation of laws. There are regulations for MSWM, however, they are less performed. As figure 4.11 shown, illegally disposed of the rubbish would take a penalty. If enforced laws strictly, the problem of MSWM could be solved better.


**Figure 4.11:** Penalty for Litter and Burning Rubbish

### 4.4.5 Upgrade Recycling Points

On the island, although there are some recycling points provided by an NGO, these stops are not specified. Referring to figure 4.3, the recyclable wastes in these cages are exposed to the sun and rain.

Actually, Malaysia has designed the recycling station, and they are already used for MSWM. As figure 4.12 shows, this station has the preliminary classification of MSW, and it has an awning. Through effective management in these stations, which obviously improve the recycling rate of MSW.


Source from the internet, The Edge Property

**Figure 4.12:** Legal Recycling Station in Malaysia

# CHAPTER 5: CONCLUSION AND RECOMMENDATION

## 5.1 Conclusions

Through investigating, this study has analyzed the existing MSWM system in Pulau Ketam, and also provided relative solutions. The MSWM on this island has made some progress, but there is still a large space for improvement.

After analyzing the situation of MSWM system on this island, there are some major issues that cannot be ignored. The first one is an unsound collection system, especially lack of facilities/dustbins, which caused by economic reasons. Then, the second one is the MSWM system lacking of management, due to the political reasons. Thirdly, the residents in Pulau Ketam lack of awareness, which can be considered to be the social reasons. Additionally, the inert waste landfill site had been a potential risk to the environment.

To implement sustainable development is not easy. In reaching this goal, MSWM in Pulau Ketam need a more advanced system which is effective and economical. After compared with other cases in Asia, especially Kamikatsu, there are some suggestions for the Pulau Ketam to achieve sustainable MSWM system. The composting is an effective way of handling organic waste. Especially, household compost bins are quite economical and easy to operate. For reducing waste, to increase the number of facilities for recycling is necessary. Segregation and recycling of MSW can significantly reduce the number of MSW to landfilling, and increase the utilization rate of resources. It is equally important to find an effective way to increase the awareness of MSWM in Pulau Ketam. Last but not least, the local authority should enhance the implementation of policies, not only to manage MSWM system operation, but also to prevent people from dumping by a mandatory administration.

In a word, local authority needs to plan and operate the system in an IWM approach. In

this approach, the local committee, NGO, relative companies and departments need to cooperation with each other and making systematic efforts to implement sustainable MSWM.

### 5.2 Recommendations for Future Study

In future studies, the challenges in implementing these suggestions can be explored. Firstly, to interview the local authority, NGO and waste collection company should be done to understand the issues faced by them as well as their future plans on this island. Secondly, the detail data of MSW generation and composition in Pulau Ketam should be collected by researchers. Thirdly, a systematic feasibility analysis of sustainable MSWM implementation on this island should be done. Then, future researchers should set out a new awareness program and carry out this program on the island, then analyzing the challenges in this process. Finally, researchers can also start a new recycling program, then analyzing the recycling rate and finding the problems with this program.

# REFERENCE


Abas, M. A., & Wee, S. T. (2014a). The Issues of Policy Implementation on Solid Waste Management in Malaysia. *Conceptions on Management and Social Sciences, 2*(3).

Abas, M. A., & Wee, S. T. (2014b). Sustainable Solid Waste Management in Malaysia: The Concept of Multi-Stakeholder Governance in Solid Waste Policy Implementation. *Public Policy and Administration Research, 4*(10), 26-35.

Bai, R., & Sutanto, M. (2002). The practice and challenges of solid waste management in Singapore. *Waste management, 22*(5), 557-567.

Bandyopadhyay, S. (2015). *Smart Meters for Accounting Smart Solid Waste Management for Smart Cities in India* (V. V. P. M. SCHRENK, P. ZEILE, P. ELISEI, C. BEYER Ed.).

Butz, W. (1997). Klimarelevanz von Deponiegasemissionen. *Trierer Berichte zur Abfallwirtschaft, 10*, 9-15.

Carey, P., & Carty, G. (2000). *Landfill manuals: landfill site design*: EPA.

Chen, X., Geng, Y., & Fujita, T. (2010). An overview of municipal solid waste management in China. *Waste management, 30*(4), 716-724. doi: http://dx.doi.org/10.1016/j.wasman.2009.10.011

Cheremisinoff, N. P. (2003). *Handbook of solid waste management and waste minimization technologies*: Butterworth-Heinemann.

Chiu, A. S. (2010). The 3Rs and Poverty Reduction in Developing Countries.

Connett, P., & Sheehan, B. (2001). Citizens Agenda for Zero Waste: A North American Perspective. *GRRN, October*.

Curran, M. A. (2006). *LIFE CYCLE ASSESSMENT: PRINCIPLES AND PRACTICE*. Retrieved from https://19-659-fall-2011.wiki.uml.edu/file/view/Life+Cycle+Assessment+Principles+and+Practice.pdf/249656154/Life+Cycle+Assessment+Principles+and+Practice.pdf

Desa, A., Yusooff, F., & Kadir, N. B. y. A. (2012). *Environmental Awareness and Education: A Key Approach to Solid Waste Management (SWM)-A Case Study of a University in Malaysia*: INTECH Open Access Publisher.

Finstein, M. S., & Morris, M. L. (1975). Microbiology of municipal solid waste composting. *Advances in applied microbiology, 19*, 113-151.

Foo, T. S. (1997). Recycling of domestic waste: early experiences in Singapore. *Habitat International, 21*(3), 277-289.

Global Environment Centre (2016). Solid Waste In Malaysia. Retrieved from http://www.gecnet.info/index.cfm?&menuid=83 Date on: 12th Oct. 2016

Hagerty, D. J., Pavoni, J. L., & Heer, J. E. (1973). *Solid waste management*: Van Nostrand Reinhold.

Hargreaves, J., Adl, M., & Warman, P. (2008). A review of the use of composted municipal solid waste in agriculture. *Agriculture, Ecosystems & Environment, 123*(1), 1-14.

Hassan, M., Awang, M., Afroz, R., & Mohamed, N. (2001). *Consumption and impacts on environment:*

*challenges of globalizations.* Paper presented at the Seminar of Sustainable Consumption: Challenges of Globalization, Kuala Lumpur, Malaysia.

Hassan, M. N., Rahman, R. A., Chong, T. L., Zakaria, Z., & Awang, M. (2000). Waste recycling in Malaysia: problems and prospects. *WASTE MANAGEMENT AND RESEARCH, 18*(4), 320-328.

Henry, R. K., Yongsheng, Z., & Jun, D. (2006). Municipal solid waste management challenges in developing countries–Kenyan case study. *Waste management, 26*(1), 92-100.

Herbert, L. (2007). *CENTENARY HISTORY OF WASTE AND WASTE MANAGERS IN LONDON AND SOUTH EAST ENGLAND*.

Hjelmar, O. (1996). Disposal strategies for municipal solid waste incineration residues. *Journal of Hazardous Materials, 47*(1), 345-368.

HKEB. Hong Kong Environment Bureau (2013). *Take action now for proper waste management*. Retrieved from http://www.enb.gov.hk/en/files/WastePlan-E.pdf. Date on: 11th Oct. 2016.

HKEPA. (2010). *Monitoring of solid waste in Hong Kong. Waste statistic for 2010*. Retrieved from http://www.epd.gov.hk/epd/english/environmentinhk/waste/waste_maincontent.html. Date on: 11th Oct. 2016.

Hoekstra, N., & Groot, H. (2013). *Temporary storage: a catalyst to enable landfill mining.* Paper presented at the 2nd International Academic Symposium on Enhanced Landfill Mining. Houthalen-Hechteren, Belgium: October.

Huri bin Zulkifli, Z. (1993). Improvement of disposal sites in Malaysia. *Regional Development Dialogue, 14*(3), 168.

Jalil, M. A. (2010). Sustainable development in Malaysia: A case study on household waste management. *Journal of Sustainable Development, 3*(3), 91.

Jamallulail, S. Z. A. (2014). *MEMORANDUM To The MINISTRY OF HOUSING AND LOCAL GOVERNMENT On An IMPROVEMENT ON MUNICIPAL SOLID WASTE MANAGEMENT (MSWM).* Universiti Teknologi Mara. Retrieved from http://www.academia.edu/8277769/MEMORANDUM_To_The_MINISTRY_OF_HOUSING_AND_LOCAL_GOVERNMENT_On_An_IMPROVEMENT_ON_MUNICIPAL_SOLID_WASTE_MANAGEMENT_MSWM

Kathirvale, S., Yunus, M. N. M., Sopian, K., & Samsuddin, A. H. (2004). Energy potential from municipal solid waste in Malaysia. *Renewable energy, 29*(4), 559-567.

Kumar, S., Bhattacharyya, J. K., Vaidya, A. N., Chakrabarti, T., Devotta, S., & Akolkar, A. B. (2009). Assessment of the status of municipal solid waste management in metro cities, state capitals, class I cities, and class II towns in India: an insight. *Waste management, 29*(2), 883-895. doi: 10.1016/j.wasman.2008.04.011

Li, T. C. (2005). Pulau Ketam dumps its dirty habit. *The Star*. Retrieved from http://www.thestar.com.my/data/archives/2013/07/04/08/42/pulau-ketam-dumps-its-dirty-habit/

Lindell, A. (2012). *Achievement of Sustainable Solid Waste Management in Developing Countries*.

LUAS/SWMA and Port Klang Project Managemen tOffice. (2006). CRAB ISLAND (PULAU KETAM). *port klang integrated coastal management project.* Retrieved from http://luas.gov.my/icm/opprtunities/main_crab_island.htm Date on: 11th Oct. 2016.

Manaf, L. A., Samah, M. A. A., & Zukki, N. I. M. (2009). Municipal solid waste management in Malaysia: Practices and challenges. *Waste management, 29*(11), 2902-2906.

McBride, M. B. (1995). Toxic metal accumulation from agricultural use of sludge: are USEPA regulations protective. *Journal of Environmental Quality, 24*(1), 5-18.

McDonough, W., & Braungart, M. (2010). *Cradle to cradle: Remaking the way we make things*: MacMillan.

McDougall, F. R., White, P. R., Franke, M., & Hindle, P. (2008). *Integrated solid waste management: a life cycle inventory*: John Wiley & Sons.

Memon, M. A. (2010). Integrated solid waste management based on the 3R approach. *Journal of material cycles and waste management, 12*(1), 30-40.

Moh, Y. C., & Abd Manaf, L. (2014). Overview of household solid waste recycling policy status and challenges in Malaysia. *Resources, Conservation and Recycling, 82*, 50-61. doi: http://dx.doi.org/10.1016/j.resconrec.2013.11.004

Mor, S., Ravindra, K., De Visscher, A., Dahiya, R. P., & Chandra, A. (2006). Municipal solid waste characterization and its assessment for potential methane generation: a case study. *Sci Total Environ, 371*(1-3), 1-10. doi: 10.1016/j.scitotenv.2006.04.014

Nema, A. (2004). Collection and transport of municipal solid waste. *Training program on solid waste management. Springer, Delhi, India*.

Onishi, N. (2005). How do the Japanese dump trash? Let us count the myriad ways. *The New York Times, 12*.

Otten, L. (2001). Wet dry composting of organic municipal solid waste: current status in Canada. *Canadian Journal of Civil Engineering, 28*(S1), 124-130.

Özeler, D., Yetiş, Ü., & Demirer, G. N. (2006). Life cycle assesment of municipal solid waste management methods: Ankara case study. *Environment International, 32*(3), 405-411. doi: http://dx.doi.org/10.1016/j.envint.2005.10.002

Palmisani, N. (2016, 20 Feb. 2016). Kamikatsu Japan: Zero Waste Town by Larry and Sarah Eppenbach. Retrieved from http://www.lopezsolidwaste.org/general/kamikatsu-japan-zero-waste-town-by-larry-and-sarah-eppenbach/

Pariatamby, A., & Periaiah, N. (2010). Waste Management on Malaysian Islands and Marine Pollution.

Periathamby, A., Hamid, F. S., & Khidzir, K. (2009). Evolution of solid waste management in Malaysia: impacts and implications of the solid waste bill, 2007. *Journal of material cycles and waste management, 11*(2), 96-103.

Phil Green, C. W., Chriswaterguy's bot. (2016, 8 Jan. 2016). Kamikatsu waste management. Retrieved from http://www.appropedia.org/Kamikatsu_waste_management

Poon, L. (2015, Dec 9, 2015). This Japanese Town Shows How 'Zero Waste' Is Done. Retrieved from http://www.citylab.com/politics/2015/12/let-this-japanese-town-show-you-how-zero-waste-is-done/419706/

Pulau Ketam. (2016). Retrieved from http://www.pulauketam.com/v3/about/populate/ Date on: 11th Oct. 2016

Saheri, S., Aghajani, M., Basri, N. E. A., Mahmod, N. Z. B., & Begum, R. A. (2011). Environmental assessment

of municipal solid waste disposal options in Malaysia. *Australian Journal of Basic and Applied Sciences, 5*(11), 1069-1073.

Samah, M. A. A., Manaf, L. A., Ahsan, A., Sulaiman, W. N. A., Agamuthu, P., & D'Silva, J. L. (2013). Household solid waste composition in Balakong City, Malaysia: trend and management. *Polish Journal of Environmental Studies, 22*(6), 1807-1816.

Scharfe, D. (2010). Integrated Waste Management Plan. *Centre & South Hastings Waste Services Board/Waste Diversion Ontario and Stewardship Ontario*.

Selangorkini. (2015). 雪政府拨款 70 万 吉胆岛设建材废料场. Retrieved from https://selangorkini.my/?p=34147?p=34147

Sh, F., Simon, C., & Agamuthu, P. (1970). Municipal solid waste management in Malaysia-Possibility of improvement? *Malaysian Journal of Science, 23*(2).

Sharholy, M., Ahmad, K., Mahmood, G., & Trivedi, R. (2008). Municipal solid waste management in Indian cities–A review. *Waste management, 28*(2), 459-467.

Shekdar, A. V. (2009). Sustainable solid waste management: an integrated approach for Asian countries. *Waste management, 29*(4), 1438-1448.

Snow, W., & Dickinson, J. (2001). The end of waste: Zero waste by 2020.

Spiegelman, H. (2006). Transitioning to zero waste-What can local governments do now. *Product Policy Institute. Local Government EPR, le*.

Staniskis, J. (2005). Integrated waste management: concept and implementation. *Environmental research, engineering and management, 3*(33), 40-46.

Tchobanoglous, G. (2009). Solid waste management. *Environmental engineering: environmental health and safety for municipal infrastructure, land use and planning, and industry. Wiley, New Jersey*, 177-307.

Tchobanoglous, G., Theisen, H., & Vigil, S. (1993). *Integrated solid waste management: engineering principles and management issues*: McGraw-Hill, Inc.

Teo, V. (2007). *Integrated Thinking – Solid Waste Management in Singapore*: Waste Management World by ISWA.

Terazono, A., Yoshida, A., Yang, J., Moriguchi, Y., & Sakai, S.-i. (2004). Material cycles in Asia: especially the recycling loop between Japan and China. *Journal of material cycles and waste management, 6*(2), 82-96.

TheWorldBank. (2012). *World Development Indicators 2012*: World Bank Publications.

Timlett, R., & Williams, I. (2009). The impact of transient populations on recycling behaviour in a densely populated urban environment. *Resources, Conservation and Recycling, 53*(9), 498-506.

Townend, W. K. (2010). Zero waste: an aspiration or an oxymoron? *WASTE MANAGEMENT AND RESEARCH, 28*(1), 1-3.

Tudor, T., Robinson, G. M., Riley, M., Guilbert, S., & Barr, S. W. (2011). Challenges facing the sustainable consumption and waste management agendas: perspectives on UK households. *Local Environment, 16*(1), 51-66.

UNEP-IETC, H. (1996). International source book on environmentally sound technologies for municipal solid waste management, United Nations Environment Programme (UNEP). *International Environmental Technology Centre (IETC)*.

UNEP. (2009). Integ g rated Solid Waste Management Technology & Infrastructure. Retrieved from http://www.unep.org/urban_environment/PDFs/ISWM2_TechnologyInfrastructure.pdf

USEPA. (2016, 2016/3/30). Municipal Solid Waste. Retrieved from https://archive.epa.gov/epawaste/nonhaz/municipal/web/html/index.html Date on: 20th Oct. 2016

Ven Te Chow, R. E. a. R. K. L. (1997). *Solid Wastes: Engineering Principles and Management Issues*. MCGRAW-HILL BOOK COMPANY.

Visvanathan, C., Tubtimthai, O., & Kuruparan, P. (2004). *Influence of landfill top cover design on methane oxidation: Pilot scale lysimeter experiments under tropical conditions.* Paper presented at the 3rd Asia Pasific Landfill Symposium. Kitakyushu, Japan. Oct.

Wan, A., & Kadir, W. (2001). A Comparative Analysis of Malaysian and the UK: Addison-Wesley Publishing Company Inc.

Woon, K. S., & Lo, I. M. C. (2013). Greenhouse gas accounting of the proposed landfill extension and advanced incineration facility for municipal solid waste management in Hong Kong. *Science of The Total Environment, 458–460*, 499-507. doi: http://dx.doi.org/10.1016/j.scitotenv.2013.04.061

Yaacob, S. (2004). Solid waste management in Pulau Ketam-Alam Flora's experience.

Yunus, M. N. M., & Kadir, K. Z. A. (2006). The development of municipal solid waste treatment technology based on refuse derived fuel and bio-gasification integration.

Zamali, T., Lazim, A. M., & Osman, M. T. A. (2009). An overview of municipal solid wastes generation in Malaysia. *Teknologi*. doi:10.11113/jt. v51.142

Zhang, D., Keat, T. S., & Gersberg, R. M. (2010). A comparison of municipal solid waste management in Berlin and Singapore. *Waste management, 30*(5), 921-933.

# APPENDIX A

## Questionnaire

A Survey for Current Situation of Municipal Solid Waste Management in Pulua Ketam, Malaysia (Sep. 2016)

1. Do you know Municipal Solid Waste Management?
你知道城市垃圾管理吗？

□ YES 是 □ NO 否

2. Do you know how to category Solid Waste?
你知道垃圾分类吗？

□ YES 是 □ NO 否

3. Do you think it is necessary to classify the garbage?
你认为有必要进行垃圾分类吗？

□ YES 是 □ NO 否 □ Don't care 不关心

4. Which kind of solid waste is the most (can choose more)?
哪种垃圾最多？（可多选）

□ paper 纸制品
□ plastic 塑料类
□ metals 金属类
□ food waste 食物/厨余
□ glass 玻璃
□ e-waste 电子垃圾
□ furniture 家具
□ others 其他

5. How often do you throw the rubbish?
你多久扔一次垃圾？

□ Twice a day 一天两次
□ Once a day 一天一次
□ Once two days 两天一次

6. Where do you usually to disposal household waste?
你通常将垃圾扔到哪里？

○ junk boxes on streets 街边垃圾箱
○ garbage station 垃圾站
○ discarded 乱扔
○ burned by yourself 自己烧掉
○ others 其他

7. Do you think the best methods of garbage disposal is:
你认为最好的垃圾处理方式是：

□ incineration 焚烧 □ landfill 填埋 □ compost 堆肥 □ others 其他

8. If 1 score is the worst, 10 score is the best, could you tell me what do you think of Pulua Ketam municipal solid waste disposal policy score?

你认为吉胆岛的垃圾处理政策能得多少分？（1~10 分）

○ 1
○ 2
○ 3
○ 4
○ 5
○ 6
○ 7
○ 8
○ 9
○ 10

9. How do you think the government should optimize Pulua Ketam municipal solid waste management policy?

你认为政府应该怎样优化螃蟹岛的垃圾处理政策？

○ Increase the number of waste treatment facilities
增加处理设施数量

○ Strengthen the management of relevant laws and regulations
加强相关法律法规管理

○ Strengthen the information of waste disposal/recycling education & publicity
加强垃圾处理/回收知识的教育与宣传

○ Using more advanced waste treatment technology and optimize existing waste management facilities
使用更先进的垃圾处理技术，以及优化现有垃圾管理设施

○ Others
其他

10. Whether you want the government to increase the amount of waste treatment facilities?

你希望政府增加垃圾处理的设施吗？

○ YES 是 ○ NO 否 ○Don't care 不关心

11. What would you most like to the government to increase the amount of waste treatment facilities?

你认为哪种垃圾处理设施是政府最应该增加的？

○ Junk boxes 垃圾箱
○ Garbage station 垃圾站
○ Garbage incinerator 垃圾焚化炉
○ Landfill area 填埋场
○ Trash pickup vehicle 垃圾运输工具
○ Recycling bins 回收箱
○ Propaganda and education center 宣传与教育中心
○ Others 其他