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LIST OF ABBREVIATIONS

MSW	Municipal solid waste
Q	Total emission of methane
WSW_T	Total solid waste generated
WSW_F	Fraction of solid waste disposed to landfill
MCF	Methane correction factor
DOC	Degradable organic carbon (fraction)
DOC_F	Dissimilated organic fraction (i.e. fraction converted to landfill gases)
F	Fraction of CH_4 in landfill gas
R	Recovered CH_4
OX	Oxidation factor

CHAPTER 1

INTRODUCTION

1.1 RESEARCH BACKGROUND

Global warming has now become an issue that is often dealt with at the international level today. A contributor to this issue is the impact of greenhouse gas from solid municipal waste collected from households. Solid waste management is becoming increasingly complex with the production of solid waste per household averaging 0.8kg/day in 1995 and continuing to increase reaching 1.4kg/day to year 2025. (Kathirvale et al, 2004).

National Strategic Plan 2005 has developed solid waste management methods for long-term in an effort to preserve the city for the convenience of future generations in Malaysia. This is in line with the use of the Cleansing Management Act 2007 which state solid waste is controlled waste. (Act 672). Methane gas and leachate must be managed properly so as not to add to the effects of greenhouse gases and pollution of underground water resources.

Study of solid waste disposal centre in Pekan and Rompin district as well as methods of waste management at present can be a model to support the government's efforts to generate energy from municipal solid waste revenue.

1.2 PROBLEM STATEMENT

Currently on-site solid waste management is a traditional junk or open dumping. One the one hand with high ambient relative humidity the solid waste will emit methane gas to the atmosphere creating global warming effect at 21 times higher than CO_2 per kilogram basis .On the other hand leachate that seeped into the soil will contaminate underground water resources for human consumption and stability of the eco system.

1.3 SIGNIFICANCE OF STUDY

After achieving the objective methods available to support government efforts in enhancing the overall solid waste management in Malaysia and see how much potential in generating electrical energy from solid waste.

1.4 RESEARCH OBJECTIVE

The objectives of this paper are as follows:

i. To study the solid waste management system in Malaysia.
ii. To study the changing technology of solid waste to energy and its potential in generating alternative energy sources.

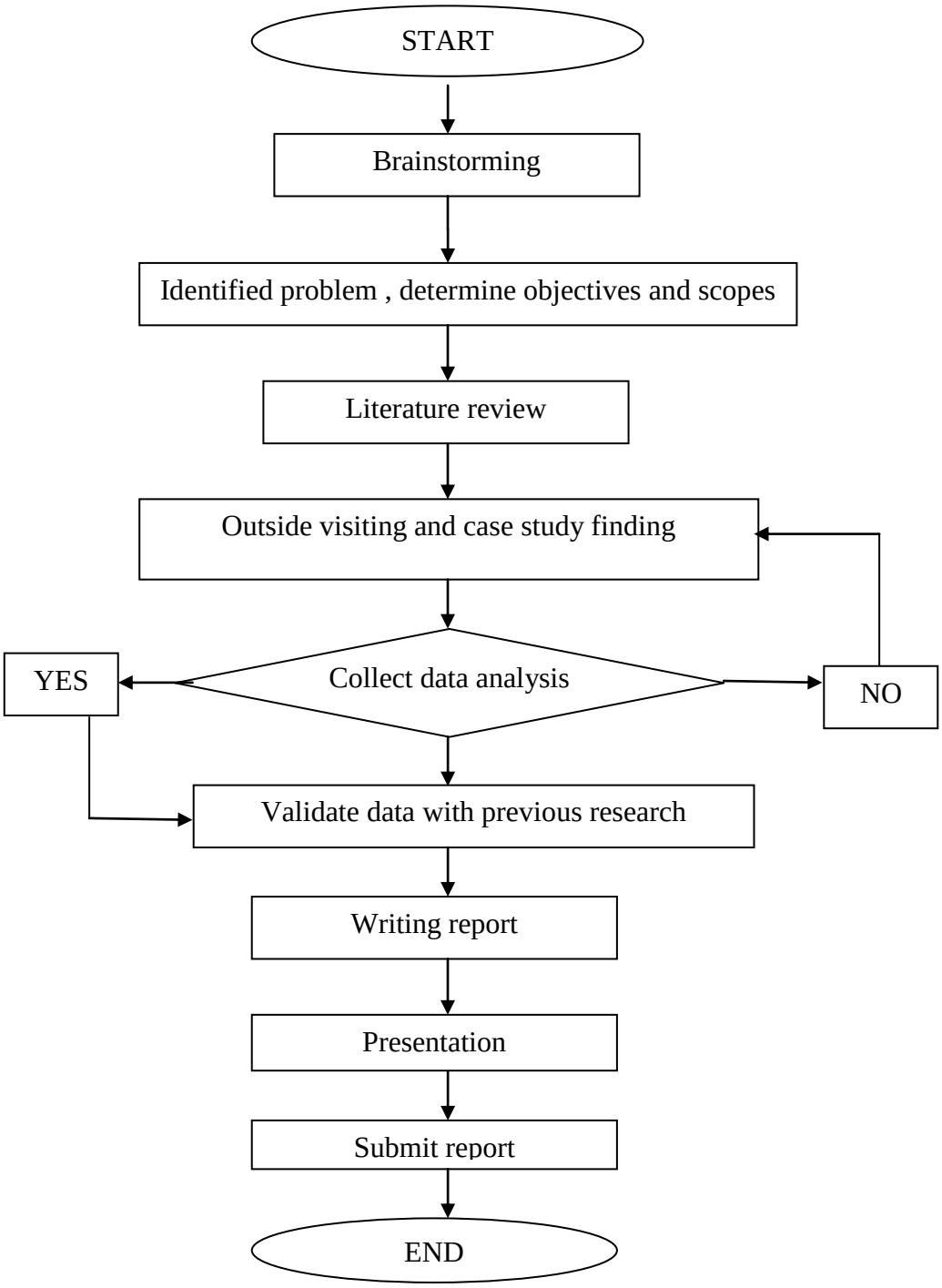
1.5 RESEARCH SCOPE

For the main purpose of this research the following scope are developed:

i. Predict the data obtained from the total collection of solid waste for Pekan municipal open landfill dumping.
ii. Study of MSW management in other countries.
iii. Analyze solid waste management method using incinerator, open dumping and sanitary landfill.
iv. Recommend the best system for managing solid waste on landfills in Malaysia using the concept of converting waste to energy for generate electricity.

1.6 PROCESS FLOW CHART

Table 1.1: Flow chart of research



CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Solid waste management in the future will face more challenges in line with the progress of development in Malaysia .The increasing population has also provided assistance in this scenario (Agamuthu, 2009). Peninsular Malaysia has produced 17.000 tonnes per day and normally increases during festival periods (6.2 million tonnes / year). (Fauziah SH, 2005)(Manaf LA, 2009)

2.2 GREENHOUSE GAS (GHG)

Methane emission from landfills is a major contributor for GHG from waste sector. The main contain GHC gas from waste sector landfill is methane and nitrous oxide. The Intergovmental Panel on Climate Change IPCC 2007 state the contribution of waste sector is 3 percent to the GHC emission (IPCC 2007). Methane production to rise each year and an issue that gained national attention conserving the environment and sustaining city. Produced of methane depending on the composition of the solid waste and the moisture contained. Strong Smell of solid waste generated showed high amounts of methane content.

2.3 LEACHATE

Pollutants can escape from improperly designed landfill in a variety of ways (Carla, 2000). If soil above or below a landfill is permeable, leachate can escape to contaminate groundwater (Carla, 2000). Recent studies indicate that small landfills

(waste volume up to 50,000 yd^3) may impact groundwater (Friedman, 1988 and Bagchi, 2004).

Once the groundwater is polluted, the pollution may be difficult to correct or even to detect. Carla (1997) predicted that in the next few decades, more contaminated aquifers will be discovered, new contaminants will be identified, and more polluted groundwater will discharged into wetlands, streams, and lakes as this groundwater passes through the hydrologic cycle. By the time groundwater pollution is detected, it may be very widespread, and the exact extent of the problem may not be readily determined without the drilling of many monitoring wells across the affected area (Bagchi, 2004). Even the source can be hard to identify unless the chemistry of the contamination is distinctive (Carla, 1997).

Contaminants carried in leachate are dependent on solid waste composition and on the simultaneously occurring physical, chemical and biological activities within the landfill (Monroe, 2001).

2.4 LAND FILLING

Land filling is an area which waste is deposited. The aim of the technology is to avoid any contact between and waste and surrounding environment include with groundwater. Landfills can be classified into a two categories, which are:

i. Open dump and open landfills: These are the most common non-engineered disposal techniques and almost used in all development country. The process involved by dumping haphazardly into low laying areas of open land. The solid waste are disposed does not protect the environment, exposed to open burning and a disease vector.

ii. Sanitary landfills: Always used in developed country and have facilities for interception and treatment of leachate. The landfill generation of leachate and obnoxious gases. The type of landfills have arranged to control of gases generated from waste decomposition(Tchoanoglous et al,1993)

Sanitary land filling is an entirely engineered disposal to avoid harmful effect of uncontrolled dumping by spreading, compact and converting the old landfill. Before converting it have more hazardous waste reaction in landfill. Wastes arriving at sanitary landfills sites is compacted and then covered with a layer of soil .The compacted soil layer restrict continued access to waste by insects or wild animals. To minimize the amount of surface water entering, it covering on the top for gas escaping from the waste.

Figure 2.1: Top covered sanitary landfills.

Source: Creig Furdenrich (2000)

2.5 INCINERATION

The Government of Malaysia has suggested the use of thermal treatment to partly solve the waste management problem currently being faced by the major cities. There is a general tendency for the government to go for the gasification technology with ash melting system as it has superior emission control systems. There are a few other cities which are planning for such a system. However, the technology that is being acquired from Japan does not conform to the best available technology not entailing excessive cost (BATNEEC) concept. The government has requested for a thorough evaluation of the project. One such evaluation is the amount of energy that would be recovered from the incineration process.

Incineration involves the combustion of typically unprepared (raw or residual) MSW. In incineration different municipal solid wastes possess different of calorific value. To allow the combustion to take place a sufficient quantity of oxygen is required to fully oxidize the fuel. Incineration plant combustion temperatures are in excess of 850^0C and the waste is mostly converted into carbon dioxide and water and any noncombustible materials (e.g. metals, glass, stones) remain as a solid, known as Incinerator Bottom Ash (IBA) that always contains a small amount of residual carbon. The direct combustion of a waste usually releases more of the available energy compared to pyrolysis and gasification.

The process for a solid waste solution that involves the combustion of organic substances contained in waste materials. Incineration is also categorized as a thermal treatment for solid waste. From the incineration burning process it is convert the waste into ash, flue gas, and heat. The ash is mostly formed by the inorganic constituents of the waste, and may take the form of solid lumps or particulates carried by the flue gas. The flue gases must be cleaned of gaseous and treatment of particulate pollutants before the gases return into the atmosphere. In some cases, the heat generated by incineration can be used to generate electric power. The high temperature of flue gases output from the incineration process can be optimized to operate the steam turbine as an alternative solution to fulfill an electricity demand.

The type of incineration process today is like fixed grate which is a simple kind of incinerator was a brick-lined cell with a fixed metal grate over a lower ash pit, with one opening in the top or side for loading and another opening in the side for removing incombustible solids called clinker. Many small incinerators formerly found in apartment houses have now been replaced by waste compactor.

The rotary-kiln incinerator is used by municipalities and by large industrial plants. This design of incinerator has two chambers a primary chamber and secondary chamber. The primary chamber in a rotary kiln incinerator consists of an inclined cylindrical tube. The inner refractory lining serves as sacrificial layer to protect the kiln structure. This layer needs to be replaced from time to time. Movement of the cylinder on its axis facilitates movement of waste. In the primary chamber, there is conversion of

solid fraction to gases, through volatilization, destructive distillation and partial combustion reactions. The secondary chamber is necessary to complete gas phase combustion reactions. The fuel for first ignition is using diesel or neutral gas.

Fluidized bed is a strong airflow is forced through a sand bed. The air seeps through the sand until a point is reached where the sand particles separate to let the air through and mixing and churning occurs, thus a fluidized bed is created and fuel and waste can now be introduced. The sand with the pre-treated waste and/or fuel is kept suspended on pumped air currents and takes on a fluid-like character. The bed mixed and agitated keeping small inert particles and air in a fluid-like state. This allows all of the mass of waste, fuel and sand to be fully circulated through the furnace.

The advanced technology in solid waste is plasma gasification. Plasma gasification is a process which converts organic matter into synthetic gas, electricity, and slag using plasma. A plasma torch powered by an electric arc is used to ionize gas and catalyze organic matter into synthetic gas and solid waste (slag). It is used commercially as a form of waste treatment and has been tested for the gasification of biomass and solid hydrocarbons, such as coal, oil sands, and oil shale.

2.6 3R (REDUCE, REUSE AND RECYCLE)

Improved municipals solid waste management and the mission of sustainable environment have to exert the smart solution for the adoption of proper methods to reduce energy consumption. The hierarchy structure of disposal municipal solid waste for the environmental divided into six levels, from low to high namely, reduce, reuse, recycle, compost, incinerate and landfill.

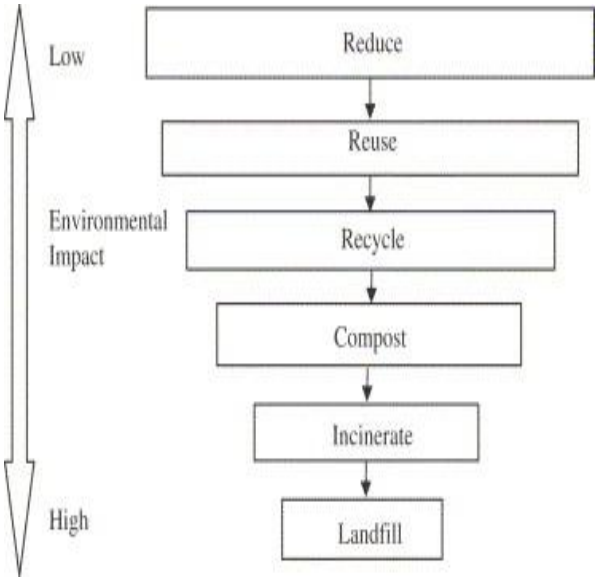


Figure 2.2: Hierarchy of Municipals Solid Waste

Source: Ottawa waste plan (2008)

From the figure, three main elements to minimize a municipal solid waste volume is Reduce, Reuse and Recycle, which simply called the ‘‘3R’’. The simple concept although commonly practice in many countries, is even seldom in Malaysia. Most of the municipal solid waste is not sorted at home before it is thrown out to the garbage bin.

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

This chapter describes in detail the method for carrying out case studies. Moreover, we give a clear picture of how each type of waste management centers operate solid waste processing.

3.2 LANDFILL VISITS

The methodology of the study began with a visit to the solid waste site landfills in Pekan, Pahang district. The sanitary landfill here operate with open methods of land dumplings landfill. Municipal solid waste collected per day will be deposited in the open without prior vanity.

Figure 3.1: Open dumping MSW in Pekan, Pahang

Figure 3.2: Leachate and methane had produced in landfill.

Methane gas and leachate would result from uncontrolled waste impact on the environment and groundwater resources. Landfill has been developed for the closure to provide space for development.

3.2.1 Rompin Sanitary Landfill

Solid waste management centre is under the supervision of the district town of Alam Flora Sdn Bhd, which is in the process of upgrading the surrounding circumstances. Project under the supervision of the Ministry of Housing and Local Government (KPKT) under construction and is expected to be fully in operation in 2013.

Figure 3.3: Sanitary landfill under construction

Sanitary landfills are built to control methane gas and leachate from escaping into the atmosphere and underground. The landfill will be closed at the top and the resulting leachate will be treated before being channeled back into the river.

Figure 3.4: Leachate treatment ponds

Figure 3.5: Methane collection drain pipe

The existing municipal landfill solid waste landfill in Rompin is being closed to accommodate the increasing quantities of waste. With a depth of over 30 meters, the landfill has a built-in pipe to drain out methane gas out to the surface. The drain pipe is built to prevent methane gas accumulated below the surface and react explosively. On the other hand, if this methane gas accumulated in the waste heap is let to escape to the

atmosphere, it will contribute to the greenhouse gas (GHG) effect. The Landfill surface is soft and easy to collect stagnant water, especially during the monsoon season. This will result in the formation. Leachate which requires duct for treatment before being discharged into the river or canal.

Figure 3.6: Methane gas drain from the old MSW landfill

The duct to collect leachate is built in order to control the occurrence of the event leachate seeping to the water table and contaminate a clean water source. The flow of leachate is controlled and protected before it undergoes a treatment process.

Figure 3.7: Leachate duct and pre-container

3.2.2 Tioman Island Incineration

Incineration in the Tioman Island uses a rotary-kiln to burn municipal solid waste using air pollution control. This process can transform municipal solid waste combustion rate depending on the rate of moisture volume formation. Incineration Plant also has a system that can treat leachate through anaerobic process.

Figure 3.8: Rotary-kiln incineration

3.2.3 Plasma Gasification

Plasma gasification is the gasification of matter in an oxygen-starved environment to decompose waste material into its basic molecular structure. Plasma gasification does not combust the waste as incinerators do. It converts the organic waste into a syngas (fuel gas) that still contains all the chemical and heat energy from the waste. It converts the inorganic waste into an inert vitrified glass. The process starts with lower emissions out of the reactor it is able to achieve significantly lower stack emissions. The process is not affected by the amount of moisture in the waste. The moisture consumes energy to vaporize and will have impact on the capacity and economics, however, it will not affect the process.

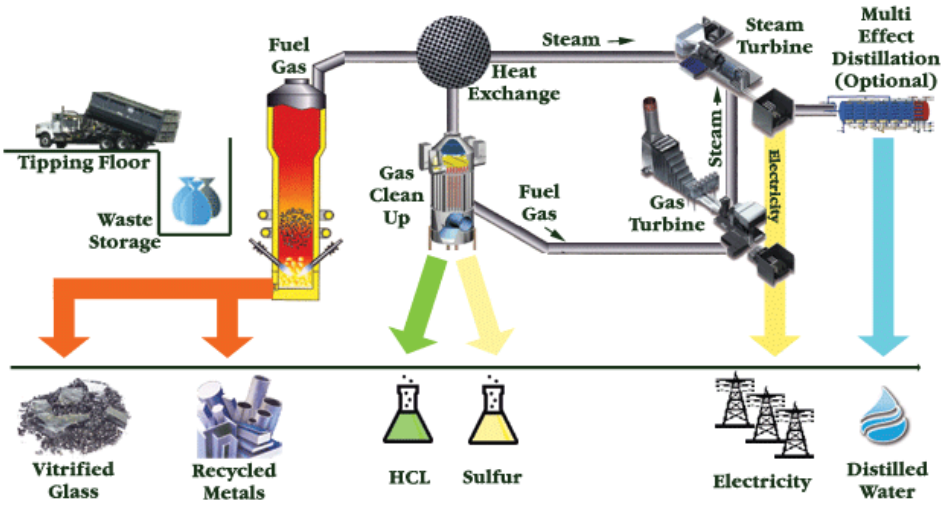


Figure3.9: Plasma gasification process

Source: Recovered Energy Inc. (1995)

CHAPTER 4

RESULT

4.1 MUNICIPAL SOLID WASTE MANAGEMENT IN MALAYSIA

Malaysia's rapidly developing towards developed nation status in 2020, has contributed to the growth of a population of nearly 30 million requires an effective waste management system to maintain the existing eco-system. Nowadays, three ways to dispose household solid waste is open dumping, sanitary land field and incinerator.

4.1.1 Open Dumping

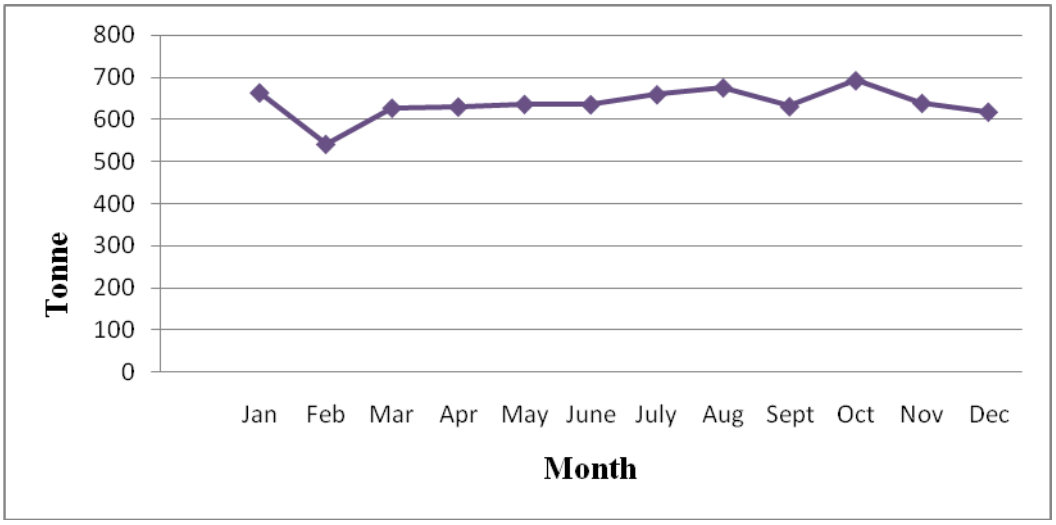


Figure 4.1: Tonnage in Pekan landfill in 2010

The total collection in 2010 have a decrease on solid waste collection on February is, the company may have a technical problem on one of the compactor truck and the schedule of collection has been changed.

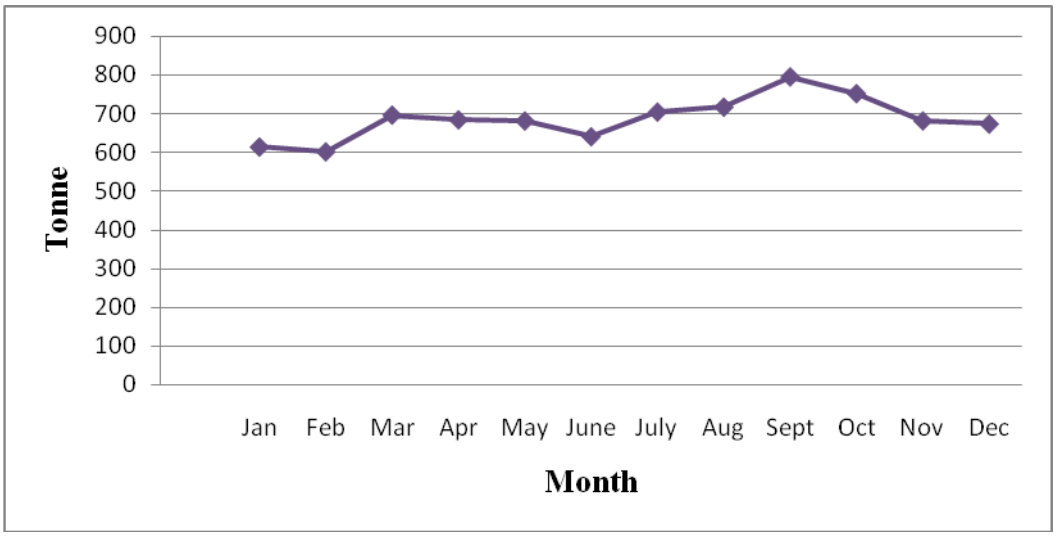


Figure 4.2: Tonnage in Pekan landfill in 2011

The total collection in 2011 is consistent increase from the January to December. The collection operations smoothly when the operation schedule of compactor truck is flexible and breakdown of truck reduced.

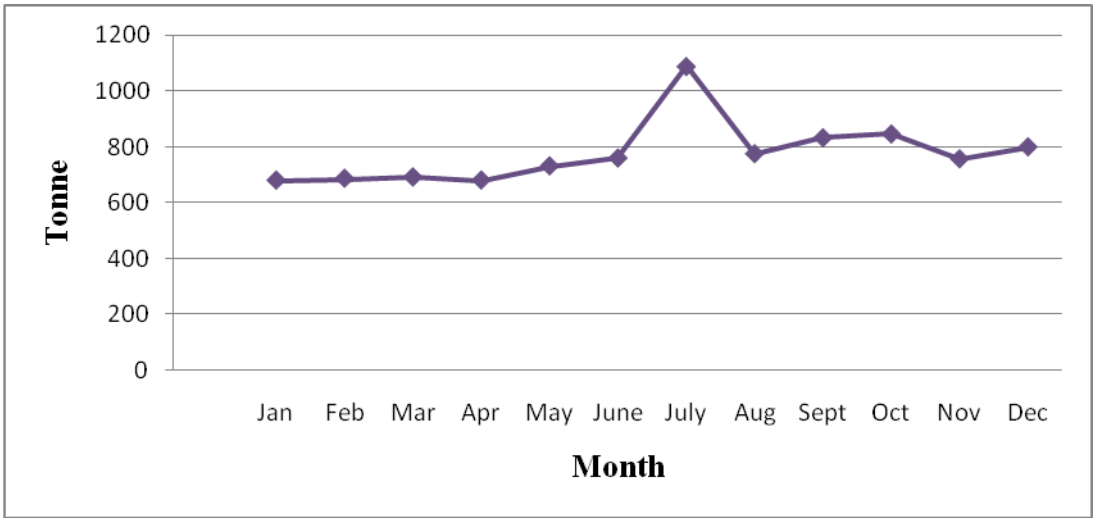


Figure 4.3: Tonnage in Pekan landfill in 2012

Total of collection in 2012 has the higher amount is in July. One of the factor contributed to this situation is the Muslim population in Pekan fasted and prepared for Hari Raya Puasa.

4.1.2 Sanitary Landfill

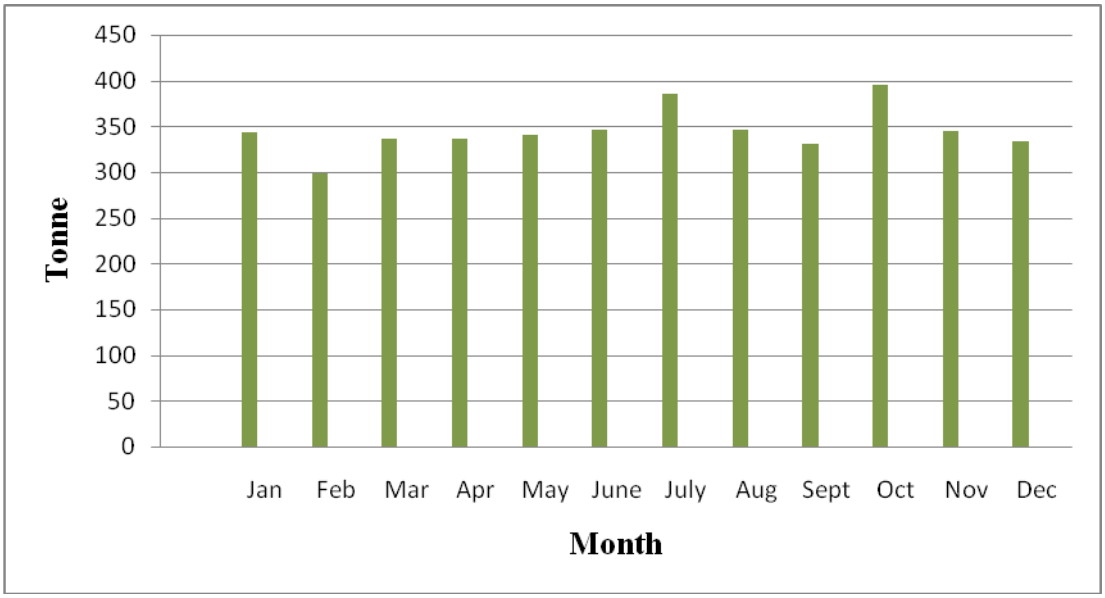


Figure 4.4: Tonnage in Rompin landfill 2010

The collection in 2010 is consistent amount in every month. In January, July and October have a small increase when the tourists come to visit the interesting place in Rompin.

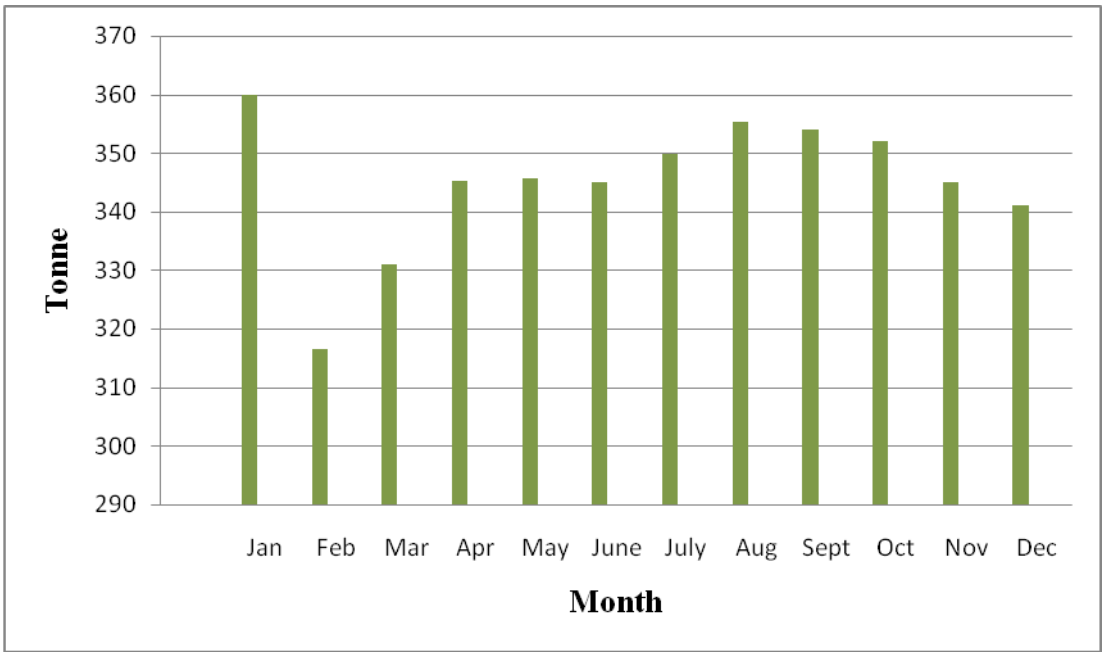


Figure 4.5: Tonnage in Rompin landfill in 2011

The graph on the 2011 has a lower amount of collection in February because the collection operations problem. The compactors truck not enough for operation on the collection route in schedule.

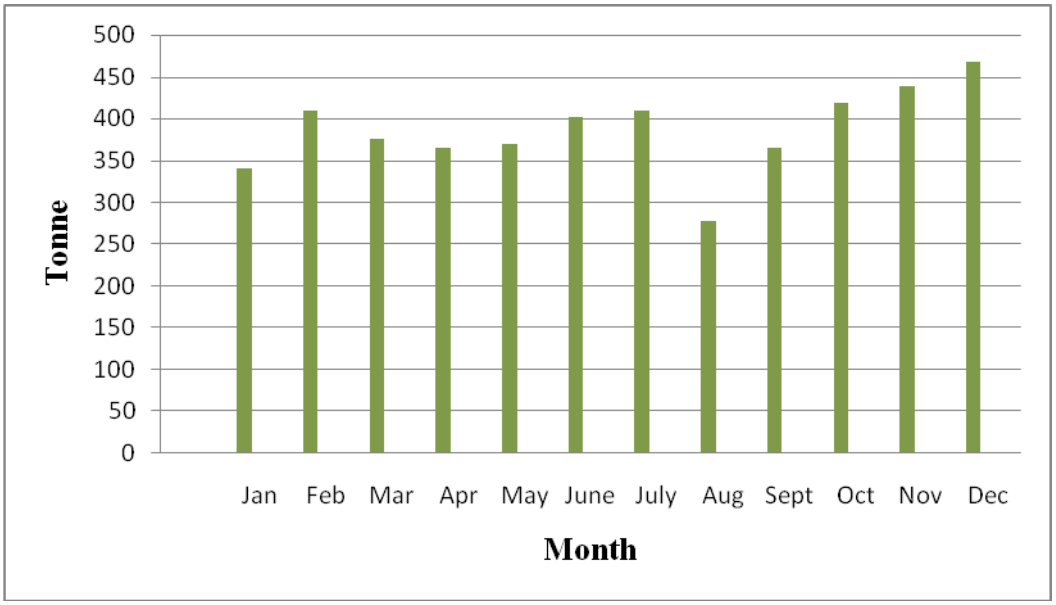


Figure 4.6: Tonnage in Rompin landfill in 2012

The graph in 2012 had shown the increasing of the amount Municipal solid waste. The factor influence the condition is the increased of population number and increased amount of waste solid waste generate per person.

4.1.3 Incinerator

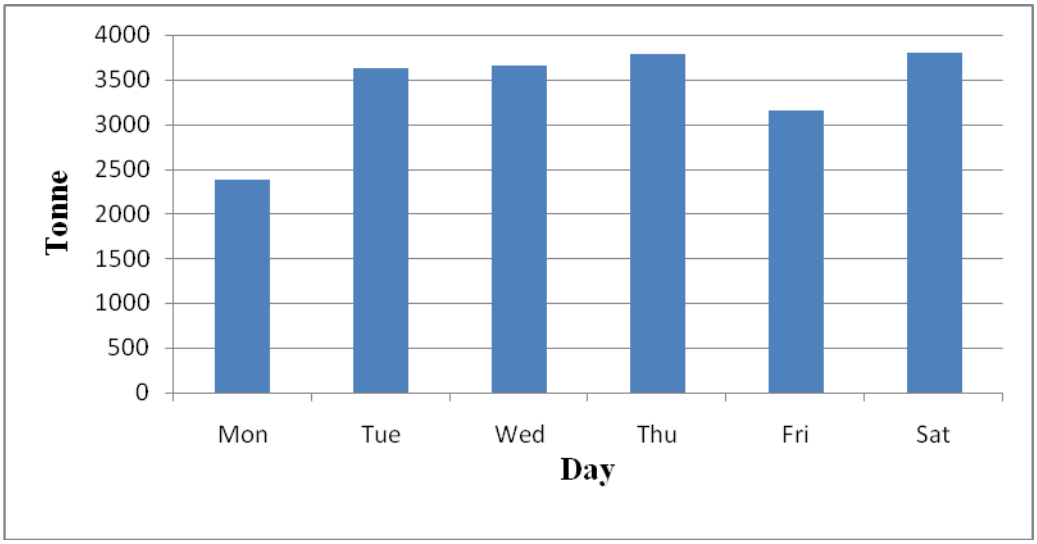


Figure 4.7: Estimation collection of solid waste in 22 April until 28 April 2013 at Pulau Tioman

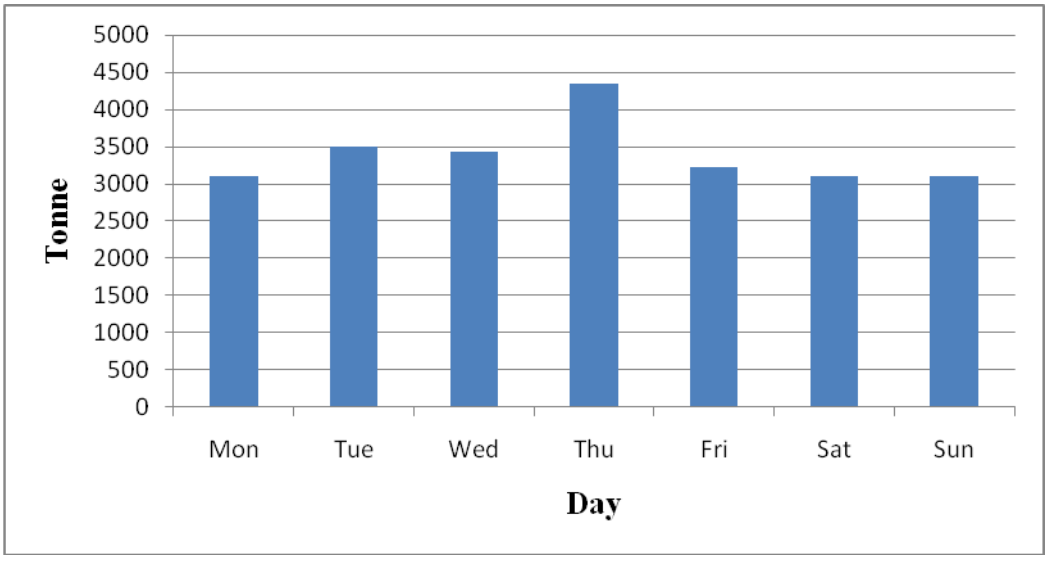


Figure 4.8: Estimation collection of solid waste in 7 May until 13 May 2013 at Pulau Tioman

The graph show the day that has a high collection of municipal solid waste is in every Thursday. This situation is influenced by the arrival of travelers to the island.

4.2 RESULT DISCUSSION

Open dumping is widely used to dispose solid waste. This due to low cost operation, easy to handle. Once maximum load in landfill area, management will transfer it to another area. For my study case in Pekan, household solid waste such as plastics, bottles, papers, glasses and so on is managed by Alam Flora Sdn Bhd. Each area is divided accordingly to the prescribed zone to facilitate the solid waste collection conducted. By practicing regular collection methods, each area in district of Pekan will undergo solid waste collection three times a week. For 2010, the annual waste collection for Pekan is 7648.44 tonne. For 2011, the waste collection was increased to 8246.05 tonne. While for 2012, waste collection was 10127.25 tonne.

Sanitary landfill is located in Rompin, Pahang. Rompin has a better ways to dispose solid waste compared to open dumping. Solid waste is treated without causing air and water pollution. The number tonnage of landfill for 2010 is 7648.46 tonne. For 2011, it increased to 8246.1 tonne. While for 2012, tonnage of landfill is around 9327.46 tonne.

Usually, leachates that produce from solid waste absorb with underground water table and contribute to water pollution. But, using sanitary land field, leachate will collected and drain through pvc pipe to the pond, where leachate treatment start. After all the leachate is treated and turn into clean water, it will release into water canal or river.

Solid waste that collected also produce methane. Methane will cause global effect warming. To prevent methane from released to air, plastic is use to cover top of landfill. Methane is collect and compress in gas container, gas container channeled to power turbine plant. Electric will produce from output of power turbine process.

This incinerator has operation in the high cost of fuel and lack of technical expertise to maintain the condition of incinerator .The incinerator here is applied the rotation kiln to combust the municipal solid waste. The operation of the rotary kiln is designed with two counter flow processes between the air and waste. The first counter flow process is opposing flow of the waste and air supply through the intake head and the air is supplied from the discharged head. The second counter flow is exists between the movement of the waste which follow the direction of the rotating kiln and the opposite flow from the air swirling. The solid waste is totally combust and produce ash, heat and flue gases.

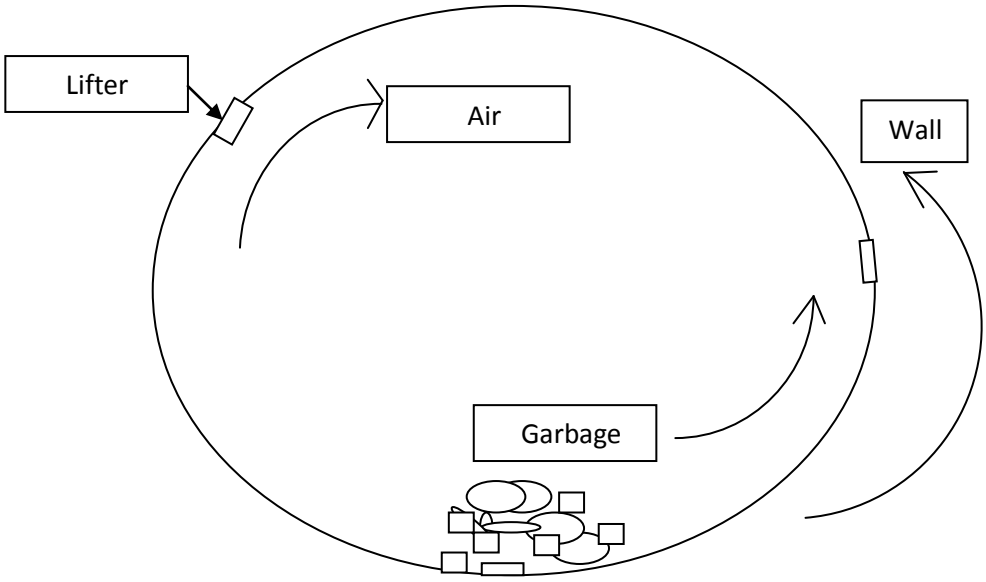


Figure 4.9: Counter flow system inside the rotary kiln incinerator

Source: A.S.A.K Sharifah (2008)

The process is started with the solid waste transfer by conveyor into the receiving hopper. Then the solid waste entry the rotary kiln chamber with shot feeding cylinder. The shot feeding process actually using is half stroke shot. It because if using the full stroke shot the shot feeding cylinder life cycle becomes short and cost to maintenance is too higher. The burning process in rotary kiln is using the diesel fuel to start the ignition .The operating system temperature initial with 800^0 C and will be increased until 1400^0 C. A condition where the municipal solid waste is higher moisture content the burning

process on the second combustion chamber temperature is more higher than the rotary kiln chamber temperature .The second combustion chamber is important to ensure the process of burning is completed. The flue gas is transferred to rapid cooling tower to decrease the temperature after the burning process. The bottom dust is collected and the output volume is controlled by bottom valve. The flue gas is transferred to the bug filter .If the detection system have a result which the content of SO_2 and NO_x higher in flue gas Calcium Hydroxide and activated charcoal is using as reagent to decrease the SO_2 and NO_x volume. In the bug filter the fly ash and gas is separated in a filter system. Fly ash is collected and contained in a flexible container. It is because the fly ash is categorizing ash scheduled solid waste. Then the flue gas going out from bug filter with suction fan into the chimney and release to the open air.

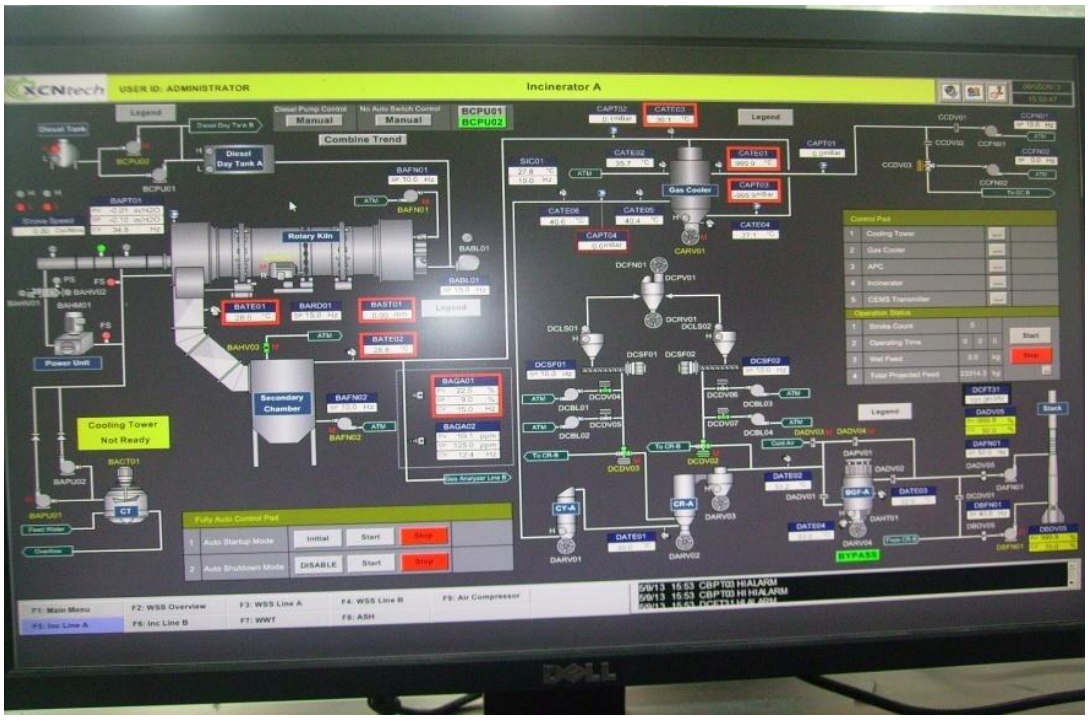


Figure 4.10: The incineration with rotary kiln system

The leachate from the municipal solid waste in this incineration centre also needs to undergo treatment before it is released to the river and water streamline. The treatment started in the equalizer tank. The equalizer tank has a reagent (micro bacteria) which activates with the leachate poison content. The process is maintained slowly to have maximum activated of process. The output from the neutralized tank is perception

with the additive coagulants. The tank system is called anaerobic treatment. The Anaerobic system is a slow process to treatment the water is neutralized with poison and bad adour. With low velocity of leachate treatment the reagent release the poison in reduction process. In the final stage the leachate is treatment using flocculants before transfer to slant plate clarifier .The filtering process is started with three stages started with sand filters, carbon filter and softener filter. The system is like R.O water (reverse osmosis) but the output is purity and clear then the R.O water. The different is quality of water in 0.1 ppm. In the situation which the water have a sludge, the water is bypass to the cake discharge to removed the sludge before the water turn back into flocculants tank. Advantages from this method is no need large space to accumulate solid waste and also will prevent from animal. The system help to protect the environment and water table in Pulau Tioman with the sustainable nature.

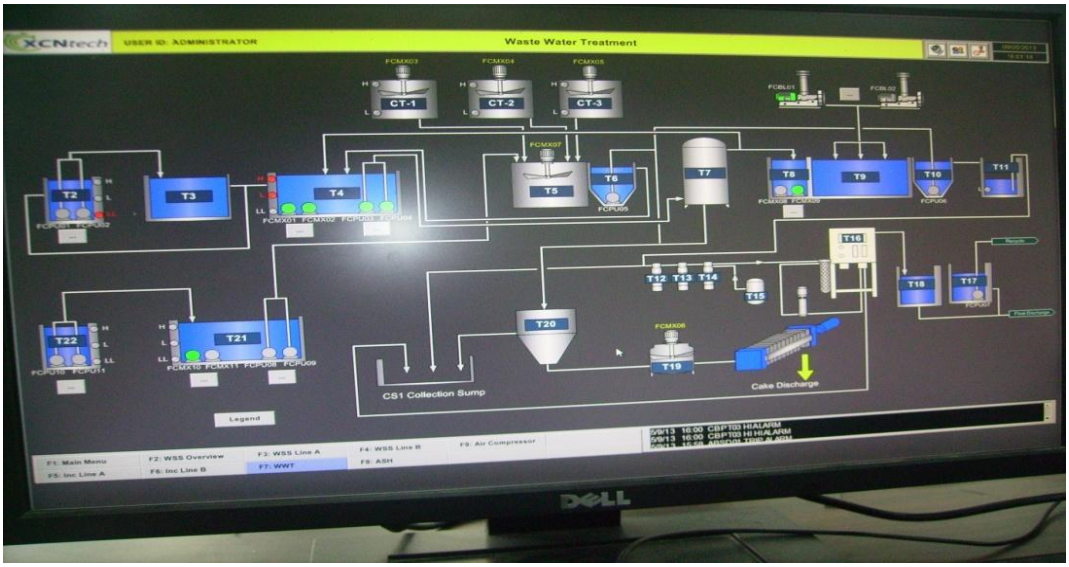


Figure 4.11: The leachate treatment in incineration centre Pulau Tioman

4.3 MUNICIPAL SOLID WASTE MANAGEMENT IN OTHER COUNTRIES

4.3.1 Incineration

The incineration is a process to dispose solid waste. This process can reduce 90 percent volume of the waste. Incinerable waste is dispose in incineration plants while landfill is used to dispose non incinerable waste.

Singapore is well known as a country that incorporate good strategies to manage their municipal solid waste. They use 3R (reduce, reuse and recycle), incineration, then ash and slag produced from incineration process transferred to landfill. Solid waste management is managed and undertaken by Ministry of environment. Incineration is preferred technique to dispose solid waste, because limitation of land in Singapore, as we know open dumping landfill need large space area and also create air pollution.

Domestic solid waste increase by year in 1980, with domestic solid waste is 640 thousand tonnes. In 1999, domestic solid waste increase to 1360 thousand tonnes. This due to increasing of population, which is the population in 1980, is 2.41 million, while population in 1999 is 3.89 million.

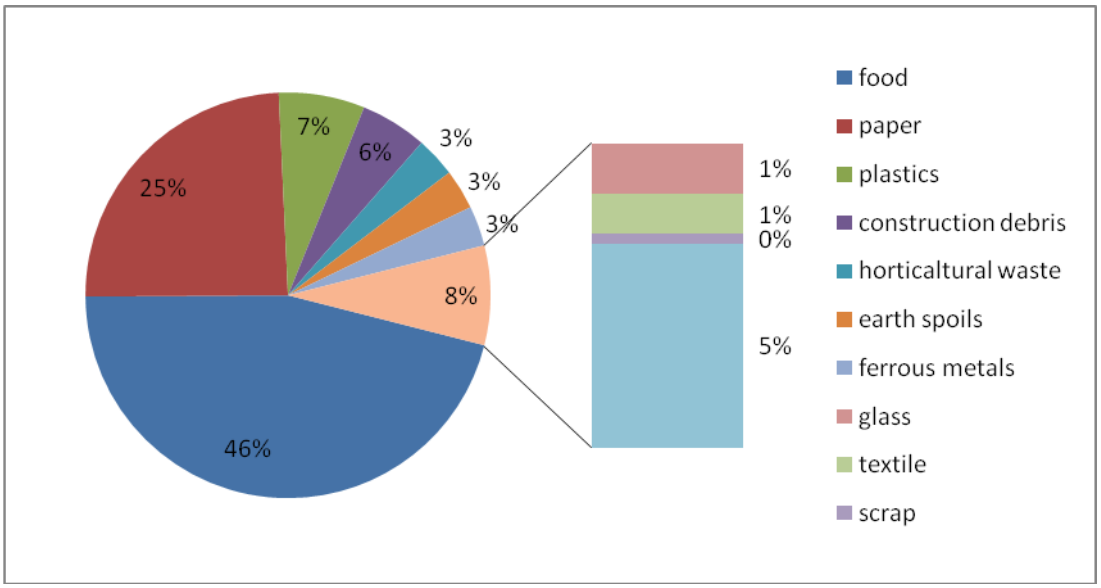


Figure 4.12: Composition solid waste in Singapore in 2000

Source: R. Bai (2002)

To manage and maintain clean environment, there are several waste collection practice. There are direct collection method and indirect collection methods. For direct collection method, waste is collect directly from individual household, private residents' estate and shop house. This method need lots of workers and time management. For indirect method, it divides into 2 ways. First ways, waste is collected in bulk containers

which located on basement of apartments. Then, this container is transfer to the bin compound, and to the refuse disposal sites. Second indirect ways is using centralized refuse-chute (CRC) system that implemented since 1989. This CRC system can control of smell and leakage of refuse. A common discharge chute allow refuse to manage from individual flats. Then, small vehicles collect refuse from each apartment block then transfer it to the waste collection truck.

For eastern part of Singapore, to improve the productivity of waste collection, the waste collected is transferred to a transfer station, formally known as Kim Chuan Transfer Station. Then, the waste transported to Tuas incineration plan and Senoko incineration plan. Tuas incineration plan located in the western part of Singapore, while Senoko incineration located in the northern part of Singapore. From 1 July 2001, Kim Chuan Transfer Station was closed due to low demand.

In Singapore 8000 tonnes of solid waste are disposed per day, which 5840 tonnes per day is incinerated. This means 73 percent of the wastes are incinerated. Incineration is believed by Ministry of Environment as the best option for waste treatment. First of all, vehicles truck that consists of waste discharge the wastes into the refuse bunker. To prevent odors from escaping to atmosphere, the bunker is kept under atmosphere pressure. Then, the waste is fed into the furnace. Then combustion process takes place. Combustion process produce heat, which steam in boilers will generate. Electricity is produced when the steam drives two steam turbines coupled to generators. 80 percent of electricity produce is sold, while 20 percent is used back by the plant. The ash and slag produced from incineration process is then disposed in Pulau Sembakau landfill.

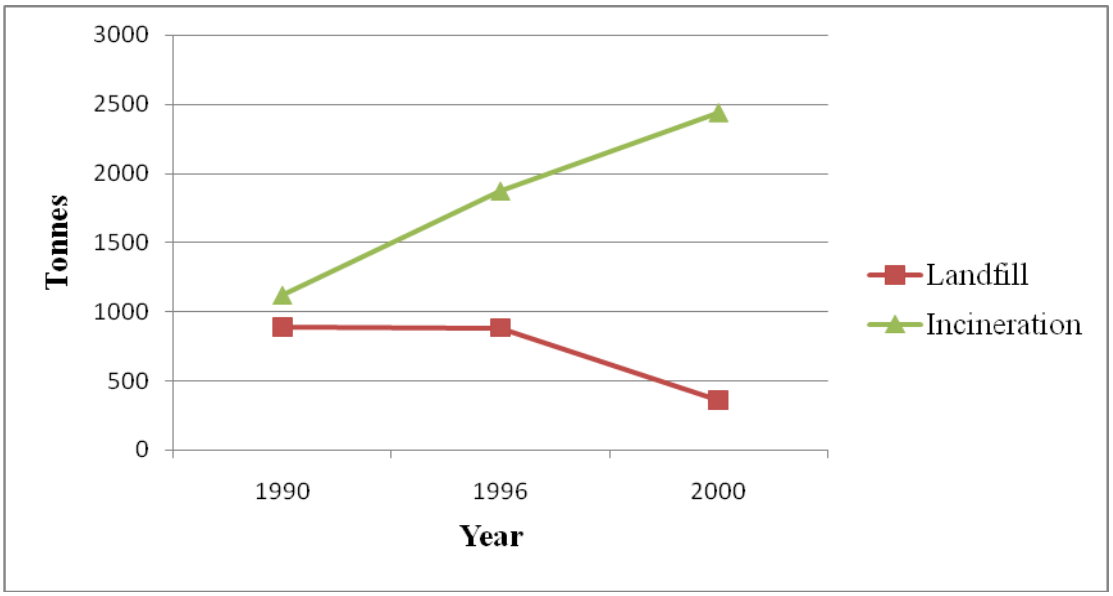


Figure 4.13: Comparison disposal of solid waste by landfill and incineration in Singapore

Source: Ministry of Environment (2000)

For management solid waste in Singapore, landfill solution is least priority. Sanitary landfill is used to dispose ash and slag (produce with incineration process) and non incinerable waste. Ministry of environment develops an offshore landfill known as Pulau Sembakau. Before leachate is released into the sea, the leachate is treated to Effluent Discharge Standard that follows the Environmental Pollution Control Act. The waste is burned by flaring system, and heat produce also can produce electricity.

4.3.2 Production of Biogas From Agricultural Waste

Ministry of Energy in Thailand is to increasing the use of alternative energy from 6.4 percent in 1998 to 20.3 percent in 2020. The purpose of using alternative energy is to decrease the need of fossil fuel and reduce global warming phenomena. Pollution gases such as CO_2 and SO_2 is emerge when burning of fusel fuel to generate energy. Accumulation polluting gases is very harmful to the atmosphere.

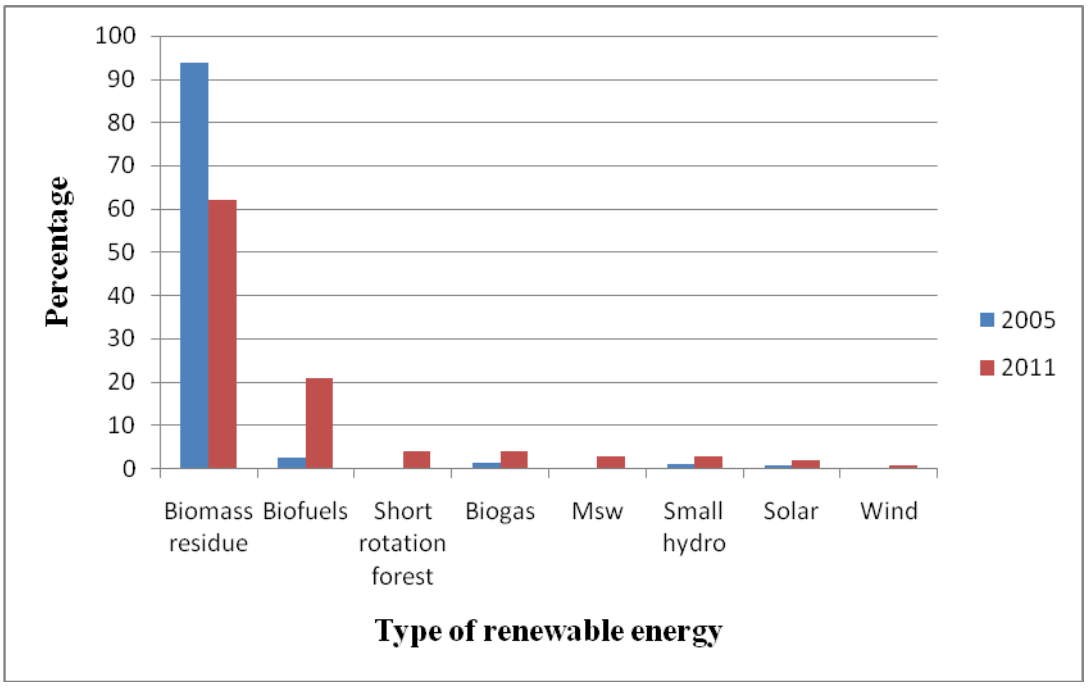


Figure 4.14: Renewable energy from bio base in Thailand

Source: JGSEE (2007)

Thailand has good opportunity to stimulate biogas because that country has abundance of agricultural waste that can produce biogas. Biogas is produced from biological process, this process known as anaerobic digestion. This low temperature and without air process Thailand have feedstock from agriculture waste that be used generate renewable energy. To produce biogas, there are four key components, which is need of biogas technology, feedstock, microorganism and controlling environment for anaerobic digestion. The major sources of feedstock are farm waste, municipal solid waste and agro industrial waste.

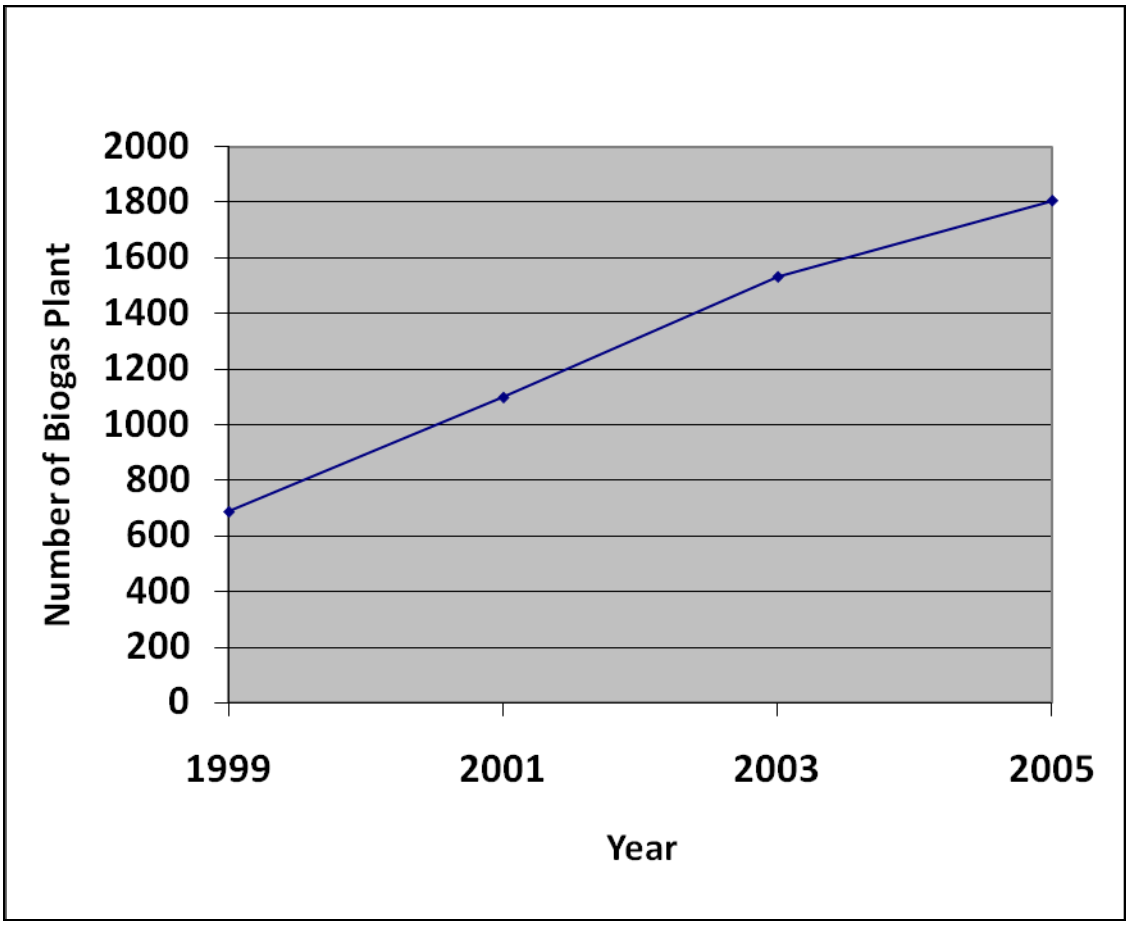


Figure 4.15: Number of Biogas plant in Thailand

Source: P.Chaiprasert (2011)

4.3.3 Plasma Gasification

Plasma gasification process is generating syngas when organic waste material is gasified. Syngas can be used for energy production through reciprocating engine generators, gas turbines and boilers. This technology was introduced by Dr. S.L Camacho in 1973. He shows this process able to produce gases that generate energy and useful byproduct such as aggregate that useful for construction. The emission of gases is under control. No ash is produced, so no need landfill to dispose the ash. This reduces landfill management cost.

Plasma gasification consists of few processes. Decomposition of waste material into basic structure occurs when matter is gasified in an oxygen starved environment. Arc is created when torch (consist of two electrode) is fed with electricity. Extremely intense energy that is maintained by constant flow of electricity through the plasma causes disintegration of garbage into its component elements. Plasma gasification Process also produces useful byproduct such as syngas and glass like substances that can produce household tiles. Syngas produce then use in cooling system to generate steam, steam then generates turbines to produce electricity. In this process, there no ash produce. So, landfill is not requiring disposing ash.

Plasma gasification process need similar cost compare to incineration process. But, plasma gasification process produce useful byproduct such as bricks and concrete aggregate that can be sold. While incineration process will produce ash and slag that need dispose in landfill. Large area of land is needed for landfill. Other than that, 50 percent more electricity will be produced by plasma gasification compare to other plasma technology.

Plasma gasification is a sustainable solution to dispose solid waste in Mahdhya Pradesh, India. This because, this technology does not require landfill, more economic because it also produce useful byproduct.

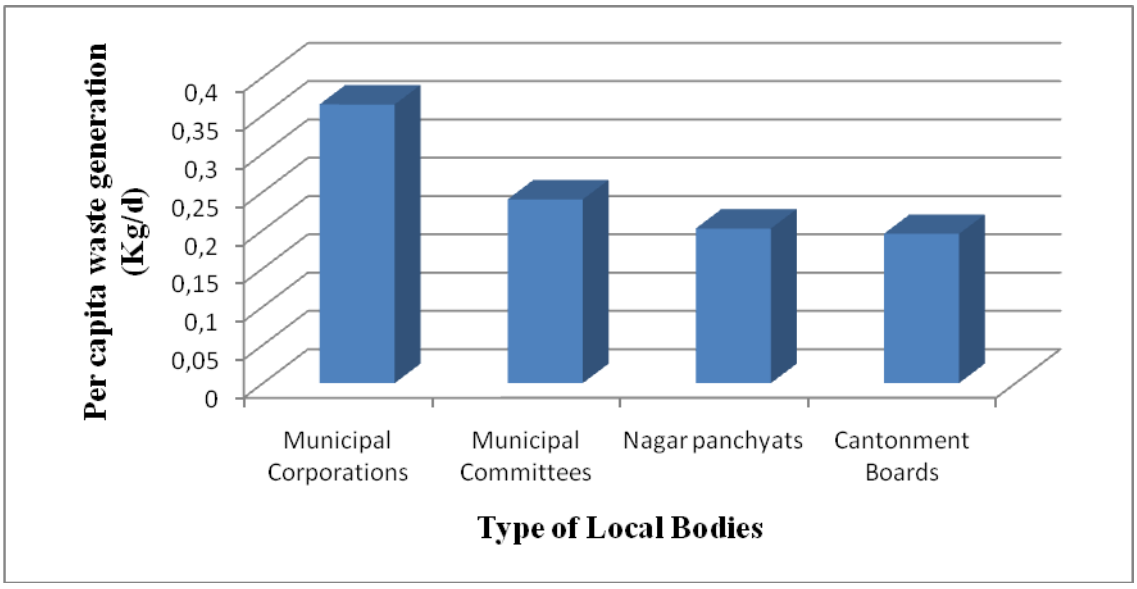


Figure 4.16: Municipal solid waste generation in Madhya Pradesh

Source: Patel Munna Lai (2012)

4.3.4 Tetra Pak

Tetra Pak packages is used for packaging of food, milk, juices and so on. In 1999, 86 billion packages were sold by Tetra Pak. Around the world, Tetra Pak has 78 marketing companies which in more than 165 countries. In packaging material, tetra Pak packages consist of paperboard, polyethene and aluminum. As example, in tetra Pak aseptic packages, it consists of large amount of paper (contribute 75 percent from total weight), aluminum (5 percent of total weight) and polyethylene (20 percent from total weight). Paperboard made from wood is use to make the package stable. Polyethylene is used to prevent from external moisture enter the product, while to prevent product from flavours, oxygen and light, aluminum (in aluminum foil form) is use.

The advantages of using Tetra Pak container compared to other paper container is it can store food without refrigerator. This is because the packaging material in tetra Pak packages can prevent product from flavours, oxygen, light and external moisture. So, no need of refrigerator to store food. Except that, we also can recycle tetra Pak packages. Paper that use in Tetra Pak packages material can recycle to new product such

as tissue, book and toilet paper. While, plastic and aluminum can be recycled to new products such as plastic pots and roof tiles.

There many countries use this Tetra Pak packages such as Brazil, China, Thailand, United Kingdom, Egypt and Japan. In China, 28000 of packages is recycled in 2008. While in Thailand, over 21 million of Tetra Pack cartoons is recycle to note book. To promote recycling in Japan, Marusan-Tetra Pak Recycling Service is develop. Those who want to recycled can mail their carton packages for free.

Tetra Pak give benefit to environmental impact. This is because Tetra Pak can be recycled. This also help to minimize the uses of paper, as paper is produced from plants. Uses of plastics in caps and also in packaging material can be reduce. Recycle of Tetra Pak also can minimize waste, so can reduce accumulation of waste that can harmful the environment by emission of methane gas that contribute to green house effect. Tetra Pak also is good food storage because the packaging material in Tetra Pak packages can prevent product from flavours, oxygen, light and external moisture.

As a conclusion, increasing of municipal solid waste collection requires appropriate method to reduce the effected to the enviroment. By taking the example of municipal solid waste management and power generation from other countries, it can serve as a model to be implemented in Malaysia. The objective of the study has been achieved.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

As we know, methane is one of the gases that contribute to green house phenomena. Municipal solid waste is one factor that increases the effect of green house gases. Through the methane emission which creates climate change such as increasing of temperature is causes by under controlling emission of green house gases. Methane and carbon dioxide released by degradation of anaerobic process in landfill area, while carbon dioxide, heat and water released by degradation of anaerobic process in landfill area. So, to reduce emission of harmful gases to atmosphere, everybody should concern about the treatment of municipal solid waste. Disposal of solid waste produce methane that is 21 times higher more damaging than carbon dioxide in resulting in global warming.

Production of methane from reaction of anaerobic in landfill consist three stages. First, Bacteria hydrolyzed complex molecules into glucose (soluble product). Then, glucose (soluble product) is converted into carbon dioxide, hydrogen and simple organic acid. The reaction shown below:

$$\underset{\text{(Glucose)}}{C_6H_{12}O_6} \longrightarrow 2C_2H_5OH + 2CO_2$$

Finally, bacteria form methane, used reducing of CO_2 into H_2, or by breaking down the acids. The reaction is shown below:

$CH_3COOH \longrightarrow CH_4 + CO_2$

(Acetic acid) (Methane)

$CO_2 + 4H_2 \longrightarrow CH_4 + 2H_2O$

(Methane)

All the reaction can be simplified in this reaction, which $C_6H_{10}O_4$ represent mix of organic waste.

$C_6H_{10}O_4 + 1.5H_2O \longrightarrow 3.25CH_4 + 2.75\ CO_2$

The equation below is use to calculate emission of methane by waste disposal:

$$Q = (MSW_T \times MSW_F \times MCF \times DOC \times DOC_F \times F \times 16/12 - R)(1-OX)$$

Where Q = total emission of methane (Gg/yr)

WSW_T = Total solid waste generated (Gg/yr)

WSW_F = Fraction of solid waste disposed to landfill

MCF = Methane correction factor

DOC = Degradable organic carbon (fraction)

DOC_F = Dissimilated organic fraction (i.e. fraction converted to landfill gases)

F = Fraction of CH_4 in landfill gas

R = Recovered CH_4 (Gg/yr)

16/12 = Molecular weight ratio of methane and carbon

OX = Oxidation factor (fraction)

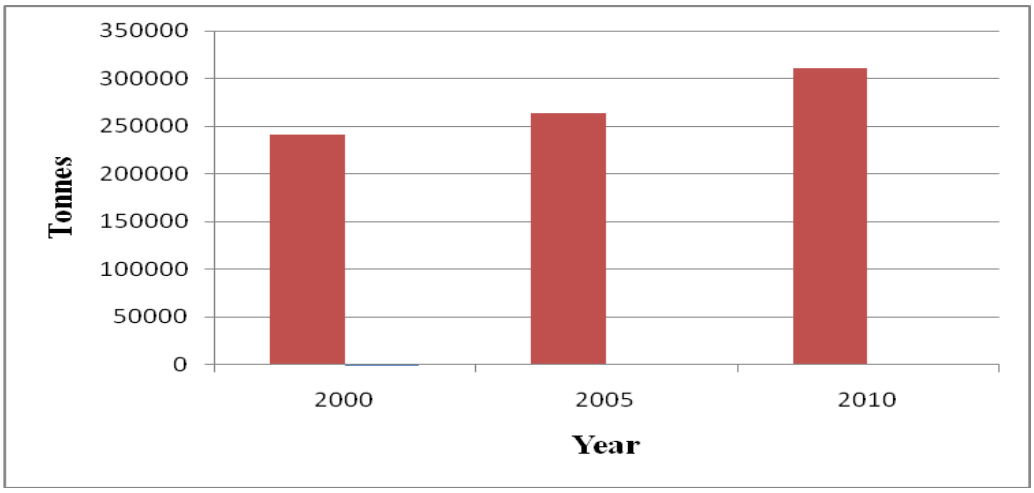


Figure 5.1: Emission of methane

Source: Z.Z. Noor et al. (2013)

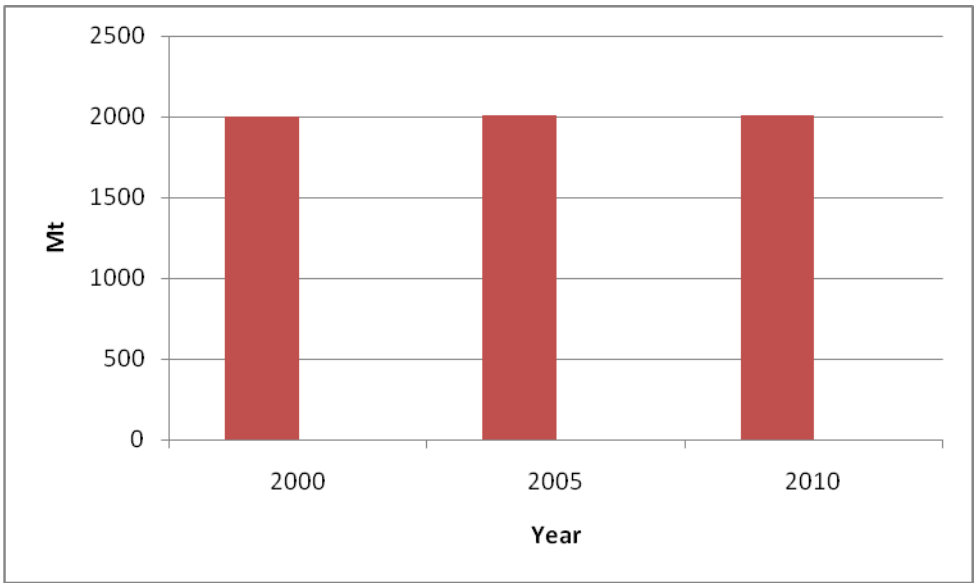


Figure 5.2: Equivalent carbon dioxide reduction

Source: Z.Z. Noor et al. (2013)

From combination of two graph above, emission of methane is parallel with carbon dioxide reduction. In 2006, emission of methane is 277824 tonnes while the carbon dioxide reduction 5.83 Mt. In 2007, emission of methane is 289747 tonnes, while carbon dioxide reduction is 6.08 Mt. In 2010, emission of methane is 310225 tonnes while carbon dioxide reduction is 6.50 Mt. This facts show that increasing number of methane emission, increasing number of equivalent carbon dioxide reduction.

Increasing of methane emission also increase equivalent electricity generation. In 2006, emission of methane is 277824 tonnes and equivalent electricity generation is 1.97×10^9 kWh. While in 2007, emission of methane is 289747 tonnes and equivalent electricity generation is 2.05×10^9 kWh. In 2010, emission of methane is 310225 tonnes and equivalent electricity generation is 2.20×10^9 kWh.

The paper reach conclusion achievement waste processing technology in Malaysia is very much different and out of practices compared with other develops countries. Validity factor is the state of the people's own attitudes regarding the lack of civic consciousness in the exposure how to manage waste and stability of the eco systems.

5.2 RECOMMENDATION

Through a survey conducted in Pekan and Rompin district, municipal solid waste management system in Malaysia needs to make upgrades in maintaining environmental balance. At the same time this indirect method can help to meet the growing electricity demand.

Plasma gasification plant is one of the efforts that the method can be applied to manage the increasing municipal solid waste. A plasma gasification plant can be proposed with its location close to the oil and gas complex in Tanjong Agas, Pekan. Located 6 kilometers from the town this proposed plant would selected to municipal

solid waste disposal and incineration indirectly puts Pekan on the world map as a centre for green technology and alternative energy.

Figure 5.3: Location of Tanjong Agas oil and gas complex

Plasma gasification plant complex near the Tanjong Agas oil and gas can use natural gas as a raw material are anxious to start the plant operation. As we know, the price of natural gas to 1 liter costs 68 cents and is lower than the price of 1 liter of diesel. Direct transmission of natural gas for this plant can save the cost of shipping raw materials.

Figure 5.4: Main entrance of Tanjong Agas oil and gas complex

Awareness and practices related to the need to maintain the stability of the environment should be applied since childhood stage.

Figure 5.5: Model of children exposure with municipal solid waste practice

The beginning is the exposure to children with physical objects that can attract them to play, made from recycle materials. As an example, of playground equipment and toys can be made using recycled plastic. Activities related to the environment would give positive response to children went through their development and everyday behavior.

Scientific approach should be used to emphasize the importance of maintaining the stability of the practice environment. A more interesting programme to children can be applied in practice through exposing the household municipal solid waste management through the viewing of videos and photographs. This exposure looked helps them to understand the value of future life with a comfortable environment.

Child growing up needs the exposure to the management of municipal solid waste to develop values not to throw garbage everywhere, not to be ashamed to collect the scattered rubbish and practice waste segregation. These values come from within the embedded childhood. This method can be used as one of the models with the community in an effort to preserve Malaysia as a country concerned with the environment.

High School level of recycling should be practiced by the community. Bins collection of recyclable materials should be created and monitored regularly. Concern in the management of solid waste that can be recycled reflect a good image of higher education is not just based on academics alone, but able to come together with the role of environmental issues.

Figure 5.6: Recycle bins location

The use of empty trash chamber can be also be used to collect as a collection of recycled materials more systematically. With the space enclosed and protected from the weather changes, this waste can be sent to the processing centre with better quality and save energy resources for processing. Location of waste chamber located between the buildings in the center of the high school learning to further facilitate the students, teacher and staff to submit material that can be recycled.

Figure 5.7: Solid waste chamber to implement a Recycle Centre

With the adoption of recycling culture in higher education at all levels of its citizens can become an example to the community about the importance of managing waste and its impact if not controlled, on Greenhouse Gas (GHG) emissions and climate change.

Figure 5.8: 3R campaign in high education institution

Source: UMP Media (2013)

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APPENDIX A1

GANTT CHART

Week/Activity	10/09 - 14/09	17/09 - 21/09	24/09 - 28/09	01/10 - 05/10	08/10 - 12/10	15/10 - 19/10	22/10 - 26/10	29/10 - 02/11	05/11 - 09/11	12/11 - 16/11	19/11 - 23/11	26/11 - 30/11	03/12 - 07/12	10/12 - 14/12	17/12- 21/12
	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12	Week 13	Week 14	Week 15
Final Year Project 1 start										Mid - term holiday					
Final Year Project title Briefing															
Final Year Project significance project study															
Idea elaboration based on journal															
Guidance and discussion															
Focus scope of research															
Literature review															
Methodology															
Submission of first draft report to supervisor and FYP coordinator															
Final Year Project 1 presentation															

Figure 6.1: Gantt chart for FYP 1

APPENDIX A2

GANTT CHART

Week/Activity	18/02 - 22/02	25/02 - 01/03	04/03 - 08/03	11/03 - 15/03	18/03 - 22/03	25/03 - 29/03	01/04 - 05/04	08/04 - 12/04	15/04 - \ 19/04	22/04 - 26/04	29/04 - 03/05	06/05 - 10/05	13/05 - 17/05	20/05 - 24/05	27/05- 31/05
	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12	Week 13	Week 14	Week 15
Final Year Project 2 start															
Guidance and disscusion															
Research															
Visit and fact finding															
Collect data of the project															
Analysis the project															
Second draft submmision								Mid - term holiday							
Final report preparation															
Final Year Project 2 presentation															
Submission final report															

Figure 6.2: Gantt chart for FYP 2