PRELIMINARY ASSESSMENT ON LAND SURFACE TEMPERATURE MAP AND SLOPE STABILITY AT JELUTONG LANDFILL

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DEDICATION

For my beloved parent, Mr. Aie Mursidi and Mdm Dahlia Abdullah,
who constantly pray for me and never give up on me.

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ABSTRACT

This project report presents preliminary assessment on land surface temperature (LST) map and slope stabilization of Jelutong landfill. Due to increasing waste produced every day, poor management of waste disposal will create more problem such as health risks and poor quality of environment. A well-designed landfill should be able to contain harmful waste by-products such as leachate, gases and heat from entering the ground or expose to the air and surrounding. Unmanned Aerial Vehicles (UAVs) are used to captured aerial view of the landfill and thermal infrared camera is used to detect the infrared range that produced warm objects stand out well against cooler backgrounds. Ground data sampling such as ground temperature also conducted to compare with hot spot detected in LST map. Leakage of gases also detected using gas detector with known concentration. In addition, the stability of landfill slopes is analysed using Slope/W Geostudio software to obtain its factor of safety (FOS). Two type of analysis method are used which are Mongerstern – Price analysis method and simplified Bishop's method to compare the results. The results obtained, and observation made in this study suggests that the integration of UAV with thermal imaging camera, respectively can be used to address this problem by monitoring the thermal signature of these waste sites and locate hotspots. The certain landfill slope stability is found to be unsafe and need to be avoided.

ABSTRAK

Laporan projek ini menjelaskan penilaian awal terhadap peta suhu permukaan tanah (SPT) dan kestabilan cerun di tapak pelupusan sampah Jelutong. Alam sekitar dan kesihatan penduduk terjejas disebabkan sistem pengurusan pelupusan sampah yang tidak teratur, oleh kerana peningkatan yang drastik dalam pembuangan sampah setiap hari. Tapak pelupusan sampah yang befungsi dengan baik seharusnya dapat mencegah hasil sampah yang merbahaya seperti larut resapan, gas berbahaya dan haba dari meresap masuk ke dalam tanah dan juga sekeliling. Pesawat tanpa pemandu (UAV) atau lebih dikenali sebagai dron digunakan untuk mengambil gambar dari pemandangan udara di tapak perlupusan sampah. Kamera thermal infrared digunakan untuk mengesan haba berdasarkan gambar yang diambil, dimana objek yang panas akan lebih menonjol berbanding objek yang sejuk. Suhu permukaan tanah juga direkod pada masa yang sama menggunakan termometer untuk dibandingkan dengan keputusan dari gambar yang diambil mengunakan dron. Di samping itu, kebocoran gas juga boleh dikesan menggunakan pengesan gas. Kestabilan cerun yang sedia ada di tapak perlupusan sampah juga boleh dianalisa menggunakan program Slope/W Geostudio. Terdapat 2 kaedah yang digunakan dalam analisa, iaitu kaedah Mongerstern – Price, dan juga kaedah Bishop. Berdasarkan pemetaan suhu permukaan tanah (LST) yang diperolehi, beberapa tempat yang mempunyai suhu yang tinggi dapat dikesan, dan kebocoran gas berpotensi untuk yang dikesan. Akhir sekali, sesetengah cerun di tapak perlupusan sampah Jelutong adalah tidak selamat dan penambahbaikan diperlukan untuk memastikan keselamatan semua pihak.

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LST	-	Land surface temperature
UAV	-	Unmanned Aerial Vehicle
FOS	-	Factor of safety
MSW	-	Municipal solid waste
LFG	-	Landfill gas
CH_4	-	Methane
CO_2	-	Carbon dioxide
ASTM	-	American Standard Test Method
RGB	-	Red green blue
NIR	-	Near-infrared
CO	-	Carbon monoxide
H_2S	-	Hydrogen sulphide
O_2	-	Oxygen
LEL	-	Lower explosion limit
RMSE	-	Root mean square error

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CHAPTER 1

INTRODUCTION

1.1 Background of the study

As human population growing day by day all around the world, production of waste is also increasing. In a developing country like Malaysia, waste production is increasing rapidly due to rapid growing population of human. There are two general classifications of waste; domestic waste and industrial waste. Domestic waste is produced from kitchen and food waste. Meanwhile, waste resulting from the manufacture, construction, processing, or maintenance works are known as industrial waste.

Waste in Malaysia dominated by organic waste, which comprises more than 40% of the total waste stream. The average organic waste was approximately 50% in the 1980s and 1990s and mainly consisted of processed kitchen waste and food waste (Periathamby *et al.*, 2009). Idris *et al.* (2004) mentioned that Asian countries with greater rural population produce more organic waste instead of recyclable items, such as kitchen waste.

Despite the massive amount and complexity of waste produced, the waste management system in Malaysia are still poor. The waste management system includes organized programs and central facilities established not only for final disposal of waste but also for recycling, reuse and composting. Due to this, landfill or waste disposal sites cause problems that may affect the environment.

Leakage of leachate, landfill gases (LFG), and heat are common problems found in landfill. Research have been conducted for the past few years to overcome these problems. Study shows that LFG are used and utilized for energy recovery such as electricity (Yip and Chua, 2008). Meanwhile, to overcome leakage of leachate, the landfill system must be design properly based on the criteria and requirement needed. Treatment of leachate also have been practiced for all over the years to reduced leachate contamination to the ground water and surface. As leachate contamination will be harmful because of the toxic in the waste composition, leachate must be treated to avoid any issues in the future. However, research to overcome heat produced from landfill are limited.

Moreover, the instability of the landfill slopes also needs concern because of several landfill slope failures had occurred at different places all around the world affecting the environment and damaging the surrounding area. Mitigation of landfill slopes must be taken care to avoid worst case scenario.

1.2 Problem statement

Regulated engineered landfill was established in the early 1990's for municipal solid waste (MSW) in Malaysia, as the population increased to protect and reduce adverse environmental impacts. Generally, most of the MSW landfill design and construction principles apply equally to hazardous waste landfills. Proper MSW management is crucial for urban public health. Currently, there are total of 155 operating non – sanitary landfills (disposal sites), and only 12 sanitary landfills available in Malaysia (Agamuthu, 2010).

Figure 1.0. Thick smoke seen after fire distinguished at Jelutong Landfill in 2017 (Thevadass, 2017).

Jelutong landfill located in Penang involved in fires in 2015 and 2017, the cause of fire has yet to be determined (Tan, 2015; Thevadass, 2017). Meanwhile, Padang Siding landfill also caught on fire in 2014

and 2016, it was believed that the fire was triggered by the hot and dry weather (Malaysian Digest, 2014; Shazwani, 2016). Landfill fires are unpredictable and can happen anytime.

There are three common products of landfilling which are leachate, gas, and heat (Hanson and Kendall, 1993). Leakage of gas generated through anaerobic processes in landfill may be one of the factors of landfill fires to occur. When MSW is disposed at a landfill, an anaerobic process will take place and eventually produce landfill gas (LFG), which consists of methane (CH_4), carbon dioxide (CO_2) and other gases (Yip & Chua, 2008). These gases can lead fire started either spontaneously or explosion to occur. According to Yip and Chua (2008), an average of 200m^3/tonne of waste at the landfill produced about 3.2 million m^3 of LFG per day. In Malaysia, to reduce the emission of the LFG to the surrounding, flaring is used as it is one of the sufficient gas treatments in small facility. In addition, the first LFG recovery plant in Malaysia operated in 2003 and used to generate electricity using LFG.

However, there is no further investigation on heat generation from landfill. Most of the investigation focuses on the LFG production and leachate treatment. Heat generated from anaerobic process in landfill can be detected using thermal cameras. Gade and Moeslund (2014) mentioned that the special detector technology used to capture thermal infrared radiation has been introduced to wide range application, such as building inspection, gas detection, industrial appliances, medical science, veterinary medicine, agriculture, fire detection, and surveillance. Over the years, thermal cameras have been used for inspecting heat loss from buildings, and this method also can be applied

to inspect heat generated from landfill. Thermal mapping can be produced from the results of the thermal images and further safety precautions can be taken in advance. Since landfill fires are difficult to extinguish, and they create a lot of smoke which may be harmful to the environment and surrounding area, it will be easier if thermal map is produced.

For the past few years, landfill slope failure caused major problem because of the affects involving major destruction to the surrounding area. In 2015, a catastrophic landslide occurred in Shenzhen, China causing 33 buildings damaged and 77 people killed (Gao *et al.*, 2019). The improper management of landfill such as poor design of stabilization of slopes may cause problem such as slid down of waste. Uncontrolled huge pile of waste can cause a problem if there are no proper design for the slopes in landfill.

1.3 Objectives of the study

This study aims to investigate the potential hotspot for landfill fires. The specific objectives are;

- To establish topographical map and land surface temperature (LST) map.
- To assess the gas in landfill from thermal imaging using thermal infrared camera (TIR).
- To analyse the stability of the existing landfill slopes

1.4 Scope of the study

This study concentrates on identifying potential hotspot of fire risks where leakage of gas occurred in landfill.

The research will be limited to:

1) The distance between the sensor (camera) and source of heat (leakage of gas) may affect the results of the image captured.
2) Weather conditions (light, wind, and surrounding temperature).
3) Time for the data collection.

On the other hand, this study also focuses on determining the factor of safety of existing slope at the landfill. The stability of the landfill slope is one of important parameter in designing landfill in order to provide a well – regulated landfill.

1.5 Significance of the study

The findings of this study are important to produce data such as land surface temperature maps and stabilization of the landfill slopes. With this information, further improvement to the existing landfills will be taken care.

1.6 Organization of thesis

This thesis consists of five chapters. Chapter 1 presents general information regarding background, problem statement, objectives, scope of study, significance of the study and the organization of the thesis.

Chapter 2 discussed on the literature review that provides the background of the study on different topics related to the research. In this chapter, topics such as landfill system in Malaysia, followed by Penang landfill system, effects of landfill to environment, how thermal infrared radiation (TIR) camera works and the stabilization of landfill slope are discussed.

Meanwhile, Chapter 3 provides the methodology of the research and discussed on the overall procedure and all equipment used while conducting this research. This chapter also includes the laboratory testing procedure used for soil testing and the analysis of the existing slope using Slope/W software analysis.

Chapter 4 represents results obtained and the analysis of the study. All thermal mapping produced are discussed and analysed in this chapter. Results of Factor of safety from Slope/W analysis also discussed.

Lastly, Chapter 5 presents the conclusion of the overall results and recommendations for further study.

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