A STUDY ON THE CHARACTERISTICS OF POTENTIAL LANDFILL SITE IN KUANTAN,PAHANG, MALAYSIA.

NURLINA AUNI BINTI MAZELAN
AA08074

A thesis submitted in fulfillment of the requirements for the award of the degree of Bachelor of Civil Engineering

Faculty of Civil Engineering & Earth Resources
University Malaysia Pahang

JUN 2012

ABSTRACT

Most countries give full attention to the selection of new waste disposal sites. When the current waste disposal sites are met, searching for a new landfill site will be a complicated process and takes a long time. Site selection is crucial and necessary for waste management in areas where are growing rapidly. Due to the complexity of waste management systems choose a new landfill as appropriate, a number of alternatives and evaluation criteria required for consideration. A study was carried out in the Kuantan to overcome the problem of waste disposal sites in Jabor, Kuantan has become critical. The main purpose of this study was to identify potential new disposal site in Kuantan, Pahang. Besides, this study was to determine the evaluation criteria which important for waste disposal sites and it will be used in the Analysis Hierarchy Process (AHP) for the selection of disposal sites. In an effort to make the right decision in assessing the important evaluation criteria, a questionnaire was designed and distributed to the experts. The data obtained from the questionnaires will be analyzed using the Statistical Package for Social Sciences (SPSS). The results from this study, the alternatives and the important criterion in the selection of disposal sites can be used for further study by using Analysis Hierarchy Process (AHP). Based on the results, four main criteria which important in the selection of a suitable waste disposal sites are hydrological and hydrogeological, morphologic, social factors and economic impact.

ABSTRAK

Kebanyakan negara memberi perhatian sepenuhnya terhadap pemilihan tapak pelupusan sisa. Apabila tapak pelupusan sisa semasa dipenuhi, pencarian tapak pelupusan baru akan menjadi satu proses yang rumit dan mengambil masa yang lama. Pemilihan tapak adalah isu yang sangat penting dan perlu untuk pengurusan sisa di kawasan-kawasan yang sedang berkembang pesat. Disebabkan kerumitan sistem pengurusan sisa memilih tapak pelupusan sampah baru yang sesuai, beberapa alternatif dan kriteria penilaian diperlukan untuk pertimbangan. Satu kajian telah dijalankan di kawasan Kuantan bagi mengatasi masalah tapak pelupusan sisa di Jabor Kuantan telah mencapai tahap kritikal. Tujuan utama kajian ini dijalankan adalah untuk mengenal pasti tapak pelupusan berpotensi yang baru di Kuantan, Pahang. Kajian ini juga adalah untuk menentukan kriteria tapak pelupusan sisa yang sesuai dan akan digunakan dalam Proses Hierarki Analisis (AHP) bagi pemilihan tapak pelupusan. Dalam usaha untuk membuat keputusan yang betul dalam menilai kriteria penilaian yang penting, satu soal selidik telah direka dan diedarkan kepada pihak yang lebih pakar. Data yang diperolehi daripada soal selidik tersebut akan di analisis menggunakan perisian Pakej Statistik untuk Sains Sosial (SPSS). Akhir sekali, keputusan daripada kajian ini, kawasan kajian dan kriteria penting dalam pemilihan tapak pelupusan boleh digunakan untuk kajian seterusnya dengan menggunakan Proses Hierarki Analisis (AHP). Berdasarkan keputusan yang diperolehi, empat kriteria utama terlibat dalam pemilihan tapak pelupusan sisa yang sesuai iaitu hidrologi dan hidrogeologi, keadaan muka bumi, social factor dan kesan ekonomi.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Waste was an early problem of mankind, and a growing one that is of major concern to every nation of the world. In early pre-industrial times, waste generation was not an issue as populations were smaller. The increasing development of urban areas and population growth caused a tremendous amount of municipal solid wastes generation, presenting a problem in urban environment. Although there is a tendency toward solid waste reduction at source through reuse and recycle of solid waste, landfill is still the final disposal method (Sumathi et al., 2007).

A landfill site is a site for the disposal of waste materials by burial and is the oldest form of waste treatment. Historically, landfills have been the most common methods of organized waste disposal and remain so many places around the world (Wikipedia). Many landfills are also used for waste management purposes, such as the temporary storage, consolidation and transfer, or processing of waste material. Landfill technique consists of loading, scattering, and covering of waste material with soil in a sanitary manner. Landfill is the most widely used methods in municipal solid waste management in urban areas, but landfill site selection is a serious issue in the urban planning process due to enormous impacts on the economy, ecology, environment and public health. The issue is particularly severe in developing-country cities where increased population, poor planning, and lack of adequate resources contribute to the poor state of municipal solid waste disposal causing environmental and health hazards (Tchobanoglous et al, 1993).

Presently, in Peninsular Malaysia, in 2002 there was 17,000 tones solid waste generated and the generation of solid waste expected will be reach to 30,000 tones per day in 2020. There are only 179 landfill include sanitary still operating compare with 291 landfill sites all over the country as at 2007. Therefore, the alternatives to solves the problem of increasing solid waste, government should find and construct the new landfill site.

1.2 Problem Statement

Pahang is one of the state which need several new landfills because at least three sites are already nearing their capacity, the landfill site in Temerloh had already exceeded its capacity and waste material was now being sent to the neighbouring district of Bera, state Local Government, Environment and Health Committee chairman Datuk Hoh Khai Mun said. The Jabor sanitary landfill in Kuantan has reached critical stage because waste is still being dumped at the site which was supposed to be closed for rehabilitation on Dec 31, 2006 (Roslina., 2008). A strategic location of landfill must be adhering with environmental, economical, and political consideration. A landfill must be chosen by the evaluation criteria determined to achieve landfill site suitability.

1.3 Objectives of Study

i. To identify potential landfill site in Kuantan, Pahang.

ii. To determine the suitable criteria to be used in AHP decision making for landfill site selection.

1.4 Scope of work

The scope of work includes the procedures which field research and analysis which important to collect data and information about the evaluation criteria needed and also prepare the questionnaire for choosing suitable sites for landfill sitting. It should be classified into 3 main categories which physical, environmental and socio economic. Then, there should be followed with software application, Statistical Package Social Sciences (SPSS) which help to analyze the survey data. Then, the potential sites will be chosen based on the criteria evaluation.

CHAPTER 2

LITERITURE REVIEW

2.1 Introduction

Urbanisation is one of the most evident global changes in the world. In the last 200 years, world population has increased six times, and the urban population has multiplied 100 times (Radzicki, 1995). The rapid urban growth has exerted heavy pressures on land and resources contained within the area surrounding cities, and resulted in serious environmental and social problems (Leao et al., 2001). So, the demand for land to dispose of this waste will increases proportionately with population. The net waste production increases as population grows, and the per capita generation of waste is also increasing, particularly in developing countries (The World Bank, 1999). Many countries and institutions currently pay great attention to landfill site selection. When current waste disposal sites are filled, the search for a new waste site can be a time consuming process. Landfilling has been used for many years as the most common method for the disposal of solid waste generated by different communities (Komilis et al., 1999). Historically, landfills were placed in a particular location more for convenience of access than for any environmental or geological reason. Now more care is taken in the siting of new landfills. For example, sites located on faulted or highly permeable rock are passed over in favor of sites with a less-permeable foundation. Rivers, lakes, floodplains, and groundwater recharge zones are also avoided. It is believed that the care taken in the initial siting of a landfill will reduce the necessity for future clean-up and site rehabilitation. Due to these and other factors, it is becoming increasingly difficult to find suitable locations for new landfills. Easily accessible open space is becoming scarce and many communities are unwilling to accept the siting of a landfill within their boundaries. Many major cities have already exhausted their landfill capacity and must export their trash, at significant expense, to other communities or even to other states and countries.

2.2 Waste Management Method

In order to define waste management, there are include several different processes such as collection, transport, processing, recycling, disposing, and monitoring of waste. Without proper waste management we are not only harming a beauty and health of our environment but we are also reducing negative effect that waste can have on our own health. Waste management significantly differs for developed and developing countries, and many developing countries are still many years away from developing proper waste management systems. There have 4 basic waste disposal method which open dumping, landfill, sanitary landfill, and incineration.

2.2.1 Open Dumping

The cheapest and the oldest easy method of municipal solid waste disposal is 'open dumping' where the waste is dumped in low - lying areas on the city outskirts and leveled by bull - dozers from time to time. Open dumping is not a scientific way of waste disposal. Open dumps refer an uncovered site used for disposal of waste without environmental controls. The waste is untreated, uncovered, and not segregated. In spite of its simplicity in execution, the financial involvement for this traditional method of waste management has been quite high particularly for the big metropolis. Uncontrolled, open dumps are not a sound practice. Open dumps are exposed to flies and rodents. It also generates foul smell and unsightly appearance. Loose waste is dispersed by the action of wind. Drainage from dumps contributes to pollution of surface and ground water and also the rainwater run-off from these dumps contaminates nearby land and water thereby spreading disease. A WHO Expert Committee (1967) condemned dumping as "a most unsanitary method that creates public health hazards, a nuisance, and severe pollution of the environment. Dumping should be outlawed and replaced by sound procedures". (Parshurame et al., 2010)

2.2.2 Landfill

Disposing of waste in a landfill involves burying the waste, and this remains a common practice in most countries. Landfills are generally located in urban areas where a large amount of waste is generated and has to be dumped in a common place. The equipment required to operate is relatively inexpensive and can be used for other municipal operations as well serious threat to community health represented by open dumping or burning is avoided. Landfills were often established in abandoned or unused quarries, mining voids or borrow pits. Unlike an open dump, it is a pit that is dug in the ground. The waste is dumped and the pit is covered at the dumping ground with debris/ soil and spread evenly in layers. At the end of each day, a layer of soil is scattered on top of it and some mechanism, usually an earth moving equipment is used to compress the garbage, which now forms a cell. Thus, every day, garbage is dumped and becomes a cell. The organic waste undergoes natural decomposition and generates a fluid, which is known a leachate, and is very harmful to the ecosystem. After the landfill is full, the area is covered with a thick layer of mud and the site can thereafter be developed as a parking lot or a park.

2.2.3 Sanitary Landfill

An alternative to landfills or modern landfill which solves the problem of leaching to some extent is a sanitary landfill which is more hygienic and built in a methodical manner. Designed "landfill" means a waste disposal site for the deposit of residual solid waste in a facility designed with protective measures against pollution of ground water, surface water and air fugitive dust, wind-blown litter, bad odour, fire hazard, bird menace, pests or rodents, greenhouse gas (Methane) emissions, slope instability and erosion. These are lined with materials that are impermeable such as plastics and clay, and are also built over impermeable soil. Deposited waste is normally compacted to increase its density and stability, and covered to prevent attracting vermin (such as mice or rats).

Many landfills also have landfill gas extraction systems installed to extract the landfill gas. Gas is pumped out of the landfill using perforated pipes and flared off or burnt in a gas engine to generate electricity. Fully operated landfills may even enhance property values. Constructing sanitary landfills is very costly and they are having their own problems. By and large, crude dumping of waste is done in the most of the cities without following the principles of sanitary landfilling. As negligible segregation of waste at source takes place, all waste including hospital infectious waste generally finds its way to the disposal site. Quite often industrial hazardous waste is also deposited at dump sites meant for domestic waste. The waste deposited at the dump site is generally neither spread nor compacted on a regular basis. It is also not covered with inert material. Thus, very unhygienic conditions prevail on the dump sites. The workers handling waste do so in highly unhygienic and unhealthy conditions. Leachate if not treated properly it penetrates the soil and, if not prevented, pollutes the ground water.

2.2.4 Incineration

The process of burning waste in large furnaces at high temperature is known as incineration. Incineration is a disposal method that involves combustion of waste material. Incineration and other high temperature waste treatment systems are sometimes described as "thermal treatment". Incineration is carried out both on a small scale by individuals and on a large scale by industry. It is used to dispose of solid, liquid and gaseous waste. Incineration facilities generally do not require as much area as landfills. Waste-to-energy or energy-from-waste is broad terms for facilities that burn waste in a furnace or boiler to generate heat, steam and/or electricity. At the end of the process all that is left behind is ash. It is recognized as a practical method of disposing of certain hazardous waste materials (such as biological medical waste). Combustion in an incinerator is not always perfect and there have been concerns about micro-pollutants in gaseous emissions from incinerator stacks. Particular concern has focused on some very persistent organics such as dioxins which may be created within the incinerator. Both the fly ash and the ash that is left in the furnace after burning have high concentrations of dangerous toxins such as dioxins and heavy metals. Disposing of this ash is a problem. Cost of incinerator and additional investment on pollution control devices make the process capital - intensive. Under Indian conditions large scale incineration plants are economically non - viable in view of their capital - intensive character and the low calorific value of city garbage available. (Parshurame et al., 2010).

2.3 Background Of Solid Waste Management

2.3.1 Waste management in South Korea

South Korea is a major industrial and trading nation. With a population of 48 million in 2001, South Korea's municipal waste is 48,499 tons per day with a very high percentage of packaging and food waste. The packaging and food waste has increased continuously as a result from the rise in consumption in proportion to the rise in income levels. According to the South Korean Ministry of the Environment, 4 million tons of food waste are generated per annum and the associated national expenditure (which includes the disposal and negative environmental impact cost from the food waste) is estimated to be US$ 12.5 billion per year. South Korean Non Governmental Organizations (NGOs) think that the large generation of food waste in South Korea is caused by the Korean food culture that prefers a rich dining table. An additional of 95,908 tons of waste per day is generated by industrial facilities and another 108,520 tons per day come from construction sites.

The solid waste treatment methods used in South Korea are landfill, dumping at sea, incineration and recycling. Since the introduction of incineration equipment in the early 1990s, the amount of incinerated waste is increasing. Incineration is seen as the best way to handle non-recyclable wastes, given the limited land space to landfill waste in South Korea. In 1995, it accounted for only 4 % of solid waste treatment but in 2000 the rate was 12 %. Even though incineration helped to solve the problem of limited landfill spaces. In South Korea, recycling is a preferable method for waste disposal due to its efficiency in waste reduction (Lau, L., 2002).

2.3.2 Waste management in South Africa

The nature and procedures for waste disposal vary from country to country. In South Africa, there are about 540 landfill sites of which 61% have permits, however, there could be 15,000 landfill sites including communal sites in the country (Ogola et al, 2009). The 5 million tons of waste produced every year, only 5% is disposed of in designated sites, thus most waste in South Africa is disposed in environmentally unsafe sites. The State of Environmental Report for the City of Cape Town (2003) outlines the expanding economy, increasing population and visitors as contributing factors to the increased waste generation rates in the city. This has contributed to 7% increase in waste landfilled between 96 Integrated Waste Management – Volume I 2001 and 2002, which is far in excess of 2% population growth.

This report reflects that 90% of waste generated in the City of Cape Town is landfilled. In 2002 a total of 1,722,807 tonnes of waste was disposed at the six landfills and this showed an increase of 7.3% as compared to 1,596,000 tonnes disposed in 2001, which was an increase of 6.5% from 1,493,000 tones generated in 2000. Waste landfilled consists of 30% household waste, 15% sewage sludge and landfill, Semakau Landfill. Waste such as construction and demolition refuse that cannot be incinerated, is directly disposed of at Semakau Landfill. As both incineration plants and landfill are capital-intensive infrastructures and require large tracts of land, it is not sustainable for land-scarce Singapore to continue building incineration plants and landfills to cope with the growing demand for waste disposal (Ministry of the Environment and Water Resources Singapore). In Singapore, the hierarchy is based on waste minimization (reduce, reuse, and recycle-3R) followed by incineration and landfill. Land is very scarce in this country and this has resulted in incineration as the most preferred method of treatment (Bai and Suntanto, 2001). The United States Environmental Protection Agency (USEPA, 2006) has ranked the most environmentally sound strategies for Municipal Solid Waste (MSW) as source reduction (including reuse) the most preferred method, followed by recycling and composting, and, lastly, disposal in combustion facilities and landfills.

2.3.4 Waste management in Gaza

The German Agency for Technical Cooperation (GTZ) recently assisted the Solid Waste Management Council of the Gaza Strip in closing down a number of open dumps and building a properly designed, constructed, and managed landfill. The first step in constructing a landfill was to assess soil and groundwater conditions at several potential locations. Two important site selection criteria were soil with enough clay content to serve as a natural barrier to leachate and a site away from major drinking water sources. Once the team found a site, it hired local contractors to prepare the landfill site and cover the surface with an asphalt liner. It then built a storage pond and installed drainage pipes that carry leachate into the pond. Since Gaza has no municipal wastewater treatment facilities to treat the leachate, the team installed pumps and a sprinkler system that recirculates the leachate back to the landfill, allowing it to evaporate. The team considered recirculation to be a reasonable option because it did not expect the region's dry climate to generate much leachate and anticipated most of the leachate would be managed through evaporation. However, the storage pond and pumping system were later enlarged to handle larger-than-expected leachate levels. Once the landfill was in operation, they closed the open dumps, controlled access to the new site and began transfer of waste into the new landfill. The team expects the landfill to last for approximately 13 years. As the team closes filled sections of the landfill, it covers the area with compost generated from digging up and screening organic material from older sections of the landfill. The compost serves as a cost-effective final cover that helps break down the methane as it leaves the landfill surface. The compost also supports vegetation that grows on the landfill surface, which helps reduce the flow of leachate. The project is a successful example of an upgrade of disposal standards (Swiss Agency for Development and Cooperation Web).

2.3.5 Waste management in Malaysia

In Malaysia, the average amount of municipal solid waste generated was approximately 1.2 kg/day in 2000 (Agamuthu, 2001). The sources and quantities of municipal solid waste vary among local authorities in Malaysia depending on the township size and level of economic standards. The amount generated may range from 45 tonnes/day of municipal solid waste (MSW) in Kluang, which is a small town in a southern part of Peninsular Malaysia, to 3000 tonnes/day in Kuala Lumpur (Agamuthu et al., 2004). Waste is grouped into three different categories in respect of disposal – solid waste, medical waste and hazardous waste. According to a study by E. Grant Anderson in five states (KualaLumpur, Selangor, Pahang, Terengganu and Kelantan) representing 64 % of the waste is domestic waste. The share of industrial waste stands at 15 % ,followed by commercial waste and construction and institution waste.

Presently, there are three types of waste disposal categories – solid waste disposal and incineration, medical waste incineration and hazardous waste incineration. The disposal of solid waste is done almost solely through landfill. There are 168 disposal sites throughout the country, of which only seven are sanitary landfills. The rest are open dumps and about 80 % of these dumps have been filled up to the brim and have to be closed in 2005(Consumer Association,2001). Table 2.2

shows the existing landfill sire for each states in Malaysia. The government then introduced a new law on solid waste management where the principal processes options are being classified in a system for integrated waste management. Within this system, there is the following hierarchy: waste minimization, reuse, material recycling, energy recovery and landfill. Beside this, the Malaysian government also launched a recycling campaign in December 2000 which sets the long term target of recycling 22 % of the waste generated by 2020 (Consumer Association,2001).

Table 2.2 : Existing landfill sites in Malaysia (Ministry of Housing and Local Government, 2002)

No.	States	Number of Landfill	Average area (ha)	Waste received (ton/day)	Landfill Level				
					Level 0	Level 1	Level 2	Level 3	Level 4
1	Johor	18	5.6	1,082	10	6	2	1	0
2	Melaka	4	18.5	1,065	2	0	1	1	0
3	Negeri Sembilan	11	10.9	727	7	3	1	0	0
4	Selangor	14	10.6	2,285	0	7	1	1	5
5	Pahang	14	8.7	895	5	3	2	3	1
6	Terengganu	8	5.6	707	2	4	1	0	1
7	Kelantan	12	5.6	424	10	1	1	0	0
8	Perak	19	10.3	1,450	9	6	3	1	0
9	Kedah	10	7.7	893	3	2	4	0	1
10	P. Pinang	2	22.3	1,400	0	0	1	1	0
11	Perlis	1	4.0	100	0	0	0	0	1
12	Sarawak	36	2.9	1,000	20	14	2	0	0
13	Sabah	20	21.7	851	15	4	1	0	0
14	KL	1	12.0	600	0	0	1	0	0
15	Labuan	1	12.1	12	0	1	0	0	0
Total		171	9.1	13,491	83 48%	51 30%	21 12%	8 5%	9 5%

Notes: Level 0: Open dumping
Level 1: Controlled tipping
Level 2: Controlled landfill with bund and daily cover soil
Level 3: Sanitary landfill with leachate recirculation system
Level 4: Sanitary landfill with leachate treatment system

2.4 Landfilling

2.4.1 Trench Method

Figure 2.1 shows trench method which the ditch or channel must be dig long and narrow through in the ground and the waste was buried in it and it will cover with soil. The trench method is very cost effective for desert regions. Soil excavated from the digging of the trench can be used as a cover material. It should have cover help control disease and odours, reduce the possibility for fires and discourage vermin such as rats and mice. The trench method of landfilling also is useful for a gently sloping site, as it reduces the need for expensive and time-consuming cut and fill work to flatten the site. A trench landfill can be designed with the trenches dug horizontally along the contour. When the landfill is in use the trenches are filled sequentially from the top of the slope to the bottom. Trenches can only be dug on a site that has soil which is easily excavated. Rocky or stony sites do not easily lend themselves to the trench method of landfilling. Size of the trenches in a trench landfill is about 50 metres long x 2.5 metres deep x 6 metres wide, or at least twice the width of the blade of the machine that will be used for dumping, pushing and compacting the waste.

Figure 2.1 : Trench method

2.4.2 Area Fill Method

For larger communities or sites that are susceptible to flooding, stony or rocky, the area fill method as shown in Figure 2.2 is useful. For this method, the waste is entirely above ground. Usually a flat area is used and the waste is deposited and then compacted so that it is not more than two meters above the ground. Sometimes you can take advantage of a natural depression or low area in the ground, filling it with rubbish and then bringing it up to the same height as the surrounding land area. This can be especially useful if you are planning to use the site as a football field when the tip is full of rubbish and finished. Waste deposited using the area fill method needs just as much cover material as waste that has been deposited in a trench; i.e.at least 150mm. The place where the waste is deposited, known as the 'active face', should be at right angles to the direction of the prevailing wind, so that litter will not be blown around. Usually, waste is deposited in layers of about one meter. If there is a natural depression there may be many layers. If the landfill is built on flat ground then there usually will be only two layers. Each layer is made up of smaller quantities of waste that are known as 'cells'. If the area method is to be used for a very large community (1,000 or more people), it will be necessary to protect the groundwater. This will mean lining the bottom of the landfill with well-compacted clay. If there is no clay available, it may be necessary to use a high-tech geotextile liner.

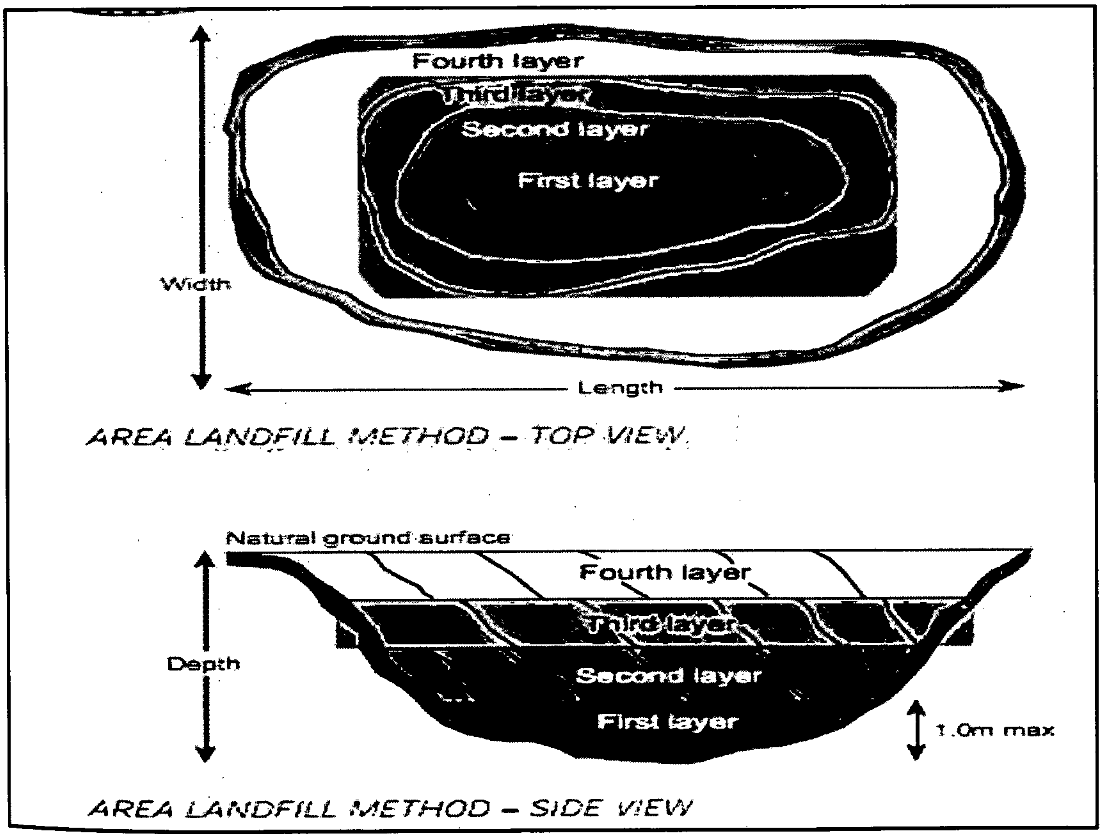

Figure 2.2 : Area landfill method

2.4.3 Cell Method

The last, cell method is a variation of the area method. It is similar to the area method in that the waste is deposited directly on top of the ground without the need for excavating trenches. However a bund wall (or berm) of earth is made and the waste is pushed up against this. This bund wall prevents stormwater from running onto the waste and diverts it away from the landfill. The cell method is useful for larger communities and stony sites, and is the best method for flood-prone areas. As with the area fill method, a large quantity of fill material willhave to be imported if the cell method of landfilling is used. In fact an even larger quantity is needed so that the bund or berm can be constructed. When a bund is constructed, it should be built up to the height of the finished landfill.

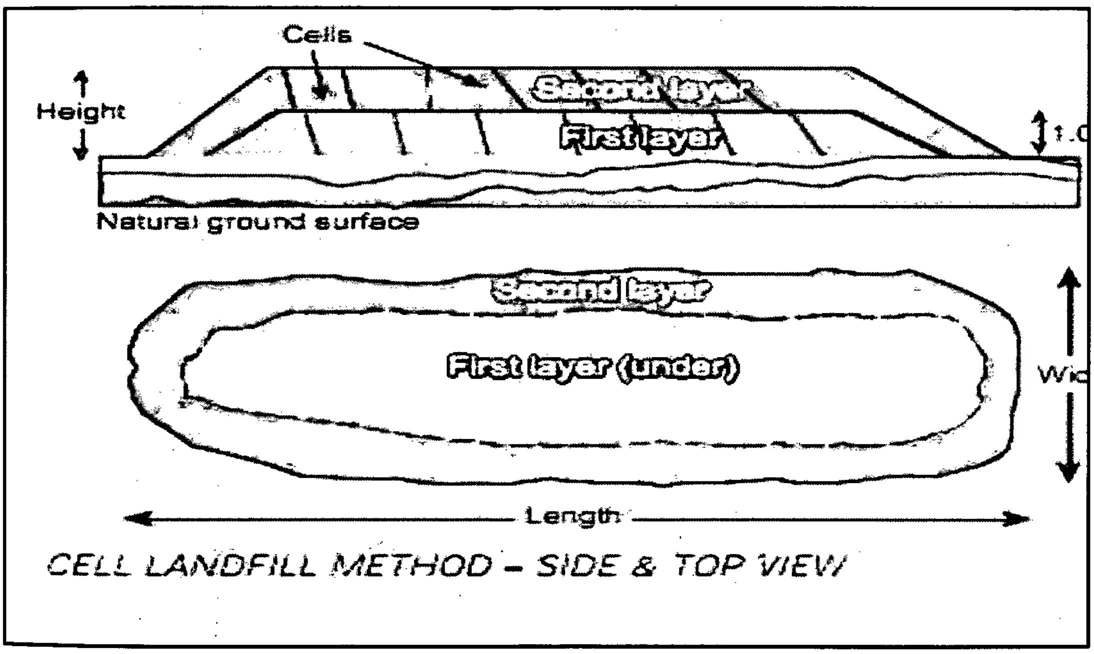

Figure 2.3 : Cell landfill method

As illustrated in Figure 2.3 above, there should be a flat section on top of the grade which should be at least the same width as the backhoe or other earthmoving machinery which will be used to cover the waste. The outside of the berm should be compacted very firmly to ensure that soil erosion does not occur. The slope of the outside of the bund should be 5:1. Drainage should be considered to ensure that