International Journal of Engineering and Science Applications
ISSN: 2406-9833

IJEScA

New Landfill System in North Kolaka Regency, Southeast Sulawesi, Indonesia

I. R. Rahim[1], & A. R. Djamaluddin[2]

[1] Environmental Engineering Study Program, Hasanuddin University, Gowa, Indonesia
[2] Department of Civil Engineering, Hasanuddin University, Gowa, Indonesia
Correspondence: Irwan Ridwan Rahim, Environmental Engineering Study Program, Hasanuddin University, Gowa, Indonesia.
Tel: (+62)-815-252-2004. E-mail: irwanrr@eng.unhas.ac.id

ABSTRACT

Most waste disposal sites in developing country are still using open dumping and open burning However, in developing countries, there are a lot of economically and technical problems with high level landfill technologies of first world countries making implementation of improvement not feasible. Therefore, there is significant need for transfer of landfill technology that is simpler, low cost, and that can be maintained locally. A method that provides this that has recently gathered attention is the Fukuoka Method (semi-aerobic landfill). By life cycle cost analysis method, with the lifespan of the landfill is 20 years and an estimated volume of 586,789 m3 (469,431tonnes), the capital investment required was about US$296,739 (natural clay liner) and US$463,406 (synthetic-liner) or about US$0.63 and US$0.99/tone of waste, the total cost of operation was about US$3,187,728 or US$6.79/ton of waste. The closure cost of the landfill was estimated to beUS$278,116 or US$0.59/ton of waste.

Keywords: Cost, analysis, semi-aerobic, landfill.

1. INTRODUCTION

In many countries with low income open dumps still are in operation. This means that no emission control takes place, the waste is not compacted, the sites are not chosen in regard to reduce environmental impact and slopes may be very steep. This way of dumping results in a variety of problems, as there are mechanical instability, fires, littering, odors, uncontrolled leachate and gas emissions etc. It is an enormous task to clean up to a certain level these dumps in order to reduce their danger and to build new landfills using the experiences from those countries which have a long tradition in this field. Mistakes made in the past should be avoided. In industrialized countries the problem of the old landfills becomes more and more evident. After closure still leachate has to be treated and gas has to be controlled. The landfills have to be further inspected and if necessary repaired. With these activities high costs are associated which would be lower if the landfills could have been operated f.e. as a bioreactor reducing the emission potential as early as possible.

Fukuoka Method (Semi-aerobic) Fukuoka method landfill is the best solution choice of landfill system to replace open dumpsite. This landfill system was developed in a joint study by Fukuoka University and Fukuoka City in Japan. This method is specially designed for temperate climate and has been adopted in Japan and in tropical countries, such as Malaysia, Indonesia, China, Sri Lanka, and Iran, since 1980s.

A semi-aerobic landfill is a landfill manner where waste goes through a decomposition process in the presence of oxygen. Decomposition progress rate of solid waste largely depend on waste characteristics. Physical decomposition occurs during the operational management of solid waste landfill and includes segregation, mechanical size, and volume reduction. Chemical decomposition involves combustion, pyrolysis, and gasification. Biological decomposition includes aerobic and anaerobic degradation. Biodegradation generate highly contaminated hazardous leachate and gases [8]. This type of landfilling method has several advantages including reduction landfill gas and faster stabilization of the waste into the landfill. Additionally, the quality of leachate was improved at a much faster rate, and the generation of methane, hydrogen sulphide and another rest of gasses was reduced significantly (A road to Semi-aerobic Landfill, 2010). In a semi-aerobic landfill, the leachate collection system consists of a central pipe with branch pipe on either side of enough spacing. Each pipe has many holes approximately around one inch, for, the purpose of water entering and air reaching to the waste layers. The pipes should be install quite well-engineered and laid slope to allow easier collection of leachate and covered with (10 to 15 cm in diameter) rocks [6]. For more details about each type and their functionality, refer to above figure 3. In addition, comparing of three types of the landfill; it well-recognized that (anaerobic have low construction cost as well as low maintenance but it has a negative impact on the environment an public health. Unlikely aerobic construction and maintenance cost are too high. Moreover low negative impact the environment and public health. Last of all, the semi-aerobic landfill have medium construction cost, low maintenance as well as low negative impact the environment and public health that the advantages are more than to disadvantages. So it seems more practical and applicable. Therefore, semi-aerobic landfill sounds reasonable which can transform a large portion of solid waste to the examine landfill. Consequently, based on three evaluation factors semi-aerobic method is an appropriate method for KM to consider as solution concrete manner [1 2].

The beneficial of this is include but not limited as those pipes act like blood vessels that convey oxygen(air) and discharge leachate from the body (waste layers) [8]. Leachate is discharged as soon as it is collected in pipes, thus reducing water.

Pressure and the likelihood of seepage. Fresh air is naturally brought in through the solid waste; it makes the waste stabilization and the leachate purification in a short time. The emission of methane is reduced although that of carbon dioxide increases, and it is simple-tech, it can be install and operate easier with a low degree of technical demand, machines, devices and easiest operation and maintenance, as well as cost effective and initial investment is low which fear is for KM. Finally, it helps mitigate global warming by reducing the amount of CH4 and (25 times more harmful than CO2) produced [8, 13].

2. METHODOLOGY

Like most developing countries, solid waste landfill sites in Indonesia are mostly practicing either open dumping or controlled dumping because proper sanitary landfill concepts are not fully implemented due to technological and financial constraints. This study aims to evaluate the feasibility of implementing a cost effective Fukuoka method semi-aerobic landfill system in North Kolaka Regency, Indonesia, including construction, operation, closure for developing a new sanitary landfill.

3. ANALYSIS AND DISCUSSION

It should be the semi-aerobic landfill structure was developed in a joint study by Fukuoka University and Fukuoka City. A leachate collecting pipe is set up at the floor of the landfill to remove leachate from the landfill, so that leachate will not remain where waste is deposited. Natural air is brought in from the open pit of the leachate collecting pipe to the landfill layer, which promotes aerobic decomposition of waste. This enables early stabilization of waste, prevents the generation of methane and greenhouse gases, which make it effective technology in the prevention of global warming. The Fukuoka method semi-aerobic landfill concept can be implemented in developing countries under many circumstances for different purposes; these include developing a new landfill site, upgrading an existing landfill site or proper closure of a completed landfill site.

A case study in North Kolaka was carried out for a population of 137,139 people (2014) [3, 4], with the projection of waste generation rate and targeted waste disposal method presented in Table 1.

Table. 1 Projection of total waste disposed of at landfill site.

Year	Population	Waste generated (t/y)	Disposal methods (%)				Waste disposed of at landfill (t/y)
			1	2	3	4	
2014	137,139	44,049	1	1	78	20	8,810
2015	140,568	45,150	2	2	74	22	9,933
2016	144,082	46,279	3	3	70	24	11,107
2017	147,684	47,436	4	4	66	26	12,333
2018	151,376	48,622	5	5	62	28	13,614
2019	159,039	51,084	6	5	58	31	15,836
2020	163,015	52,360	7	5	54	34	17,803
2021	167,091	53,670	8	5	50	37	19,858
2022	171,268	55,011	9	5	46	40	22,004
2023	175,550	56,387	10	5	42	43	24,246
2024	179,939	57,796	11	10	38	41	23,696
2025	184,437	59,241	12	10	34	44	26,066
2026	189,048	60,722	13	10	30	47	28,540
2027	193,775	62,240	14	10	26	50	31,120
2028	198,620	63,797	15	10	22	53	33,812
2029	203,585	65,392	16	20	18	46	30,080
2030	208,675	67,026	17	20	14	49	32,843
2031	213,892	68,702	18	20	10	52	35,725
2032	219,240	70,420	19	20	10	51	35,914
2033	224,721	72,180	20	20	10	50	36,090
Total		1,147,565					469,431

Notes: 1, recycling; 2, composting; 3, others or uncollected; 4, landfill

Based on the projection, the total waste expected to be disposed of at the landfill site for the projected 20 years is about 469,431 tonnes. Assuming that the specific density of waste is about 800 kg/m3 (common value used for compacted wastes at sanitary landfills) [5], the total volume required for the landfill is 586,789m^3.

It was assumed that the use of cover materials is contributing another 15% of the volume; thus the actual volume required is 88,018 m3. In order to estimate the landfill area required, it was assumed that the landfill has a depth of 15 m (3 layers of 5 m each), thus the landfill surface area required is 44,987m^2 (4,5 ha).

Besides, other areas required for other facilities and some contingency space for wastes, 40% additional space was included to make the total area of about 7 ha. Detailed information on the design of the facilities such as the size and number of leachate collection ponds required, and the length and size of the main leachate collection pipes, branch pipes, gas pipes, etc., were calculated and the specifications are listed as below:

- Leachate collection and aeration ponds – 3 ponds, 5,100 m3 each.
- Leachate main pipe –concrete pipe, 600 mm diameter • 135 m length.
- Leachate branch pipes – concrete pipe, 16 pipes, each 450 mm diameter • 50 m length.
- Gas venting pipes – concrete pipe, 30 pipes, each 375 mm diameter • 6 m length.
- Gravel – 688 m3 (933tonnes).

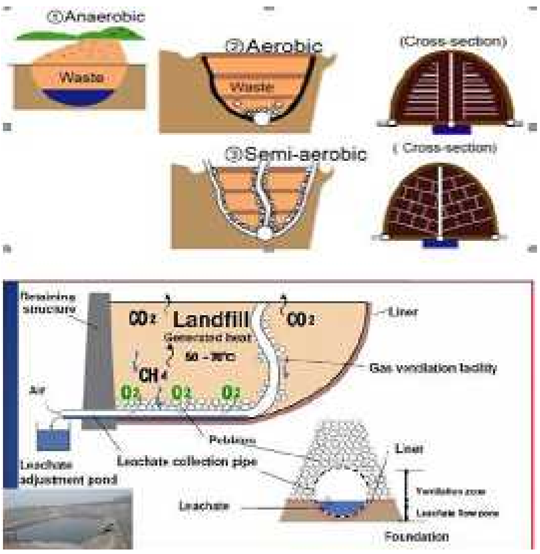

Fig. 1 Landfill type and Schematic diagram of a semi-aerobic Fukuoka landfill method

Based on the estimations calculated and assumptions mentioned above, a conceptual diagram of a newly developed semi-aerobic landfill site is shown in Fig.1.The costs estimations were mainly conducted onfour different stages, namely the pre-preparation stage, construction stage, operational stage and closurestage. The costs for each stage were estimated separatelyin order to have a clear impression of the development, operational and closure costs of the entire Fukuoka method. Some basic items considered attach stage are as follows:

- Pre-preparation stage such as a detailed environmental impact assessment (EIA). At this stage, costs include the cost for laboratory analysis, construction of boreholes, etc.
- Construction stage includes construction of facilities including foundation works. The costs involved are material costs, labour costs as well as other management expenses (Fig.2).

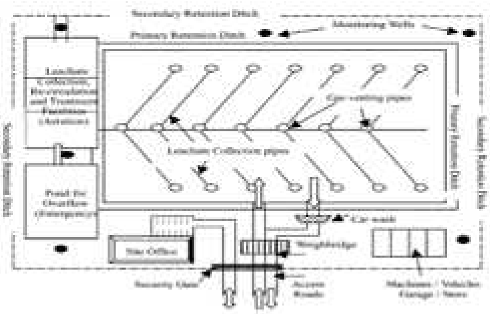

Fig. 1 Conceptual diagram of a semi-aerobic landfill site [1]

Operational stage such as application of cover materials, landfilling activities, maintenance, monitoring, inspection and some other miscellaneous expenses (Fig.3).

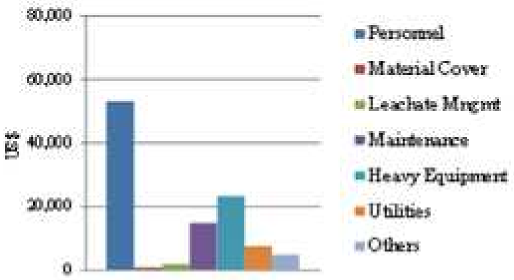

Fig. 2 Components of operating costs

(Closure stage includes activities such as applying final top cover soil, planting vegetation, maintaining necessary facilities and monitoring the quality of the leachate and gas, etc., for a certain periodof time (Fig.4).

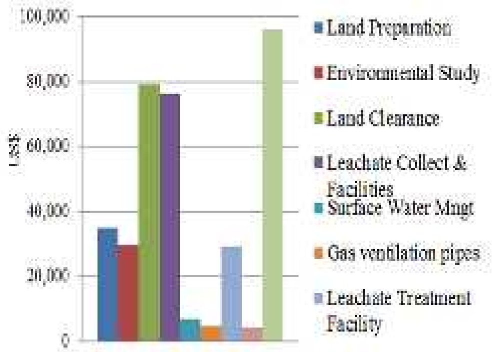

Fig. 3 Components of capital costs

For this study, the landfill site is assumed to operate for 20 years, while the time frame used for closure is assumed to be 10 years after completion of landfill operations. The estimations were conducted based on information collected on the prices of local materials and labour in North Kolaka Regency. It should be emphasised that the estimated capital costs are based on the assumption that the landfill site has natural clay soil with low permeability and thus a synthetic or geomembrane liner is not required. Otherwise the overall costs required are expected to increase by about 80–150% due to the high costs of liner systems.

According to the information shown in Table 1, the total wastes disposed of at this landfill is estimated to be 469,431tonnes; thus the overall disposal costs required for each tonne of waste can be calculated as shown in Table 2.

Table. 2 Overall disposal costs per tonne of waste

	Capital	Operating	Closure
NPV Costs (US$)	296,739	3,187,728	278,116
Total waste (tonne)	469,431		
Average cost (US$/t)	0.63	6.79	0.59
	8.02		

Note: Total waste disposed at the landfill site is estimated to be 469,431tonnes

4. CONSLUSION

All From the general findings of this study, it can be concluded that the Fukuoka semi-aerobic landfill system is available method to be used in developing countries such as Indonesia, based on the results of the cost analysis of the entire implementation process, from the development stage to final closure. The overall cost ofUS$8.02/tons of waste is more expensive as compared with the existing average tipping fees in some major cities US$1.94-6.59/tons [2] but relatively reasonable because it can suppress the negative impact on the environment with the treatment of odors, leachate and methane gas emissions. This is very important information to ensure that the development and operation of landfill sites in developing countries should take into consideration proper development, operation and closure plans so that a sanitary landfill concept is operated and maintained efficiently. In addition,

The results obtained from this study also provide information that can be used when considering privatization of the waste disposal system as a whole, to ensure more effective and efficient operation and management of a sanitary landfill.

5. REFERENCES

[1] Chon T. L., Matsufuji Y., & Hassan M. N. (2005). Implementation of the semi-aerobic landfill system (Fukuoka method) in developing countries: A Malaysia cost analysis. J. Waste Management, 25, 702-711.

[2] Rahim I. R., Shimaoka T., & Nakayama H. (2013). Cost Analysis of Municipal Solid Waste Management in Major Indonesian Cities, J. Japanese Society of Civil Engineers, Division. G (Environmental Research). Vol. 68(6).

[3] BAPEDA North Kolaka Regency. (2013). Sanitation Report.

[4] Center Statistic Bureau (BPS), North Kolaka in number, 2010-2013

[5] North Kolaka Regency. (2013). Environmental and Cleanliness Departement. Annual report.

[6] Matsufuji. (2004). A Road to Semi-aerobic Landfill. Experience of Semi-aerobic Landfills in Japan and Malaysia. Yasushi Matsufuji, Fukuoka University, Japan. 29-Dec-2004, Hokkaido, Japan.

[7] UNU-IAS. (2014). Guidebook the Co-benefits Evaluation Tool for Municipal Solid Waste 2014. http://tools.ias.unu.edu/node/1.

[8] Takeda, Eang, & Masaki. (2014). Urban Environemt 3. Solid Waste Management. Edited by: Nbuo Takeda, Wei Eang, Masaki Takaoka. 2014