Environmental Evaluation of Sanitary Landfills Establishment: Malaysian Case Studies
Zhang Chen¹,a, Santha A/P Chenayah@Ramu²,b and Fauziah Shahul Hamid³,c

¹,³ Institute of Biological Sciences, Faculty of Science, University of Malaya (UM) 50603 Kula Lumpur, Malaysia
² Faculty of Economics and Administration, University of Malaya (UM), Malaysia

a zhangchen@siswa.um.edu.my, b santha@um.edu.my, c fauziahsh@um.edu.my

Keywords: Solid Waste Management; Landfill; Economic Evaluation; Economic Efficiency

Abstract Poor management of dump-sites creates significant risks to environment and human health. Thus, sanitary landfills are required to be more effective to minimize the impacts of waste disposal. This research assesses the environmental economic evaluation focused on the economically efficiency of Malaysian sanitary landfills. Two landfills were selected based on their different operation. Landfill A incurred RM 128 million (USD 41.8 million) as the total cost within 20 operational period. Thus, it is estimated that the cost may be covered within 15 operational years. On the other hand, the total costs for Landfill B are estimated at RM 198 million (USD 64.8 million) with RM 245 million (USD 80.2 million) are expected to be obtained as profit within eight operational years. Landfill B has high initial costs of design and construction. However, the costs are covered within the first five years. This is because Landfill B introduces a new green technology namely landfill-gas power generator. This indicates that, Landfill B has stronger market competition ability as compared to Landfill A. It can be concluded that the implementation of green technology namely landfill gas harvesting system has higher impact to improve the economic value of a landfill thus making it more economical and environmentally sustainable.

Introduction
In developing countries such as China, Malaysia and India, the traditional dumping of waste is already out of date. It is because it cannot achieve the requirements of sustainable development due to emerging environmental problems. It is crucial to find out the reasons of these environmental problems by researching for proper patterns to achieve the sustainable and conservational development of human society.

It is reported that 95% of Malaysian MSW are disposed into landfills [1]. As one of the rapidly developing countries in south-east Asia, Malaysia has been practicing both controlled dumping and sanitary landfills as a common way for solid waste disposal. Even though the sanitary landfills are more effective, it is not fully implemented because of technical and financial limitation [1, 2]. This paper is aimed to propose a proper sanitary landfill management and the most appropriate approach to implement an integrated management of municipal solid waste in Malaysia.

Developed nations have a higher proportion of recyclable materials compared to low GDP countries [3, 4]. The low percentage of recyclables in developing nations is ascribed to the market value of recycling system and policies [3]. In some highly developed regions, many programs were started to reduce waste generation, and the target is to minimize the amount of waste disposing to landfills ultimately [4]. In Malaysia, the amount of waste generation is increasing at 2% per year, which requires an efficient integrated waste treatment, disposal and management system in the future development [4].
Methodology

Economic methods have been implemented in research areas of environmental policy decision-making, sustainability development and relative environment projects management. Higher environmental requirements need to be considered in policy decision-making and projects assessment to preserve nature [5]. The economical conceptions applied in environmental projects can explain proposed policies and approaches logically [5, 6].

Waste minimization and pollution controls require considerable expenditures from the government budgets or private investments. Estimation of the economic value can be a useful evaluation tool for waste minimization and pollution controls activities. It can help to determine whether converting natural resources to goods and services leads to more opulent society or shortening the human generations [7].

Fukuoka Method (FM) is a well-known cost-effective and environmental friendly disposal method. Stabilization and decomposition of waste can be improved in the presence of air as it increases the rate of microbial activity [8]. The FM landfill is currently constructed in many developing nations for different purpose. There are basically three main concepts of FM in developing countries: a) Low cost; b) simple and easy maintenance and c) Sustainability [8]. Additionally, leachate generated is of a better quality with high microbial reaction rate, while landfill gases, such as hydrogen sulphide and methane, was markedly decreased [8]. To analyze the current efficiency level of landfill in Malaysia, an economic efficiency evaluation can be done with the standard use of FM as a baseline. Landfill B, a Malaysian sanitary landfill as the same level with FM landfill, offers the information for economic evaluation in this research.

To analyze the current efficiency level of landfill in Malaysia, an economic efficiency evaluation can be done with the standard use of FM as a baseline. Landfill B, a Malaysian sanitary landfill as the same level with FM landfill, offers the information for economic evaluation in this research.

Result and discussion

Evaluating the efficiency is a key tool to help improve the existing waste management activities. Therefore, the required data from a FM landfill (Landfill A) and a local landfill site (Landfill B) is to analyze the efficiency of different waste disposal options in Malaysia.

Landfill A (FM Landfill) is designed to service an area with a population of 500,000 people. The total amount of solid waste disposed to Landfill A in 20 years is around 1.5 million tonnes. If the density of waste is 700 kg/m³, the volume requirement of Landfill A could be around 5.0 million m³. It is assumed that the usage of cover may require 15% extra volume of calculated capacity, so the actual capacity volume is 5,702,582 m³. The average depth of Landfill A is 15 m while the disposal area is 380,172 m² (38 ha). Since 40% additional area for facilities is required, the total area of Landfill A is about 50ha. Details costs for construction, operation and closure of Landfill A is illustrated in Figure 1-3.

The average tipping fees is RM36 per tonne in Malaysia, and the annual growth rate of tipping fees is around 3% annually. Landfill A has a recycling program and leachate circulation system which can create environmental benefit of around RM15,000 monthly. Figure 4 indicates the relationship between cost and benefit, in which the economical balance point Q, can be estimated.

Figure 4 shows that the economical balance will be reached after 15 operational years. Because Landfill A has low investment of basic construction, the capital cost can be recovered within a short period of time. However, the requirements of maintenance and professionals are specific and high. Therefore, the costs of operation, maintenance of facilities, and costs of training and management increase slightly in the long-term.
Landfill B receives and treats waste from western Klang Valley covering a population of approximately 0.6 million in 2007. The total landfill area is 160 acres. In landfill B, the average depth of excavation is around 2.5m, and the lowest point of the landfill bottom liner is at an elevation of 0.5 m in general. The total amount of municipal waste disposed may reach around 8 million tonnes after 8 years under the current operational practice.

In economic terms, the multiplier effects of developing Landfill B are much higher than the cost of development calculated in this study. This is because any amount of money pumped into the economy often generates a cycle of business that in turn spins other businesses directly and indirectly. The values gathered do not include escalation factors (interest rates), project financing and tax. The estimated costs included capital cost, operating cost, and closure cost in absolute values(Figure 5– 7). Besides the revenue, Landfill B is proposing to invest on a new technology that transfer bio-gases into power from 2012. It contributes to decrease electricity bills and enhance the environmental benefit.

The cost-benefit analysis of Landfill B is illustrated in Figure 8. Figure 8 is formed on the basis of the calculation and estimation of the overall costs during the actual operational life span. It illustrates that Landfill B can achieve economical efficiency at point Q after about 5 operational years. Therefore, it is proved that Landfill B is an effective waste disposal system. The costs keep increasing because of various factors, which include the net present value and the internal return rate. A steady growth of economical and environmental benefits can be indicated in the Figure 4.

New green technology application and bio-gases power generation improve the benefits of both aspects (technical and economical) significantly. There is a steady increase of the existing benefit, but the costs of landfill construction and operation(including new technology investment) still outstrip the value of benefits. It is suggested to introduce different approaches of final waste
disposal like incineration and composting. New green technologies can generate power from incineration of waste or bio-gases conversion from landfills. The landfill managers can also benefit from the internal power generation and the reduction in the operational cost.

Since the study involved operational and financial aspects, technical and economic information have to be estimated based on average market value to avoid the impacts of market competitions. In reality, some values may differ with different location, currency rate changes, time and distance alteration. In this research, all benefits gained by landfills are from direct aspects. Indirect benefits are not presented in the data gathering. It is know that proper closure of landfill sites can gain significant benefits including reduction of the risks to environment and public health, though it is impossible to be quantified.

Within 20 operational years, Landfill A can receive 3,471,137 tonnes of waste and it is estimated to spend RM 127,720,897 (USD 41.8 million) and gain a direct benefit of RM 122,933,368. Averagely, to dispose 1 tonne of waste, it will cost around RM 37 per tonne and the environmental benefit will be RM 35 per tonne. However, after 16 years, the capacity of Landfill A will be exhausted that the efficiency will decrease. Because of some other approaches implementation, such as recycling programmes, the amount of waste disposed to Landfill A will reduce significantly. Therefore, it is recommended to arrange an early-closure for Landfill A. Landfill B is operated exceeding the designed daily capacity and the life span is cut to 8 years. Landfill B has total direct investment of RM 198 million (USD 64.8 million) It is estimated to gain RM 245 million (USD 80.2 million) within the actual operational period. Landfill B can achieve the economical efficiency point after 5 operational years. Apparently, Landfill B is more effective than Landfill A. According to the local circumstance, adjustments of semi-aerobic sanitary landfill concepts can be implemented efficiently. Thus, Landfill B has a stronger competition in the market.
Conclusions and recommendations

According to the main findings in this research, semi-aerobic sanitary landfill model is a good waste disposal option for developing nations. Based on the study, both FM landfill system (Landfill B) and reformatory landfill (Landfill A) can achieve economical efficiency point.

It is found that FM landfill system is proved as a proper option to convert open dumping sites to sanitary landfills since the low initial cost. In a long-term operation, FM landfill can improve the efficiency of the entire waste management system in a proper approach. It is suggested that the local authorities can to develop some recycling programmes, which will to help reduce the amount of waste disposed to landfills, thus extending the life span of sanitary landfills.

As a tropical developing nation, Malaysia needs to conduct ISWM system for sustainable development. This can be achieved by improving and developing the solid waste disposal system.

References


Environmental Evaluation of Sanitary Landfills Establishment: Malaysian Case Studies
10.4028/www.scientific.net/AMR.599.224