SUSTAINABLE MANAGEMENT OF BROWNFIELD GREENSPACE: A STUDY OF WORLDWIDE LANDFILLS PARK AIR HITAM, PUCHONG, MALAYSIA

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ABSTRACT

Decades ago, landfills were designed and operated on the outskirts of the city. However, due to the sprawl of urbanization, many residential areas have been developed around the landfill areas. Therefore, the environmental and hazardous issues such as landfill gas, leachate and foul odour have risen up. As the greenspaces have recently decreased, Malaysia government in 2010 suggested that the ex-landfill areas which are part of the brownfields should be turned into valuable urban greenspaces. This study thus reviews the management practices of closed landfill to become a sustainable greenspace. A case study was carried out at the Worldwide Landfills Park Air Hitam Puchong, Selangor Malaysia. It is the first ex-landfill in Klang Valley Malaysia developed as a park. Two research methods were adopted for this study, namely key informant approach and secondary data analysis. The result indicated that the safe closure and post-closure management including leachate management and landfill gas management using the gas collection system have successfully rehabilitated the site into a park. A reduction of CO_2e using landfill gas collector and natural absorber i.e. vegetation is also discussed in this review.

Keywords: *: Landscape management, ex-landfill, sustainable planning, urban greenspace*

1. INTRODUCTION

Landfill is a major issue of urban management in the world due to the problems of environmental pollution and the shortage of urban land (Hoornweg & Bhada-Tata, 2012). As consequences, many of the ex-landfills in urban area have been turned into beneficial alternative spaces to urban dwellers.

Currently, there are 303 landfills in total available in Malaysia, where 143 of them were declared closed (SWCorp, 2017). The number of closed landfills increased each year from 115 in 2003 to 131 in 2012, and expected to be 296 in the year 2020 (Simis et al., 2016). It has been expected that more than 70.0% of the future ex-landfills would be located in urban areas and become a major concern of the urban communities (Chun-Yang & Talib, 2006) due to the health and environmental problems such as foul odours, leachate released and gas pollution (Simis et al., 2015). Therefore, the Act 672 for Solid Waste and Public Cleansing Management 2007 enforced in September, 1st 2011. The act requires that every ex-landfill must undergo waste recovery through new technologies such as (i) waste to energy facilities; (ii) construction and demolition recovery facilities; (iii) organic waste facilities; (iv) landfill closure, and (v) integrated waste management.

As the natural areas in every state have been declining at a great speed due to rapid urbanization, the Department of Town and Country Planning Peninsular

Malaysia in 2010 has thus specified that the urban ex-landfills are assets of greenfield for future developments and provisions according to the standard of 2 hectares per 1,000 urban populations. Consequently, future rehabilitation of 303 urban ex-landfills will lead to an increasing of 462,500 social recreation opportunities for the urban population in 2020 (Mazifah et. al., 2014) as inherently sustainable greenspace.

The question is how the landfills are rehabilitated and managed for sustainable use by community. What are the actions needed and stressed during restoring them into greenspaces or public parks? As the restoration process is time-consuming, the right management practices must be carefully planned to prevent future problems.

Hence, a study was carried out at the Worldwide Landfills Park Air Hitam Puchong, which is the first ex-landfill park in Malaysia. It has been 10 years since the landfill turned into a public park. This study aimed to investigate the management practices of the park, and the process to become an ex-landfill's public park. It is important to be a guide for similar development of other landfills in the country.

2. EX-LANDFILL AND GREENSPACES

2.1 Ex-landfill

Ex-landfill is a former land of a big rubbish bin (JICA, 2010) which closed due to the completion of waste filling activities. However, there are few factors to consider before announcing the land to be closed such as over the limit design capacity or improper construction and design that cause serious environmental problem and health hazards. It is clearly stated in the Volume 5 Technical guideline for Sanitary Landfill, Design and Operation Landfill (MHLG, 2004b) that there are three functions of the landfill which are storage and treatment, environmental protection, and land development. Therefore, a proper management of the landfills are essential to preserve the functionality of the landfills as a safe solid waste disposal site and to prevent environmental pollution such as leachate and landfill gas. After a completion of landfilling activities, the sanitary landfills should be closed in a safe and proper manner.

Based on the Volume 3 Guideline for Safe Closure and Rehabilitation of MSW Landfill Sites (MHLG, 2004a), safe closure consists of 4 levels of environmental pollution and hazardous prevention. Each landfill site should be assigned with a targeted closure level at the initial stages of the safe closure process as shown in table 1.

Table 1 : Closure level at the initial stage of the safe closure process

Level	Requirement
C1	Minimal closure level (to provide final cover and drainage system around the site)
C2	Low closure level (similar to C1, but with the addition of dike, controlled slope and gas ventilation system)
C3	Middle closure level (similar to C2, but with the addition of semi-aerobic landfill system with leachate re-circulation)
C4	High closure level (similar to C3, but with the addition of groundwater pollution control measures with leachate treatment)

In order to implement the safe closure of landfill site, proper physical closure and post closure management should be carried out. The Physical Closure (PC) consists of the measures or facilities necessary for the safe storage of waste, prevention of environmental pollution and early stabilization of waste. While, the Post Closure Management (PCM) consists of the operation of landfill facilities such as leachate treatment plant, the maintenance of the facilities including soil treatment and the monitoring of environment pollution and stabilization of waste.

2.2 Brownfield

The term brownfield has different definition within countries throughout the world. The Europe's Sustainable Brownfield Regeneration Network (CABERNET, 2006) defined that brownfield is a site which (i) has been affected by previous uses of the site or surrounding land, (ii) is abandoned or underused, (iii) is fully or partial urban development areas, (iv) may have or to be considered having a contamination problem, and/or (v) requires intervention to reinvigorate the beneficial use.

In Malaysian context, brownfield is defined as an area that has been developed but derelict or neglected, or an area which having a possibility to be contaminated, or an area which is the development is not fully completed or abandoned, or a building structure that are completed but not sold within 10 years, neither on a government land or private land (Department of Town and Country Planning Peninsular Malaysia, 2012).

Therefore, the Department of Town and Country Planning Peninsular Malaysia (2012) came out with Brownfield Areas Redevelopment Planning Guidelines and Environmentally Sensitive Areas Planning Guidelines which emphasizes six categories of brownfield area that should be developed. Taking the Worldwide Landfill Park at Air Hitam Puchong for an example, the expansion of urban area has led the site to be categorized as Category B brownfield (ex-landfill areas that are full of solid wastes or no longer in use permanently) which was located in the urban fringe area to be part of urban image (Simis et al., 2015), as shown in Figure 1.

Based on the guideline, there are several types of development for Category B brownfield, such as (i) recreational area; (ii) golf course, biogas power plant area, and (iii) agricultural area with fertigation system. However, housing, big structure or building should be avoided for development due to the instability of the ground.

Figure 1 : Air Hitam Sanitary Landfill (source: Google Map, 2017)

2.3 Urban Greenspace

According to the Department of Statistics Malaysia (2016), the total population of Malaysia in 2016 was estimated at 31.7 million people, an increment of 0.5 million people compared to previous year, and estimated to reach 32.3 million people in 2020. Malaysia is a developing nation that going forward into urbanised nation and expected to have 78% of urban population by 2030 (UN-HABITAT, 2012).

Urbanisation creates urban areas or cities. A city is said to be the most suitable habitat for humans as they provide with a variety urban infrastructures and environments for a good quality of life (Sham, 1982). Quality of life usually refers to individual wellbeing and satisfaction and used as a reference in reflecting urban society's quality of life (Burc et al., 2001). According to Burc et al. (2001), there are four keys in creating sustainable urban development that bring positive impact of quality of life among urban society which are physical environment, economic environment, social and transport and communication. Unfortunately, most cities were unprepared in facing the spatial and demographic challenges associated with urbanization and even worst in facing the environmental nature.

Greenspace is an alternative in planning to support the health and wellbeing of urban residents (Barton, 2009, Carmichael et al., 2013, Ambrey, 2016). It plays an important role in providing an ecosystem services, improving the quality of life and welfare of citizens (Latinopoulus et al., 2016; Livesley et al., 2016). According to Carrus et al. (2015), greenspaces or parks give a direct effect on the welfare of local residents and increase the aesthetic value of the green areas. In addition, these natural green canopies could improve the air quality by reducing the presence of polluted gases and particulate matter (Beckett et al., 2000; Dzierzanowski et al., 2011).

In the case of the Worldwide Landfills Park Air Hitam, the residential areas were developed around the landfill site in year 2000 due to the rapid population growth in Klang valley. Several residential areas were developed namely as Taman Lestari Putra, Taman Lestari Perdana, Taman Equine, Taman Sri Indah, Taman Kota Perdana and Taman Desaminium as shown in Figure 1. The development made the landfill an island of brownfield in settlement areas. Thus, the best solution for this situation is to transform the brownfield to be a valuable greenspace or safe public park.

3. METHODOLOGY

3.1 Site of Study

The study was conducted at the Worldwide Landfills Park Air Hitam, which previously called the Air Hitam Sanitary Landfill. It is located at the longitude 101°39'55''E and latitude 03°0'10'' N close to the Air Hitam Forest Reserve in Petaling, Puchong, Selangor with. The site was selected due to the fact that it was the only Category B brownfield area turned into a greenspace or public park.

The landfill was the first engineered sanitary landfill in Malaysia which received 6.2 million tonnes of domestic waste in 2006. It was operated by the Worldwide Landfills Sdn. Bhd. which is a subsidiary of Worldwide Holdings Berhad (WHB). It was opened on April 1st 1995 for the 100 acres of land. Air Hitam Sanitary Landfill received 3,000 tonnes of garbage per day from six local authorities of Kuala Lumpur, Petaling Jaya, Shah Alam, Subang Jaya, Ampang Jaya and Kajang.

The landfill was designed for 20 years lifespan with 6 million tonne capacity. Unfortunately, it reached the limits within 10 years after accumulating 6.3 million tonnes of total deposited waste. In year 2000, the development of residential areas started to sprawl around the site. Therefore, it was closed on 31st December 2006 with total 6,207,684.59 tonne of domestic waste and then underwent landfill closure and post closure maintenance activity from January 2007 untill December 2011. The closure was planned and monitored by the highest requirements initiated by the Department of Environment Malaysia. (Worldwide Landfills Sdn. Bhd., 2013).

3.2 Case Study

This is an exploratory research focusing on the case study of the Worldwide Landfills Park Air Hitam, Puchong. Two research methods were adopted for this study. Key informants were selected from the Facility Management officials of the Department of SWCorp Malaysia and from the Management Department of the Worldwide Environment Sdn. Bhd. The informal qualitative approaches were used for the study and the primary information was gathered via direct interviews with an open-ended questionnaire. To validate the above viewpoints as well as deeper understanding on certain details, the secondary data were also gathered and analysed. The secondary data were collected from the Volume 3 Guideline for Safe Closure and Rehabilitation of MSW Landfill Sites and Volume 5 Technical guideline for Sanitary Landfill Design and Operation, Guidebook for Safe Closure of Disposal Site, and Brownfield Areas Redevelopment Planning Guidelines and Environmentally sensitive Areas Planning Guidelines which was provided by Department of Town and Country Planning Peninsular Malaysia, Japan International Cooperation Agency (JICA) and Ministry of Housing and Local Government Malaysia. All the information gathered were used as the means in analysing the management practices of the park.

4. RESULT AND DISCUSSION

The management practices practiced by the Worldwide Landfills Park Air Hitam Puchong are elaborated in this section. It consists of the technical design for solid waste management, leachate and gas management, landscape management, and sustainable treatment of the site.

4.1 Solid Waste Management

Plan of Air Hitam Sanitary Landfill in Figure 2 shows that the landfill has been divided into 3 parts which are Area A, B and C for management purposes. Based on the Volume 3 Guideline for Safe Closure and Rehabilitation of MSW Landfill Sites (MHLG, 2004a), Air Hitam Sanitary Landfill was classified as sanitary level 4 i.e. sanitary landfill with leachate treatment facilities measured daily. The landfill closure considered as safe closure Level C2, i.e. low closure level that provides final cover and drainage system around the site, addition of dike, controlled slope and gas ventilation system. Based on the interview, it stated that the 100 acre site had produced two megawatt gas power plant that had provided 2000 households with electricity since 2004. The biogas plant in Air Hitam Sanitary Landfill is the first plant in Malaysia that generates electricity using landfill gas in trapping and burning the by-product of decaying waste-methane gas.

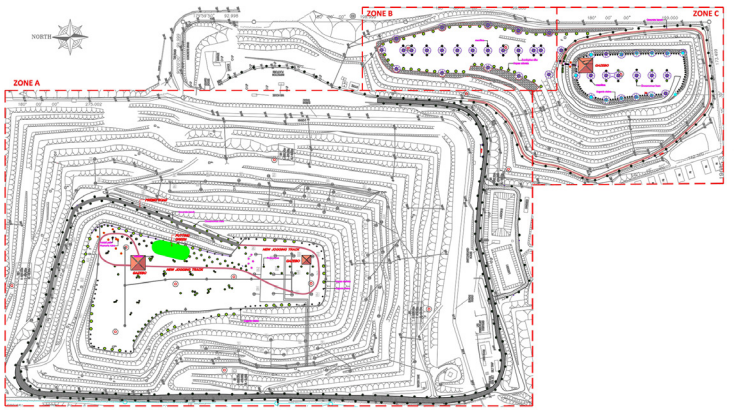

Figure 2 : Plan of Air Hitam Sanitary Landfill
(Source: Worldwide Holdings Bhd., 2010)

According to MHLG (2004a), the classification of group C with low environmental impact risks but having high land utilization potential. Therefore, Worldwide Holdings Bhd. took the initiative to turn the Air Hitam Sanitary Landfill into Worldwide Landfills Park Air Hitam Puchong. Based on Figure 2, several basic facilities such as 5km of jogging track with both permeable pavement and interlocking brick, bicycle track, playground, street lights and gazebos were introduced in the park.

4.2 Management of Post Closure

Before regenerating the ex-landfill into a park, it needed to undergo the management of post closure. Based on Volume 5 Technical Guideline for Sanitary Landfill, Design and Operation, Guidebook for Safe Closure of Disposal Site (MHLG, 2004b), there are several factors should be considered and to be taken care in handling the management of post closure, which are (i) the necessity of management of post closure of landfill site, (ii) leachate control, (iii) control of generated gas, (iv) control of land subsidence, (v) monitoring of the degradation and stabilisation of the waste, and (vi) utilization and management of post closure landfill site.

MHLG (2004b) stated that 'even long after the landfilling of the waste has been completed, the degradation process of waste will continue. Leachate and landfill gases are still being produced; hence, the management of the landfill facilities should be continued even after the closure of landfill site and throughout the post closure land use phase'.

4.2.1 Leachate Management

In controlling leachate at the site, the suitable pipe line should be designed based on the topography of the landfill site. As shown in Figure 3 and Figure 4, the Worldwide Landfills Sdn. Bhd. preferred a ladder pattern to be installed in area A and C, while, herring bone pattern for area B. The ladder pattern is usually installed in flat area whereas herring bone pattern is used to connect branch pipes to the main pipelines. Hence the leachate is collected by branch pipes and discharged to the main pipelines.

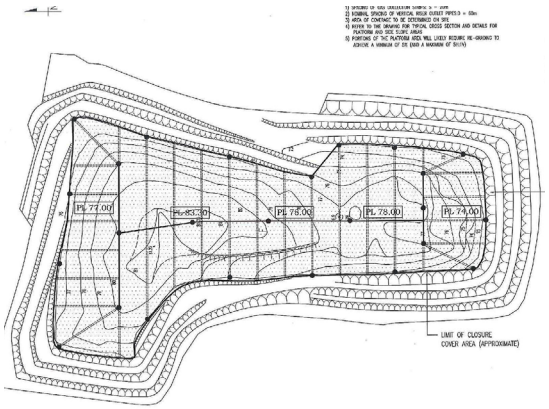

Figure 3 : Plan of final cover system: Area A in Air Hitam Sanitary Landfill (Source: Worldwide Holdings Bhd., 2010)

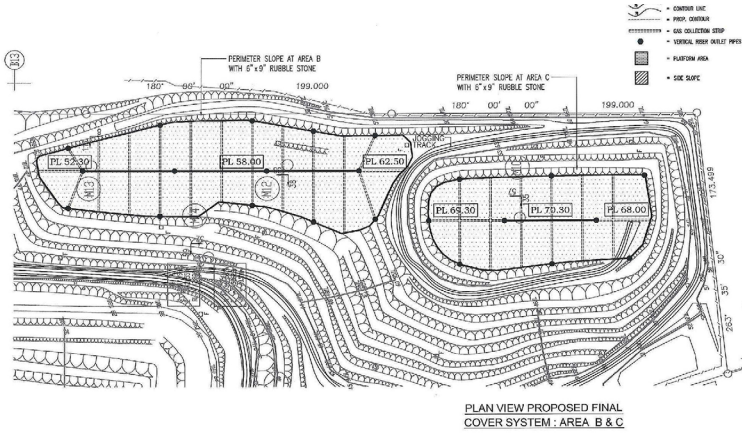

Figure 4 : Plan of final cover system: Area B and C in Air Hitam Sanitary Landfill (Source: Worldwide Holdings Bhd., 2010)

Based on the Volume 3 Guideline for Safe Closure and Rehabilitation of MSW Landfill Sites (MHLG, 2004a), safe closure consists of 4 levels of environmental pollution and hazardous prevention. Each landfill site should be assigned with a targeted closure level at the initial stages of the safe closure process as shown in table 1.

4.2.2 Gas Management

The main function of gas venting facility is to remove the gas generated within the landfill layers, as shown in Figure 5. Trench was installed at the original existing level and within the earthfill which consisted of the compacted waste, gas pressure relief layer, sand layer then barrier to protect the upper trench and gas layer. Next, another layer of sand for drainage was used to protect the barrier then covered with earthfill. The groundcovers have then been planted for the green surface.

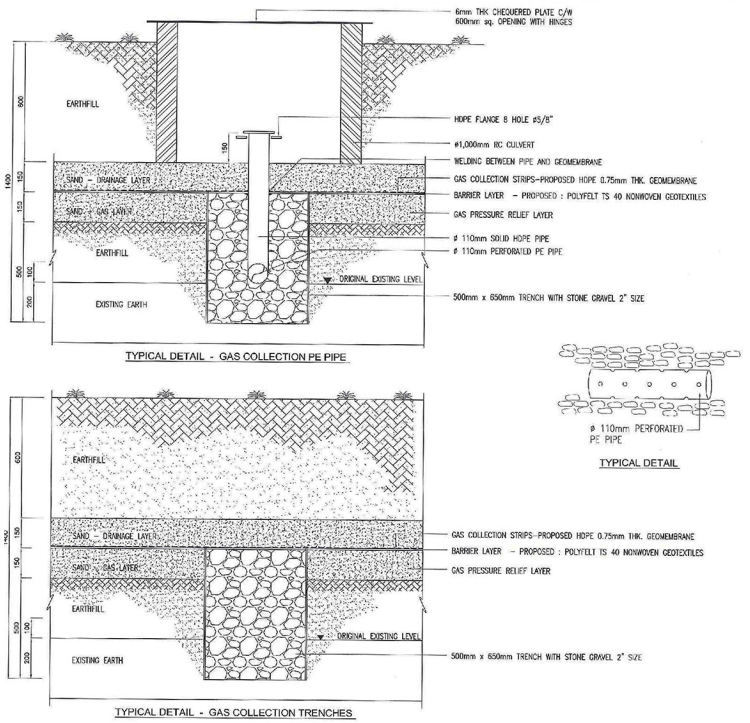

Figure 5 : Drawing detail of trench
(Source: Worldwide Holdings Bhd., 2010)

The gas collection pipe was constructed at the equal pace during the landfilling works progress. The gas collection system includes a network of vertical gas extraction wells, dewatering units and High-Density Polyethylene (HDPE) geomembrane pipelines, as shown in Figure 6. The degassing unit of Air Hitam Sanitary Landfill was installed with equipment that functioned for measuring continually the remote access of the equipment and data. The system connected through a Programmable Logic Control (PLC) tool that operated the unit's main variables. From there, the continuously measured data, such as methane content and flows were monitored.

The controlled activities for the system consisted of periodic adjusting of the gas wells by means of measuring equipment. 71 gas wells were dug as deep as 30m to extract the gas. The gas flow, the methane content and the oxygen content were the very important parameters. Some of the gases were flared, or burnt, daily to convert it into carbon dioxide and water. The maintenance works consisted of the control of subsiding and distortion of the gas wells and the pipeline system. The gas extraction plant was equipped with blowers to create a suction pressure in the system necessary for extraction of the Landfill gas (LFG).

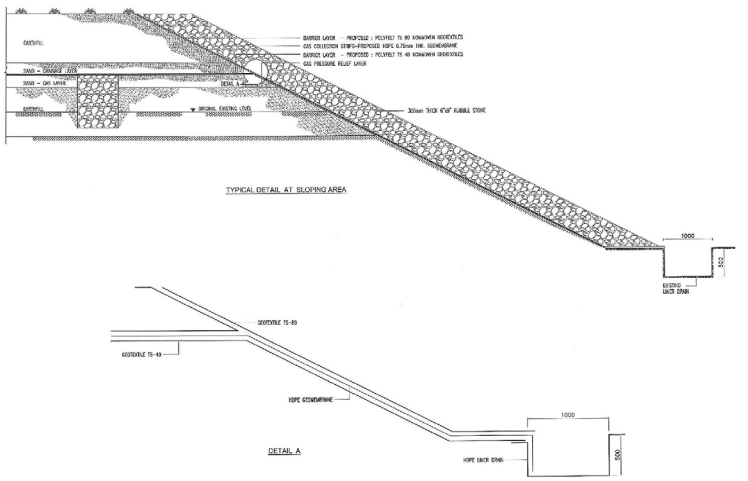

Figure 6 : Section of side slope for gas collection header pipe
(Source: Worldwide Holdings Bhd., 2010)

Table 2 shows that the annual estimation of emission reductions in tonnes of CO_2e was decreasing from 2007 to 2016 equivalent to 10 years after the safe closure operation. The CO_2e is 'a standard unit for measuring carbon footprints'. Therefore, it showed that the Air Hitam Sanitary Landfill had a positive effect where it contributed less CO_2e each year. The greenhouse gas emission or methane reduction in tonnes CO_2e achieved by the gas collection which were combusted or destroyed during the gas flared. However, it was not covered for the whole of the landfill site. Therefore, every reduction achieved above the reductions made by gas collection system was considered additional. Thus, vegetation is still needed in order to reduce CO_2e naturally.

Table 2: Annual estimation of emission reduction after safe closure (Worldwide Environment Sdn. Bhd., 2006)

Year	Annual estimation of emission reductions in tonnes of CO_2e
2007	79.395
2008	107.013
2009	99.306
2010	92.196
2011	85.636
2012	79.571
2013	74.014
2014	68.849
2015	63.774
2016	58.806
Total estimated reductions (tonnes of CO_2e)	808.559
Total number of crediting years	10
Annual average over the crediting period of estimated reductions (tonnes of CO_2e)	80.856

4.3 Landscape Management

Based on the Guidebook for Safe Closure of Disposal Site (JICA, 2010), the standard depth of soil on the site ground were based on the site functions, which is 600mm depth for bare area, 1000mm depth for flower and grass area, 1500mm depth for small tree area and 2000mm depth for tree area including 150mm of topsoil and 450mm of compacted soil. The purposes of the final cover were to improve the condition of the site, landscape, post-closure land use, minimize leachate generation, offensive odour, prevention of outbreak fire and serve as vegetation layer. However, as shown in Figure 5 the earthfill after capping system was just 600mm depth of soil was provided for ground covers, trees and palm trees.

Table 3 shows that 671 trees were planted along the road and jogging track, 457 trees in zone A, 60 trees in zone B and 154 trees in zone C. The number of trees per track and road length were considered dense visually (Figure 2), if taking into accounts the maximum size of the matured canopy and the topography of the site.

Table 3: Landscape planting scheme of Worldwide Landfills Park Air Hitam Puchong (Source: Worldwide Holdings Bhd., 2010)

Botanical Name	Overall Height (m)	Trunk Height (m)	Trunk Diameter (mm)	Zone A	Zone B	Zone C	Quantity
			Tree				
Bucida molineti	1.5	0.8	25	194	-	58	250
Eugenia oleina	1.5	0.3	25	72	-	78	150
Maniltoa lenticellata	1.5	0.8	25	6	11	6	23
Cinnamomum iners	1.5	0.8 - 1.0	25	38	-	6	44
Podocarpus macrophyllus	1.5	0.3	25	45	-	-	45
Eucalyptus alba	1.5	0.8-1.0	25	16	9	-	25
Plumeria rubra	1.5	0.8	25	14	-	2	16
Hopea odorata	1.5	0.8	25	40	40	-	80
Baphia nitida	1.5	0.8	25	20	-	-	20
			Palm				
Wodyetia bifurcata	1.8	1.5m	50mm	2	-	2	4
Cyrtostachys renda	1.8	1.5m	50mm	10	-	4	14
						Total Overall Zones	671

Table 4 shows that the exotic species were dominant in the Worldwide Landfills Park Air Hitam Puchong which 7 exotic species and 4 native species. The overall heights of trees during transplant were between 1.5m to 1.8m. Based on the interviews, after 10 years from transplanting, the overall height of the trees was between 2 to 3m. However, the growth rate for each species was different. The fast grower species could reach the optimum height within 10 to 15 years. Meanwhile, the slow grower could reach the optimum height within 20 to 30 years. There are only two fast growing species namely Bucida molineti and Baphia nitida which achieved their height between 3m to 7m and 3m to 10m respectively whereas the other species were between medium and slow grower which cannot be determined by their range of height. There are many factors need to be looked into in determining the growth performance of each species.

Table 4: Planting list of Worldwide Landfills Park Air Hitam Puchong (Source: Worldwide Holdings Bhd., 2010)

Botanical name	Overall height (m)	Range of height (m)	Native species	Exotic species	Growth speed
Bucida molineti	1.5	3 - 7		▪	Fast
Eugenia oleina	1.5	2 - 20	▪		Medium
Maniltoa lenticellata	1.5	10 - 12		▪	Medium
Cinnamomum iners	1.5	20	▪		Slow
Podocarpus macrophyllus	1.5	20		▪	Slow
Eucalyptus alba	1.5	18		▪	Medium
Plumeria rubra	1.5	8		▪	Medium
Hopea odorata	1.5	25 - 30	▪		Slow
Baphia nitida	1.5	3 - 10		▪	Fast
Wodyetia bifurcata	1.8	6 - 15		▪	Medium
Cyrtostachys renda	1.8	16	▪		Slow

4.4 Sustainable Management Applied

In general, leachate and biogases are major problems in landfill management. A few strategies or techniques of treatment were applied at the Air Hitam Sanitary Landfill site as it closed, to fulfil requirement of sustainable treatment. These techniques are specific to the site, explained in the following table 5.

Table 5 shows that Air Hitam Sanitary Landfill has practiced the vital factors of sustainable management for environmental protection i.e. leachate and gas managements as well as land development i.e. ecological and social functions as suggested by MHLG (Ministry of Housing and Local Government Malaysia). It also fulfilled three out of four keys suggested by Burc et al. (2001) as stated earlier in this paper, except for the factor of transport and communication, which is irrelevant to the landfill development issue.

The achievement of the Air Hitam Sanitary Landfill to become a public park is summarized in Figure 7. Starting from it closure in 2006, the leachate and gas plant were immediately installed to regulate the environmental and economically benefits. As the soil stabilized, vegetation were then introduced and planted to stimulate the land regenerative process. It is a smart effort in landscape management that benefit to the social as future users as well as to the nature in accelerating the succession process.

5. CONCLUSION AND IMPLICATION

The study indicated that the Worldwide Landfills Park Air Hitam Puchong successfully practised the sustainable management approaches in managing the ex-landfill. This fact is not surprising as the landfill was the first engineered landfill in Malaysia.

Table 5: Summary of sustainable treatment applied at Air Hitam Sanitary Landfill

Treatment Applied	Issue	Applicable Source
a. Leachate treatment plant system has been introduced to remove leachate from the site. A series of piping system has been designed to collect residual liquid from the waste mass and discharged to the plant.	Leachate Removal	MHLG (2004b) Burc *et al.* (2001)
b. Landfill gas power plant has been built to generate energy i.e. electricity power. This vertical gas extraction wells collect the gasses through intricate and systematic network of collection pipes which eventually transferred to landfill gas power plant.	Landfill Gas Renewal	MHLG (2004b) Burc *et al.* (2001)
c. Planting of fast growing plants which include trees, shrubs and groundcovers. These plants are important in stabilizing the soil fertility and protecting slopes. As the plant matured, the site can be opened to the public for recreational purpose.	Ecological Engineering	MHLG (2004a) Burc *et al*. (2001)
d. In order to turn the site into a park, the basic facilities such as walking track using permeable materials, playground, signage, shelter and proper circulation have been provided.	Recreational Functions	MHLG (2004a) Burc *et al.* (2001)

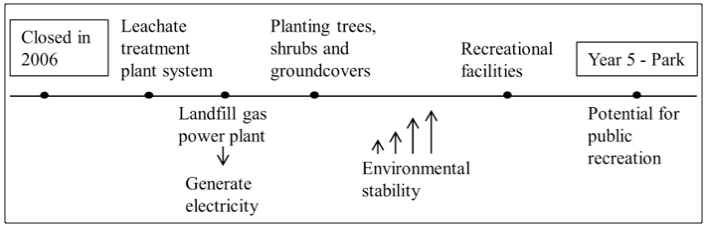

Figure 7 : Summary of Air Hitam Sanitary Landfill rehabilitation process

The landfill park was well planned and managed from the safe closure and post closure throughout the rehabilitation process especially on the leachate management and landfill gas management. The secure liner system, drainage system, pipelines and wells constructed were considered successful and the Worldwide Landfills Park Air Hitam Puchong is the first renewable energy power plant in Malaysia. Consequently, the management company grab the

opportunity of 15 years agreement between the state government and the Tenaga Nasional Berhad (TNB) of the right to extract the gas and generate power from the ex-landfill. The power plant has been able to generate energy with 2MW by converting methane gas to electricity power up to 2000 household and leachate treatment plant. Meanwhile, the HDPE geomembrane pipelines which were used for gas collection system has contributed to the reduction of CO_2e. Therefore, the existing methane gas from the former landfill, one of the pollutant that contributed to greenhouse effect has been reduced.

After 5 years of undertaking safe-closure and post closure planning, Air Hitam Sanitary Landfill was ready to serve as a public park which consists of 5km jogging track made of permeable pavement and interlocking brick, bicycle track, playground and exercise area. After a year of opening, it received 60 to 70 visitors from neighbouring areas such as Lestari Puchong and Taman Equine during weekend (Worldwide Landfills Sdn. Bhd., 2013). On top of that, as the first brownfield transformed into a public park, the management teams took an effort by planting 671 trees with 11 different species of native and exotic species along the road and jogging track as a natural absorber of landfill gas. However, the reduction of the gas cannot be determined by the existing data accumulated. Further studies need to be done and explored for better results of vegetation performance in restoring the nature.

Based on the current distribution of the plants and activities provided, the park is considered as a functional public park and greenspace. However, to become a community public park, further comprehensive landscape design study should be implemented.

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