CHAPTER 2 INTERVIEW SURVEYS ON CLOSURES OF LANDFILL SITES

In preparation for an action plan for safe closures of landfill sites, social impact shall be assessed for some negative impact that would be caused by the closures. In this context, therefore, small-scale interview surveys were launched with structured questionnaires (see Appendix) by the JICA Study Team to identify a general view of the closures.

2.1 PURPOSES

- To identify briefly a general view and perception on safe closures of land fill sites
- To refer the view and perception to elaborate a practical action plan with due considerations to social impact

2.2 TARGET GROUPS

Principally, the following are the population who may suffer negative impact directly caused by the closures.

- Scavengers working at landfill sites
- Households live in surrounding areas of landfill sites

2.3 DESCRIPTION OF THE SURVEYS

2.3.1 Survey Plan

The surveys were executed based on a survey plan as shown in **Table 2.3.1**, which was prepared by the JICA Study Team in consultation with MHLG.

Table 2.3.1 Survey Plan

	A. Scavengers	B. Surrounding Households
1. **Survey Method**	Interview Survey with Questionnaire A	Interview Survey with Questionnaire B
2. **Interviewee**	10-15 scavengers per each site	10-15 Households per each site
3. **Survey Sites**	Three-Five landfill sites at which scavengers exist shall be selected around KL.	Surrounding areas of the Three-Five landfill sites around which households exist shall be selected around KL. (For example: 7 households located in the surrounding area of a landfill site and 5 households located along access roads to a land fill site)
4. **Criteria on Site Selection**	- Level 1, 2, 3 - Landfill sites in question on scavengers - Others	Follow the selection of the landfill sites selected for the survey A.
5. **Interviewers**	3 persons (One from MHLG, 2 local consultants employed by JICA Study Team)	3 persons (One from MHLG, 2 local consultants employed by JICA Study Team)
6. **Site Selection**	Survey sites shall be selected by the JICA Study Team in cooperation with and in accordance with an opinion of MHLG (For example: a boss of scavengers ,a person of influence among scavengers and etc.)	Survey sites shall be selected by the JICA Study Team in cooperation with and in accordance with an opinion of MHLG (For example: A representative of population, general households and etc.)
7. **Survey date**	21st – 23rd July 2003	21st – 23rd July 2003

The JICA Study Team

2.3.2 Site Selection to be Surveyed

The selection of landfill sites to be surveyed was done in reference to a perambulation of a reconnaissance survey, which had been made by the JICA Study Team beforehand, other relevant reports and the survey plan mentioned above. Finally, the JICA Study Team in cooperation with MHLG identified suitable sites for surveys as summarized in **Table 2.3.2**.

Table 2.3.2 Landfill Sites for the Interview Surveys

Landfill Site	Predicted Scavengers	Households (500m around the site)	Surveys A	Surveys B	Remarks
1 *Taman Beringin – K.L*	>40	Many	◎	◎	
2 *Jinjang – Utara*	< 5(not sure)	Some	△	◎	A closed site once
3 *Teluk Kapas – Klang*	≒ 20	Some	◎	◎	
4 *Kundang – Selayang*	≒ 10	Few	○	△	Main target is for Scavengers
5 *Sg. Kembong – Kajang*	≒ 40	Some	◎	○	

◎ Site to be fairly surveyed ○ Site to be surveyed △ Site to be surveyed according to site situation

The JICA Study Team

2.3.3 Samples

Sample numbers for the surveys were decided on site by the survey team under the supervision of the JICA Study Team, according to each site situation, that is the numbers of scavengers who were working at each site and residential areas located around each site as shown in **Table 2.3.3**. As for sampling for Survey B around Kundang site, actually, there is no residential area within several kilometers from the edge of the site so that no sample for the survey was taken at all around the site.

Table 2.3.3 Samples

Site	Survey A (Scavengers)			Survey B (Households)		
	Male	Female	Sub-total	Male	Female	Sub-total
1 *Taman Beringin – K.L*	16	4	20	9	8	17
2 *Jinjang - Utara*	14	3	17	6	10	16
3 *Teluk Kapas – Klang*	12	1	13	4	10	14
4 *Kundang – Selayang*	8	0	8	0	0	0
5 *Sg. Kembong – Kajang*	12	5	17	8	12	20
Total	62	13	75	27	40	67

The JICA Study Team

2.4 SURVEY RESULTS

2.4.1 Survey A (Scavengers)

(1) Respondents Profile

1) Sex

Approximately 83% of the respondents involved in the survey A (scavengers) were Male as shown in **Table 2.4.1**.

Table 2.4.1 Sex of Respondents (%)

Male	Female
82.7	17.3

The JICA Study Team (Survey A)

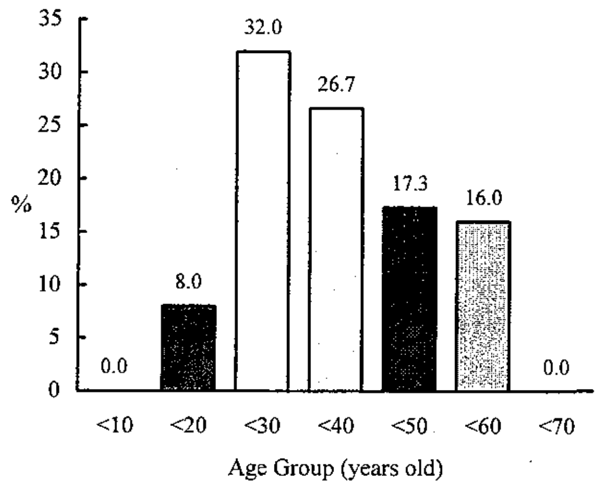
2) Age

The breakdown of age groups of the respondents were less than 20 years old (8%), less than 30 years old (32.0%), less than 40 years old (26.7%), less than 50 years old (17.3%) and less than 60 years old (16.0%). The oldest respondent was 56 years old, while the youngest was 14 years old. The average age of the respondents was 34.2 years old.

Table 2.4.2 Age rang of the Respondents (years old)

The Oldest	The Youngest	Average
56	14	34.2

The JICA Study Team (Survey A)

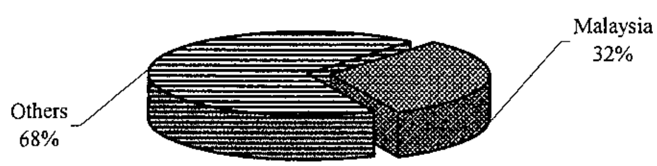


The JICA Study Team (Survey A)

Figure 2.4.1 Breakdown of the Age Groups

3) Nationality

The survey revealed that one-third (1/3) of respondents were Malaysian, while the reminders, namely two-thirds (2/3), of the respondents were from Indonesia as shown in **Figure 2.4.2.**



The JICA Study Team (Survey A)

Figure 2.4.2 Nationalities

4) Dwelling

Approximately 60% of the respondents live at and around (fringe areas of) land fill sites as shown in **Table 2.4.3**.

Table 2.4.3 Dwelling of the Respondents (%)

At and around the landfill sites	Away from the landfill sites
58.7	41.3

The JICA Study Team (Survey A)

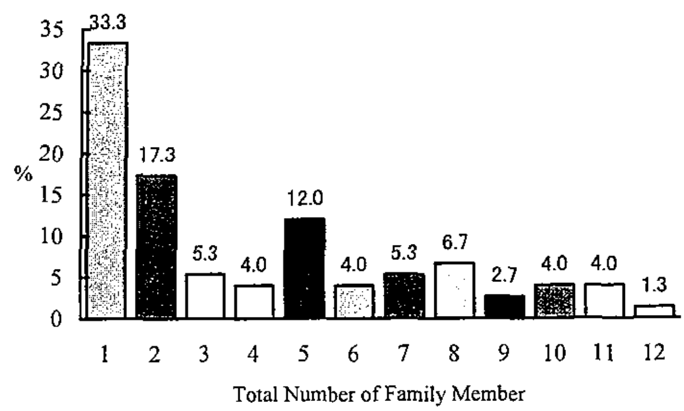
5) Family Size

Half of the respondents (50.6%) were 1-2 persons per family as shown in **Figure 2.4.3**. The maximum number of the family size among the respondents was 12 persons and the average family size was 4 persons as shown in **Table 2.4.4**.

Table 2.4.4 Family Size (People)

Max.	Min.	Average
12	1	4.0

The JICA Study Team (Survey A)



The JICA Study Team (Survey A)

Figure 2.4.3 Family Size

6) Income

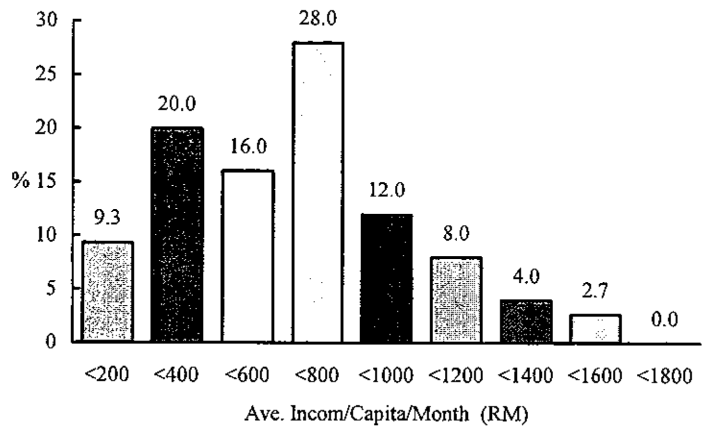
The survey reveled that the average income per month per respondent was RM 587.3 while the maximum income was RM 1,500 and the minimum one was RM 100. It is considered that the differences of the income may be related to their status as scavengers, namely permanent scavengers (who work exclusively as scavengers) or pert-time scavengers (who have other jobs), and other factors such as items collected (scavenged).

Table 2.4.5 Income/month/respondent (RM)

Max.	Min.	Ave.
1,500	100	587.3

The JICA Study Team (Survey A)

Figure 2.4.4 shows that more than 85% of the respondents earn less than RM 1,000 per month.



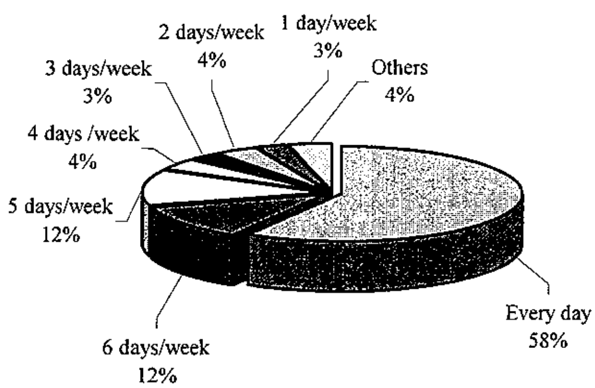
The JICA Study Team (Survey A)

Figure 2.4.4 Average Income/Capita/Month

(2) Scavenging

1) Working day

Most of the respondents (82%) work as scavengers for 5-7days /weeks as shown in **Figure 2.4.5.**



The JICA Study Team (Survey A)

Figure 2.4.5 Working Day

2) Working Hours

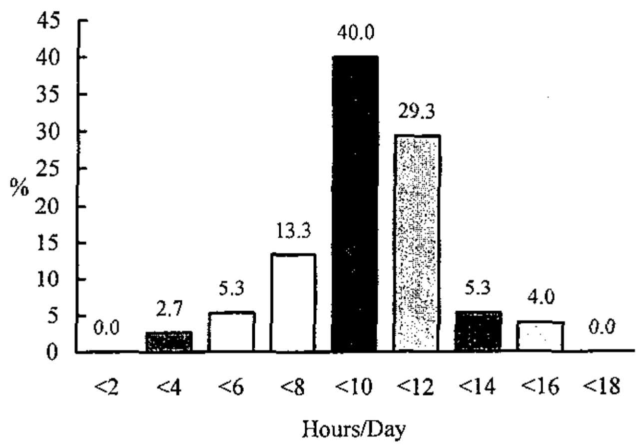
As shown in **Figure 2.4.6**, the survey revealed that most of the respondents (82.6%) work as scavengers for 8 – 12 hours pre day, while the maximum of working hours was

15 hours per day and the minimum was 2 hours per day. It is simply calculated that the average is 9 hours per day.

Table 2.4.6 Working Hours (hours)

Max.	Min.	Ave.
15	2	9.0

The JICA Study Team (Survey A)



The JICA Study Team (Survey A)

Figure 2.4.6 Working Hours

3) Type of Scavenger

As for the type of scavenger, the survey revealed that most of the respondents (85.3%) were full-time scavengers as shown in **Figure 2.4.7.**

Table 2.4.7 Type of Scavenger (%)

Full-Time	Part-Time
85.3	14.7

The JICA Study Team (Survey A)

Table 2.4.8 shows other Jobs of the part-time scavengers. The item of "Others" in the Table includes "Housewife", "Construction Worker", and so on.

Table 2.4.8 Other Jobs of Part-Timers (%)

Other Jobs	% of Part-Time Scavengers
Company Workers	36.4
Farming	18.2
Vendors	9.1
Service Business	9.1
Others	27.3
Total	100.0

The JICA Study Team (Survey A)

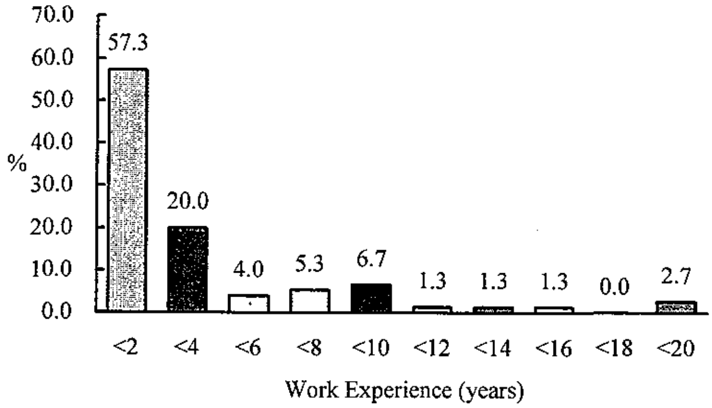
4) Work Experience as Scavengers

Most of the respondents (77.3%) have worked as scavengers for less than 4 years. It is calculated that the arithmetic average of the work experience is 2.9 years.

Table 2.4.9 Work Experience (years)

Max.	Min.	Ave.
18	0.019 (=7days)	2.9

The JICA Study Team (Survey A)



The JICA Study Team (Survey A)

Figure 2.4.7 Work Experience

5) Old Occupation before Scavenging at the Sites

44 % of the respondents did farming work before scavenging at each site, followed by "company workers (16%)", "manufacturing (12 %)", and "others (9.3%)" that includes housewives, students and construction workers.

Table 2.4.10 Old Occupation before Scavenging

Occupation	%
Farming	44.0
Company workers	16.0
Manufacturing	12.0
Scavenger at other sites	4.0
Restaurant or any food outlet	1.3
Scavenger at other sites & Company Workers	1.3
Others	9.3
No Answer	12.0
Total	100

The JICA Study Team (Survey A)

6) Items collected

Table 2.4.11 shows items of solid waste collected by the respondents and the ratio of the scavengers who collect those items. Based on the data, the most popular item was paper (54.7%), which was followed by Aluminum (50.7%), Iron Scraps (49.3%), Coppers (37.3%), plastic (30.7%), pet bottles (26.7%) and so on. "Glass", however, was collected by 1.3% of the respondents only. Nobody collected "rubber" at all.

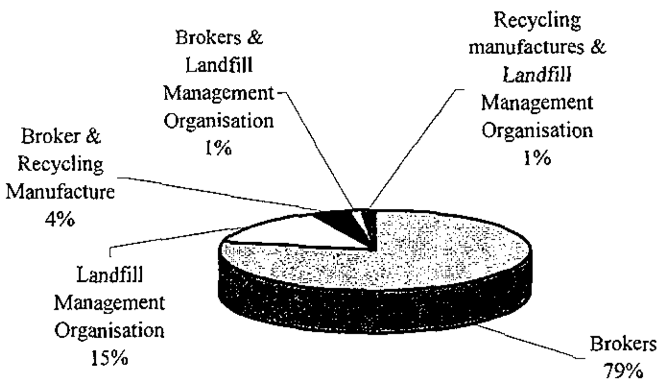
Table 2.4.11 Items Collected and the Ratio

Items	Ratio of the Scavengers who collect items (%)
Paper	54.7
Aluminum	50.7
Iron Scrap	49.3
Copper	37.3
Plastic	30.7
Pet Bottles	26.7
Wire	25.3
Cardboard	22.7
Glass	1.3
Rubber	0.0

The JICA Study Team (Survey A)

7) Customers (Buyers) of items collected

Figure 2.4.8 shows customers of items collected by the respondents. Most of the respondents (79%) sell items collected to "brokers", which is followed by "Landfill Management Organization (15%).



The JICA Study Team (Survey A)

Figure 2.4.8 Customers (Buyers)

8) Problems encountered with others

Most of the respondents (93.3%) have not encountered any problems with others for scavenging activities as shown in **Table 2.4.12.**

Table 2.4.12 Ratio of Respondents who Encountered Problems (%)

Had Problems	Had no Problem
6.7	93.3

The JICA Study Team (Survey A)

The problems encountered by 6.7% of the respondents were as follows:

- Territory dispute with other scavengers
- Bad mouth (Verbal dispute)
- Snatch of things

(3) Perspective and the Closures

1) Willingness to Work as a Scavenger in Future

In terms of a perspective, as shown in **Table 2.4.13**, most of the respondents (77.3%; "as long as possible" 72% & "as a pert time" 5.3%) have answered their willingness to work as scavengers in future.

Table 2.4.13 Willingness to Work as Scavengers

Willingness to Work as a Scavenger	Ratio (%)
Yes, I would like to work as long as possible	72.0
Yes, as a part time only for additional income	5.3
No, if I can get a better and permanent job	16.0
I don't know	6.7

The JICA Study Team (Survey A)

2) Action taken by Scavengers when the landfill site is to be closed

For the question "If this landfill site is to be closed, what action will you take?", more than half of the respondents (57.3% = 52%+5.3%) answered "move to other sites" as shown in **Table 2.4.14**. Respondents who answered that "protest the closure", were only 2.7% of all respondents.

Table 2.4.14 Action taken by Scavengers

Action	Ratio (%)
Move to other sites	52.0
Follow my broker, move to other site	5.3
Quit scavenger and find a new job	18.7
Protest the closure	2.7
Don't know	17.3
Others	4.0

The JICA Study Team (Survey A)

3) Action should be taken by Authorities

For the question "What kind of action to be taken by the Authorities, in your opinion, if the landfill is to be closed?", as shown in **Table 2.4.15**, approximately half of the respondents (43.2%) answered "Scavengers be allowed to operate at other landfill sites" which was followed by "Explanation about the closure shall be done in advance" (25.3%), and "Authorities shall consider to provide some form of incentives to Scavengers" (21.1%).

Table 2.4.15 Actions should be taken by Authorities

Expected Actions	Ratio (%)
Explanation about the closure shall be done in advance	25.3
Scavengers shall be consulted to get their views	7.4
Scavengers be allowed to operate at other landfill sites	43.2
Authorities shall consider to provide some form of incentives to Scavengers	21.1
Others	3.2

Note: The data was calculated by cumulative accounting due to multiple selections of the answers
The JICA Study Team (Survey A)

For those who answered "Authorities shall consider to provide some form of incentives to Scavengers"(21.1%), **Table 2.4.16** shows their preferable incentives. Most of the respondents (77.3%) showed their preference to get "Job Search (employment) services".

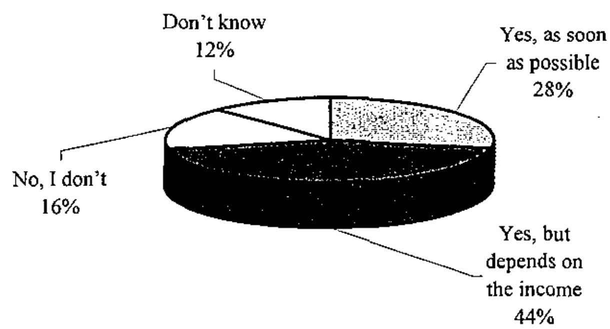
Table 2.4.16 Incentives Expected by Scavengers

Incentives	Ratio (%)
One off Compensation in monetary return	4.5
Job Search Service (Including employment)	77.3
Others	4.5
Don't know	13.6

Note: The data was calculated by cumulative accounting due to multiple selections of the answers
The JICA Study Team (Survey A)

4) Willingness to take up New Jobs

For the question "If the Authorities concerned is proposing to construct a recycling plant or other solid waste management jobs such as primary collection workers, are you willing to take up the job in place of scavengers?", more than 70% of the respondents (28%+44%) have showed their willingness to take up such jobs as shown in **Figure 2.4.9**.



The JICA Study Team (Survey A)

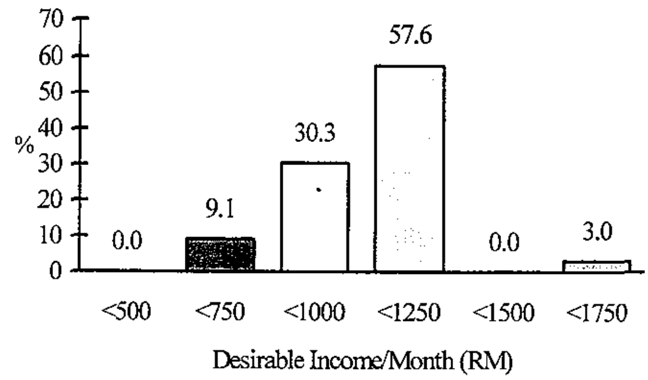
Figure 2.4.9 Willingness to take up New Jobs

For those who answered that "Yes, but depends on the income" (44%), **Table 2.4.17** and **Figure 2.4.10** shows their desirable income/month as the minimum requirement for working for new jobs. The survey revealed that the average of the desirable income/moth was RM 942.4.

Table 2.4.17 Desirable Income/Month (RM)

Max.	Min.	Ave.
1,500	500	942.4

The JICA Study Team (Survey A)

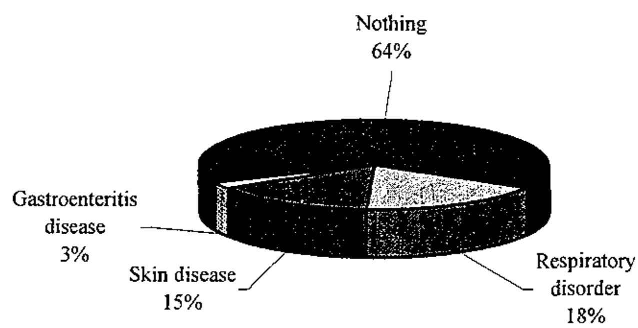


The JICA Study Team (Survey A)

Figure 2.4.10 Desirable Income/Month for New Jobs

(4) Health Problems

As for health problems, 64% of the respondents did not suffer any ailment at all. However, they suffered "Respiratory disorder (18%)", "Skin disease (15%)" and "Gastroenteritis (3%)" as shown in **Figure 2.4.11.**



Note: The data was calculated by cumulative accounting due to multiple selections of the answers
The JICA Study Team (Survey A)

Figure 2.4.11 Health Problems

Photo 2.4.1 A Scene of the Interview Survey A

2.4.2 Survey B (Households)

(1) Respondents Profile

1) Sex

Approximately 60% of the respondents involved in the survey B (households) were Female as shown in **Table 2.4.18**. This was because that the survey had been executed during daytime.

Table 2.4.18 Sex of Respondents (%)

Male	Female
40.3	59.7

The JICA Study Team (Survey B)

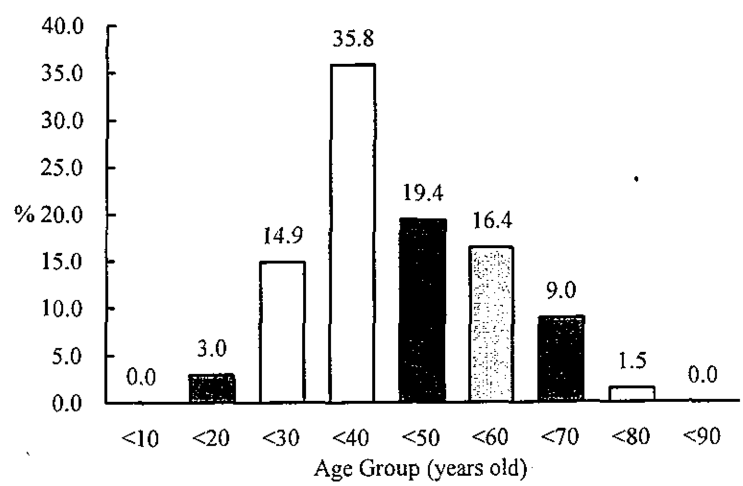
2) Age Group

The breakdown of age groups of the respondents were less than 20 years old (3.0%), less than 30 years old (3.0%), less than 40 years old (35.8%), less than 50 years old (19.4%), less than 60 years old (16.4%), less than 70 years old (9.0%) and less than 80 years old (1.5%). The oldest respondent was 76 years old, while the youngest was 16 years old. The average age of the respondents was 41.0 years old.

Table 2.4.19 Age rang of the Respondents (years old)

The Oldest	The Youngest	Average
76	16	41.0

The JICA Study Team (Survey B)



The JICA Study Team (Survey B)

Figure 2.4.12 Breakdown of the Age Groups

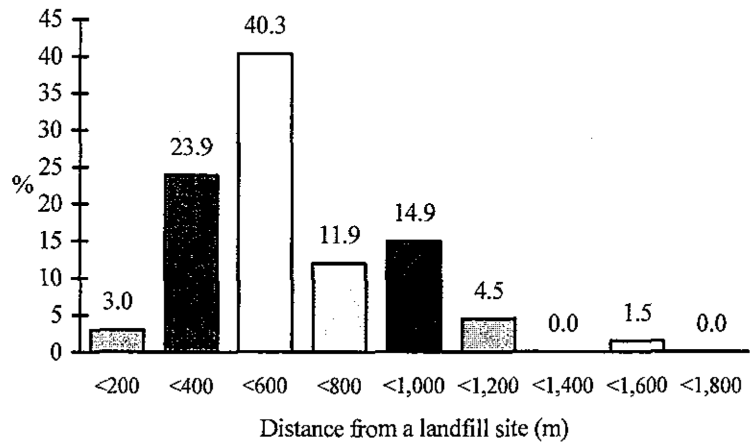
3) Distance from Landfill Sites

Houses of the respondents involved in the survey B are located around landfill sites with distances ranging from 100 m to 1,400 m as shown in **Table 2.4.20** and **Figure 2.4.13**.

Table 2.4.20 Distance from Landfill Sites (m)

The Farthest	The Nearest	Average
1,400	100	522.4

The JICA Study Team (Survey B)



The JICA Study Team (Survey B)

Figure 2.4.13 Breakdown of the Age Groups (%)

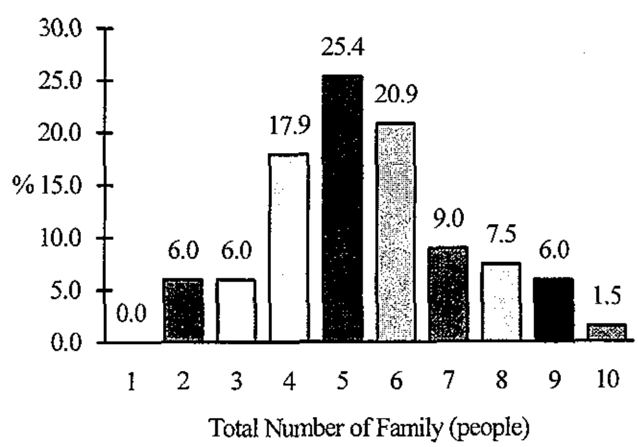
4) Family Size

Half of the respondents (80.7%) were 4-8 persons per family as shown in **Figure 2.4.14**. The maximum number of the family size among the respondents was 10 persons and the average family size was 5.4 persons as shown in **Table 2.4.21**.

Table 2.4.21 Family Size (people)

Max.	Min.	Average
10	2	5.4

The JICA Study Team (Survey B)



The JICA Study Team (Survey B)

Figure 2.4.14 Family Size (%)

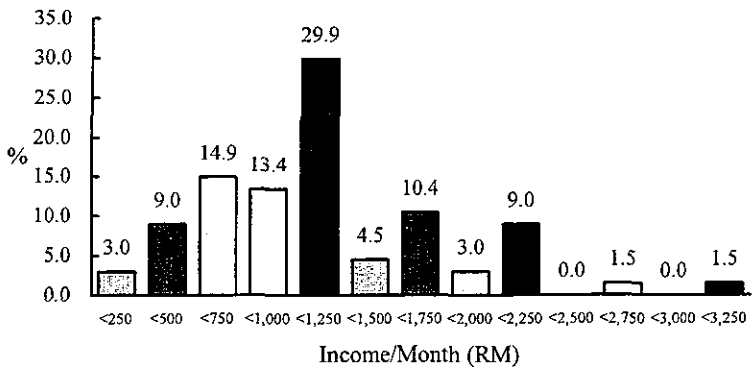
5) Income

The survey reveled that the average income per month per respondent (household) was RM 1,089.1while the maximum income was RM 3,000 and the minimum one was RM 100. It is considered that the differences of the income may be related to their status of income sources. As well, due to a very critical question to the respondents, false answerers might be there.

Table 2.4.22 Income/month/respondent (RM)

Max.	Min.	Ave.
3,000	100	1,089.1

The JICA Study Team (Survey B)



The JICA Study Team (Survey B)

Figure 2.4.15 Average Income/Capita/Month (%)

As for occupation for the main income source, 28.4% of the respondents do company workers, followed by "manufacturing (17.9%)", "public employee (11.9%) and "service business (7.5%)". "Others" (26.9%) includes retired persons, nurse, army and so on.

Table 2.4.23 Main Income Source

Main Income Source	%
Manufacturing	17.9
Vendor	4.5
Service Business	7.5
Public Employee	11.9
Restaurant or similar food outlet	3.0
Company workers	28.4
Others	26.9
Total	100.0

The JICA Study Team (Survey B)

(2) Landfill Sites

1) Environmental Problems perceived by the Respondents

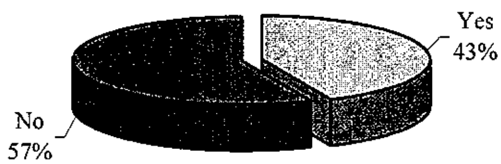
As for environmental problems and issues caused by the operation of the landfill sites, as shown in **Table 2.4.24**, 36.5% of the respondent perceived offensive odour, which was followed by Noise (3.1%). "Others" includes generation of vector insects (flies, mosquitoes) and animals (dogs, rats) and so on.

Table 2.4.24 Environmental Problems

Problems	%
Offensive odor	36.5
Noise	3.1
Vibration	2.1
Leachate spill	1.0
Reduction of crop yields	1.0
No problem at all	1.0
Others	54.2
No Answered	1.0
Total	100

Note: The data was calculated by cumulative accounting due to multiple selections of the answers
The JICA Study Team
(Survey B)

For the question "Do you think that those problems and issues will come to an end?", 56.7% of the respondents answered "No, due to insufficient countermeasures taken by municipality/management" as shown in **Figure 2.4.16.**



The JICA Study Team (Survey B)

Figure 2.4.16 Environmental Problems are Solved

2) Issues on Scavengers

Half of the respondents (50.6%) answered that Scavengers were "no problem", which are followed by "Not so good activities for health reasons"(26.0%), "Scavengers create social problem and their activities, therefore to be prohibited" (11.7%) and "Such activities should be promoted for generating their income and promoting waste recycling activities"(7.8%) as shown in **Table 2.4.25.**

Table 2.4.25 Issues on Scavengers

Issues on Scavengers	%
1. No problem	50.6
2. Not so good activities for health reasons	26.0
3. Such activities should be promoted for generating their income and promoting waste recycling activities	7.8
4. Scavengers create social problem and their activities, therefore to be prohibited	11.7
5. Scavengers are nuisance and therefore should be relocated elsewhere	3.9
Total	100

Note: The data was calculated by cumulative accounting due to multiple selections of the answers
The JICA Study Team (Survey B)

3) Opinion on Closures of landfill Sites

For the question "What do you think if the landfill is to be closed?", as shown in **Table 2.4.26**, most of the respondents (66.7%) answered that "The closure will improve the conditions of the surrounding environment", followed by "The closure has been desired by surrounding residents" (20%). Therefore, it is evaluated that nearly 90% of the respondents showed their positive opinion on the closures of the landfill sites. On the other hand, 6.7% perceived that "Worried about the secondary environmental pollutions and impact caused by the closure" as a negative opinion for the closures.

Table 2.4.26 Opinion on Closures of Landfill Sites

Opinion on Closures of Landfill Sites	%
1. The closure will improve the conditions of the surrounding environment	66.7
2. The closure has been desired by surrounding residents	20.0
3. Worried about a new and much bigger alternative landfill site to be constructed here if the existing landfill is to be closed	1.1
4. Worried about the secondary environmental pollutions and impact caused by the closure	6.7
5. No comment	4.4
6. No Answered	1.1
Total	100

Note: The data was calculated by cumulative accounting due to multiple selections of the answers
The JICA Study Team (Survey B)

4) Request to Authorities on Closures of landfill Site

For the question "What is your request to municipality/operating contractor if the landfill is to be closed?", as shown in **Table 2.4.27**, many of the respondents(32.2%) showed that "A public explanatory meeting/public hearing for the closure of the landfill sites shall be done", followed by "no request"(17.8%), "Municipal/operating contractors should pay attention to public opinion"(13.3%) and "Utilization plans for the closed landfill sites shall be explained"(13.3%), and so on.

Table 2.4.27 Request to Authorities on Closures of landfill Site

Requests	%
1. A public explanatory meeting/public hearing for the closure of the landfill sites shall be done.	32.2
2. Municipal/operating contractors should pay attention to public opinion	13.3
3. Environmental pollution and impact, which would be caused by the closure, shall be thoroughly prevented	10.0
4. Environmental management shall be done during the construction phase of landfill closure	12.2
5. Utilization plans for the closed landfill sites shall be explained	13.3
6. No request	17.8
7. No Answered	1.1
Total	100

Note: The data was calculated by cumulative accounting due to multiple selections of the answers
The JICA Study Team (Survey B)

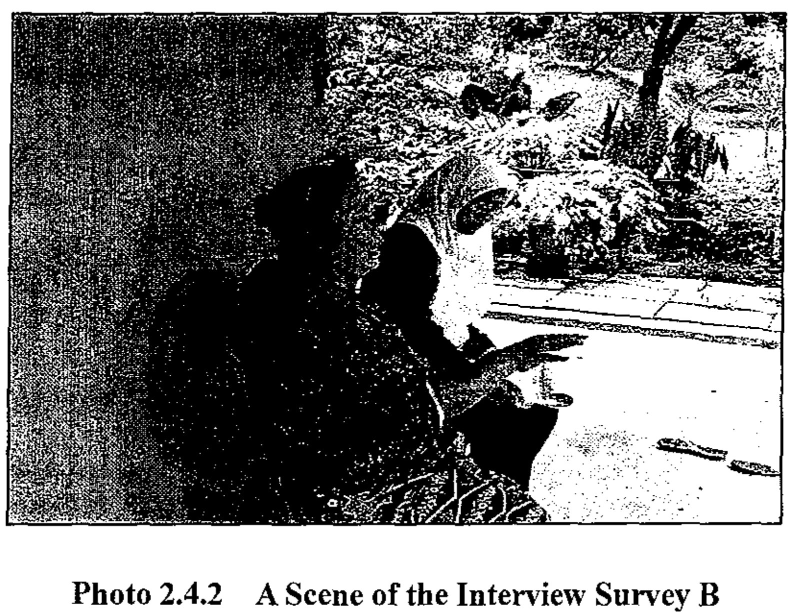


Photo 2.4.2 A Scene of the Interview Survey B

2.5 REVIEW OF A STUDY ON "SOCIAL IMPACT ASSESSMENT OF LANDFILL SITES"

In order to complement the results of the Interview Survey B conducted by the JICA study team, reference was made to "Social Impact Assessment of Landfill Sites in Kuala Lumpur", which was conducted by the *Universiti Putra Malaysia* (*Azizi Haji Muda*) in 1998, as follows.

2.5.1 Outline of the Study

(1) Purpose

The purpose of this study was to determine whether a closed landfill has any impact on the surrounding area, if it were to be redeveloped.

(2) Component of the Study

The study on "Social Impact Assessment of Landfill Sites in Kuala Lumpur" was composed of two studies, namely, "Initial Social Impact Assessment Study" and "The Second Stage of the Study", as summarized in **Table 2.5.1**.

Table 2.5.1 Component of the Study

Item	The Initial Social Impact Assessment Study	The Second Stage of the study
Study Year	1998	1998
Study Sites	Ten selected ten ex-landfill sites, which are situated in *Taman Beringin, Jinjang Utara, Sungai Besi, Kg. Paka 1, Kg. Paka 2, Sri Petaling, Air Panas, Dewan Bandaraya, Abdullah Hukum* and *Semarak*.	The residents of nearby *Taman Beringin* landfill area.
Data Collection	Interviews with residents at each site based on pre-structured questionnaires	Interviews with residents of nearby *Taman Beringin* landfill area based on pre-structured questionnaires
Sample Number	2,651	591

Source: *"Social Impact Assessment of Landfill Sites in Kuala Lumpur", Aziz Haji Muda, Department of Environmental Sciences, Faculty of Science and Environmental Studies, Universiti Putra Malaysia, Workshop on Disposal of Solid Waste Through Sanitary Landfill – Mechanisms, Processes, Potential Impact, and Post-Closure Management, August 1999, Universiti Putra Malaysia*

Note: *Table was made by the JICA Study Team.*

(3) Sequence between Two Studies

The following shows the sequence between two studies as summarized in **Table 2.5.1**, which can be identified in the discussion in the abstract of the report (*Azizi Haji Muda*).

- The result of the first survey revealed that problems encountered at the ex-landfill sites were site-specific and the study identified that *Taman Beringin*, DBKL and *Sri Petaling* as the three most critical sites. Since *Taman Beringin* is still in operation, problems associated with land filling activities such as aesthetic problems due to scattered rubbish, flies, rats, bad smell and gas emissions are to be expected.
- At the second stage of the study the focus was conducted among the residents of nearby *Taman Beringin* landfill area. The main objective is to assess their perception and opinion on several issues and problems pertaining to the surrounding areas of the landfill sites along with future strategic development of the area.

2.5.2 Principal Outcomes

Based on the Study, the author analyzed the data obtained and concluded the results and discussions. The following shows the principal results, discussions and conclusions.

(1) Respondents' Perception towards Pollution Problem

An initial study was conducted among local residents as to investigate their responses towards the dumping activity at the landfill site. Since some part of the *Taman Beringin* landfill site is still in operation, problems that arise from landfill operations causing disturbances to the residents of the surrounding areas are then to be expected. However, the extent of the problem is dependent on the level of tolerance of the residents. The study showed the following:

- Dust and burning smoke do not pose any problems or if the residents could tolerate any. This probably has to do with the current wet and rainy season where dust is suppressed and activities of burning of refuse are reduced.
- Besides these, noise problems and scattered rubbish from garbage trucks were also considered minor problems **Table 2.5.2** shows the respondents' perception (based on acceptance level) of the Problems encountered.

Table 2.5.2 Respondent' Perception towards Issues (%)

Problem	Too Bad	Acceptable	No Problem	Can't Tolerate	Total
Dust	31.7	37.4	19.6	11.3	100
Burning Smoke	20.0	44.5	30.5	5.0	100
Noise	20.7	42.2	33.0	4.1	100
Scattered Rubbish	23.1	39.4	33.6	3.9	100

Source: "Social Impact Assessment of Landfill Sites in Kuala Lumpur", Aziz Haji Muda, Department of Environmental Sciences, Faculty of Science and Environmental Studies, Universiti Putra Malaysia, Workshop on Disposal of Solid Waste Through Sanitary Landfill – Mechanisms, Processes, Potential Impact, and Post-Closure Management, August 1999, Universiti Putra Malaysia

- However there were several problems, which were considered major. These include problems with flies, rats and presence of bad smell.
- The source of bad smells, wet rubbish, also attracts rats and other vectors such as flies to the area. **Table 2.5.3** shows the respondents' perception on these issues.

Table 2.5.3 Level of Perception towards the Major Problem (%)

Problem	Too Bad	Acceptable	No Problem	Can't Tolerate	Total
Flies	57.5	16.4	7.3	19.0	100
Rats	48.5	24.9	12.9	13.7	100
Bad Smell	42.3	11.2	8.1	38.4	100

Source: "Social Impact Assessment of Landfill Sites in Kuala Lumpur", Aziz Haji Muda, Department of Environmental Sciences, Faculty of Science and Environmental Studies, Universiti Putra Malaysia, Workshop on Disposal of Solid Waste Through Sanitary Landfill – Mechanisms, Processes, Potential Impact, and Post-Closure Management, August 1999, Universiti Putra Malaysia

- Leachate or liquid from the landfill could possibly contaminate water in the area, however, respondents did not consider it as an issue as the majority of them (67.2 %) did not think of it as a problem. This was due to the fact that the current rainy season dilutes the leachate concentration thus reducing contamination concentration.
- When questioned on types of diseases often contacted, 41.6 % faced problems with skin, 40.4 % developed cough problems, 14.5 % had eye problems and 1.2 %

experienced diarrhea while the remaining had experienced a deterioration of their asthma condition.

(2) Future Development

- Majority of the respondents agreed that if the landfill site was to be developed, detailed studies should be conducted.
- Respondents felt that development of the site could benefit them especially from the aspects of social convenience (39.9%) and improvement to the environment (20.5%).
- In response to the question on types of strategic development, the respondents proposed the development of single terrace houses (57.4 %), or 3-6 story apartments (48.6 %) or 2 story shop houses (45 %) or recreational parks with trees lining the streets (46.8 %).
- Cross-tab analysis present in **Table 2.5.4** shows the relationships between level of agreeing and the type of development. It shows that the level of respondents' agreeing influences their perceptions towards the types of development (P=0.05).

Table 2.5.4 Agree to Develop Landfill Sites vs Type of Development (%)

Issues	Type of Development Suitable						
	Housing	Township	Recreation	Parking	Factory	School	Others
Yes	59.2	7.5	20.7	2.0	2.7	2.7	0.2
No	2.6	0.4	1.3	0.4	0.2	0.0	0.2
Total	61.8	7.9	21.9	2.4	2.9	2.7	0.4

N=13.185, P=0.040

Source: "Social Impact Assessment of Landfill Sites in Kuala Lumpur", Aziz Haji Muda, Department of Environmental Sciences, Faculty of Science and Environmental Studies, Universiti Putra Malaysia, Workshop on Disposal of Solid Waste Through Sanitary Landfill – Mechanisms, Processes, Potential Impact, and Post-Closure Management, August 1999, Universiti Putra Malaysia

- However, some of the respondents oppose to the development of the landfill site citing reasons such as unstable ground (90.6%), leachate problem (1.9%) and emissions of gases (7.2%).
- Cross-tabulation analysis shows that there was a relationship between respondents' occupation towards their perceptions on level of agreeing (P=0.01) and the types of development at significant level P=0.05 (See **Table 2.5.5** and **Table 2.5.6**).
- 90.7 % of respondents agreed to redevelopment of *Taman Beringin* landfill site once operation has ceased.
- About 61.8 % of the residents choose housing as the most important project to be carried out on the site.
- In spite of that, about 21.9 % felt that the site was only suitable for sport and other recreational centres.

Table 2.5.5 Occupation * Agree to Develop Landfill Sites

	Agree to Develop Landfill Sites		
Occupation	Yes	No	Total
Government	59	3	62
Factory	38	2	40
Business	93	25	118
Agriculture	3		3
Executive	10	1	11
Others	330	25	355
Total	533	56	589
Chi-square Test, Value= 24.047, N=589, P=0.009			

Source: "Social Impact Assessment of Landfill Sites in Kuala Lumpur", Aziz Haji Muda, Department of Environmental Sciences, Faculty of Science and Environmental Studies, Universiti Putra Malaysia, Workshop on Disposal of Solid Waste Through Sanitary Landfill – Mechanisms, Processes, Potential Impact, and Post-Closure Management, August 1999, Universiti Putra Malaysia

Table 2.5.6 Occupation * Agree to Develop Landfill Sites

	Agree to Develop Landfill Sites							
Occupation	Housing	Township	Recreation	Parking	Factory	School	Others	Total
Government	38	2	11	2	2	3	1	59
Factory	31	4	4					39
Business	56	6	29	7	2	3		103
Agriculture	2				1			3
Executive	6	3	2					11
Others	205	28	73	4	11	9	1	331
Total	398	43	119	13	16	15	2	546
Chi-square Test, Value= 45.764, N=546, P=0.033								

Source: "Social Impact Assessment of Landfill Sites in Kuala Lumpur", Aziz Haji Muda, Department of Environmental Sciences, Faculty of Science and Environmental Studies, Universiti Putra Malaysia, Workshop on Disposal of Solid Waste Through Sanitary Landfill – Mechanisms, Processes, Potential Impact, and Post-Closure Management, August 1999, Universiti Putra Malaysia

(3) Conclusion by the Author

The author concluded the study based on the findings from this study as follows.

- Majority of the respondents agreed that if the landfill site were to be developed, detailed study should be conducted.
- Respondents felt that development of the site could benefit them especially from the aspects of social convenience and improvement to the environment.
- About 61.9 % of the residents chose housing as the most important project that may be carried out on the site.
- Nevertheless, about 21.9 % felt that the site was only suitable for sport and other recreational centres.
- There are three types of developments considered being the most suitable type of development that may be carried out after closure of the landfill sites. Those developments are housing, recreational park and parking space.

2.6 OVERALL CONCLUSION

As the result of the discussion above, the following are the overall conclusion. The conclusion may be utilized to elaborate social consideration in an action plan on safe closures of landfill sites to be prepared in this study.

- Printed information and materials in *Bahasa* Malaysia, English and Chinese etc., can be entirely utilized for the closures because of the quite high literacy rate.

- Adequate environmental health education shall be set out for scavengers and surrounding people at the time of operation, closing and post-closure stages, to prevent health hazard including rampant communicable diseases in Malaysia.
- It is necessary to launch detailed social surveys at landfill sites and the vicinities at every specific event in the operation, closing and post-closure stages.
- Due to a relatively small number of scavengers at each site, it is predicted that issues on scavengers in Malaysia are not like those in other countries like Indonesia.
- Some attention shall be made on scavengers who are not Malaysian for the closures.
- It is identified scavengers spontaneously will move to other sites if a landfill is closed.
- Therefore, impacts on scavengers caused by the closures would be limited.
- As a necessary action for surrounding households of landfills, explanatory meetings shall be convened before landfill sites are closed.
- For the residential population, it can be said that housing developments are a suitable utilization plan for post-closures of landfills.

THE STUDY OF THE SAFETY CLOSURE AND REHABILITATION OF LANDFILL SITES IN MALAYSIA

A - -
Landfill Code - Serial no

FORM A : Questionnaire for Social Survey (Scavengers)
Landfill code : 1 : Tmn Beringin, KL 2: Jinjang Utara, KL 3: Telok Kapas, Klang
4: Kundang, Selayang 5: Sungai Kembong, Kajang

Q1 Name of Landfill : ______________________

Q2 Name of Scavenger: ______________________

Q3 Sex
3.1 Male ☐ 3.1
3.2 Female ☐ 3.2

Q4 Age: ________ years old

Q5 Nationality :
5.1 Local ☐ 5.1
5.2 Foreigner (specify the country of origin) ______________ ☐ 5.2

Q6 Location of House
6.1 At and around the landfill sites ☐ 6.1
6.2 Away from the landfill sites (specify distance) _______ km ☐ 6.2

Q7 Total number of members in the family _________

Q8 No of family members working as scavengers _________
Male _____ Age range from ______yrs to _____yrs
Female _____ Age range from ______yrs to _____yrs

Q9 Avg income/cap/month: RM__________

Q10 How many days do you work as a scavenger?
10.1 everyday ☐ 10.1
10.2 6 days per week ☐ 10.2
10.3 5 days per week ☐ 10.3
10.4 4 days per week ☐ 10.4
10.5 3 days per week ☐ 10.5
10.6 2 days per week ☐ 10.6
10.7 once a week ☐ 10.7
10.8 2x a week ☐ 10.8
10.9 others (please specify) ______________________ ☐ 10.9

Q11 Working hours from : ________am/pm to _____am/pm

Q12 Type of Job: Permanent _____ Part Time _______
(if permanent go to Q15)

Q13 State the other job (for part time scavengers)
13.1 Farming ☐ 13.1
13.2 Manufacturing ☐ 13.2
13.3 Vendor ☐ 13.3
13.4 Service Business ☐ 13.4
13.5 Public Employee ☐ 13.5
13.6 Restaurant or any food outlet ☐ 13.6
13.7 Fishing ☐ 13.7
13.8 Company workers ☐ 13.8
13.9 Others (please specify) ______________ ☐ 13.9

Q14 Income from other job/month : RM__________

Q15 How long have you started working as scavengers at landfill _____ years

Q16 Where did you work before working here as a scavenger:
16.1 Scavenger at other site;(if yes, specify the location) ________ ☐ 16.1
16.2 Farming ☐ 16.2
16.3 Manufacturing ☐ 16.3
16.4 Vendor ☐ 16.4
16.5 Service Business ☐ 16.5
16.6 Public Employee ☐ 16.6
16.7 Restaurant or any food outlet ☐ 16.7
16.8 Fishing ☐ 16.8
16.9 Company workers ☐ 16.9
16.10 Others (please specify) ________ ☐ 16.10

Q17 Principal items that are collected

	Items	Quantity (kg/month)	Price RM/kg
17.1	Pet Bottles		
17.2	Plastic		
17.3	Glass		
17.4	Aluminium		
17.5	Iron Scrap		
17.6	Copper		
17.7	Rubber		
17.8	Rubber		
17.9	Others (please specify)		
17.10	Others (please specify)		

Q18 Where are the recyclables sold?
18.1 Brokers ☐ 18.1
18.2 Direct selling to recycling manufactures ☐ 18.2
18.3 Landfill Management Organisation ☐ 18.3
18.4 Others (please specify) ________ ☐ 18.4

Q19 Do you know how many brokers (traders) who deal with recyclables are active in this landfill?
19.1 One ☐ 19.1
19.2 Two ☐ 19.2
19.3 Three ☐ 19.3
19.4 Four ☐ 19.4
19.5 Five ☐ 19.5
19.6 more than 5 ☐ 19.6
19.7 no traders here ☐ 19.7
19.8 don't know ☐ 19.8

Q20 How frequent do you sell your recyclables to recycling traders/manufacturers?
20.1 once a week ☐ 20.1
20.2 twice a week ☐ 20.2
20.3 three times a week ☐ 20.3
20.4 daily ☐ 20.4
20.5 once a month ☐ 20.5
20.6 twice a month ☐ 20.6
20.7 don't know ☐ 20.7
20.8 others (please specify) ________ ☐ 20.8

Q21 How many recycling manufacturers deal directly with you (without brokers)
21.1 One ☐ 21.1
21.2 Two ☐ 21.2
21.3 Three ☐ 21.3
21.4 Four ☐ 21.4
21.5 Five ☐ 21.5
21.6 more than 5 ☐ 21.6
21.7 no traders here ☐ 21.7
21.8 don't know ☐ 21.8

Q22 Have you encountered any problems with landfill management, surrounding people, collection workers or other scavengers during scavenging activities:

- 22.1 Yes,(please elaborate the cause of trouble)________________________ ☐ 22.1
- 22.2 Nothing at all ☐ 22.2

Q23 Have you seen collection of composts that is produced naturally from organic waste at the landfill sites done by the farmers,peasants and others?

- 23.1 Yes, everyday ☐ 23.1
- 23.2 Yes sometimes ☐ 23.2
- 23.3 Never seen ☐ 23.3

Q24 Do you still want to work as a scavenger in future?

- 24.1 Yes, I would like to work as long as possible ☐ 24.1
- 24.2 Yes, as a part time only for additional income ☐ 24.2
- 24.3 No, if I can get a better and permanent job ☐ 24.3
- 24.4 I don't know ☐ 24.4

Q25 If this landfill site is to be closed, what action will you take?

- 25.1 move to other sites ☐ 25.1
- 25.2 Quit scavenger and find a new job ☐ 25.2
- 25.3 Protest the closure ☐ 25.3
- 25.4 Don't know ☐ 25.4
- 25.5 Others (please specify) ________________________ ☐ 25.5

Q26 What kind of action to be taken by the Authorities, in your opinion, if the landfill is to be closed?

- 26.1 Explanation about the closure shall be done in advance ☐ 26.1
- 26.2 Scavengers shall be consulted to get their views ☐ 26.2
- 26.3 Scavengers be allowed to operate at the other landfill site ☐ 26.3
- 26.4 Authorities shall consider to provide some form of incentives to the scavengers due to this closure ☐ 26.4
- 26.5 Others (please specify) ________________________ ☐ 26.5

Q27 If the answer for Q 26 is **26.4**, what kind of incentives do you prefer?

- 27.1 One off Compensation in monetary return ☐ 27.1
  Please state how much = RM______________
- 27.2 Job Search Service ☐ 27.2
- 27.3 Others (please specify) ________________________ ☐ 27.3
- 27.4 Don't know ☐ 27.4

Q28 If the Authorities concerned is proposing to construct a recycling plant or other solid waste management jobs such as primary collection workers, are you willing to take up the job in place of scavengers?

- 28.1 Yes, as soon as possible ☐ 28.1
- 28.2 Yes, but depends on the income of minimum RM________/month ☐ 28.2
- 28.3 No, I don't ☐ 28.3
- 28.4 Don't know ☐ 28.4

Q29 Have you suffered or contracted any of the following diseases?

- 29.1 Respiratory diseases ☐ 29.1
- 29.2 Skin diseases ☐ 29.2
- 29.3 Gastro Entiritis diseases ☐ 29.3
- 29.4 Others (please specify) ________________________ ☐ 29.4
- 29.1 No ☐ 29.5

THE STUDY OF THE SAFETY CLOSURE AND REHABILITATION OF LANDFILL SITES IN MALAYSIA

B - -
Landfill Code - Serial no

FORM B : Questionnaire for Social Survey (Scavengers)
Landfill code : 1 : Tmn Beringin, KL 2: Jinjang Utara, KL 3: Telok Kapas, Klang
4: Kundang, Selayang 5: Sungai Kembong, Kajang

Name of Surveyor : ____________ *date of survey* ______

1 Name of Landfill : ____________

2 Name of Respondent: ____________

3 Sex
3-1 Male ☐ 3-1
3-2 Female ☐ 3-2

4 Age : ________ years old

5 House Address ____________

6 Distance from landfill ________ m

7 Total number of members in the family ______
Male ______
Female ______

8 Monthly Earning RM________

9 Main income Source
9-1 Farming ☐ 9-1
9-2 Manufacturing ☐ 9-2
9-3 Vendor ☐ 9-3
9-4 Service Business ☐ 9-4
9-5 Public Employee ☐ 9-5
9-6 Restaurant or similar food outlet ☐ 9-6
9-7 Fishing ☐ 9-7
9-8 Company workers ☐ 9-8
9-9 Others (please specify) ____________ ☐ 9-9

10 Are there any environmental problems and issues caused by operation of the landfill?

- 10-1 Offensive ordour ☐ 10-1
- 10-2 Noise ☐ 10-2
- 10-3 Vibration ☐ 10-3
- 10-4 Leachate spill ☐ 10-4
- 10-5 Road accidents ☐ 10-5
- 10-6 Reduction of crop yields ☐ 10-6
- 10-7 No problem at all ☐ 10-7
- 10-8 Others (please specify) ______________________ ☐ 10-8

11 Do you think that those problems and issues will come to an end?

- 11-1 *Yes, since countermeasures will be taken by the municipality/contractorl* management ☐ 11-1
- 11-2 No, due to insufficient countermeasures taken by municipality/managemen ☐ 11-2

12 At present, there are scavengers at the landfill sites. What do you think of those scavengers

- 12-1 No problem ☐ 12-1
- 12-2 Not so good activities for health reasons ☐ 12-2
- 12-3 Such activities should be promoted for generating their income and promoting waste recycling activities ☐ 12-3 ☐
- 12-4 Scavengers create social problem and their activities are therefore to be prohibited ☐ 12-4 ☐
- 12-5 Scavengers are nuisance and therefore should be relocated elsewhere ☐ 12-5
- 12-6 Others(specify requests and comments on scavengers ☐ 12-6

____

13 What do you think if the landfill is to be closed?

- 13-1 The closure will improve the conditions of the surrounding environment ☐ 13-1
- 13-2 The closure has been desired by surrounding residents ☐ 13-2
- 13-3 Worried about a new and much bigger alternative landfill site to be constructed here if the existing landfill is to be closed ☐ 13-3
- 13-4 Worried about the secondary environmental pollutions and impact caused by the closure ☐ 13-4
- 13-5 No comment ☐ 13-5
- 13-6 Others (please specify) ______________________ ☐ 13-6

14 What is your request to municipality/operating contractor if the landfill is to be closed?

- 14-1 A public explanatory meeting/public hearing for the closure of the landfill sites shall be done. ☐ 14-1
- 14-2 Municipal/operating contractors should pay attention to public opinion ☐ 14-2
- 14-3 Environmental pollution and impact, which would be caused by the closure, shall be thoroughly prevented ☐ 14-3
- 14-4 Environmental management shall be done during the construction phase of landfill closure ☐ 14-4
- 14-5 Utilization plans for the closed landfill sites shall be explained ☐ 14-5
- 14-6 No request ☐ 14-6
- 14-7 Others (please specify) ______________________ ☐ 14-7

Data Book 5

Amount of Methane Gas Reduction by Introducing Semi-Aerobic Landfill

AMOUNT OF METHANE GAS REDUCTION BY INTRODUCING SEMI-AEROBIC LANDFILL

CHAPTER 1 INTRODUCTION

In recent years, the issue of global warming has brought to the forefront the importance of the need to reduce greenhouse gas (GHC) as a global environmental concern. For the solid waste management sector, there is concern about the effects of GHG generated from sanitary landfill sites. Measures should be taken in landfills to reduce the GHC amounts generated.

Wastes disposed at sanitary landfill sites are generally decomposed by proliferation activities of bacteria, then broken down into water, gases, and mineral salts and reduced in amount and stabilized. Nevertheless, appearance of generated gas varies widely according to whether bacteria decompose in aerobic or anaerobic. More specifically, in aerobic biodegradation, organic components such as carbohydrates or fats within wastes are finally broken down into carbon dioxide, water, etc. On the other hand, in anaerobic biodegradation, organic components are break down into methane, carbon dioxide, and so forth. Considering that Global Warming Potential (GWP) of methane is twenty-one times as much as that of carbon dioxide, it is required to keep landfill layers in aerobic condition to restrain methane gas emissions. Chemical equation of anaerobic decomposition of organic matter is shown as follows:

Methane has twenty-one times more potential as a GHG compared with carbon dioxide.

$C_6H_{12}O_6$	$\rightarrow$	CO_2 +	CH_4	+ N_2 + (NH_3, H_2S, etc.)
(organic matter/anaerobic)		(about 40%)	(about 60%)	

The JICA study has adopted the basic policy of introduction of semi-aerobic sanitary landfill for the safe closure of landfill sites.

The mechanism of semi-aerobic landfill is described as follows. A leachate collection system of perforated pipes are laid at the lower layers of the landfill and surrounded by graded aggregates. The leachate is collected and discharged out of the landfill system as quickly as possible, to prevent water from stagnating in the landfill layers and infiltrating into the layers underneath the landfill.

Furthermore the installed leachate collection system shall introduce oxygen from the atmosphere air into the waste layers, thereby promoting an aerobic state at these layers. Vertical gas ventilation pipes, installed for the purpose of releasing GHG the atmosphere, are connected to the collection pipes and have the additional function of making landfill layers aerobic.

Based on this principal, reduction of GHG emissions shall be calculated on the assumption that there are two cases: one assumes that the safe closure plan proposed by JICA Study Team has been implemented; while the second case assumes that it has not been.

CHAPTER 2 CALCULATION OF GHG EMISSIONS REDUCTION

2.1 Prerequisites

Sanitary Landfill Sites intended for the study

Out of the 147 identified landfills, both closed and in operation, landfills targeted under this study shall meet the following requirements:

Inventory

- * Landfill sites which have already been closed from the 1995 to 2003.
- * Landfill sites which are expected to be closed from the year 2004 to 2020.
- * Landfill sites requiring safe closure levels of C3 and C4

(Landfill sites with unidentified closure years or areas are excluded.)

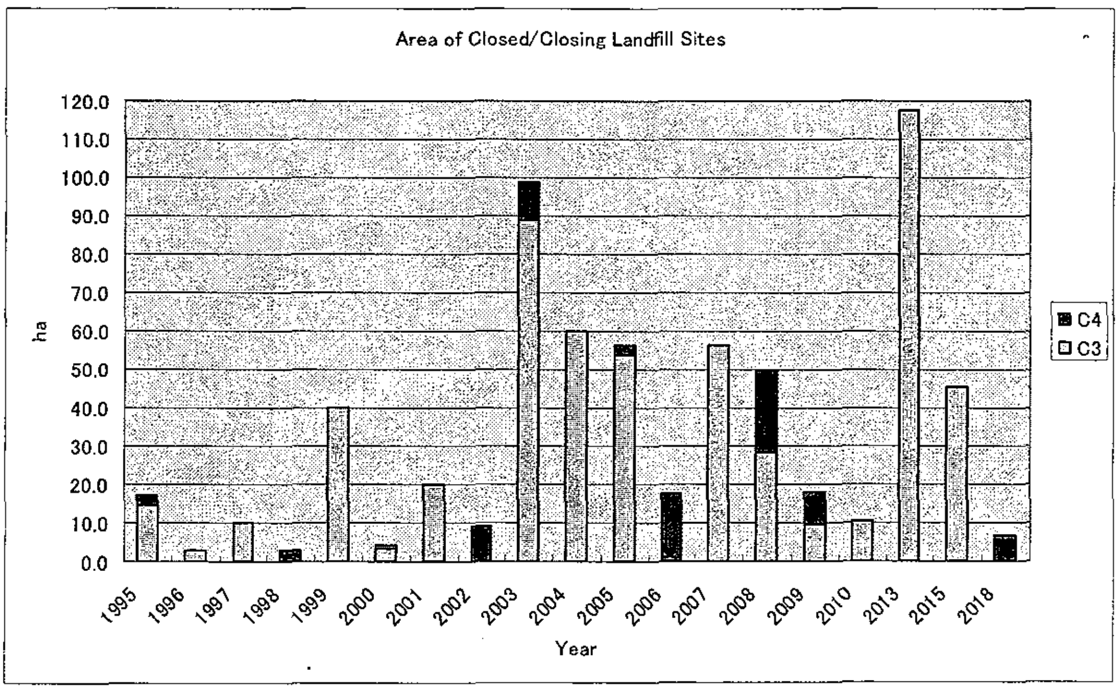


Figure 5.2.1 Area of Closed/Closing

Table 5.2.1 Landfill Sites in Closure Level C3 and C4

Year of Closure of Landfills	*1995*	*1996*	*1997*	*1998*	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*	*2008*	*2009*	*2010*	*2013*	*2015*	*2018*
	0.5	3.0	10.0		40.0	3.2	20.0		10.1	12.0	27.7		50.0	16.2	9.7	2.5	25.0	2.4	
	14.0								5.3	6.0	14.6		6.1	3.2		4.0	2.1	43.0	
Area of Each									17.4	13.3	5.0			4.9		4.0	51.0		
Closing Landfill									19.0	21.5	4.4			4.0			9.5		
(C3 Level) (ha)									17.0	7.0	2.0						30.0		
									8.0										
									12.0										
	2.5			3.0		1.0		9.2	10.1		2.4	3.0		20.0	8.4				6.8
												13.4		0.4					
Area of Each												1.2		0.8					
Closing Landfill																			
(C4 Level) (ha)																			
Total Area (ha)	17.0	3.0	10.0	3.0	40.0	4.2	20.0	9.2	98.9	59.8	56.1	17.6	56.1	49.5	18.1	10.5	117.6	45.4	6.8
(1000m2)	170.0	30.0	100.0	30.0	400.0	42.0	200.0	92.0	989.0	598.0	561.0	176.0	561.0	495.0	181.0	105.0	1176.0	454.0	68.0

(Source: Inventory Survey of JICA Study Team)

* Landfill sites of which areas or target years for closure are unidentified are excluded from this list.

Wastes intended for the study

Municipal solid wastes (MSW) are intended for the study. As for GHG emissions, biodegradable wastes (food or organic waste and yard waste) are intended.

Duration for GHG Emissions

GHG generated during the period of 2005 to 2020 is intended for the study. It is assumed that duration in which GHG is emitted is ten years, considering period for decomposition of organic wastes at a landfill site. Hence, closed landfill sites for which 10 years have passed since suspension of operation are excluded. Examples are as follows:

Ex 1: For a landfill site, which has been closed in 1995, GHG emissions during the year of 2005 only are considered in the study.

Ex 2: For a landfill site, which is supposed to be closed in 2013, GHG emissions during a seven-year period from year 2014 to 2020 are considered in the study.

Gases considered are GHG, methane and carbon dioxide.

2.2 Calculation Method

Calculation of GHG reduction is estimated by following process.

(1) Calculation of Amount of MSW Disposed to a Landfill Site

Quantity of wastes reclaimed at a landfill site is estimated by multiplying the plane area of each post-closure landfill site (m^3) by average landfill height (m) after reclamation and coefficient (0.9) which is based on consideration of angle surrounding slope and thickness of soil cover.

Degradable Organic Carbon in Wastes Reclaimed to a Landfill

Degradable Organic Carbon (DOC) in MSW per unit volume is estimated as emission factor. In this study, DOC is calculated based on amount of MSW generated in all of Malay Peninsula and composition of wastes generated in Kuala Lumpur.

Waste considered as source of DOC, so-called degradable organic wastes, is set as a mixture of "Food & Organic Wastes" and "Yard Wastes" categorized in past research of MHLG.

Calculation of Methane and Carbon Dioxide Emissions for Different Landfill System

Total GHG emissions for is estimated as follows (in case of methane emissions):

$$\text{Methane emissions (Gg/yr)} = \Sigma\,(MSW_{landfill} \times DOC \times DOCf \times F \times 16/12 - R) \times (1 - OX)$$

Where;

$MSW_{landfill}$:	total MSW disposed to solid waste disposal sites
DOC:	Degradable Organic Carbon (m^3),
DOCf:	Annual fraction dissimilated DOC (using DOCf Forecasting Model Equation)
F:	Fraction CH_4 (or CO_2) of GHG in Landfill Gas
16/12:	Conversion Factor CH_4-C (or CO_2-C)
R:	recovered CH_4 (default value is 0 as IPCC guideline)
OX:	oxidation factor (default value is 0 as IPCC guideline)

(Source: Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual)

For computing the fraction of DOC dissimilated, the Forecasting Model Equation developed by Fukuoka University, Japan, has been adopted. This equation is aimed at calculating the fraction of DOC dissimilated. The equation model is based on the phenomena that the amount of gas emissions fluctuates depending on the structure of a landfill site and the elapsed duration since wastes were disposed to the landfill site. Concept of the forecasting model is described hereafter.

Calculation of GHG Emission Reduction

GHG emissions reduction is expressed as the remainder of the total GHG emissions generated from anaerobic landfill sites minus the total GHG emissions generated from semi-aerobic landfill sites. Gaseous amount of methane is expressed in terms of CO_2 equivalents.

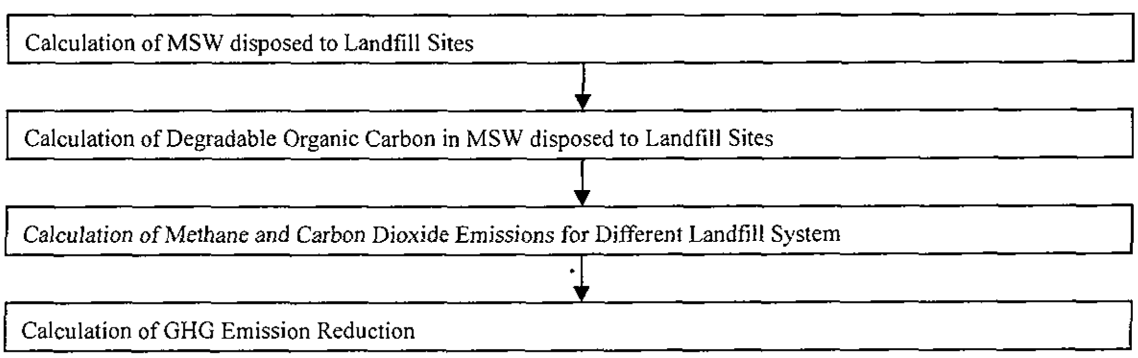


Figure 5.2.2 Flow of Calculation of GHG Emissions Reduction

2.3 Parameters of Calculation for GHG Emissions Reduction

The necessary parameters for calculating GHG emissions reduction are outlined as follows.

(2) Area of landfill sites

This is the summation of plane areas of sanitary landfill sites targeted in this study.

Landfill height

Although the average height of landfill sites is estimated as 10m, the target height of landfill layers in a landfill site intended for GHG emissions is 5m (the average of the following two cases), because of reasons mentioned below.

* Post-closure sanitary landfill needs excavation work when introducing semi-aerobic structure for the purpose of safe closure process of the landfill. Practically, 3 to 4m are considered as the limit of excavation work for construction.

* At operating sanitary landfill sites, conversion of anaerobic landfill into semi-aerobic landfill structure is required. Based on average landfill height and the number of years for operation of anaerobic landfill sites, the landfill height is assumed to be 6 to 7m after conversion into semi-aerobic system.

Volume of Wastes reclaimed

Volume of reclaimed (m^3) = Area for reclamation x Height of landfill layers x coefficient (0.9)

Degradable Organic Carbon (fraction) in Wastes Disposed to Landfill Sites

Degradable organic carbon fraction (DOC fraction) of wastes is estimated from the composition of MSW in Malaysia.

MSW generated

MSW Generated from whole Malay Peninsula: 6,173,650(t/y)

(Source : Publications by Ministry of Housing and Local Government, Malaysia, 2002)

Estimated Recycling Ratio: 4%

(Source: Ministry of Housing & Local Government, Novermber.2001)

Estimated generation of wastes : 5,926,704(t/y)

Generation amount of Degradable Organic Wastes

Degradable Organic Wastes

Out of the biodegradable organic carbon included in wastes disposed to landfill sites in Peninsula Malaysia, paper, textile and wood wastes are more refractory than food and organic or yard wastes. Therefore, during the 10-year period immediately after closure of the landfill site, decomposition of Degradable Organic Carbon will precede that of non-degradable organic carbon.

On the grounds of the aforesaid, unit amount of degradable organic carbon contents occupied per unit volume included in wastes reclaimed at landfill sites is estimated as follows:

Table 5.2.2 Degradable Organic Carbon Amount

(unit: t/yr)

Item	Annual tonnage of wastes generated Generation		Food & Organic Generation		Yard Waste Generation	
		ratio[1)]		ratio[2)]		ratio[2)]
Residential (High)	533,403,	9%	330,710	62.0%	62,942	11.8%
Residential (Middle)	1,600,210	27%	1,132,949	70.8%	75,210	4.7%
Residential (Low)	533,403	9%	381,917	71.6%	5,334	1.0%
Commercial	2,370,682	40%	1,872,838	79.0%	4,741	0.2%
Institutional	889,006	15%	521,846	58.7%	86,234	9.7%
Waste generated(t): (A)	5,926,704	100%	4,240,260		234,460	
Degradable organic carbon (fraction)[3)]: (B)	C_{total}/A_{total} = 16% (B_{total})		21.4% (Bf)		30.0% (By)	
Degradable organic carbon (amount): (C)	Cf+Cy =977,754 (C_{total})		Af×Bf=907,416 (Cf)		Ay×By=70,338 (Cy)	

1) (Source : In-house Questionnaire Survey, Yachiyo Engineering Co., Ltd., 2002)

2) (Source : NREB and DANCED, 2001)

3) (Source :Integrated Solid Waste Management, McGraw-Hill, 1993)

(by weight)	Moisture	Volatile Matter	Fixed Carbon	Non-combustible
Food wastes	70.0 %	21.4 %	3.6%	5.0 %
Yard wastes	60.0 %	30.0 %	9.5%	0.5 %

* Percentage of contents of volatile matter is defined as organic carbon content ratio.

As stated above, roughly outlined degradable organic carbon included in the wastes reclaimed at landfill sites intended for this study (categorized as closure levels C3 and C4) is estimated as 16%.

Degradable Organic Carbon (1000m^3)

Degradable organic carbon including wastes reclaimed at landfill sites intended for this study is obtained by following equation:

$$\text{Degradable Organic Carbon } (1000m^3) = \frac{\text{Degradable Organic Carbon (fraction) (\%)} \times \text{MSW disposed to Landfill Sites}(1000m^3)}{100}$$

Fraction of GHG in Landfill Gas

After disposal of wastes to sanitary landfills, organic component of wastes shall be decomposed and generated into the atmosphere as landfill gases. Main components of landfill gas depend on a variety of structures comprising the landfill system in place. In this study, components of landfill gas shall be set as follows:

* Composition of GHG Emissions in Anaerobic Landfill Sites: CH_4 60%, CO_2 40%
* Composition of GHG Emissions in Semi-aerobic Landfill Sites: CH_4 20%, CO_2 80%

(Source: Clean Development Mechanism Project Study Report on Restraint Effect of Global Warming by reduction of Methane Gas Emissions through conversion of sanitary landfill from anaerobic system into semi-aerobic system, Kyushu Environmental Evaluation Association, Contract Work for Ministry of Environment in Fiscal year 1999)

Carbon-CH_4 and Carbon-CO_2 Conversion

While methane (CH_4) or carbon dioxide (CO_2) is generated from degradable organic carbon in wastes reclaimed at sanitary landfill, conversion factor of weight from carbon (C) to methane (CH_4) shall be expressed as the ratio of molecular weight of CH_4 to that of C.

* Conversion Factor of Methane to Carbon = 16/12 = 1.33
* Conversion Factor of Carbon Dioxide to Carbon = 44/12 = 3.67

(Source: Implementation Manual for Clean Development Mechanism Project Survey for Actions against Global Warming / Version 6, 2003, Global Environment Centre Foundation)

Apparent Specific Gravity of Degradable Organic Wastes

It is reported that apparent specific gravity of wastes disposed to landfill sites is 0.7-1.1 t/m^3. Therefore, apparent specific gravity of mixed composition of food wastes and yard wastes is assumed to be $0.8t/m^3$.

Apparent Specific Gravity of Degradable Organic Wastes = $0.8t/m^3$

Degradable Organic Carbon Content (Weight) in Wastes Disposed to Landfill Sites

Degradable organic carbon content (in weight) is the product of degradable organic carbon included in the wastes reclaimed at landfill sites multiplied by apparent specific gravity of degradable organic wastes.

Degradable Organic Carbon Content (tons) = DOC ($1000m^3$) x Apparent Specific Gravity of Degradable Organic Wastes

GHG Emissions

GHG emissions generated from sanitary landfill sites are calculated by using the equation as follows:

Gas emissions = Degradable Organic Carbon content (tons per year) x Annual Fraction Dissimilated DOC (%) x conversion factor of gas (for methane (CH_4): 16/12; for carbon dioxide (CO_2): 44/12)

(Source: Clean Development Mechanism Project Study Report on Restraint Effect of Global Warming by reduction of Methane Gas Emissions through conversion of sanitary landfill from anaerobic system into semi-aerobic system, Kyushu Environmental Evaluation Association, Contract Work for Ministry of Environment in Fiscal year 1999)

The total amount of GHG emissions which shall be generated during the period from 1995 to 2020 is calculated by sum of annual GHG emissions generated from each landfill.

Forecasting Model for Fraction Dissimilated Degradable Organic Carbon for Different Systems of Landfills

Fraction dissimilated degradable organic carbon (DOCf) is the portion of DOC that is converted to landfill gas. In this study, in order to estimate the GHG emissions generated from sanitary landfills, the following equations were applied. This estimation method is the degradable organic carbon dissimilated forecasting model which was established by Hydraulic and Sanitary Engineering Laboratory, Department of Civil Engineering, Faculty of Engineering, Fukuoka University.

This forecasting model is established on the basis of empirical data obtained by experiment with lysimeter over a long period and demonstrates the mechanism of gas generation from the actual landfill system in the lysimeter.

Semi-aerobic landfill: $y=(29.00 \log x + 0.77)/100$

Anaerobic landfill: $y=(0.76x - 0.02)/100$ (0～3years)

$y=(30.61 \log x - 6.91)/100$ (4～10years)

where

y : Fraction dissimilated DOC (DOCf) (%)

x : Elapsed time (month)($x > 1$)

(Source: Clean Development Mechanism Project Study Report on Restraint Effect of Global Warming by reduction of Methane Gas Emissions through conversion of sanitary landfill from anaerobic system into semi-aerobic system, Kyushu Environmental Evaluation Association, Contract Work for Ministry of Environment in Fiscal year 1999)

Table 5.2.4 Fraction dissimilated DOC

Item	Anaerobic Landfill		Aerobic Landfill	
	Accumulative DOCf	Annual DOCf	Accumulative DOCf	Annual DOCf
12month	0.089	0.089	0.321	0.321
24 month	0.180	0.091	0.408	0.087
36 month	0.272	0.091	0.459	0.051
48 month	0.446	0.174	0.495	0.036
60 month	0.475	0.030	0.523	0.028
72 month	0.499	0.024	0.546	0.023
84 month	0.520	0.020	0.566	0.019
96 month	0.538	0.018	0.583	0.017
108 month	0.553	0.016	0.597	0.015
120 month	0.567	0.014	0.611	0.013

Baseline Setting

Baseline scenario is a forecasting scenario for GHG emissions if the safe closure project had not been carried out. In this investigation, if the project had not been implemented, at past closed (or future closing) landfill sites, conversion of anaerobic structure into semi-aerobic structure will have not been done.

Hence, in the target area, at landfill sites which shall be closed during the period from the year 1995 to 2020, in case that semi-aerobic system is not applied to landfills (which means that these landfills shall be closed as they remain anaerobic), accumulative GHG emissions (expressed in CO_2 equivalent) which have been generated after closure of landfill in maximum 10-year duration will be set as the baseline.

GHG emissions generated from post-closure landfills in target area of this study are expressed in ton-CO_2 equivalent.

Calculation of GHG Emissions Reduction

Reduction of GHG emissions is the remaining amount of the total amount of GHG (methane plus carbon dioxide) emissions generated from semi-aerobic landfill sites after subtracting that from anaerobic landfill sites.

CO_2 Conversion Value

Amount of methane (CH_4) gas emissions shall be expressed in CO_2 equivalent. CO_2 conversion amount is the product of CH_4 gas emissions multiplied by a scaling factor of 21, based on the assumption that intensity of efficiency of global warming of methane (CH_4) (the ratio of relative heat-absorbing value) is 21 times as much as that of CO_2.

The ratio of intensity of efficiency on global warming caused by CH_4 to that by CO_2 is termed the Global Warming Potential (GWP).

* A scaling factor of gas that allows their relative efficiency of producing global temperature increases to be compared.

* The GWP of a GHG is the ratio of the time-integrated radiative forcing from 1 kg of the gas in question compared to 1 kg of carbon dioxide. These GWP values are calculated over a 100 year time horizon and take into consideration not only the absorption of radiation at different wavelengths, but also the different atmospheric lifetimes of each gas and secondary effects such as effects on water vapor.

CH_4 emissions (in CH_4 equivalent) x 21 (GWP of CH_4) = CH_4 emissions (in CO_2 equivalent)

2.4 Example Calculation: GHG Emissions and Reductions in 2010

As an example, GHG emissions and reductions in the year 2010 are calculated as follows. The results for these calculations are included in Table 5.3.4(a).

1. Calculate amount of municipal solid wastes disposed at landfill sites in each year (during 2000 - 2009)

Year of closure of landfill sites	Total area of landfill sites to be closed	Total volume of wastes reclaimed at landfill sites Area x Height x 0.9 = Waste amount
2000	42,000m^2	42,000m2 x 5m x 0.9 = 189,000m^3
2001	200,000 m^2	200,000m2 x 5m x 0.9 = 900,000 m^3
2002	92,000 m^2	92,000m2 x 5m x 0.9 = 414,000 m^3
2003	989,000 m^2	989,000m2 x 5m x 0.9 = 4,451,000 m^3
2004	598,000 m^2	598,000m2 x 5m x 0.9 = 2,691,000 m^3
2005	561,000 m^2	561,000m2 x 5m x 0.9 = 2,525,000 m^3
2006	176,000 m^2	176,000m2 x 5m x 0.9 = 792,000 m^3
2007	561,000 m^2	561,000m2 x 5m x 0.9 = 2,525,000 m^3
2008	495,000 m^2	495,000m2 x 5m x 0.9 = 2,228,000 m^3
2009	181,000 m^2	181,000m2 x 5m x 0.9 = 815,000 m^3

2. Calculate weight of degradable organic carbon component in the wastes disposed at landfill sites in each year (during 2000 - 2009)

Year of closure of landfill sites	Total volume of degradable organic carbon Waste amount x Fraction of DOC = DOC amount	Total weight of degradable organic carbon DOC amount x Specific Gravity = DOC weight
2000	189,000 m^3 x 0.16 = 30,240 m^3	30,240m3 x 0.8tons/ m^3 = 24,192tons
2001	900,000 m^3 x 0.16 = 144,000 m^3	144,000m3 x 0.8tons/ m^3 = 115,200tons
2002	414,000 m^3 x 0.16 = 66,240 m^3	66,240m3 x 0.8tons/ m^3 = 52,992tons
2003	4,451,000 m^3 x 0.16 = 712,080 m^3	712,080m3 x 0.8tons/ m^3 = 569,664tons
2004	2,691,000 m^3 x 0.16 = 430,560 m^3	430,560m3 x 0.8tons/ m^3 = 344,448tons
2005	2,525,000 m^3 x 0.16 = 403,920 m^3	403,920m3 x 0.8tons/ m^3 = 323,136tons
2006	792,000 m^3 x 0.16 = 126,720 m^3	126,720m3 x 0.8tons/ m^3 = 101,376tons
2007	2,525,000 m^3 x 0.16 = 403,920 m^3	403,920m3 x 0.8tons/ m^3 = 323,136tons
2008	2,228,000 m^3 x 0.16 = 356,400 m^3	356,400m3 x 0.8tons/ m^3 = 285,120tons
2009	815,000 m^3 x 0.16 = 130,320 m^3	130,320m3 x 0.8tons/ m^3 =104,256tons

3. Calculate GHG emissions under anaerobic and semi-aerobic conditions.

GHG (CH_4) emissions under anaerobic conditions in 2010

Year of closure of landfill sites	Weight of waste		Fraction of CH_4		CH4-C conversion		Fraction dissimilated DOC		GHG (CH_4) emissions	Nos. of Years since closure
2000	24,192tons	x	0.6	x	(16/12)	x	0.014	=	270 tons	After 10 years
2001	115,200tons	x	0.6	x	(16/12)	x	0.016	=	1,471 tons	After 9 years
2002	52,992tons	x	0.6	x	(16/12)	x	0.018	=	761 tons	After 8 years
2003	569,664tons	x	0.6	x	(16/12)	x	0.020	=	9,092 tons	After 7 years
2004	344,448tons	x	0.6	x	(16/12)	x	0.024	=	6,597 tons	After 6 years
2005	323,136tons	x	0.6	x	(16/12)	x	0.030	=	7,736 tons	After 5 years
2006	101,376tons	x	0.6	x	(16/12)	x	0.174	=	14,076 tons	After 4 years
2007	323,136tons	x	0.6	x	(16/12)	x	0.091	=	23,465 tons	After 3 years
2008	285,120tons	x	0.6	x	(16/12)	x	0.091	=	20,250 tons	After 2 years
2009	104,256tons	x	0.6	x	(16/12)	x	0.089	=	7,404 tons	After 1 year
Total									91,577 tons	

CH_4 emissions (in CH_4 equivalent) x 21 (GWP of CH_4) = CH_4 emissions (in CO_2 equivalent)

(GWP: Global Warming Potential; GWP of CH_4 = 21)

91,577 tons x 21 = 1,923,117 tons in CO2 equivalent

GHG (CH_4) emissions under semi-aerobic conditions in 2010

Year of closure	Weight of waste	Fraction of CH_4	CH4-C conversion	Fraction dissimilated DOC	GHG (CH_4) emissions	Nos. of Years since closure
2000	24,192tons	x 0.2	x (16/12)	x 0.013	= 84 tons	After 10 years
2001	115,200tons	x 0.2	x (16/12)	x 0.015	= 460 tons	After 9 years
2002	52,992tons	x 0.2	x (16/12)	x 0.017	= 240 tons	After 8 years
2003	569,664tons	x 0.2	x (16/12)	x 0.019	= 2,879 tons	After 7 years
2004	344,448tons	x 0.2	x (16/12)	x 0.023	= 2,634 tons	After 6 years
2005	323,136tons	x 0.2	x (16/12)	x 0.028	= 2,407 tons	After 5 years
2006	101,376tons	x 0.2	x (16/12)	x 0.036	= 971 tons	After 4 years
2007	323,136tons	x 0.2	x (16/12)	x 0.051	= 4,384 tons	After 3 years
2008	285,120tons	x 0.2	x (16/12)	x 0.087	= 6,598 tons	After 2 years
2009	104,256tons	x 0.2	x (16/12)	x 0.086	= 8,902 tons	After 1 year
Total					29,559 tons	

29,559tons x 21 = 620,739 in CO_2 equivalent

GHG (CO_2) emissions under anaerobic conditions in 2010

Year of closure	Weight of waste	Fraction of CO_2	CO_2-C conversion	Fraction dissimilated DOC	GHG (CO_2) emissions	Nos. of Years since closure
2000	24,192tons	x 0.4	x (44/12)	x 0.014	= 497 tons	After 10 years
2001	115,200tons	x 0.4	x (44/12)	x 0.016	= 2,706 tons	After 9 years
2002	52,992tons	x 0.4	x (44/12)	x 0.018	= 1,400 tons	After 8 years
2003	569,664tons	x 0.4	x (44/12)	x 0.020	= 16,725 tons	After 7 years
2004	344,448tons	x 0.4	x (44/12)	x 0.024	= 12,136 tons	After 6 years
2005	323,136tons	x 0.4	x (44/12)	x 0.030	= 14,231 tons	After 5 years
2006	101,376tons	x 0.4	x (44/12)	x 0.174	= 25,895 tons	After 4 years
2007	323,136tons	x 0.4	x (44/12)	x 0.091	= 43,167 tons	After 3 years
2008	285,120tons	x 0.4	x (44/12)	x 0.091	= 38,089 tons	After 2 years
2009	104,256tons	x 0.4	x (44/12)	x 0.089	= 13,621 tons	After 1 year
Total					168,467 tons	

GHG (CO_2) emissions under semi-aerobic conditions in 2010

Year of closure	Weight of waste	Fraction of CO_2	CO_2-C conversion	Fraction dissimilated DOC	GHG (CO_2) emissions	Nos. of Years since closure
2000	24,192tons	x 0.8	x (44/12)	x 0.013	= 923 tons	After 10 years
2001	115,200tons	x 0.8	x (44/12)	x 0.015	= 5,073 tons	After 9 years
2002	52,992tons	x 0.8	x (44/12)	x 0.017	= 2,645 tons	After 8 years
2003	569,664tons	x 0.8	x (44/12)	x 0.019	= 31,778 tons	After 7 years
2004	344,448tons	x 0.8	x (44/12)	x 0.024	= 23,260 tons	After 6 years
2005	323,136tons	x 0.8	x (44/12)	x 0.089	= 26,564 tons	After 5 years
2006	101,376tons	x 0.8	x (44/12)	x 0.089	= 10,715 tons	After 4 years
2007	323,136tons	x 0.8	x (44/12)	x 0.089	= 48,385 tons	After 3 years
2008	285,120tons	x 0.8	x (44/12)	x 0.089	= 72,829 tons	After 2 years
2009	104,256tons	x 0.8	x (44/12)	x 0.089	= 98,257 tons	After 1 year
Total					320,429 tons	

4. Calculate GHG reductions.

GHG reductions = GHG emissions (anaerobic) – GHG emissions (semi-aerobic)
Please note that the total reductions must be calculated in CO_2 equivalent.

Results: GHG emissions and reductions in 2010

CH_4 Emissions	Anaerobic	①	91,577 tons
	(in CO_2 equiv.)	① x 21	1,923,117 tons
	Semi-aerobic	②	29,559 tons
	(in CO_2 equiv.)	② x 21	620,739 tons
CO_2 Emissions	Anaerobic	③	168,467 tons
	Semi-aerobic	④	320,429 tons
GHG Emissions	Anaerobic	(① x 21)+③ = A	2,091,584 tons
	Semi-aerobic	(② x 21)+④ = B	941,168 tons
GHG Reductions	CH_4 Reductions	① – ②	62,018 tons
	CH_4 Reductions (in CO_2 equiv.)	(① x 21) – (② x 21) = C	1,302,378 tons
	CO_2 Reductions	③ – ④ = D	– 151,962 tons
	Total Reductions (in CO_2 equiv.)	A – B (= C + D)	1,150,416 tons

CHAPTER 3 RESULT OF COMPUTATION

Results of calculation of GHG emissions reduction are shown below.

Table 5.3.1 GHG Emissions and Reduction

(unit: tons)

CH_4 Emissions	Accumulated Amount (Year of 2005～2020)
From Anaerobic Landfills (Baseline)	1,367,768
(CO_2equivalent)	28,723,128
Semi-aerobic Landfills	451,939
(CO_2equivalent)	9,490,719
CO_2 Emissions	Accumulated Amount (Year of 2005～2020)
From Anaerobic Landfills (Baseline)	2,456,025
Semi-aerobic Landfills	4,982,593
CH_4 Reductions	915,829
(CO_2equivalent)	19,232,409
CH_4 Reductions	−2,526,568
GHG Reductions (CO_2equivalent)	16,705,841

Table 5.3.2(a) CH_4 Emissions from Anaerobic Landfill Sites during year 2005 to 2020

Year of Closure	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2013	2015	2018
①Area (10^3m2)	170	30	100	30	400	42	200	92	989	598	561	176	561	495	181	105	1,176	454	68
②Depth (m)	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
* Coefficient	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
③Volume of Reclaimed Waste(10^3m3)	765	135	450	135	1,800	189	900	414	4,451	2,691	2,525	792	2,525	2,228	815	473	5,292	2,043	306
④Degradable Organic Carbone (fraction) (%)	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%
⑤Degradable Organic Carbone (Volume) (10^3m3)	122.4	21.6	72	21.6	288	30.24	144	66.24	712.08	430.56	403.92	126.72	403.92	356.4	130.32	75.6	846.72	326.88	48.96
⑥fraction of CH4 in Landfill gas	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
⑦CH4-C Conversion Factor (16/12)	1.33	1.33	1.33	1.33	1.33	1.33	1.33	1.33	1.33	1.33	1.33	1.33	1.33	1.33	1.33	1.33	1.33	1.33	1.33
⑧Specific Weight of Biodegradable Waste (t/m3)	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
⑨Degradable Organic Carbone (Weight) (ton)	97,920	17,280	57,600	17,280	230,400	24,192	115,200	52,992	569,664	344,448	323,136	101,376	323,136	285,120	104,256	60,480	677,376	261,504	39,168
2005	1,094	221	827	276	4,413	579	15,996	3,848	41,368	24,463									
2006		193	735	248	3,677	463	2,758	7,358	41,368	25,013	22,950								
2007			644	221	3,309	386	2,206	1,269	79,099	25,013	23,465	7,200							
2008				193	2,942	347	1,839	1,015	13,638	47,827	23,465	7,362	22,950						
2009					2,574	309	1,655	846	10,910	8,246	44,868	7,362	23,465	20,250					
2010						270	1,471	761	9,092	6,597	7,736	14,076	23,465	20,705	7,404				
⑩Sub total(2005~2010)	1,094	414	2,206	938	16,915	2,354	25,925	15,097	195,475	137,159	122,484	36,000	69,880	40,955	7,404	0	0	0	0
2011							1,287	677	8,183	5,497	6,189	2,427	44,868	20,705	7,571	4,295			
2012								592	7,273	4,948	5,157	1,942	7,736	39,589	7,571	4,392			
2013									6,364	4,398	4,642	1,618	6,189	6,826	14,476	4,392			
2014										3,848	4,126	1,456	5,157	5,461	2,496	8,398	48,109		
2015											3,610	1,294	4,642	4,551	1,997	1,448	49,190		
2016												1,133	4,126	4,095	1,664	1,158	49,190	18,573	
2017													3,610	3,640	1,498	965	94,055	18,990	
2018														3,185	1,331	869	16,216	18,990	
2019															1,165	772	12,973	36,310	2,782
2020																676	10,811	6,260	2,844
⑪Sub total(2005~2020)	1,094	414	2,206	938	16,915	2,354	27,212	16,366	217,295	155,850	146,208	45,870	146,208	129,007	47,173	27,365	280,544	99,123	5,626
CO2 Equivalent	22,974	8,694	46,326	19,698	355,215	49,434	571,452	343,686	4,563,195	3,272,850	3,070,368	963,270	3,070,368	2,709,147	990,633	574,665	5,891,424	2,081,583	118,146
TOTAL(CH4)																			1,367,768
CO2 Equivalent																			28,723,128

Table 5.3.2(b) CH_4 Emissions from Semi-aerobic Landfill Sites during year 2005 to 2020

Year of Closure	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2013	2015	2018
①Area (10^3m2)	170	30	100	30	400	42	200	92	989	598	561	176	561	495	181	105	1,176	454	68
②Depth (m)	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
* Coefficient	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
③Volume of Reclaimed Waste(10^3m3)	765	135	450	135	1,800	189	900	414	4,451	2,691	2,525	792	2,525	2,228	815	473	5,292	2,043	306
④Degradable Organic Carbone (fraction) (%)	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%
⑤Degradable Organic Carbone (Volume) (10^3m3)	122.4	21.6	72	21.6	288	30.24	144	66.24	712.08	430.56	403.92	126.72	403.92	356.4	130.32	75.6	846.72	326.88	48.96
⑥fraction of CH4 in Landfill gas	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
⑦CH4-C Conversion Factor (16/12)	1.33	1.33	1.33	1.33	1.33	1.33	1.33	1.33	1.33	1.33	1.33	1.33	1.33	1.33	1.33	1.33	1.33	1.33	1.33
⑧Specific Weight of Biodegradable Waste (t/m3)	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
⑨Degradable Organic Carbone (Weight) (ton)	97,920	17,280	57,600	17,280	230,400	24,192	115,200	52,992	569,664	344,448	323,136	101,376	323,136	285,120	104,256	60,480	677,376	261,504	39168.0
2005	339	69	260	87	1,410	180	1,103	719	13,183	29,411									
2006		60	230	78	1,164	148	858	507	7,728	7,971	27,591								
2007			199	69	1,042	122	705	395	5,455	4,673	7,478	8,656							
2008				60	919	109	582	324	4,243	3,298	4,384	2,346	27,591						
2009					797	97	521	268	3,485	2,565	3,094	1,375	7,478	24,345					
2010						84	460	240	2,879	2,634	2,407	971	4,384	6,598	8,902				
⑩Sub total(2005~2010)	339	129	689	294	5,332	740	4,229	2,453	36,973	50,552	44,954	13,348	39,453	30,943	8,902	0	0	0	0
2011							398	211	2,576	1,741	1,977	755	3,094	3,868	2,413	5,164			
2012								183	2,273	1,558	1,633	620	2,407	2,730	1,414	1,400			
2013									1,970	1,374	1,461	512	1,977	2,124	998	820			
2014										1,191	1,289	458	1,633	1,744	776	579	57,838		
2015											1,117	404	1,461	1,441	638	450	15,676		
2016												351	1,289	1,289	527	370	9,189	22,329	
2017													1,117	1,138	471	306	6,487	6,052	
2018														986	416	273	5,045	3,548	
2019															361	241	4,144	2,504	3,344
2020																209	3,423	1,948	906
⑪Sub total(2005~2020)	339	129	689	294	5,332	740	4,627	2,847	43,792	56,416	52,431	16,448	52,431	46,263	16,916	9,812	101,802	36,381	4,250
CO2 Equivalent	7,119	2,709	14,469	6,174	111,972	15,540	97,167	59,787	919,632	1,184,736	1,101,051	345,408	1,101,051	971,523	355,236	206,052	2,137,842	764,001	89,250
TOTAL(CH4)																			451,939
CO2 Equivalent																			9,490,719

Table 5.3.3(a) CO_2 Emissions from Anaerobic Landfill Sites during year 2005 to 2020

Year of Closure	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2013	2015	2018
①Area (10^3m2)	170	30	100	30	400	42	200	92	989	598	561	176	561	495	181	105	1, 176	454	68
②Depth (m)	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
* Coefficient	0. 9	0. 9	0. 9	0. 9	0. 9	0. 9	0. 9	0. 9	0. 9	0. 9	0. 9	0. 9	0. 9	0. 9	0. 9	0. 9	0. 9	0. 9	0. 9
③Volume of Reclaimed Waste(10^3m3)	765	135	450	135	1, 800	189	900	414	4, 451	2, 691	2, 525	792	2, 525	2, 228	815	473	5, 292	2, 043	306
④Degradable Organic Carbone (fraction) (%)	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%
⑤Degradable Organic Carbone (Volume) (10^3m3)	122. 4	21. 6	72	21. 6	288	30. 24	144	66. 24	712. 08	430. 56	403. 92	126. 72	403. 92	356. 4	130. 32	75. 6	846. 72	326. 88	48. 96
⑥fraction of CO2 in Landfill gas	0. 4	0. 4	0. 4	0. 4	0. 4	0. 4	0. 4	0. 4	0. 4	0. 4	0. 4	0. 4	0. 4	0. 4	0. 4	0. 4	0. 4	0. 4	0. 4
⑦CO2-C Conversion Factor (44/12)	3. 67	3. 67	3. 67	3. 67	3. 67	3. 67	3. 67	3. 67	3. 67	3. 67	3. 67	3. 67	3. 67	3. 67	3. 67	3. 67	3. 67	3. 67	3. 67
⑧Specific Weight of Biodegradable Waste (t/m3)	0. 8	0. 8	0. 8	0. 8	0. 8	0. 8	0. 8	0. 8	0. 8	0. 8	0. 8	0. 8	0. 8	0. 8	0. 8	0. 8	0. 8	0. 8	0. 8
⑨Degradable Organic Carbone (Weight) (ton)	97, 920	17, 280	57, 600	17, 280	230, 400	24, 192	115, 200	52, 992	569, 664	344, 448	323, 136	101, 376	323, 136	285, 120	104, 256	60, 480	677, 376	261, 504	39, 168
2005	2, 012	406	1, 522	507	8, 117	1, 065	29, 426	7, 079	76, 100	45, 003									
2006		355	1, 353	457	6, 765	852	5, 073	13, 536	76, 100	46, 014	42, 218								
2007			1, 184	406	6, 088	710	4, 059	2, 334	145, 510	46, 014	43, 167	13, 245							
2008				355	5, 412	639	3, 382	1, 867	25, 088	87, 983	43, 167	13, 543	42, 218						
2009					4, 735	568	3, 044	1, 556	20, 070	15, 169	82, 539	13, 543	43, 167	37, 251					
2010						497	2, 706	1, 400	16, 725	12, 136	14, 231	25, 895	43, 167	38, 089	13, 621				
⑩Sub total (2005~2010)	2, 012	761	4, 059	1, 725	31, 117	4, 331	47, 690	27, 772	359, 593	252, 319	225, 322	66, 226	128, 552	75, 340	13, 621	0	0	0	0
2011							2, 368	1, 245	15, 053	10, 113	11, 385	4, 465	82, 539	38, 089	13, 927	7, 902			
2012								1, 089	13, 380	9, 102	9, 487	3, 572	14, 231	72, 829	13, 927	8, 079			
2013									11, 708	8, 090	8, 539	2, 976	11, 385	12, 557	26, 630	8, 079			
2014										7, 079	7, 590	2, 679	9, 487	10, 045	4, 591	15, 449	88, 501		
2015											6, 641	2, 381	8, 539	8, 371	3, 673	2, 664	90, 489		
2016												2, 083	7, 590	7, 534	3, 061	2, 131	90, 489	34, 166	
2017													6, 641	6, 697	2, 755	1, 776	173, 024	34, 934	
2018														5, 860	2, 449	1, 598	29, 832	34, 934	
2019															2, 143	1, 421	23, 865	6, 680	5, 117
2020																1, 243	19, 888	11, 517	5, 232
⑪Sub total (2005~2020)	2, 012	761	4, 059	1, 725	31, 117	4, 331	50, 058	30, 106	399, 734	286, 703	268, 964	84, 382	268, 964	237, 322	86, 777	50, 342	516, 088	122, 231	10, 349
TOTAL(CO2)																			2, 456, 025

Table 5.3.3(b) CO_2 Emissions from Semi-aerobic Landfill Sites during year 2005 to 2020

Year of Closure	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2013	2015	2018
①Area (10^3m2)	170	30	100	30	400	42	200	92	989	598	561	176	561	495	181	105	1, 176	454	68
②Depth (m)	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
* Coefficient	0. 9	0. 9	0. 9	0. 9	0. 9	0. 9	0. 9	0. 9	0. 9	0. 9	0. 9	0. 9	0. 9	0. 9	0. 9	0. 9	0. 9	0. 9	0. 9
③Volume of Reclaimed Waste(10^3m3)	765	135	450	135	1, 800	189	900	414	4, 451	2, 691	2, 525	792	2, 525	2, 228	815	473	5, 292	2, 043	306
④Degradable Organic Carbone (fraction) (%)	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%
⑤Degradable Organic Carbone (Volume) (10^3m3)	122. 4	21. 6	72	21. 6	288	30. 24	144	66. 24	712. 08	430. 56	403. 92	126. 72	403. 92	356. 4	130. 32	75. 6	846. 72	326. 88	48. 96
⑥fraction of CO2 in Landfill gas	0. 8	0. 8	0. 8	0. 8	0. 8	0. 8	0. 8	0. 8	0. 8	0. 8	0. 8	0. 8	0. 8	0. 8	0. 8	0. 8	0. 8	0. 8	0. 8
⑦CO2-C Conversion Factor (44/12)	3. 67	3. 67	3. 67	3. 67	3. 67	3. 67	3. 67	3. 67	3. 67	3. 67	3. 67	3. 67	3. 67	3. 67	3. 67	3. 67	3. 67	3. 67	3. 67
⑧Specific Weight of Biodegradable Waste (t/m3)	0. 8	0. 8	0. 8	0. 8	0. 8	0. 8	0. 8	0. 8	0. 8	0. 8	0. 8	0. 8	0. 8	0. 8	0. 8	0. 8	0. 8	0. 8	0. 8
⑨Degradable Organic Carbone (Weight) (ton)	97, 920	17, 280	57, 600	17, 280	230, 400	24, 192	115, 200	52, 992	569, 664	344, 448	323, 136	101, 376	323, 136	285, 120	104, 256	60, 480	677, 376	261, 504	39, 168
2005	3, 737	761	2, 875	964	15, 558	1, 989	12, 176	7, 935	145, 510	324, 627									
2006		660	2, 537	862	12, 853	1, 634	9, 470	5, 601	85, 299	87, 983	304, 541								
2007			2, 198	761	11, 500	1, 350	7, 779	4, 356	60, 211	51, 576	82, 539	95, 542							
2008				660	10, 147	1, 207	6, 426	3, 578	46, 831	36, 407	48, 385	25, 895	304, 541						
2009					8, 794	1, 065	5, 750	2, 956	38, 468	28, 316	34, 154	15, 180	82, 539	268, 713					
2010						923	5, 073	2, 645	31, 778	23, 260	26, 564	10, 715	48, 385	72, 829	98, 257				
⑩Sub total (2005~2010)	3, 737	1, 421	7, 610	3, 247	58, 852	8, 168	46, 674	27, 071	408, 097	552, 169	496, 183	147, 332	435, 465	341, 542	98, 257	0	0	0	0
2011							4, 397	2, 334	28, 433	19, 215	21, 821	8, 334	34, 154	42, 693	26, 630	57, 000			
2012								2, 023	25, 088	17, 192	18, 026	6, 846	26, 564	30, 136	15, 611	15, 449			
2013									21, 743	15, 169	16, 128	5, 655	21, 821	23, 439	11, 019	9, 056			
2014										13, 147	14, 231	5, 060	18, 026	19, 254	8, 571	6, 392	638, 397		
2015											12, 333	4, 465	16, 128	15, 905	7, 040	4, 972	173, 024		
2016												3, 869	14, 231	14, 231	5, 816	4, 084	101, 428	246, 456	
2017													12, 333	12, 557	5, 204	3, 374	71, 596	66, 796	
2018														10, 882	4, 591	3, 019	55, 686	39, 157	
2019															3, 979	2, 664	45, 742	27, 640	36, 914
2020																2, 308	37, 787	21, 498	10, 005
⑪Sub total (2005~2020)	3, 737	1, 421	7, 610	3, 247	58, 852	8, 168	51, 071	31, 428	483, 361	616, 892	578, 722	181, 561	578, 722	510, 639	186, 718	108, 318	1, 123, 660	401, 547	46, 919
TOTAL(CO2)																			4, 982, 593

Table 5.3.4(a) GHG Emissions and Reductions from Year 2005 to 2010

Year		2005	2006	2007	2008	2009	2010	Sub Total
CH4 Emissions	Anaerobic	93,085	104,763	142,812	121,578	120,485	91,577	674,300
	(in CO2 equiv.)	1,954,785	2,200,023	2,999,052	2,553,138	2,530,185	1,923,117	14,160,300
	Semi-aerobic	46,761	46,335	28,794	43,856	44,025	29,559	239,330
	(in CO2 equiv.)	981,981	973,035	604,674	920,976	924,525	620,739	5,025,930
CO2 Emissions	Anaerobic	171,237	192,723	262,717	223,654	221,642	168,467	1,240,440
	Semi-aerobic	516,132	511,440	317,812	484,077	485,935	320,429	2,635,825
GHG Emissions	Anaerobic	2,126,022	2,392,746	3,261,769	2,776,792	2,751,827	2,091,584	15,400,740
	Semi-aerobic	1,498,113	1,484,475	922,486	1,405,053	1,410,460	941,168	7,661,755
GHG Reductions	CH4 Reductions	46,324	58,428	114,018	77,722	76,460	62,018	434,970
	(in CO2 equiv.)	972,804	1,226,988	2,394,378	1,632,162	1,605,660	1,302,378	9,134,370
	CO2 Reductions	-344,895	-318,717	-55,095	-260,423	-264,293	-151,962	-1,395,385
	GHG Reductions (in CO2 equiv.)	627,909	908,271	2,339,283	1,371,739	1,341,367	1,150,416	7,738,985

Table 5.3.4 (b) GHG Emissions and Reductions from Year 2011 to 2020

Year		2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Sub Total	Grand Total
CH4 Emissions	Anaerobic	101,699	79,200	48,905	79,051	66,732	79,939	122,758	40,591	54,002	20,591	660,789	1,367,768
	(in CO2 equiv.)	2,135,679	1,663,200	1,027,005	1,660,071	1,401,372	1,678,719	2,577,918	852,411	1,134,042	432,411	14,562,828	28,723,128
	Semi-aerobic	22,197	14,218	11,236	65,508	21,187	35,344	15,571	10,268	10,594	6,486	212,609	451,939
	(in CO2 equiv.)	466,137	298,578	235,956	1,375,668	444,927	742,224	326,991	215,628	222,474	136,206	4,464,789	9,490,719
CO2 Emissions	Anaerobic	187,086	145,696	89,964	145,421	122,758	147,054	225,827	74,673	39,226	37,880	1,215,585	2,456,025
	Semi-aerobic	245,011	156,935	124,030	723,078	233,867	390,115	171,860	113,335	116,939	71,598	2,346,768	4,982,593
GHG Emissions	Anaerobic	2,322,765	1,808,896	1,116,969	1,805,492	1,524,130	1,825,773	2,803,745	927,084	1,173,268	470,291	15,778,413	31,179,153
	Semi-aerobic	711,148	455,513	359,986	2,098,746	678,794	1,132,339	498,851	328,963	339,413	207,804	6,811,557	14,473,312
GHG Reductions	CH4 Reductions	79,502	64,982	37,699	13,543	45,545	44,595	107,187	30,323	43,408	14,105	448,180	915,829
	(in CO2 equiv.)	1,669,542	1,364,622	791,049	284,403	956,445	936,495	2,250,927	636,783	911,568	296,205	10,098,039	19,232,409
	CO2 Reductions	-57,925	-11,239	-34,066	-577,657	-111,109	-243,061	53,967	-38,662	-77,713	-33,718	-1,131,183	-2,526,568
	GHG Reductions (in CO2 equiv.)	1,611,617	1,353,383	756,983	-293,254	845,336	693,434	2,304,894	598,121	833,855	262,487	8,966,856	16,705,841

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