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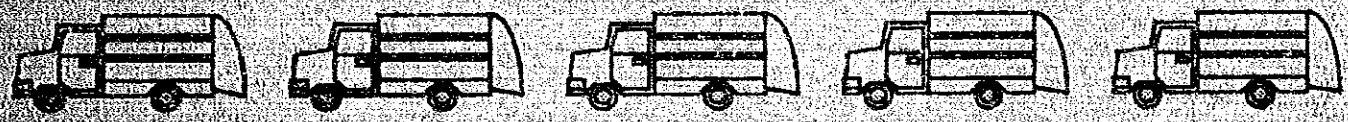
No. 52

THE ROYAL THAI GOVERNMENT
THE BANGKOK METROPOLITAN ADMINISTRATION

THE STUDY ON BANGKOK

SOLID WASTE MANAGEMENT

FINAL REPORT



VOL.4

SUPPORTING REPORT

MARCH 1991

JAPAN INTERNATIONAL COOPERATION AGENCY

SSS
91-014

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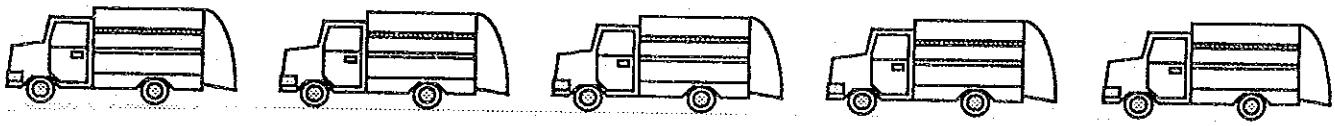

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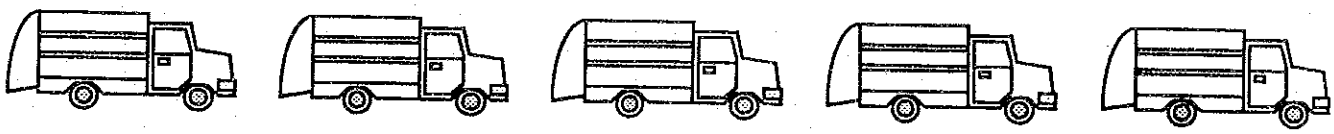


JAPAN INTERNATIONAL COOPERATION AGENCY

Abbreviations (Listed in alphabetical order)

B	Baht
BMA	Bangkok Metropolitan Administration
BOD	Biochemical Oxygen Demand
BPP	Beneficiary Pay Principle
$Ca(OH)_2$	Calcium Hydroxide
COD	Chemical Oxygen Demand
DDS	Department of Dranage and Sewage
DPC	Department of Public Cleansing
DTEC	Department of Technical and Economic Cooperation
F／S	Feasibility Study
GDP	Gross Domestic Product
GPP	Gross Provincial Product
HCl	Hydrogen Chloride
JICA	Japan International Cooperation Agency
LHV	Low Heat Value
MB	Million Baht
MMD	Mechanical and Maintenance Division (Central Workshop) of Finance Department, BMA
m^3N/h	Cubic meter Normal / hour
M／P	Master Plan
N.D.	Not Detective
NESDB	National Economic Social Development Board
ONEB	Office of National Environmental Board
PPP	Polluter Pay Principle
Pt-Co unit	unit of Platinum-Cobalt method
PVC	Poly Vinyl Chloride
SWM	Solid Waste Management
SS	Suspended Solid
t/d	tons/day
T－KN (T－N)	Total Nitrogen (Kjeldahl method)

Rai (Thai Unit) = 1,600 m^2
Soi (Thai Words) : Narrow Street
Khlong (Thai Words) : Canal

Exchange Rate (as of January 1991)

1 $ = 25 Baht = 130 Yen (Approximately)

Study on Bangkok Solid Waste Management

VOLUME 4 SUPPORTING REPORT

CONTENTS

Part I

Estimation of Waste Amount and Quality

Chapter 1 Waste Amount

1.1 Method of Estimation

1.1.1 Data Abailability and Method of Estimation

The amount of Solid waste is projected in order to examine a final disposal plan, collection, and a haulage plan in particular, accordingly, the projection of each district is required. For this projection, data on the amount of waste, collection rate, population and economic statistics are required. However, the available data is limited as shown in Table 1.1-1.

Table 1.1-1 Data Availability

Data	Availability	
	Whole Bangkok	District Level
Population	Available	Available
GPP	Available (until 1987)	Not Available
Collected Waste Amount	Available	Available
Collection Rate	Available (1989 only)	Available (1989 only)

To project the waste amount by districts, the annual collection rate of Bangkok has to be estimated first, then, the total waste amount is divided into each district according to population.

The increase of per capita generation amount is projected using a regression analysis.

The flow chart showing the method of the waste amount estimation in Bangkok is given in Fig. 1.1-1.

1.1.2 Assumptions

For projection, certain conditions in the future have to be assumed and a desirable policy target also has to be set, in particular, the collection rate.

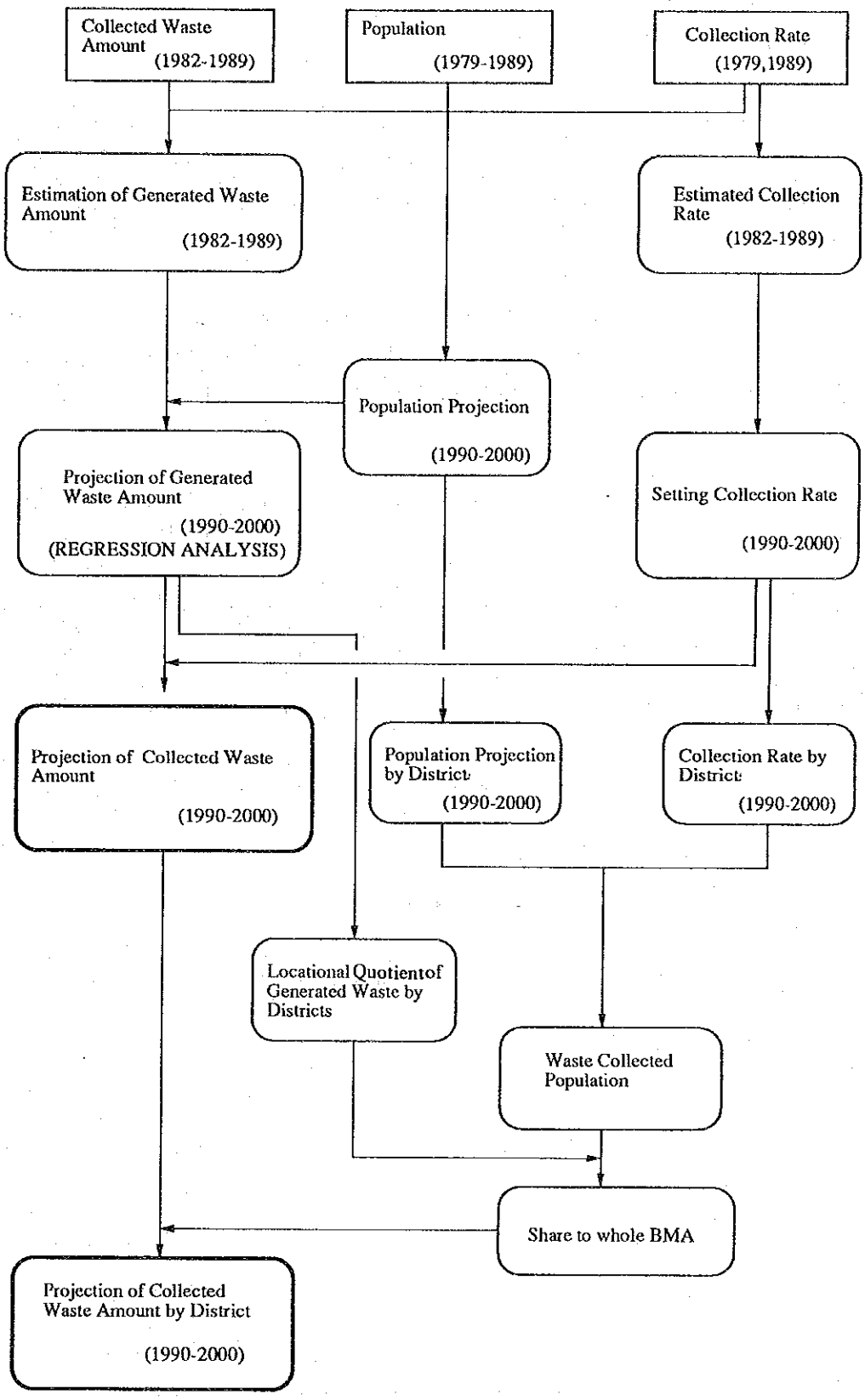


Fig. 1.1-1 Flow Chart of Projection

1) Population

The population of Bangkok is increasing at a stable rate of growth, which is 2.2 % per year. This trend, however, has slowed down in recent years. On the other hand, neighboring provinces are growing rapidly with new factories and residential areas, as are shown in Fig. 1.1-2 and Table 1.1-2.

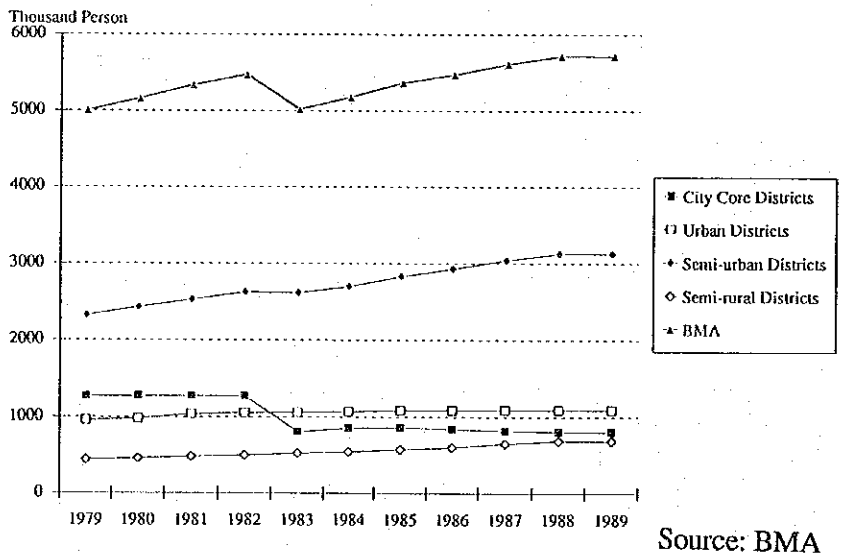
The population of Bangkok will increase at a more modest rate of 1.5 % per annum until 2000, using data from the third BMA development plan and the master plan for garbage disposal prepared by the DPC. Table 1.1-3 shows the result of future estimation by districts.

Table 1.1-2 Population Growth of Bangkok Metropolitan Region(BMR) between 1970 and 1989

	Number(Thousands)			Annual Growth Rate(%)	
	1970	1980	1989	1970-80	1980-89
Bangkok	3,185	4,852	5,717	4.30	0.18
Samut Prakan	341	503	742*	3.96	5.71
Nontha Buri	278	383	572*	3.26	5.90
Pathum Thani	242	332	415*	3.21	3.24
Nakorn Pathom	434	545	620*	2.30	1.86
Samut Sakhon	207	256	334*	2.15	3.87
BMR	4,687	6,871	5,717	3.90	2.72

* Data in 1987

Source: NESDB



Source: BMA

Fig. 1.1-2 Population Growth of Bangkok from 1978 to 1989

Table 1.1-3 Population Projection during 1990 to 2000

(Person)

DISTRICT\YEAR	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
1. Phra Nakhon	101,300	100,200	99,100	98,100	97,100	96,200	95,300	94,400	93,600	92,800	92,000
2. Pom Prab	80,300	79,200	78,100	77,100	76,100	75,200	74,300	73,400	72,600	71,800	71,000
3. Sam Pan Thawong	47,900	47,400	46,900	46,400	45,900	45,500	45,100	44,700	44,300	43,900	43,500
4. Phatum Wan	150,500	154,500	158,600	162,700	166,900	171,100	175,400	179,700	184,100	188,500	193,000
5. Bang Rak	87,000	86,800	86,600	86,400	86,200	86,000	85,800	85,600	85,500	85,400	85,300
6. Yannawa	115,800	116,400	117,000	117,600	118,200	118,800	119,400	120,000	120,600	121,100	121,600
7. Sathon	149,000	149,800	150,600	151,400	152,200	152,900	153,600	154,300	155,000	155,700	156,400
8. Bang Kho Laem	149,700	150,500	151,300	152,100	152,900	153,700	154,400	155,100	155,800	156,500	157,200
9. Dusit	268,800	269,900	271,000	272,100	273,200	274,300	275,300	276,300	277,300	278,300	279,300
10. Bang Sue	306,200	307,500	308,800	310,000	311,200	312,400	313,600	314,800	316,000	317,100	318,200
11. Phaya Thai	227,800	227,400	227,000	226,600	226,200	225,800	225,400	225,000	224,700	224,400	224,100
12. Rat Thewee	112,000	111,800	111,600	111,400	111,200	111,000	110,800	110,600	110,400	110,200	110,000
13. Huai Khwang	268,600	272,000	275,400	278,800	282,200	285,500	288,800	292,100	295,400	298,700	302,000
14. Phra Khanong	192,900	195,800	198,700	201,600	204,500	207,400	210,300	213,100	215,900	218,700	221,500
15. Klong Toi	281,200	285,400	289,600	293,800	298,000	302,200	306,400	310,500	314,600	318,700	322,800
16. Pra Weat	200,200	203,200	206,200	209,200	212,200	215,200	218,200	221,200	224,100	227,000	229,900
17. Bang Khen	205,900	212,300	218,800	225,400	232,100	238,900	245,900	253,000	260,200	267,600	275,100
18. Dong Muang	213,400	220,000	226,700	233,500	240,500	247,600	254,800	262,200	269,700	277,300	285,100
19. Jatujak	205,800	212,200	218,700	225,300	232,000	238,800	245,800	252,900	260,100	267,500	275,000
20. Bang Kapi	223,100	231,900	241,000	250,300	259,900	269,800	280,000	290,500	301,300	312,400	323,800
21. Lad Phaow	121,200	126,000	130,900	136,000	141,200	146,600	152,100	157,800	163,700	169,700	175,900
22. Bung Kum	153,500	159,600	165,800	172,200	178,800	185,600	192,600	199,800	207,200	214,800	222,700
23. Nong Chok	62,300	63,200	64,100	65,000	65,900	66,800	67,600	68,400	69,200	70,000	70,800
24. Min Buri	89,400	92,300	95,300	98,400	101,500	104,700	107,900	111,200	114,600	118,100	121,600
25. Lad Kra Bang	67,400	69,600	71,800	74,000	76,300	78,600	81,000	83,400	85,900	88,400	91,000
26. Thon Buri	270,200	270,400	270,600	270,800	271,000	271,200	271,400	271,600	271,800	272,000	272,200
27. Klong San	146,600	147,300	148,000	148,700	149,300	149,900	150,500	151,100	151,700	152,300	152,900
28. Bangkok Noi	153,900	154,800	155,600	156,400	157,200	158,000	158,800	159,600	160,400	161,200	162,000
29. Bang Plat	146,200	147,000	147,800	148,600	149,400	150,200	151,000	151,700	152,400	153,100	153,800
30.Bangkok Yai	107,900	108,300	108,700	109,100	109,500	109,900	110,300	110,600	110,900	111,200	111,500
31. Pasi Charoen	247,500	251,800	256,100	260,400	264,700	269,000	273,300	277,600	281,900	286,200	290,500
32. Bang Khun Thian	122,000	125,400	128,900	132,400	136,000	139,700	143,400	147,200	151,000	154,900	158,800
33. Jom Thong	185,400	188,600	191,800	195,000	198,200	201,400	204,600	207,800	211,000	214,200	217,400
34. Taling Chan	107,800	111,100	114,500	117,900	121,400	125,000	128,600	132,300	136,100	139,900	143,800
35. Rat Burana	160,700	164,300	168,000	171,700	175,400	179,100	182,900	186,700	190,500	194,400	198,300
36. Nong Khaem	73,200	75,900	78,700	81,600	84,600	87,600	90,700	93,900	97,200	100,600	104,100
TOTAL	5,802,600	5,889,800	5,978,300	6,068,000	6,159,100	6,251,600	6,345,300	6,440,100	6,536,700	6,634,600	6,734,100

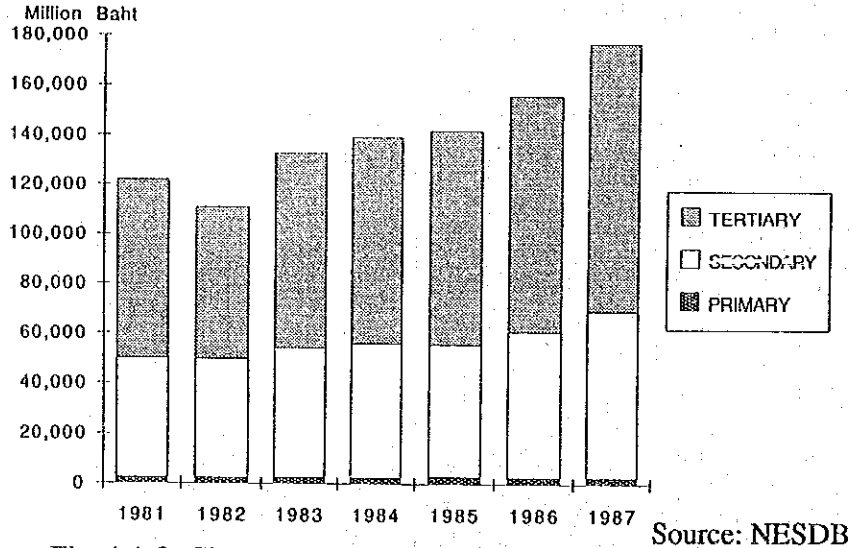
2) Economic Growth

Thailand, particularly Bangkok, has experienced very rapid economic growth in recent years, which is illustrated in Fig. 1.1-3. This economic growth is expected to continue for several years. This study applies a 7.4 % per year growth rate until 1997 and 5 % per year until 2000 as estimated in the GPP growth rate of Bangkok.

3) Collection Rate

The collection rate shows the proportion of service provided to the population of the BMA to that of the total BMA's population. This data is new, and is collected from districts every four months by the DPC, so the only available data is that for 1989. This study applies the collection rate estimated by the JICA 1982 Study as the collection rate in 1980. The annual collection rate is estimated using the assumption that the collection rate has been increasing at a constant from 1980 to 1989.

The current collection rate is a result of the BMA policy. The present BMA governor has created the policy of "Clean Bangkok", hence, the collection rate has increased by the many efforts of BMA. It can be said that the collection rate depends greatly on the BMA's future policy on the solid waste management. This study assumes that the BMA will try to continue to increase the collection ratio at the same rate as in the recent years, under the present political structure of the BMA. The collection rate by districts is shown in Fig. 1.1-4.



Source: NESDB

Fig. 1.1-3 Change of GPP of Bangkok from 1990 to 2000

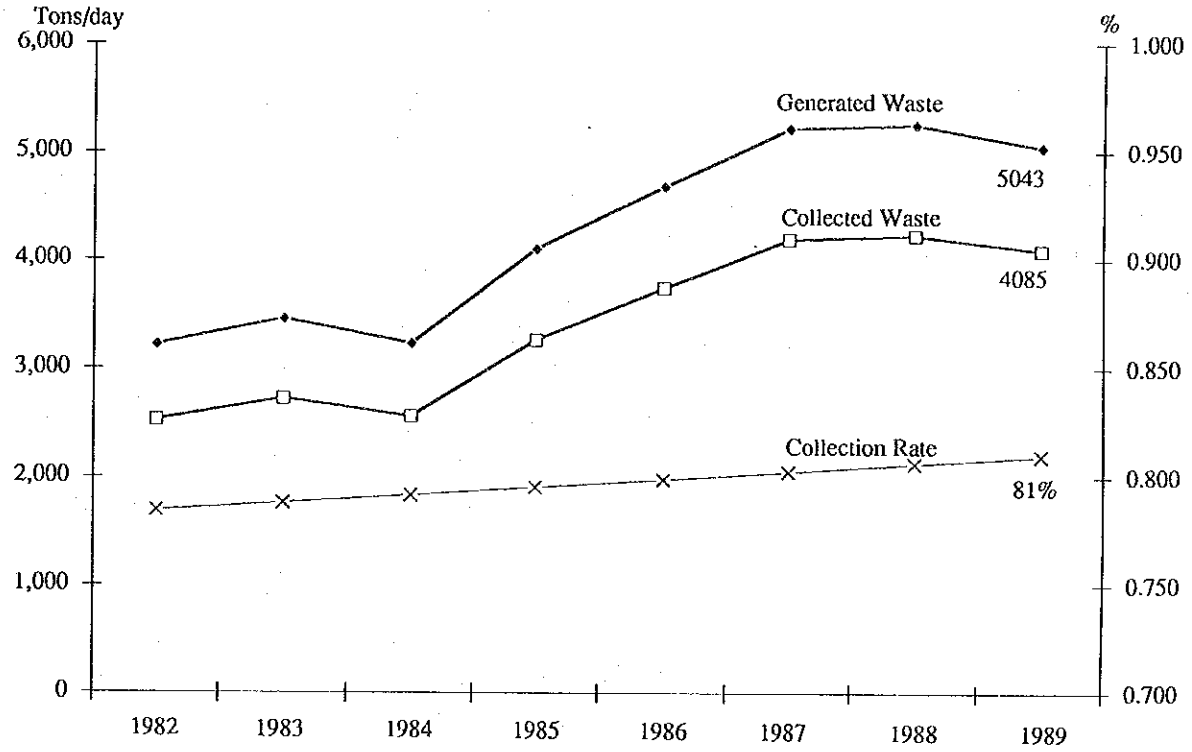


Fig. 1.1-4 Estimation of Collection Rate and Generated Solid Waste Amount

4) Generated Waste Amount

Generated waste per person (Generated Waste Unit) is the result of personal consumption and business activities. In Bangkok, both have changed rapidly under the recent favorable economic growth, Thus, the generated waste unit will increase in the future. If it is a short period, the increase of the generated waste unit can fit to a linear curve. This study, hence, applies simple regression analysis in order to estimate the generated waste unit. Table 1.1-4 and Fig. 1.1-5 show the results of the regression analysis.

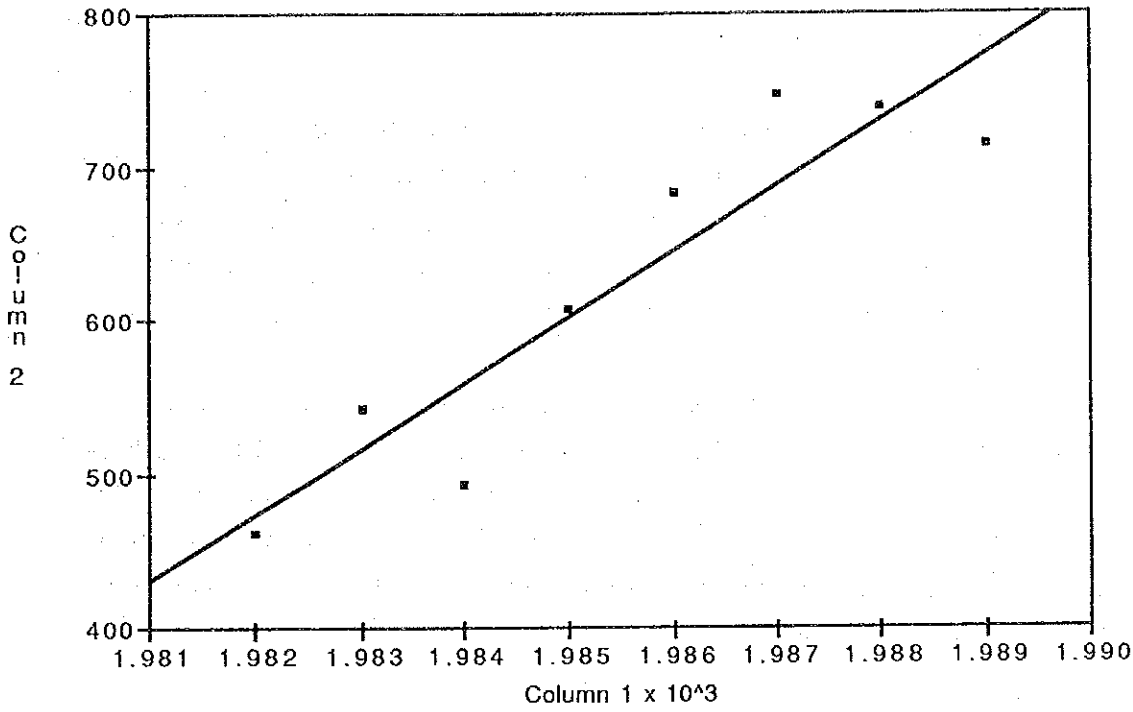


Fig.1.1-5 Result of Regression Analysis

Table 1.1-4 Result of Regression Analysis

Variable Name	Coefficient	Std. Err. Estimate	t Statistic	Prob > t
Constant	-84114.429	14572.981	-5.772	0.001
Column 1	42.679	7.340	5.815	0.001

Source	Sum of Squares	Deg. of Freedom	Mean Squares	F-Ratio	Prob>F
Model	76501.339	1	76501.339	33.811	0.001
Error	13575.536	6	2262.589		
Total	90076.875	7			

Coefficient of Determination (R^2)	0.849
Adjusted Coefficient (R^2)	0.824
Coefficient of Correlation (R)	0.922
Standard Error of Estimate	47.567
Durbin-Watson Statistic	1.749

1.2 Results of the Estimation

Estimated generated waste amount and collected waste amount during 1990 to 2000 are shown in Fig. 1.2-1 and Table 1.2-1. In the year 2000, 10,200 tons/day of solid waste will be generated, and 8,700 tons/day are expected to be collected. At that time, the population will be 6,734 thousand people with a GPP per capita of 68,000 Baht. Estimated collected waste amount by districts is shown in Table 1.2-2.

There have been two main studies relevant to the solid waste management in Bangkok. There are two previous studies, one is the JICA study in 1982, and the other is "Feasibility Study on The Management of The Disposal of Bangkok Municipal Waste". Each study employs a different approach for projecting the solid waste amounts in Bangkok. Table 1.2-3 shows a comparison of the studies in terms of data used, method of projection and results.

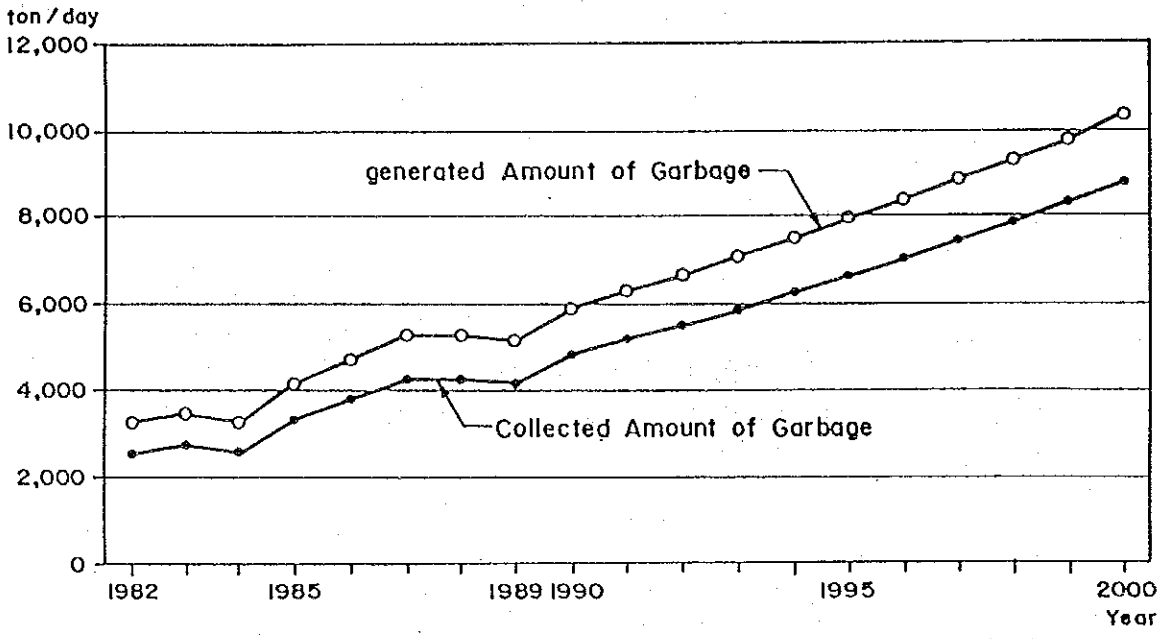


Fig. 1.2-1 Generated and Collected Waste Amount toward the Year 2000

Table 1.2-1 Result of Waste Amount Projection

								PROJECTION		
	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
POPULATION	5,468,286	5,018,327	5,174,682	5,363,378	5,468,915	5,609,352	5,716,779	5,716,739	5,802,600	5,889,800
GPP (M.BAHTS)	121,720	132,818	139,981	142,092	153,631	177,140	200,522	224,986	246,400	264,600
GPP/CAPITA(BAHTS)	22,259	26,467	27,051	26,493	28,092	31,579	35,076	39,356	42,500	44,900
COLLECTED WASTE	**922,379**	**993,770**	**933,177**	**1,189,973**	**1,364,243**	**1,529,385**	**1,546,291**	**1,491,068**	**1,740,600**	**1,849,800**
CW/DAY (TON)	**2,527**	**2,723**	**2,557**	**3,260**	**3,738**	**4,190**	**4,225**	**4,085**	**4,800**	**5,100**
CW/P/D (g)	462	543	494	608	683	747	739	715	830	870
COLLECTION RATE*	0.785	0.788	0.792	0.795	0.799	0.803	0.806	0.810	0.814	0.817
GENERATED WASTE	1,175,561	1,260,803	1,178,559	1,496,062	1,707,379	1,905,375	1,917,700	1,840,825	2,139,100	2,263,000
GW/DAY (TON)	3,221	3,454	3,229	4,099	4,678	5,220	5,254	5,043	5,861	6,200
GW/P/D (g)	589	688	624	764	855	931	919	882	1,010	1,060

CW;COLLECTED WASTE , P;PERSON, D;DAY

*; Collection rate is estimated.

1992	1993	1994	1995	1996	1997	1998	1999	2000
5,978,300	6,068,000	6,159,100	6,251,600	6,345,300	6,440,100	6,536,700	6,634,600	6,734,100
284,200	305,200	327,800	352,100	378,200	397,100	417,000	437,900	459,800
47,500	50,300	53,200	56,300	59,600	61,700	63,800	66,000	68,300
1,978,100	**2,107,500**	**2,268,400**	**2,400,200**	**2,533,200**	**2,698,100**	**2,864,400**	**3,032,100**	**3,170,300**
5,400	**5,800**	**6,200**	**6,600**	**6,900**	**7,400**	**7,800**	**8,300**	**8,700**
900	960	1,010	1,060	1,090	1,150	1,190	1,250	1,290
0.821	0.825	0.829	0.832	0.836	0.840	0.844	0.848	0.852
2,409,000	2,555,000	2,737,500	2,883,500	3,029,500	3,212,000	3,394,500	3,577,000	3,723,000
6,600	7,000	7,500	7,900	8,300	8,800	9,300	9,800	10,200
1,110	1,160	1,210	1,260	1,310	1,360	1,420	1,470	1,520

Table 1.2-2 Result of Collected Waste Amount Projection by Districts

DISTRICT\YEAR	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
1. Phra Nakhon	76,083	78,867	82,252	85,519	89,826	92,783	95,569	99,346	103,008	106,472	108,690
2. Pom Prab	38,525	39,820	41,407	42,934	44,969	46,330	47,595	49,343	51,036	52,621	53,581
3. Sam Pan Thawong	24,065	24,957	26,039	27,058	28,404	29,355	30,254	31,468	32,612	33,692	34,377
4. Phatum Wan	61,655	66,330	71,801	77,364	84,216	90,011	95,942	103,153	110,511	117,965	124,370
5. Bang Rak	50,299	52,591	55,329	57,979	61,384	63,849	66,233	69,345	72,431	75,424	77,574
6. Yannawa	44,082	46,647	49,668	52,674	56,437	59,409	62,366	66,077	69,760	73,362	76,200
7. Sathon	47,225	49,983	53,230	56,462	60,507	63,662	66,799	70,742	74,650	78,534	81,601
8. Bang Kho Laem	39,848	42,174	44,913	47,639	51,050	53,746	56,393	59,720	63,019	66,295	68,883
9. Dusit	80,860	85,085	90,088	95,006	101,225	105,960	110,575	116,462	122,228	127,887	132,160
10. Bang Sue	64,604	67,990	71,999	75,916	80,871	84,640	88,343	93,065	97,691	102,202	105,603
11. Phaya Thai	73,048	76,418	80,441	84,340	89,341	92,981	96,506	101,097	105,578	109,923	113,038
12. Rat Thewee	62,372	65,545	69,308	72,996	77,675	81,205	84,666	89,095	93,423	97,664	100,841
13. Huai Khwang	55,185	58,831	63,099	67,398	72,723	77,056	81,414	86,809	92,222	97,662	102,138
14. Phra Khanong	53,489	57,157	61,443	65,775	71,126	75,548	80,013	85,474	90,969	96,507	101,106
15. Klong Toi	104,360	111,000	118,772	126,558	136,220	144,022	151,829	161,467	171,079	180,681	188,443
16. Pra Weat	34,626	36,999	39,772	42,574	46,035	48,895	51,783	55,341	58,897	62,480	65,456
17. Bang Khen	47,523	51,584	56,317	61,212	67,193	72,435	77,875	84,467	91,256	98,290	104,521
18. Dong Muang	62,136	67,437	73,612	79,998	87,835	94,708	101,799	110,434	119,328	128,493	136,652
19. Jatujak	85,291	92,161	100,162	108,376	118,426	127,088	136,014	146,861	157,948	169,351	179,273
20. Bang Kapi	82,409	89,768	98,376	107,313	118,245	127,976	138,095	150,356	163,076	176,276	188,138
21. Lad Phaow	34,408	37,657	41,442	45,429	50,280	54,673	59,248	64,801	70,618	76,668	82,204
22. Bung Kum	40,547	44,181	48,398	52,796	58,173	62,957	67,928	73,951	80,197	86,675	92,533
23. Nong Chok	2,631	2,809	3,018	3,229	3,490	3,705	3,917	4,178	4,440	4,704	4,921
24. Min Buri	17,610	19,140	20,934	22,806	25,077	27,092	29,163	31,684	34,302	37,021	39,429
25. Lad Kra Bang	13,880	15,089	16,489	17,930	19,708	21,263	22,887	24,843	26,880	28,970	30,848
26. Thon Buri	53,952	56,840	60,255	63,623	67,873	71,137	74,358	78,447	82,468	86,431	88,662
27. Klong San	45,959	48,614	51,742	54,851	58,707	61,733	64,738	68,520	72,265	75,982	78,906
28. Bangkok Noi	41,111	43,532	46,352	49,158	52,671	55,445	58,205	61,669	65,108	68,527	71,236
29. Bang Plat	44,364	46,746	49,562	52,338	55,838	58,528	61,179	64,501	67,761	70,968	73,411
30.Bangkok Yai	29,294	30,954	32,911	34,852	37,289	39,197	41,090	43,435	45,752	48,045	49,832
31. Pasi Charoen	50,751	54,356	58,564	62,828	68,081	72,462	76,896	82,340	87,837	93,394	98,059
32. Bang Khun Thian	22,979	24,865	27,075	29,343	32,130	34,566	37,061	40,105	43,218	46,430	49,237
33. Jom Thong	36,231	38,800	41,798	44,837	48,581	51,702	54,861	58,740	62,655	66,614	69,935
34. Taling Chan	11,326	12,288	13,415	14,575	15,998	17,252	18,539	20,106	21,728	23,391	24,870
35. Rat Burana	38,464	41,400	44,843	48,356	52,659	56,315	60,068	64,641	69,286	74,048	78,133
36. Nong Khaem	19,409	21,187	23,271	25,458	28,136	30,513	32,999	36,015	39,163	42,450	45,438
DPC	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000
TOTAL (Ton)	1,740,600	1,849,800	1,978,100	2,107,500	2,268,400	2,400,200	2,533,200	2,698,100	2,864,400	3,032,100	3,170,300

Table 1.2-3 Copmarison of Studies

	Present JICA Study	JICA 1980 Study	Feasibility Study on the Management of the Disposal of Bangkok Municipal Waste
Used Data	Collected Waste 1982-1989 Collection Rate 1979-1989	Disposal Amount 1960-1978 Collected Waste 1979-1980	Collected Waste 1984-1987 Collection Rate 1987
Method of Projection	Generated waste amount is projected by regression analysis. Variables are generated waste unit and year.	Generated waste amount is projected by assumed formula. Variables are generated waste and GPP.	Waste amount is assumed by GDP growth.
Projected Waste Amount (Tons/day)	1990 4,770	3,310	5,206
	1995 6,600	4,300	7,308
	2000 8,700	5,540	9,896

1.3 Results of Questionnaire Survey Regarding Business Waste

1.3.1 Implementation of Questionnaire Survey

An "business waste questionnaire survey" has been conducted in order to obtain data regarding what is business waste and who is business waste discharger. The questionnaire survey was implemented in the following manner:

1) Survey Method

The questionnaire has been distributed by mail to 36 district offices. The district office completed the questionnaire from the records which the district office keeps for charging collection fees.

2) Survey Period

5 October to 2 November 1990

3) Sample

All waste dischargers who pay more than 500 Baht/year are targeted except residences. Data of 2,190 business establishments are obtained through 36 districts as a result.

1.3.2 Results of Questionnaire Survey

1) Business Waste Discharger

"Factory" and "office" have the two largest shares among all types of the business waste dischargers; which is approximately 35% and 30% respectively. "Market" follows with approximately 6% share to the total number of the business waste dischargers. Table 1.3-1 shows the number of dischargers by district and by types of business.

Table 1.3-1 Number of Dischargers by District sand by Types of Business

District	Resturant	(%)	Office	(%)	Hotel	(%)	Shop	(%)	School	(%)	Recreational Facility	(%)	Governmental Office	(%)	Market	(%)	Temple	(%)	Factory	(%)	Others	(%)	Total
1. Phra Nakhon	2	0.041	8	0.163	6	0.122	7	0.143	0	0.000	0	0.000	11	0.224	13	0.265	0	0.000	0	0.000	2	0.041	49
2. Pom Prab	0	0.000	3	0.125	5	0.208	2	0.083	1	0.042	0	0.000	5	0.208	5	0.208	0	0.000	1	0.042	2	0.083	24
3. Sam Pan Thawong	2	0.028	58	0.817	4	0.056	3	0.042	0	0.000	0	0.000	0	0.000	4	0.056	0	0.000	0	0.000	0	0.000	71
4. Phaum Wan	20	0.164	47	0.385	9	0.074	11	0.090	14	0.115	2	0.016	7	0.057	7	0.057	0	0.000	0	0.000	5	0.041	122
5. Bang Rak	10	0.060	114	0.683	19	0.114	6	0.036	8	0.048	2	0.012	0	0.000	6	0.036	0	0.000	1	0.006	1	0.006	167
6. Yannawa	5	0.042	87	0.731	0	0.000	1	0.008	2	0.017	0	0.000	0	0.000	5	0.042	0	0.000	18	0.151	1	0.008	119
7. Sathon	0	0.000	14	0.700	0	0.000	0	0.000	2	0.100	0	0.000	0	0.000	2	0.100	0	0.000	2	0.100	0	0.000	20
8. Bang Kho Laem	0	0.000	19	0.514	2	0.054	8	0.216	0	0.000	0	0.000	0	0.000	2	0.054	0	0.000	6	0.162	0	0.000	37
9. Dusit	0	0.000	0	0.000	0	0.000	3	0.167	0	0.000	1	0.056	9	0.500	5	0.278	0	0.000	0	0.000	0	0.000	18
10. Bang Sue	0		0		0		0		0		0		0		0		0		0		0		0
11. Phaya Thai	10	0.065	49	0.316	20	0.129	21	0.135	15	0.097	4	0.026	23	0.148	7	0.045	0	0.000	0	0.000	6	0.039	155
12. Rat Thewee	2	0.016	44	0.341	30	0.233	11	0.085	20	0.155	9	0.070	10	0.078	3	0.023	0	0.000	0	0.000	0	0.000	129
13. Huai Khwang	4	0.056	32	0.444	5	0.069	2	0.028	5	0.069	8	0.111	0	0.000	2	0.028	0	0.000	14	0.194	0	0.000	72
14. Phra Khanong	0	0.000	20	0.606	2	0.061	1	0.030	0	0.000	1	0.030	0	0.000	6	0.182	0	0.000	3	0.091	0	0.000	33
15. Klong Toi	8	0.107	45	0.600	9	0.120	5	0.067	4	0.053	0	0.000	2	0.027	1	0.013	0	0.000	1	0.013	0	0.000	75
16. Pra Weat	5	0.278	8	0.444	0	0.000	1	0.056	1	0.056	0	0.000	1	0.056	2	0.111	0	0.000	0	0.000	0	0.000	18
17. Bang Khen	0	0.000	0	0.000	0	0.000	3	0.176	0	0.000	0	0.000	4	0.235	5	0.294	1	0.059	4	0.235	0	0.000	17
18. Dong Muang	3	0.068	5	0.114	2	0.045	2	0.045	0	0.000	0	0.000	0	0.000	6	0.136	0	0.000	26	0.591	0	0.000	44
19. Janujak	16	0.232	37	0.536	1	0.014	5	0.072	0	0.000	3	0.043	0	0.000	0	0.000	1	0.014	5	0.072	1	0.014	69
20. Bang Kapi	12	0.211	2	0.035	3	0.053	8	0.140	0	0.000	3	0.053	0	0.000	9	0.158	0	0.000	19	0.333	1	0.018	57
21. Lad Phaow	0	0.000	2	0.400	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	3	0.600	0	0.000	0	0.000	0	0.000	5
22. Bung Kum	0	0.000	2	0.083	0	0.000	0	0.000	4	0.167	0	0.000	0	0.000	2	0.083	0	0.000	16	0.667	0	0.000	24
23. Nong Chok	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	9	1.000	0	0.000	9
24. Min Buri	3	0.061	3	0.061	0	0.000	0	0.000	1	0.020	1	0.020	1	0.020	1	0.020	0	0.000	37	0.755	2	0.041	49
25. Lad Kra Bang	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	2	0.038	0	0.000	50	0.962	0	0.000	52
26. Thon Buri	1	0.053	0	0.000	0	0.000	1	0.053	0	0.000	0	0.000	0	0.000	14	0.737	0	0.000	0	0.000	0	0.000	19
27. Klong San	6	0.158	2	0.053	3	0.079	2	0.053	1	0.026	3	0.079	0	0.000	9	0.237	0	0.000	14	0.368	0	0.000	38
28. Bangkok Noi	0	0.000	0	0.000	1	0.071	1	0.071	1	0.071	1	0.071	1	0.071	1	0.071	0	0.000	0	0.000	0	0.000	14
29. Bang Plat	9	0.281	4	0.125	9	0.281	3	0.094	6	0.188	2	0.063	0	0.000	2	0.063	0	0.000	4	0.125	1	0.031	32
30. Bangkok Yai	0	0.000	1	0.045	1	0.045	0	0.000	11	0.500	0	0.000	2	0.091	5	0.227	0	0.000	3	0.136	0	0.000	22
31. Pasi Charoen	1	0.010	20	0.190	0	0.000	1	0.010	8	0.076	0	0.000	0	0.000	4	0.038	0	0.000	69	0.657	2	0.019	105
32. Bang Khun Thian	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	1	0.067	0	0.000	14	0.933	0	0.000	15
33. Jom Thong	0	0.000	13	0.135	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	3	0.031	0	0.000	80	0.833	0	0.000	96
34. Taling Chan	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	1	1.000	0	0.000	1
35. Rat Burana	0	0.000	19	0.049	0	0.000	1	0.003	2	0.005	0	0.000	0	0.000	1	0.003	0	0.000	357	0.927	5	0.013	385
36. Nong Khaem	0	0.000	18	0.643	0	0.000	0	0.000	2	0.071	0	0.000	2	0.071	2	0.071	0	0.000	4	0.143	0	0.000	28
Total	119	0.054	676	0.309	131	0.060	109	0.050	108	0.049	40	0.018	78	0.036	140	0.064	2	0.001	758	0.346	29	0.013	2,190

2) Business Waste Amount

The business waste from office and factory are the largest amount, approximately 28% and 25% of the total respectively. "Hotel" and "Market" discharge relatively large amounts of waste, 8.3% and 16.4% respectively, compared their number of dischargers. It means that each hotel and market discharges a large amount of waste individually as shown in Table 1.3-2.

More than half of business establishments who pay more than 500 Baht discharge less than $3m^3$ waste. The business establishments who discharge more than $5m^3$ are approximately 19% only. For the types of the business waste dischargers, office and market discharge relatively large amounts of waste. Table 1.3-3 shows waste amount by types of business.

3) Collection Fee

Approximately 61% of the business waste dischargers pay less than 1,440 Baht per year as a collection fee. Among types of business, 1,,440 Baht to 2,400 Baht is largest proportion for restaurants, 960 Baht to 1,440 Baht is largest for offices, shops and government offices, and 600 Baht to 960 Bahts is largest for factories. Hotels and markets pay more collection fee, with the largest proportion of dischargers belonging to 2,400 Baht to 4,800 Baht rate collection fee. Table 1-3-4 shows distribution of collection fee by types of business.

Table 1.3-5 shows a relationship between collection fee and waste amount. If the 1962 fee rate is applied, approximately 54% of the business waste dischargers pays appropriate level of collection fee and 15% of office pay lower than that and 31% of office pay higher that.

Table 1.3-2 Waste Amount by District sand by Types of Business

(Ton/day)

District	Resturant	(%)	Office	(%)	Hotel	(%)	Shop	(%)	School	(%)	Recreational Facility	(%)	Governmental Office	(%)	Market	(%)	Temple	(%)	Factory	(%)	Others	(%)	Total
1. Phra Nakhon	0.5	0.002	3.6	0.012	2.3	0.007	4.2	0.013	0.0	0.000	0.0	0.000	8.1	0.026	61.4	0.196	0.0	0.000	0.0	0.000	1.3	0.004	81.4
2. Pom Prab	0.0	0.000	3.1	0.031	3.1	0.031	1.0	0.010	0.5	0.005	0.0	0.000	2.9	0.028	14.3	0.140	0.0	0.000	0.5	0.005	1.0	0.010	26.5
3. Sam Pan Thawong	6.2	0.016	52.3	0.135	7.8	0.020	21.6	0.056	0.0	0.000	0.0	0.000	0.0	0.000	12.7	0.033	0.0	0.000	0.0	0.000	0.0	0.000	100.6
4. Phatum Wan	7.0	0.012	52.1	0.092	20.7	0.037	30.2	0.053	14.8	0.026	4.4	0.008	8.1	0.014	7.6	0.013	0.0	0.000	0.0	0.000	3.0	0.005	147.7
5. Bang Rak	11.2	0.016	104.8	0.154	33.0	0.048	6.8	0.010	7.5	0.011	2.1	0.003	0.0	0.000	9.4	0.014	0.0	0.000	1.6	0.002	1.0	0.002	177.3
6. Yannawa	6.5	0.011	69.6	0.120	0.0	0.000	4.2	0.007	2.1	0.004	0.0	0.000	0.0	0.000	21.6	0.037	0.0	0.000	45.0	0.077	2.1	0.004	151.0
7. Sathon	0.0	0.000	16.0	0.193	0.0	0.000	0.0	0.000	1.6	0.019	0.0	0.000	0.0	0.000	1.7	0.020	0.0	0.000	2.3	0.028	0.0	0.000	21.6
8. Bang Kho Laem	0.0	0.000	27.8	0.096	13.3	0.046	5.7	0.020	0.0	0.000	0.0	0.000	0.0	0.000	9.9	0.034	0.0	0.000	18.7	0.065	0.0	0.000	75.4
9. Dusit	0.0	0.000	0.0	0.000	0.0	0.000	4.8	0.100	0.0	0.000	1.8	0.038	2.3	0.047	3.6	0.075	0.0	0.000	0.0	0.000	0.0	0.000	12.6
10. Bang Sue	0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0
11. Phaya Thai	3.5	0.010	19.3	0.054	12.5	0.035	9.1	0.026	6.2	0.017	1.6	0.004	19.8	0.056	16.6	0.047	0.0	0.000	0.0	0.000	3.6	0.010	92.2
12. Rat Thewee	1.0	0.002	41.1	0.071	39.2	0.068	19.1	0.033	16.6	0.029	11.8	0.020	10.3	0.018	11.1	0.019	0.0	0.000	0.0	0.000	0.0	0.000	150.2
13. Huai Khwang	2.1	0.012	19.4	0.113	3.3	0.019	3.1	0.018	3.1	0.018	4.2	0.024	0.0	0.000	1.2	0.007	0.0	0.000	8.5	0.049	0.0	0.000	44.7
14. Phra Khanong	0.0	0.000	20.9	0.095	1.8	0.008	1.0	0.005	0.0	0.000	0.3	0.001	0.0	0.000	29.9	0.136	0.0	0.000	3.1	0.014	0.0	0.000	57.1
15. Klong Toi	5.2	0.015	48.1	0.135	19.2	0.054	7.5	0.021	4.4	0.012	0.0	0.000	7.4	0.021	0.5	0.001	0.0	0.000	0.4	0.001	0.0	0.000	92.7
16. Pra Weat	5.7	0.049	16.3	0.138	0.0	0.000	1.3	0.011	1.3	0.011	0.0	0.000	0.8	0.007	5.2	0.044	0.0	0.000	0.0	0.000	0.0	0.000	30.6
17. Bang Khen	0.0	0.000	0.0	0.000	0.0	0.000	3.3	0.033	0.0	0.000	0.0	0.000	2.5	0.025	13.9	0.142	0.7	0.007	5.1	0.052	0.0	0.000	25.4
18. Dong Muang	1.8	0.006	4.6	0.015	3.1	0.010	2.2	0.007	0.0	0.000	0.0	0.000	0.0	0.000	23.3	0.075	0.0	0.000	45.5	0.147	0.0	0.000	80.5
19. Jatujak	10.1	0.060	23.0	0.135	0.8	0.005	3.8	0.022	0.0	0.000	1.6	0.009	0.0	0.000	0.0	0.000	0.5	0.003	3.4	0.020	1.0	0.006	44.2
20. Bang Kapi	5.3	0.026	0.8	0.004	1.2	0.006	11.7	0.056	0.0	0.000	1.2	0.006	0.0	0.000	20.0	0.096	0.0	0.000	11.7	0.056	2.1	0.010	54.0
21. Lad Phaow	0.0	0.000	7.8	0.166	0.0	0.000	0.0	0.000	0.0	0.000	0.0	0.000	0.0	0.000	4.4	0.094	0.0	0.000	0.0	0.000	0.0	0.000	12.2
22. Bung Kum	0.0	0.000	0.6	0.006	0.0	0.000	0.0	0.000	1.6	0.016	0.0	0.000	0.0	0.000	2.2	0.022	0.0	0.000	21.5	0.216	0.0	0.000	25.8
23. Nong Chok	0.0	0.000	0.0	0.000	0.0	0.000	0.0	0.000	0.0	0.000	0.0	0.000	0.0	0.000	0.0	0.000	0.0	0.000	3.4	0.260	0.0	0.000	3.4
24. Min Buri	1.3	0.006	1.3	0.006	0.0	0.000	0.0	0.000	0.5	0.002	2.1	0.010	0.8	0.004	5.2	0.024	0.0	0.000	43.9	0.203	1.0	0.005	56.2
25. Lad Kra Bang	0.0	0.000	0.0	0.000	0.0	0.000	0.0	0.000	0.0	0.000	0.0	0.000	0.0	0.000	3.1	0.010	0.0	0.000	80.6	0.250	0.0	0.000	83.7
26. Thon Buri	0.7	0.006	0.0	0.000	0.0	0.000	5.9	0.058	0.0	0.000	0.0	0.000	0.0	0.000	19.9	0.196	0.0	0.000	0.0	0.000	0.0	0.000	26.4
27. Klong San	4.9	0.061	0.5	0.006	0.8	0.010	2.1	0.026	0.3	0.003	0.8	0.010	0.0	0.000	7.0	0.087	0.0	0.000	4.6	0.057	0.0	0.000	20.9
28. Bangkok Noi	0.0	0.000	0.0	0.000	0.5	0.026	0.5	0.026	0.3	0.013	0.5	0.026	0.8	0.039	2.6	0.130	0.0	0.000	0.0	0.000	0.0	0.000	5.2
29. Bang Plat	6.9	0.059	1.6	0.013	4.2	0.036	7.8	0.067	3.3	0.028	1.2	0.010	0.0	0.000	1.2	0.011	0.0	0.000	3.6	0.031	0.4	0.003	30.1
30. Bangkok Yai	0.0	0.000	0.5	0.009	0.5	0.009	0.0	0.000	7.0	0.123	0.0	0.000	1.8	0.032	3.4	0.059	0.0	0.000	1.6	0.027	0.0	0.000	14.8
31. Pasi Charoen	0.3	0.002	5.6	0.038	0.0	0.000	0.5	0.004	2.5	0.017	0.0	0.000	0.0	0.000	9.4	0.063	0.0	0.000	19.9	0.135	0.3	0.002	38.4
32. Bang Khun Thian	0.0	0.000	0.0	0.000	0.0	0.000	0.0	0.000	0.0	0.000	0.0	0.000	0.0	0.000	0.5	0.015	0.0	0.000	8.3	0.245	0.0	0.000	8.8
33. Jom Thong	0.0	0.000	3.4	0.033	0.0	0.000	0.0	0.000	0.0	0.000	0.0	0.000	0.0	0.000	2.6	0.025	0.0	0.000	20.8	0.202	0.0	0.000	26.8
34. Taling Chan	0.0	0.000	0.0	0.000	0.0	0.000	0.0	0.000	0.0	0.000	0.0	0.000	0.0	0.000	0.0	0.000	0.0	0.000	1.6	0.260	0.0	0.000	1.6
35. Rat Burana	0.0	0.000	9.0	0.013	0.0	0.000	5.2	0.008	2.1	0.003	0.0	0.000	0.0	0.000	3.1	0.005	0.0	0.000	152.4	0.228	1.8	0.003	173.5
36. Nong Khaem	0.0	0.000	17.9	0.180	0.0	0.000	0.0	0.000	2.3	0.023	0.0	0.000	1.4	0.014	2.3	0.023	0.0	0.000	1.9	0.019	0.0	0.000	25.9
Total	80.2	0.040	571.0	0.283	167.3	0.083	162.5	0.080	77.9	0.039	33.3	0.017	66.8	0.033	330.9	0.164	1.2	0.001	509.7	0.252	18.7	0.009	2019.5

Note: It is assumed that 1m3 of waste equal to 0.26 ton at the time of discharging.

Table 1.3-3 Waste Amount by Types of Business

Type of Business	0- 1m3	(%)	1m3 - 2m3	(%)	2m3 - 3m3	(%)	3m3 - 5m3	(%)	5m3 - 10m3	(%)	10m3 - 20m3	(%)	20m3 -	(%)	Total
Restaurant	3	0.025	51	0.429	30	0.252	22	0.185	10	0.084	3	0.025	0	0.000	119
Office	33	0.049	126	0.186	177	0.262	231	0.342	87	0.129	17	0.025	5	0.007	676
Hotel	1	0.008	21	0.160	43	0.328	23	0.176	21	0.160	20	0.153	2	0.015	131
Shop	0	0.000	24	0.220	23	0.211	19	0.174	28	0.257	10	0.092	5	0.046	109
School	3	0.028	41	0.380	30	0.278	24	0.222	8	0.074	1	0.009	1	0.009	108
Recreational Facility	0	0.000	13	0.325	12	0.300	9	0.225	5	0.125	1	0.025	0	0.000	40
Governmental Office	2	0.026	35	0.449	13	0.167	13	0.167	7	0.090	8	0.103	0	0.000	78
Market	0	0.000	11	0.079	19	0.136	35	0.250	33	0.236	29	0.207	13	0.093	140
Temple	0	0.000	0	0.000	2	1.000	0	0.000	0	0.000	0	0.000	0	0.000	2
Factory	22	0.029	458	0.604	108	0.142	70	0.092	73	0.096	22	0.029	5	0.007	758
Others	2	0.069	11	0.379	10	0.345	3	0.103	3	0.103	0	0.000	0	0.000	29
Total	66	0.030	791	0.361	467	0.213	449	0.205	275	0.126	111	0.051	31	0.014	2,190

Table 1.3-4 Collection Fee by Types of Business

(Baht)

Type of Business	-600	(%)	600-960	(%)	960-1440	(%)	1440-2400	(%)	2400-4800	(%)	4800-9600	(%)	9600-	(%)	Total
Restaurant	1	0.008	9	0.076	74	0.622	18	0.151	14	0.118	3	0.025	0	0.000	119
Office	1	0.001	111	0.164	314	0.464	115	0.170	91	0.135	39	0.058	5	0.007	676
Hotel	0	0.000	4	0.031	34	0.260	25	0.191	35	0.267	22	0.168	11	0.084	131
Shop	0	0.000	7	0.064	43	0.394	3	0.028	13	0.119	29	0.266	14	0.128	109
School	0	0.000	9	0.083	58	0.537	17	0.157	22	0.204	1	0.009	1	0.009	108
Recreational Facility	0	0.000	1	0.025	21	0.525	7	0.175	7	0.175	1	0.025	3	0.075	40
Governmental Office	1	0.013	1	0.013	37	0.474	20	0.256	7	0.090	7	0.090	5	0.064	78
Market	0	0.000	2	0.014	23	0.164	29	0.207	45	0.321	29	0.207	12	0.086	140
Temple	0	0.000	0	0.000	1	0.500	0	0.000	1	0.500	0	0.000	0	0.000	2
Factory	1	0.001	433	0.571	140	0.185	52	0.069	94	0.124	27	0.036	11	0.015	758
Others	0	0.000	6	0.207	12	0.414	4	0.138	4	0.138	3	0.103	0	0.000	29
Total	4	0.002	583	0.266	757	0.346	290	0.132	333	0.152	161	0.074	62	0.028	2,190

Table 1.3-5 Collection Fee by Waste Amount

(Baht)

	-600	600-960	960-1440	1440-2400	2400-4800	4800-9600	9600-	Total
0 -1 m3	2	46	15	1	2	0	0	66
1 - 2 m3	1	464	257	38	28	2	1	791
2 - 3 m3	0	67	293	44	55	8	0	467
3 - 5 m3	0	2	184	165	75	21	2	449
5 - 10m3	1	3	6	41	158	55	11	275
10 - 20m3	0	0	2	1	13	69	26	111
20 m3 -	0	1	0	0	2	6	22	31
Total	4	583	757	290	333	161	62	2,190

4) Others

(1) Collection Frequency

Every day and 3 times a week are the most dominant collection frequency. The business establishments which are supposed to discharge perishable waste and are required to have a high sanitary condition such as restaurant, hotel, shop and market have a high percentage of daily collection service. Meanwhile, more than half of factories receive every other day collection service. Refer to Table 1.3-6.

(2) Type of Receptacle

The business establishments, use various types of receptacles for discharging the waste. In particular, bamboo basket, container and concrete container are widely used, see Table 1.3-7.

Table 1.3-6 Collection Frequency by Types of Business

Type of Business	Every Day	(%)	6 Times	(%)	5 Times	(%)	4 Times	(%)	3 Times	(%)	2 Times	(%)	1 Time	(%)	No Answer	(%)	Total
Resturant	95	0.798	0	0.000	4	0.034	1	0.008	3	0.025	14	0.118	0	0.000	2	0.017	119
Office	280	0.414	43	0.064	16	0.024	10	0.015	196	0.290	87	0.129	27	0.040	17	0.025	676
Hotel	76	0.580	0	0.000	1	0.008	2	0.015	41	0.313	9	0.069	0	0.000	2	0.015	131
Shop	69	0.633	3	0.028	0	0.000	1	0.009	32	0.294	4	0.037	0	0.000	0	0.000	109
School	27	0.250	2	0.019	11	0.102	7	0.065	39	0.361	18	0.167	0	0.000	4	0.037	108
Recreational Facility	26	0.650	0	0.000	0	0.000	1	0.025	9	0.225	3	0.075	0	0.000	1	0.025	40
Governmental Office	23	0.295	0	0.000	1	0.013	4	0.051	42	0.538	6	0.077	0	0.000	2	0.026	78
Market	101	0.721	3	0.021	1	0.007	2	0.014	25	0.179	8	0.057	0	0.000	0	0.000	140
Temple	1	0.500	0	0.000	0	0.000	0	0.000	0	0.000	1	0.500	0	0.000	0	0.000	2
Factory	49	0.065	49	0.065	0	0.000	37	0.049	463	0.611	145	0.191	15	0.020	0	0.000	758
Others	10	0.345	4	0.138	2	0.069	2	0.069	6	0.207	2	0.069	0	0.000	3	0.103	29
Total	757		104		36		67		856		297		42		31		2,190

Table 1.3-7 Type of Receptacle by Types of Business

Type of Business	Bamboo Basket	(%)	Plastic Bag	(%)	Plastic Bin	(%)	Container (Less than 1m3)	(%)	Hauled-in-Container	(%)	Concret Container	(%)	Others	(%)	No Answer	(%)	Total
Restaurant	5	0.042	22	0.185	11	0.092	57	0.479	2	0.017	13	0.109	3	0.025	6	0.050	119
Office	56	0.083	180	0.266	78	0.115	193	0.286	39	0.058	76	0.112	22	0.033	32	0.047	676
Hotel	1	0.008	13	0.099	7	0.053	28	0.214	0	0.000	70	0.534	9	0.069	3	0.023	131
Shop	7	0.064	0	0.000	2	0.018	50	0.459	7	0.064	29	0.266	6	0.055	8	0.073	109
School	6	0.056	4	0.037	2	0.019	41	0.380	8	0.074	39	0.361	4	0.037	4	0.037	108
Recreational Facility	2	0.050	0	0.000	1	0.025	19	0.475	1	0.025	9	0.225	6	0.150	2	0.050	40
Governmental Office	3	0.038	2	0.026	1	0.013	18	0.231	2	0.026	35	0.449	2	0.026	15	0.192	78
Market	22	0.157	4	0.029	2	0.014	23	0.164	12	0.086	61	0.436	5	0.036	11	0.079	140
Temple	0	0.000	0	0.000	0	0.000	1	0.500	0	0.000	0	0.000	0	0.000	1	0.500	2
Factory	336	0.443	14	0.018	2	0.003	169	0.223	166	0.219	54	0.071	13	0.017	4	0.005	758
Others	8	0.276	4	0.138	0	0.000	4	0.138	3	0.103	7	0.241	0	0.000	3	0.103	29
Total	446	0.204	243	0.111	106	0.048	603	0.275	240	0.110	393	0.179	70	0.032	89	0.041	2,190

Table A-1 Collected Waste Amount by Districts from 1982 to 1989

(TON)

DISTRICT\YEAR	1982	1983	1984	1985	1986	1987	1988	1989
1. Phra Nakhon	83,741	64,028	66,255	68,675	70,744	73,430	69,999	66,063
2. Pom Prab	28,923	55,387	32,273	34,252	36,208	36,109	34,497	32,855
3. Sam Pan Thawong	22,578	22,098	21,995	25,043	27,466	27,295	24,211	21,602
4. Phatum Wan	46,201	50,688	42,698	47,698	57,236	56,471	51,026	52,533
5. Bang Rak	41,140	44,387	40,073	43,607	48,392	48,963	44,796	44,320
6. Yannawa	64,769	62,731	65,364	95,619	107,091	116,158	114,830	72,123
7. Sathon								26,419
8. Bang Kho Laem								15,359
9. Dusit	110,999	101,594	90,294	88,951	104,368	128,500	126,884	111,405
10. Bang Sue								
11. Phaya Thai	77,716	84,381	83,111	108,847	120,552	130,339	129,527	104,368
12. Rat Thewee								13,714
13. Huai Khwang	33,969	44,158	37,712	61,612	68,383	72,924	71,811	66,929
14. Phra Khanong	104,482	132,164	104,598	116,519	144,544	163,058	150,816	73,338
15. Klong Toi				34,219	38,376	42,335	40,511	100,690
16. Pra Weat								11,802
17. Bang Khen	50,238	67,986	75,292	94,174	112,168	130,726	157,483	99,528
18. Dong Muang								20,438
19. Jatujak								30,240
20. Bang Kapi	29,349	32,292	31,113	64,390	88,757	108,902	113,770	98,505
21. Lad Phaow								4,790
22. Bung Kum								12,996
23. Nong Chok	1,682	1,747	1,456	1,274	1,953	1,984	1,955	1,888
24. Min Buri	9,790	9,703	10,005	6,059	11,154	13,293	13,359	13,043
25. Lad Kra Bang	3,967	4,935	4,026	3,997	6,023	9,936	9,480	11,467
26. Thon Buri	32,226	31,674	33,270	35,292	41,117	47,591	48,567	45,107
27. Klong San	35,946	35,890	30,864	32,609	37,128	42,101	42,926	40,131
28. Bangkok Noi	43,200	47,868	45,771	47,786	47,414	55,389	67,349	68,148
29. Bang Plat				9,545	16,691	22,218	22,708	21,723
30.Bangkok Yai	15,817	17,056	17,184	19,739	22,207	25,176	25,638	24,369
31. Pasi Charoen	19,256	18,923	16,005	29,890	34,814	38,499	42,356	40,332
32. Bang Khun Thian	21,157	22,808	24,692	26,185	33,142	39,847	43,096	30,297
33. Jom Thong								13,331
34. Taling Chan	4,013	4,419	3,927	4,953	6,004	7,269	7,453	8,998
35. Rat Burana	15,384	15,676	16,086	25,254	28,423	30,982	32,509	31,148
36. Nong Khaem	3,083	3,599	4,639	5,968	7,115	9,614	10,921	11,532
DPC	22,753	17,578	34,474	57,820	46,774	50,273	47,811	49,536
TOTAL	922,379	993,770	933,177	1,189,973	1,364,243	1,529,385	1,546,291	1,491,068
TON/DAY	2,527	2,723	2,557	3,260	3,738	4,190	4,225	4,085

Table A-2 Population by Districts from 1979 to 1989

DISTRICT\YEAR	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1. Phra Nakhon	124,854	123,109	121,935	117,649	113,376	112,332	114,124	111,875	104,791	102,382	102,382
2. Pom Prab	194,299	190,450	190,093	189,207	92,950	89,330	89,539	87,955	83,412	81,440	81,440
3. Sam Pan Thawong	78,151	77,112	76,559	75,581	53,504	52,816	52,397	51,121	50,089	48,377	48,377
4. Phatum Wan	233,050	235,647	233,884	233,978	114,820	157,330	155,868	143,199	145,110	146,499	146,499
5. Bang Rak	126,487	131,542	136,673	141,667	88,869	88,197	91,088	90,672	88,554	87,175	87,175
6. Yannawa	375,213	380,416	382,585	386,843	392,279	396,420	410,288	415,703	414,235	412,311	115,132
7. Sathon											148,242
8. Bang Kho Laem											148,897
9. Dusit	462,210	479,659	528,357	546,868	550,369	558,832	565,339	562,990	561,979	572,455	267,601
10. Bang Sue											304,854
11. Phaya Thai	514,177	519,869	520,443	520,507	346,319	357,726	360,603	359,604	350,780	340,473	228,234
12. Rat Thewee											112,239
13. Huai Khwang	195,112	201,334	208,129	231,069	235,739	239,742	247,274	255,774	262,262	265,164	265,164
14. Phra Khanong	502,287	523,831	545,926	559,812	578,541	594,902	614,854	629,386	650,572	664,248	190,044
15. Klong Toi											276,978
16. Pra Weat											197,226
17. Bang Khen	367,402	388,333	408,720	429,977	457,544	483,717	520,861	548,078	581,508	606,201	199,670
18. Dong Muang											206,925
19. Jatujak											199,606
20. Bang Kapi	218,703	255,555	291,484	314,780	335,171	356,033	386,005	409,785	442,420	478,748	214,519
21. Lad Phaow											116,595
22. Bung Kum											147,634
23. Nong Chok	50,136	51,224	52,131	51,799	54,011	54,952	56,863	57,704	60,142	61,417	61,417
24. Min Buri	52,579	55,369	58,451	61,349	64,266	66,966	70,289	74,052	81,110	86,558	86,558
25. Lad Kra Bang	40,996	42,567	43,990	45,303	48,836	50,541	56,023	59,070	63,875	65,311	65,311
26. Thon Buri	256,740	262,097	267,398	268,662	267,767	267,616	273,542	274,176	274,949	269,975	269,975
27. Klong San	140,943	140,249	139,625	139,310	139,736	139,444	142,590	143,719	146,781	145,901	145,901
28. Bangkok Noi	378,817	382,621	385,286	388,325	283,296	285,265	291,035	294,938	297,324	298,390	153,018
29. Bang Plat											145,372
30.Bangkok Yai	100,051	101,198	102,719	103,365	104,024	104,716	107,486	106,732	108,171	107,548	107,548
31. Pasi Charoen	176,282	183,385	190,108	196,138	207,409	211,125	219,606	228,202	236,572	243,195	243,195
32. Bang Khun Thian	197,082	204,434	213,440	223,388	232,532	240,835	254,597	265,453	286,165	300,858	118,609
33. Jom Thong											182,249
34. Taling Chan	65,269	67,746	70,201	72,608	78,995	81,349	85,559	90,135	98,552	104,538	104,538
35. Rat Burana	108,447	113,769	118,099	122,614	127,726	131,550	140,245	148,166	154,177	157,124	157,124
36. Nong Khaem	40,228	42,386	45,166	47,487	50,248	52,946	57,303	60,426	65,822	70,491	70,491
TOTAL	4,999,515	5,153,902	5,331,402	5,468,286	5,018,327	5,174,682	5,363,378	5,468,915	5,609,352	5,716,779	5,716,739

Chapter 2 Waste Quality

2.1 Present Waste Quality

2.1.1 Physical Composition

Quality of solid waste affects the method of intermediate treatment, in particular the type or use of incineration plant. The composition of the solid waste, therefore, is analyzed from the viewpoint of possibility of using incineration plant.

The DPC examines physical components of the solid waste monthly using sampling methods at the final disposal sites of On Nut and Nong Khaen. Table 2.1-1 shows that the physical composition in air dried waste basis. Moisture content is about 50 to 60% of total weight of the waste. Major composition items are paper, fruit/vegetable and plastic materials which are approximately 12% to 18%, 4% to 23% and 9% to 12% respectively. On the other hand, the JICA Team has conducted examination of physical composition of the waste at On Nut in August 1990. The results show the same trend as the DPC's examination.

Table 2.1-2 shows the physical composition of the waste by weight base by type of collection areas. Commercial waste has a higher percentage of paper, garbage and textiles, while industrial waste has a higer percentage of paper, textiles, rubber and leather, and residential waste contains more garbage and plastic. As a result, the commercial waste and the industrial waste have a higher calorific value than residential waste.

Table 2.1-1 Physical Composition of Solid Waste by Weight

Location		Nong Khaem				On Nut					
Date		Jan./23/89	May/15/90	Jan./23/90	Jul./9/90	Mar./13/89	Jul./11/89	Nov./14/89	May/9/90	Aug./23/90	Aug./30/90
Agency		BMA	BMA	BMA	BMA	BMA	BMA	BMA	BMA	JICA	JICA
	Moisture	51.2	63.7	48.1	60.5	62.7	59.4	60.2	59.7	55.4	56.9
Component	Combustible	30.9	27.1	23.8	22.3	24.6	5.5	22.4	19.4	35.0	32.3
(%)	Ash	17.9	9.2	28.1	17.2	12.7	15.1	17.4	20.9	9.6	10.8
	Paper	12.5	16.9	12.2	13.9	14.3	15.7	17.6	15.7	15.9	17.0
	Fruit,Vegetable	6.0	23.0	4.5	10.5	16.3	9.0	9.7	13.9	10.9	16.3
	Bone,Shell	3.3	7.2	3.7	4.7	9.7	2.9	2.1	4.6	2.5	4.5
	Textile	17.7	0.9	5.6	8.0	4.7	5.3	4.7	4.4	6.1	3.1
Physical	Wood,Leaves	4.0	16.5	11.0	9.5	5.2	18.3	9.1	2.9	8.0	3.9
Component	Plastic	11.1	9.4	9.8	9.8	9.9	10.7	11.8	9.1	13.5	10.1
(%)	Leather,Rubber	1.4	0.2	4.0	5.4	0.3	0.4	1.1	0.2	5.0	0.2
	Metal	7.1	1.0	3.4	3.2	3.1	3.3	5.8	3.1	3.6	5.7
	Glass	1.9	6.8	5.6	7.2	3.5	3.3	8.6	9.9	7.4	5.6
	Stone,Ceramic	12.3	2.7	7.8	1.9	8.4	7.9	2.4	10.7	1.5	7.4
	Miscellaneous										
	< 5mm	13.4	6.2	12.2	8.1	12.0	15.5	12.8	9.3	6.9	11.2
	> 5mm	9.3	9.2	20.2	17.8	12.6	7.7	14.3	16.2	18.7	15.0

Note; Percentage of physical component is calculated on dry basis.

Table 2.1-2 Physical Composition of Waste by Weight by Type of Areas

	Analytical Parameter	A1	A2	B	C	D1	D2	E	F
I	Waste Components, wet weight								
1	Combustible								
1.1	Paper	17.73	12.80	22.03	15.15	11.64	13.76	7.73	12.40
1.2	Garbage	40.02	43.35	23.41	27.86	28.71	34.46	43.46	39.19
1.3	Textile	5.55	10.13	11.42	1.96	9.12	7.18	3.97	3.22
1.4	Wood and Grass	10.10	9.38	7.70	22.99	12.29	16.62	21.92	15.16
1.5	Plastic	10.62	10.68	9.23	13.17	10.18	13.60	6.59	9.44
1.6	Rubber and Leather	0.17	0.58	10.74	2.13	1.17	2.16	7.39	1.91
Sub-Total		84.19	87.12	84.59	83.26	83.11	87.78	91.12	81.32
2	Non-Combustible								
2.1	Ferrous Metal	1.71	1.58	4.01	1.46	1.21	1.52	0.94	1.59
2.2	Non-ferrous Metal	0.21	0.11	0.05	0.19	0.62	0.11	0.12	0.07
2.3	Glass	2.14	2.39	0.62	1.88	2.24	2.45	0.97	3.24
2.4	Stone and Ceramics	5.58	2.56	2.14	8.56	5.20	3.68	3.20	6.77
Sub-Total		9.64	6.64	6.02	12.03	3.27	7.76	5.23	11.67
3	Miscellaneous								
3.1	Size > 5 mm	4.30	4.41	5.44	3.81	5.84	3.32	3.12	6.43
3.2	Size < 5 mm	1.89	1.85	3.17	0.83	1.76	1.14	0.58	0.60
Sub-Total		6.19	6.26	8.61	4.64	7.60	4.46	3.71	7.03
Total		100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
II	Waste Components, wet weight								
1	Moisture Content, wet weight	60.52	60.05	43.19	56.08	60.44	59.50	67.00	60.45
2	Ash Content, % wet weight	10.29	10.01	21.25	17.28	12.37	11.92	9.05	15.01
3	Combustion Content, wet weight	29.19	29.94	33.37	26.64	27.19	28.58	23.93	24.54
Total		100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
4.	Gross Calorific value (Kcal/kg, adjusted dry basis)	4,126.26	4,180.12	4,234.12	3,213.62	4,017.59	3,909.17	3,652.68	3,534.97
5.	Combustion Content of Miscellaneous Against Miscellaneous	-	23.43	-	-	46.18	-	14.59	-
III	Number of Samples	6	6	4	5	7	14	6	2

Notes:

A1 - Commercial Refuse, Central City Core and Urban Zones
A2 - Commercial Refuse, Semi-Urban and Semi-Rural Zones
B - Industrial Wastes, Factories within Industrial Estates
C - Institutional Wastes, Government Offices and Educational Institutes
D - Residential Refuse, Households in the Central city Core and Urban Zones
D2 - Residential Refuse, Semi-Urban and Semi-Rural Zones
E - Market Waste, Fresh Products Markets which include some Rating Stands
F - Residential Refuse, Low Income Level (51 um) Housing Areas

Source: Feasibility Study on The Management of the Disposal of Bangkok Municipal Waste, 1989

2.1.2 Chemical Analysis

Chemical composition is analyzed in order to determine the probable composition of compost products and of the waste generated gases from the incineration plant. The chemical composition of combustible waste is shown in Table 2.1-3. The waste comprises prinncipally 51% - 54% carbon, 6% - 8% hydrogen and 38% oxygen.

Table 2.1-3 Chemical Composition of Combustible Waste at On Nut, 1990

(Unit: % Dry Base)

Date	Carbon	Hydrogen	Nitrogen	Chlorine	Sulfur	Oxygen
Aug. 23	51.88	7.56	1.82	0.70	0.02	38.02
Aug. 30	53.13	6.56	1.91	0.33	0.06	38.01

Note: The waste of On Nut disposal sites comes from Phra Kanong, Praweet, Yannawa, Huai Khway, Bang Rak, Pathum Wan, Bay Kapi and Phaya Thai districts.

2.2 Estimated Waste Quality

Waste analyses were made by both the present and previous JICA Study Teams as well as by Mr. Sakai, the former JICA Expert attached to the DPC. Fig. 2.2-1 shows the results of the waste analyses (contents of moisture, volatile substances and ash). Fig. 2.2-1 also shows the percentages of respective contents projected for the year 2000.

Table 2.2-1 Past, Present and Future Waste Composition

	In 2000	In 1990	In 1980
Moisture	57% (±0%)	57%	57%
Volatile	31% (+4%)	29%	27%
Ash	12% (-4%)	14%	16%
Total	100%	100%	100%

It is estimated that LHV (low heat value) in 1980 was 1,000 Kcal/Kg, while LHV in 2000 will be 1,200 Kcal/Kg using the following formula:

LHV= 4500 Kcal/Kg (Volatile - Volatile x plastic ratio 12 %)
+ 8000 Kcal/Kg (Volatile x plastic ratio 12 %)
- 600 Kcal/Kg (Moisture)

Table 2.2-2 shows the results of the chemical composition analyses made in 1980 and 1990.

Table 2.2-2 Chemical Composition Unit: %

SURVEY DATE	C	H	O	N	S	Cl	Total
Rainy season, 1980	54.96	8.23	34.38	1.40	0.25	0.79	100
Dry season, 1980	53.28	11.07	33.49	1.12	0.15	0.89	100
23, Aug, 1990	51.88	7.56	38.02	1.82	0.02	0.70	100
30, Aug, 1990	53.13	6.56	38.01	1.91	0.06	0.33	100

Note: The first two surveys were made by the previous JICA Study Team, while the last two surveys were made by the present JICA Study Team.

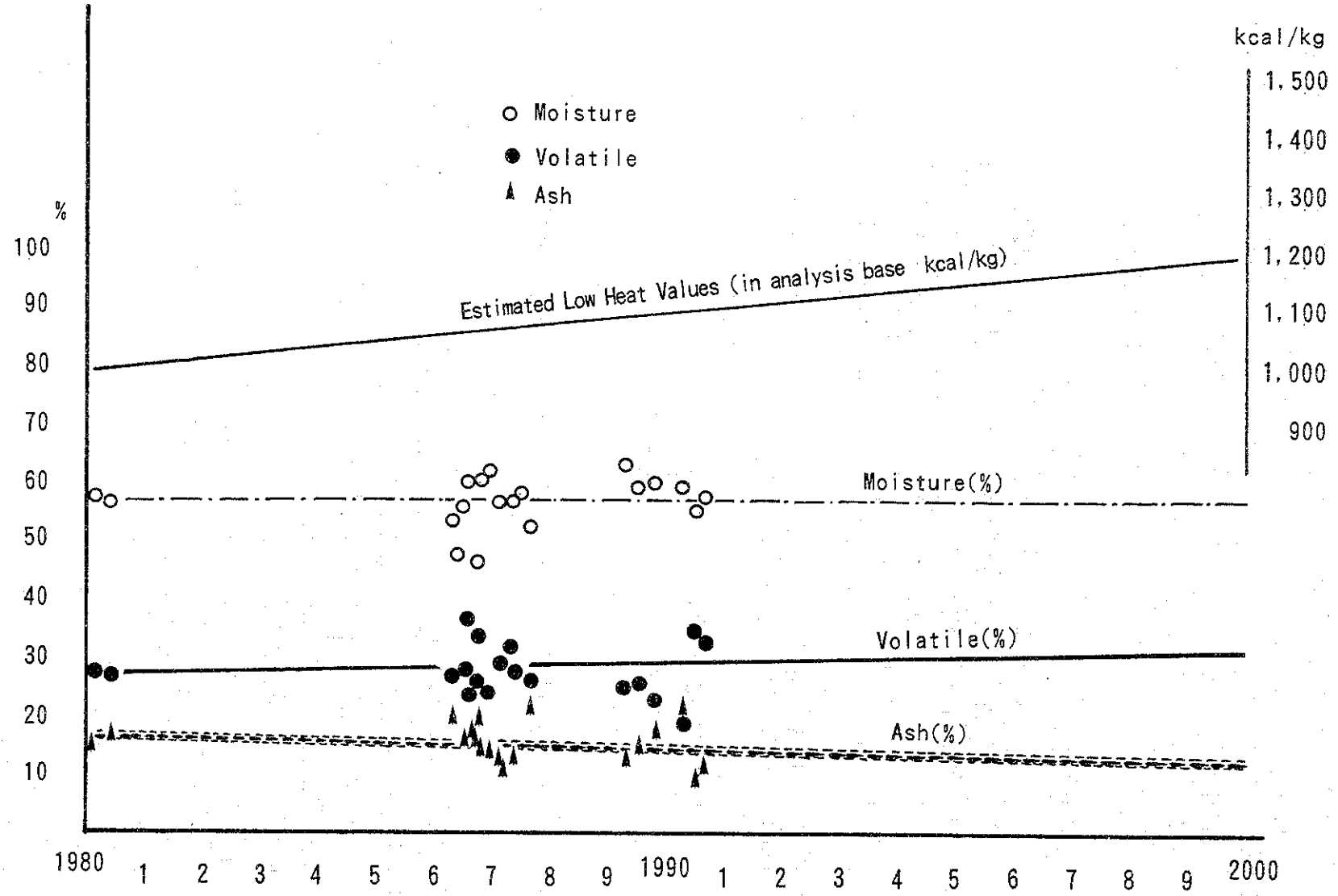


Fig. 2.2-1 Estimated Waste Composition and Low Heat Values of Waste

Part II

Present Conditions

of

the Solid Waste Management

Chapter 3. Waste Collection and Haulage

3.1 Use of Contractors

3.1.1 Areas Served and Waste Amounts Collected by Contractors

Private contractors served 7 % of the population in Bangkok from 1987 to 1989. As shown in Table 3.1-1, 84,451 households and 354,280 persons were served in Klong Toey, Klong Ton sub-districts and Bangkok Noi district.

Table 3.1-1 Area and Population served by Collection Contractors

AREA	NO. OF HOUSEHOLDS	NO. OF POPULATION
Klong Toey Subdistrict	27,676	103,790
Klong Ton Subdistrict	13,017	52,496
Bangkok Noi District	43,758	197,976
Total	84,451	354,280

Source: DPC, BMA

As shown in Table 3.1-2, contractors collected 467.9 tons/day on average in 1989, which represents approximately 13 % of the total solid waste amount. As shown in Table 3.1-3, the average tonnage per trip of the contractors was 4.04 tons/day in 1989, while the BMA's corresponding amount was 3.75 tons/day.

Table 3.1-2 The Amount of Waste Collected by BMA and Contractors (tons/day)

	1985	1986	1987	1988	1989
BMA	3,196.36	3,661.0	3,737.17	3,796.24	3,640.12
Private Contractor	63.86	121.43	452.93	440.17	467.9
- Klong Ton	63.86	121.43	190.87	145.58	138.69
- Klong Toey	-	-	113.32	110.60	137.32
- Bangkok Noi	-	-	148.76	183.99	191.89

Source: DPC, BMA

Table 3.1-3 Average Collection Amount Per Trip (ton/trip)

	1987	1988	1989
BMA	3.83	3.92	3.75
Contractors (average)	4.25	3.62	4.04
- Klong Ton	4.58	3.24	3.49
- Klong Toey	3.71	3.46	4.38
- Bangkok Noi	4.32	4.13	4.29

Source: DPC, BMA

3.1.2 Contents of Contract

Contracts between the BMA and private contractors include conditions on fees, fines, and terms of work as well as supervision and advice. For example, the contract of Bangkok Noi district has 20 sections. Sections 1 to 5 stipulated terms of work and fees. The Private contractor has to finish collection before 6:00 pm except in certain areas. Payment is made at the rate of 202 Baht/ton, not to exceed 33,178,500 Bahts. The private contractor must also give a guarantee to the BMA amounting to 5 % of total wages.

Section 7 of the contract stipulates fines. For instance, the private contractor has to pay 1,500 Bahts per day if he cannot arrange collection vehicles as stated in the contract. Sections 11 to 15 stipulate the supervision and inspection by the BMA. The BMA can appoint an inspection committee for inspecting, advising and ordering the private contractors.

3.1.3 Evaluation of Contractors

Several problems have arisen with the private contractors. Firstly, private contractors cheat on the volume of garbage collected by adding stones and water to the collected waste because the BMA pays fees by weight. Secondly workers of private contractors have a low consciousness of public cleansing; therefore, some garbage were left uncollected on the streets. Thirdly, there was not enough equipment used, and it was not well maintained.

In spite of those problems, the use of contractors is effective in reducing costs of waste collection and haulage.

3.2 Operation Records of Waste Collection Vehicles

Monthly operation records of the three (3) districts (Huai Khwang, Patuwan & Klong Toy) during the month of August 1990 are shown in the following tables.

Table 3.2-1 Operation Records of Waste Collection Vehicles in Huai Khwang District for the Month of August 1990

Table 3.2-2 Operation Records of Waste Collection Vehicles in Patuwan District for the Month of August 1990

Table 3.2-3 Operation Records of Waste Collection Vehicles in Klong Toy District for the Month of August 1990

Table 3.2-1 Operation Records of Waste Collection Vehicles in Huai Khwang District for the Month of August 1990

	Vehicle Number	Total Work Days	Number of Crew	Total Trips	Total Weight	Total Spended Time	Average Trips	Average Weight	Average Spended Time	Average Weight / person	1 Trip Weight	2 Trip Weight	3 Trip Weight	4 Trip Weight	1 st. Average	2 st. Average	3 st Average	4 st Average
SD1	1068 (SL,12)	28	3	51	164510	179.11	1.82	3226	6.36	1075	95050	66760	2700	—	3395	3035	2700	—
DB CP2	1213 (CP,—)	29	3	46	287610	195.66	1.59	6239	6.75	2080	187110	99900	—	—	6452	5877	—	—
SD3	992 (SL,12)	31	2	55	197830	179.90	1.77	3597	5.32	1799	126150	53580	18100	—	4069	2979	3017	—
CP4	953 (CP,30)	29	3	52	303940	195.84	1.79	5845	6.74	1948	181290	122650	—	—	6251	5333	—	—
5	1298 (CP,—)	30	2	47	279580	187.64	1.57	5906	6.26	2953	181500	96080	—	—	6050	5652	—	—
SD6	838 (SL,12)	28	4	46	159300	150.85	1.64	3463	5.39	866	101600	57700	—	—	3629	3206	—	—
Small SD7	2 (—,—)	30	1	75	87080	202.07	2.50	1146	6.74	1146	36130	28370	21480	1100	1204	1125	1074	1100
DB CP8	1215 (CP,30)	31	3	58	357100	354.19	1.87	6191	11.43	2064	204300	154200	—	—	6590	5733	—	—
CP9	952 (CP,30)	30	3	45	194980	172.51	1.50	4333	5.75	1444	139100	55880	—	—	4627	3725	—	—
SD10	1066 (SL,12)	29	3	47	159240	140.02	1.62	3388	4.83	1129	99490	59970	—	—	3430	3321	—	—
SD11	1067 (SL,12)	26	3	45	128140	123.98	1.93	2848	4.76	949	78490	49650	—	—	3019	2613	—	—
CP12	686 (CP,16)	29	3	50	179142	202.04	1.72	3583	6.99	1194	107692	69960	3510	—	3713	3398	3510	—
X13	93-3326 (SL,—)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
CP14	954 (CP,30)	15	3	25	143180	103.57	1.69	5727	6.91	1909	89130	49410	4600	—	5945	5490	4600	—
15	114 (—,—)	8	3	12	37500	43.61	1.50	3117	5.45	1039	25200	12300	—	—	3150	3075	—	—
X16	5ฬ 4014 (—,—)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
CP17	688 (CP,16)	30	1	57	192000	198.09	1.90	3368	6.60	3368	104900	81400	5700	—	3497	3256	2850	—
CP18	620 (—,—)	26	3	43	146200	130.34	1.65	3400	5.01	1133	91800	54400	—	—	3531	3200	—	—
19	3243 (—,—)	15	3	26	98660	99.04	1.73	3795	6.43	1265	56450	42210	—	—	3763	3837	—	—
CT 20	9J .86 (CT,2)	28	—	59	191200	102.20	2.11	3241	3.65	—	91100	71900	25200	3000	3254	3126	3150	3000
Small SD 21	5 (9J 3253) (SL,—)	25	1	62	67300	39.19	2.48	1086	1.57	1086	28400	24100	14000	800	1136	1096	1000	800
DB CP 22	1214 (CP,30)	31	3	56	341640	225.09	1.81	6101	7.26	2034	200740	140900	—	—	6476	5636	—	—
23	1252 (CP,—)	31	3	46	247090	236.17	1.48	5372	7.62	1791	166120	80740	—	—	5359	5398	—	—
24	1299 (CP,—)	19	3	20	114590	186.28	1.05	5730	9.80	1910	109270	5320	—	—	5751	5320	—	—
SD25	1070 (SL,12)	31	3	57	171600	220.33	1.84	3011	7.11	1004	99550	72050	—	—	3211	2791	—	—
X26	5333 (—,—)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
CP27	955 (CP,30)	31	3	55	266890	220.44	1.77	4853	7.11	1618	153830	113060	—	—	4962	4711	—	—
Small SD 28	3 (—,—)	22	1	57	62900	124.44	2.59	1104	5.66	1104	25600	22300	15000	—	1164	1115	1000	—
CP 29	9021 (—,—)	20	2	34	116440	99.58	1.70	3425	4.48	1142	70640	42400	3400	—	3532	3262	3400	—
30																		
Total		682	66	1226	4695042	4295.94	46.40	103095	162.40	39050	2850632	1725820	113690	4900	107170	97298	26301	3910
Average		26.2	2.64	47.2	180,579	165.23	1.79	3965	6.25	1562	109640	66378	11369	1633	4121	3,742	2,630	1303

CP = Compactor
CT = Container
SD = Side Loader

Table 3.2-2 Operation Records of Waste Collection Vehicles in Patuwan District for the Month of August 1990

PTW No4

	Vehicle Number	Total Work Days b	Number of Crew a	Total trips c	Total Weight d	Total Spended Time e	Average Trips c÷b	Average Weight d÷c (F)	Average Spended Time e÷b	Average Weight /person F÷a	1 Trip Weight	2 Trip Weight	1nd Average	2st Average	3 trip Weight	4 trip Weight	3rd. Average	4th Average
1	1198 (CP, 30)	30	4	32	206660	296.25	1.07	6458	9.88	1615	198870	7790	6629	3895	—	—	—	—
2	857 (CP, 12)	31	4	32	192906	249.48	1.03	6028	8.05	1507	187726	5180	6056	5180	—	—	—	—
3	963 (CP, 30)	19	4	22	166940	173.55	1.16	7588	9.13	1897	145460	21480	7656	7160	—	—	—	—
4	964 (CP, 30)	31	4	31	266990	233.19	1.00	8613	7.52	2153	266990	—	8613	—	—	—	—	—
5	1014 (SL, 12)	30	5	51	130750	247.24	1.70	2564	8.24	513	81860	45030	2729	2252	3860	—	3860	—
6	1015 (SL, 12)	14	4	23	63818	136.11	1.64	2775	9.72	694	41838	19770	2988	2471	2210	—	2210	—
7	856 (CP, 12)	26	—	29	191715	248.35	1.12	6611	9.55	—	173365	18350	6668	6117	—	—	—	—
8	855 (CP, 12)	31	—	32	166640	251.43	1.03	5208	8.11	—	160810	5830	5187	5830	—	—	—	—
9	854 (CP, 12)	25	4	26	163420	215.53	1.04	6285	8.62	1571	156250	7170	6250	7170	—	—	—	—
10	784 (SL, 10)	26	4	40	115170	212.43	1.54	2879	8.17	720	74230	40940	2855	2924	—	—	—	—
11	697 (CP, 10.11)	19	4	21	87330	164.10	1.11	4159	8.64	1040	79190	8140	4168	4070	—	—	—	—
12	U. 84 (CT, 8)	29	—	57	114500	165.36	2.19	2009	5.70	—	56580	40540	1951	1931	14170	3210	2362	3210
13	U. 85 (CT, 8)	29	—	66	141600	162.13	2.28	2146	5.59	—	58080	44750	2003	2034	24400	14370	2440	2874
14	U. 72 (CT, 8)	12	—	32	90770	87.00	2.67	2837	7.25	—	33970	30190	2831	2745	13890	12740	2774	3185
15	1016 (SL, 12)	29	5	47	142560	289.32	1.62	3033	9.98	607	84120	58440	2901	3247	—	—	—	—
16	1017 (SL, 12)	5	4	7	24160	41.35	1.40	3451	8.27	863	17020	7140	3404	3570	—	—	—	—
17	1091 (SL, 12)	30	5	48	164890	329.51	1.60	3435	10.98	687	102540	53280	3418	3552	9070	—	3023	—
18	1092 (SL, 12)	31	3	47	135460	298.10	1.52	2882	9.62	961	86730	48730	2798	3046	—	—	—	—
19	92. 8667 (SL, -)	6	2	6	4310	30.25	1.00	718	5.04	359	4310	—	718	—	—	—	—	—
20	92. 3348 (SL, -)	16	2	16	15740	72.20	1.00	984	4.51	492	15740	—	984	—	—	—	—	—
21	36. 7943 (?)	29	1	30	88470	240.53	1.04	2949	8.29	2949	83640	4830	2884	4830	—	—	—	—
22	26. 6889 (?)	16	4	16	48030	124.08	1.00	3002	7.76	751	48030	—	3002	—	—	—	—	—
23	1308 (CP, -)	31	3	34	189340	287.38	1.10	5569	9.27	1856	170970	18370	5515	6123	—	—	—	—
24	1307 (CP, -)	31	4	33	241360	381.52	1.07	7314	12.31	1829	225900	15460	7287	7730	—	—	—	—
25	1254 (CP, -)	29	3	29	246280	227.10	1.00	8492	7.83	2831	246280	—	8492	—	—	—	—	—
26	1253 (CP, -)	29	3	30	155910	256.42	1.04	5197	8.84	1732	153230	2680	5284	2680	—	—	—	—
27	1239 (CP, 30)	27	4	27	166680	221.53	1.00	6173	8.21	1543	166680	—	6173	—	—	—	—	—
28	1199 (CP, 30)	25	3	28	186360	216.25	1.12	6656	8.65	2219	162510	18600	6500	9300	5250	—	5250	—
29	1093 (SL, 12)	29	3	42	130850	252.25	1.45	3116	8.70	1039	92630	38220	3194	2940	—	—	—	—
30	1123 (CP, 30)	29	4	38	182410	293.19	1.31	4800	10.11	1200	139450	42960	4809	4773	—	—	—	—
31	1122 (CP, 30)	31	4	40	254680	277.27	1.29	6367	8.94	1592	216110	38570	6971	4286	—	—	—	—
32	1095 (SL, 12)	30	4	45	151450	260.35	1.50	3366	8.68	842	107670	38080	3589	2929	5700	—	2850	—
33	1094 (SL, 12)	31	4	31	120140	172.58	1.00	3876	5.67	969	120140	—	3876	—	—	—	—	—
Total		807	102	1088	4748289	7113.33	43.64	147540	275.83	37031	3958919	680520	148383	112485	78530	30320	24769	9269
Average		24.46	3.64	32.97	143888	215.56	1.32	4471	8.36	1323	119967	26174	4497	4326	9816	10107	3096	3090

CP = コンパクター
CT = コンテナー
SD = サイドローダー

Table 3.2-3 Operation Records of Waste Collection Vehicles in Klong Toy District for the Month of August 1990

	Vehicle Number	Total Work Days (a)	Number of Crew (b)	Total Trips (c)	Total Weight (d)	Total Spended Time (e)	Average Trips (c/a)	Average Weight (d/a)	Average Spended Time (e/a)	Average Weight / person (d/b)	1 Trip Weight	2 Trip Weight	1st Average	2ST Average
1	ม.91 (CT.-)	3	—	124	237260	341.58	4.00	1913	11.02	—	65440	57500	2111	1917
2	1153 (CP.-)	16	—	17	50900	85.31	1.06	2994	5.33	—	47190	3730	2748	3730
3	973 (SL.-)	31	—	59	169240	241.45	1.90	2869	8.11	—	28460	25470	2854	2903
4	ม.57 (CT.-)	31	—	92	197280	111.24	2.32	2940	3.59	—	89120	63930	2875	2660
5	ม.90 (CT.-)	30	—	141	305510	309.39	4.70	2167	10.31	—	65680	64890	2189	2163
6	1012 (SL.-)	29	—	52	120240	218.34	1.79	2312	7.53	—	68510	51730	2362	2351
7	712 (?)	28	—	48	142140	195.52	1.91	2961	6.27	—	81510	52590	2911	3084
8	1065 (SL.-)	20	—	29	72661	127.40	1.45	2506	6.37	—	50090	22521	2505	2502
9	948 (CP.-)	31	—	58	300110	253.42	1.79	5457	8.18	—	196650	94270	13344	3925
10	1155 (CP.-)	25	—	39	130490	161.55	1.56	3346	6.46	—	89560	40830	3582	2924
11	972 (SL.-)	31	—	95	129250	135.47	1.45	2828	4.37	—	90640	36610	2924	2615
12	981 (?)	30	—	51	149490	198.07	1.70	2931	5.94	—	87380	62110	2913	2958
13	522 (SL.6)	31	—	45	104020	178.00	1.45	2312	5.74	—	79030	24990	2549	1785
14	457 (?)	30	—	39	124090	128.41	1.30	3182	4.28	—	101200	22890	3733	2543
15	592 (?)	26	—	44	135100	139.00	1.67	3071	5.27	—	80380	54500	3092	3029
16	1154 (CP.-)	4	—	6	20900	28.52	1.50	3483	7.13	—	12440	8460	3110	4230
17	523 (SL.6)	15	—	32	83560	125.52	2.13	2611	9.04	—	38920	26650	2541	2618
18	719 (CP.16)	15	—	30	67230	126.31	2.00	2241	8.42	—	33690	25800	2246	1985
19	0.8 (?)	23	—	40	120550	139.09	1.74	3014	6.05	—	64010	56590	2783	3326
20	1243 (CP.-)	29	—	71	295360	357.15	2.45	4160	12.32	—	112890	97420	3893	3897
21	494 (?)	30	—	55	135500	234.24	1.83	2464	7.81	—	77240	58260	2595	2330
22	440 (?)	31	—	48	115860	228.18	1.55	2414	9.36	—	73490	42370	2371	2492
23	0.40 (?)	25	—	48	91110	181.29	1.92	1898	7.45	—	42820	37420	1713	2202
24	791 (?)	31	—	58	173390	181.21	1.87	2990	5.85	—	99220	73350	3136	2821
25	715 (?)	31	—	47	100390	228.03	1.52	2136	7.36	—	66240	34450	2137	2134
26														
27														
28														
29														
30														
Total		654	—	1297	3569631	4636.69	48.36	71000	177.56	—	1899330	1201991	72417	69127
Average		26.16	—	51.88	142785	185.47	1.93	2840	7.10	—	95973	48080	2899	2765

	3 trip Weight	4 trip Weight	3rd. Average	4th Average	5 trip Weight	6 trip Weight	5th Average	6th Average	? trip Weight	?rd. Average
1	54380	42810	1813	1825	13310	2220	1901	2220	—	—
2	—	—	—	—	—	—	—	—	—	—
3	5310	—	2655	—	—	—	—	—	—	—
4	37500	6830	2679	2277	—	—	—	—	—	—
5	58340	48220	2012	2097	36840	26090	2108	2609	8450	2817
6	—	—	—	—	—	—	—	—	—	—
7	2040	—	2040	—	—	—	—	—	—	—
8	—	—	—	—	—	—	—	—	—	—
9	9190	—	4595	—	—	—	—	—	—	—
10	—	—	—	—	—	—	—	—	—	—
11	—	—	—	—	—	—	—	—	—	—
12	—	—	—	—	—	—	—	—	—	—
13	—	—	—	—	—	—	—	—	—	—
14	—	—	—	—	—	—	—	—	—	—
15	3220	—	3220	—	—	—	—	—	—	—
16	—	—	—	—	—	—	—	—	—	—
17	8490	—	2830	—	—	—	—	—	—	—
18	9740	—	3890	—	—	—	—	—	—	—
19	—	—	—	—	—	—	—	—	—	—
20	69150	15900	4939	5300	—	—	—	—	—	—
21	—	—	—	—	—	—	—	—	—	—
22	—	—	—	—	—	—	—	—	—	—
23	19910	1150	1942	1150	—	—	—	—	—	—
24	2820	—	2820	—	—	—	—	—	—	—
25	—	—	—	—	—	—	—	—	—	—
26										
27										
28										
29										
30										
Total	265886	115910	35415	12649	49150	28910	4009	5429	8450	2817
Average	22158	23182	2951	2530	24575	14455	2005	2715	8450	2817

Chapter 4. Intermediate Treatment

4.1 Existing Conditions

At present, there are 3 compost plants of the building type (2 in On Nut and 1 in Nong Khaem) and 1 compost plant of the rotary kiln type in Nong Khaem as shown in Fig. 4.1-1.

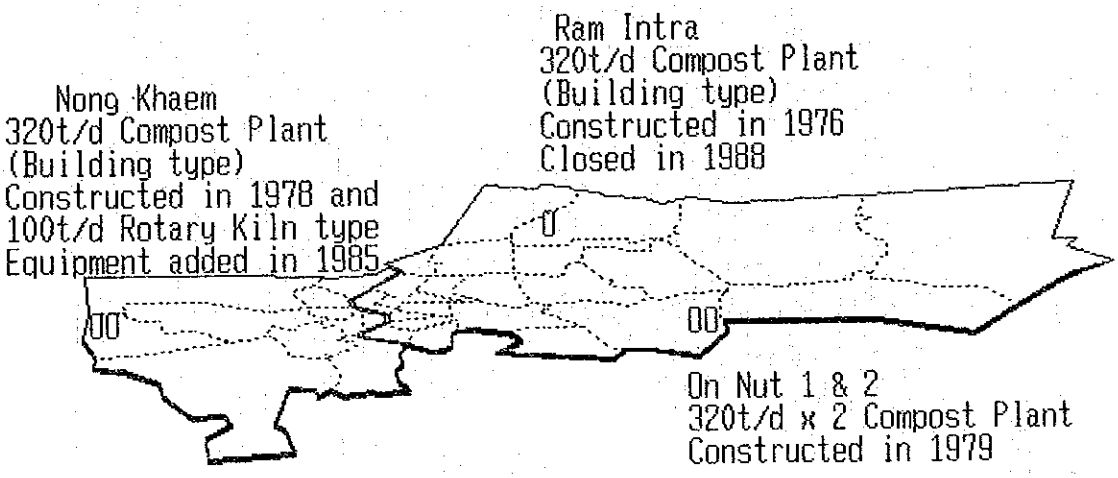


Fig. 4.1-1 Location & Situation of Compost Plants

Actual mass balance of a typical compost plant (building type) is estimated below. Incoming waste is 90 - 100 tons/day, the final compost production is about 3 tons/day.

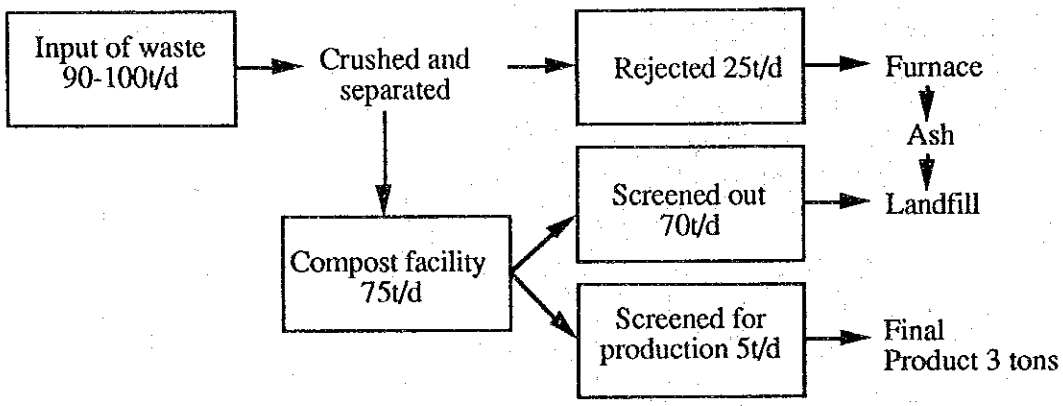


Figure 4.1-2 Mass Balance of Compost Plant

Figure 4.1-3 schematically shows the process of the compost plant at Nong Khaem. The existing rotary disc separator has not been working effectively. Compost materials still contain much plastic even after separation. On the other hand, much of the kitchen garbage has been rejected together with other rejected materials. The process flow of the compost plant in On Nut is same as the one in Nong Khaem except that the plant in On Nut does not have a rotary kiln digester.

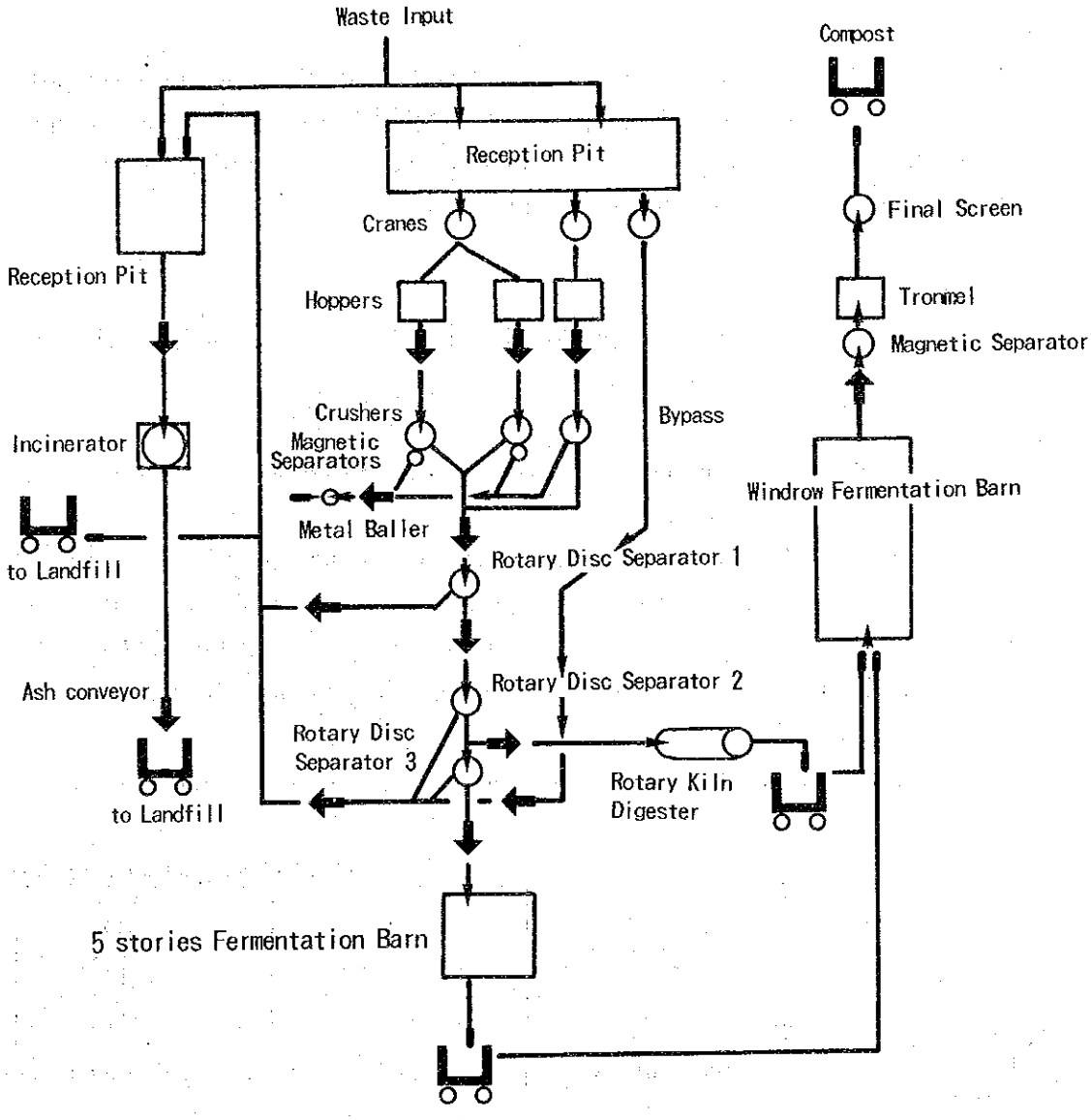


Figure 4.1-3 Process of the Compost Plant in Nong Khaem (Rotary Kiln Type)

4.2 Economic Evaluation of the BMA's Compost Business

1) Introduction

DPC has four units of compost plant: 3 building-type units and 1 rotary-kiln type unit.

At present, it is the BMA Fertilizer Enterprise that produces marketable compost products. DPC supplies "compost materials" to the Enterprise.

2) Important Facts

Fact 1

For the production of the marketable compost products, the BMA Fertilizer Enterprise uses mostly natural old waste lying on the dump site instead of using "compost material" produced by DPC's compost facilities because the Enterprise judges that the quality of former is better than that of the latter.

Fact 2

Majority of "compost materials" produced by DPC's plants are carried back to the dumping ground due to its poor quality.

3) Estimated Costs and Benefit of the BMA's Compost Business

It is estimated that the BMA's compost business, during the past 11 years since 1979 (the opening of the DPC's compost plants), brought about a total benefit to the BMA worth 174 million Baht, while it cost 905 million at least, resulting in a net loss of at least 731 million Baht . See the table below for the estimation of the benefits and costs.

BMA's Benefits and Costs of Compost Business Accumulated during the Past 11 years 1979 - 1989

Unit: million Baht at present price

	(1) BMA FERTILIZER ENTERPRISE	(2) DPC	(3) (1) + (2) BMA TOTAL
a. Benefit	172	2	174
b. Cost	165	740	905
c. Net Benefit (a - b)	+7	-738	-731

(The construction cost of the rotary Kiln type compost plant is not included in the above costs.)

Note: Basis of the Estimation of the Benefits and Costs

1) Benefit (172 million Baht) of the BMA Fertilizer Enterprise

750 Baht/ton x 230,000 ton = 172,500,000 Baht

where: 750 Baht/ton is an average present sales price of the compost products. 230,000 ton is the total amount of compost product sold during 11 years from 1979 till 1989.

2) Cost (165 million Baht) of the BMA Fertilizer Enterprise

172,500,000 Baht x 96 % = 165,600,000 Baht

where: 172,500,000 Baht is the above-estimated benefit. 96 % is an estimated cost percentage assuming the Enterprise's profit is 4 % of the sales. (According to some officials of the Enterprise, the Enterprise yielded a slight profits over the period.)

3) Benefit (2 million Baht) of DPC

This benefit is indirect benefit deriving from the waste volume reduction effect.

230,000,000 x 1.0 x 10 Baht/ton = 2,300,000 Baht

where: 230 million is the total amount of compost products produced and sold by the BMA. 10 Baht/ton is the current cost of waste disposal that was saved because of the waste reduction. It is assumed that the production of 1 ton of compost would contribute to 1.0 ton of the waste reduction.

4) Cost (7.4 million Baht) of DPC

300,000,000 Baht + 440,000,000 Baht = 770,000,000 Baht

Where: 300,000,000 Baht is the cost of construction of 4 building-type compost plants in On Nut, Nong Khaem and Ram Intra excluding the construction cost of the existing rotary kiln-type compost plant in Nong Khaem. 440,000,000 Baht is the total operation/maintenance costs estimated for 11 years with an average cost of 40 million per year.

4) Conclusion

1) The BMA should discontinue the DPC's compost operation as soon as possible because:

a. DPC's composting plants have not been performing the function for which they were constructed.
b. The continuation of the DPC's plants would incur roughly 100 million Baht of loss to the BMA a year.

2) The compost business is feasible for the Fertilizer Enterprise which produces compost mostly from natural old waste by using simple facilities such as screening and conveyors.

3) Composting business employing large capital investments as in the case of DPC are not feasible.

4.3 Evaluation of the New Compost Plant

The BMA in August 1990 concluded a contract for the construction of a new compost plant with capacity of receiving 1,000 tons/day, and producing 300 tons/day of compost product. After studying the contract specifications of the compost plant, the JICA Study Team has evaluated the compost plant as follows:

1) It is not technically possible for the BMA to produce 300 tons/day of compost product from 1,000 tons/day of general waste of Bangkok. It is estimated that the compost production will be 170 tons/day at most, judging from the following:

a. The existing compost plant produces only 3 tons/day of final product from 100 tons/day of general waste.

b. The removal of plastics will be still far from perfect even with the introduction of an air separator. It is very likely that good compost material will be rejected together with unremoved plastics at the sieving process.

c. Removal of materials unsuitable for composting.such as glass, will be very difficult even if mechanical separators are introduced. It is even more difficult to

remove those materials by manual sorting. (The manual sorting will be effective only for sorting useful materials.)

2) It is anticipated that operation costs of the new compost plant may exceed the sales of the final compost.

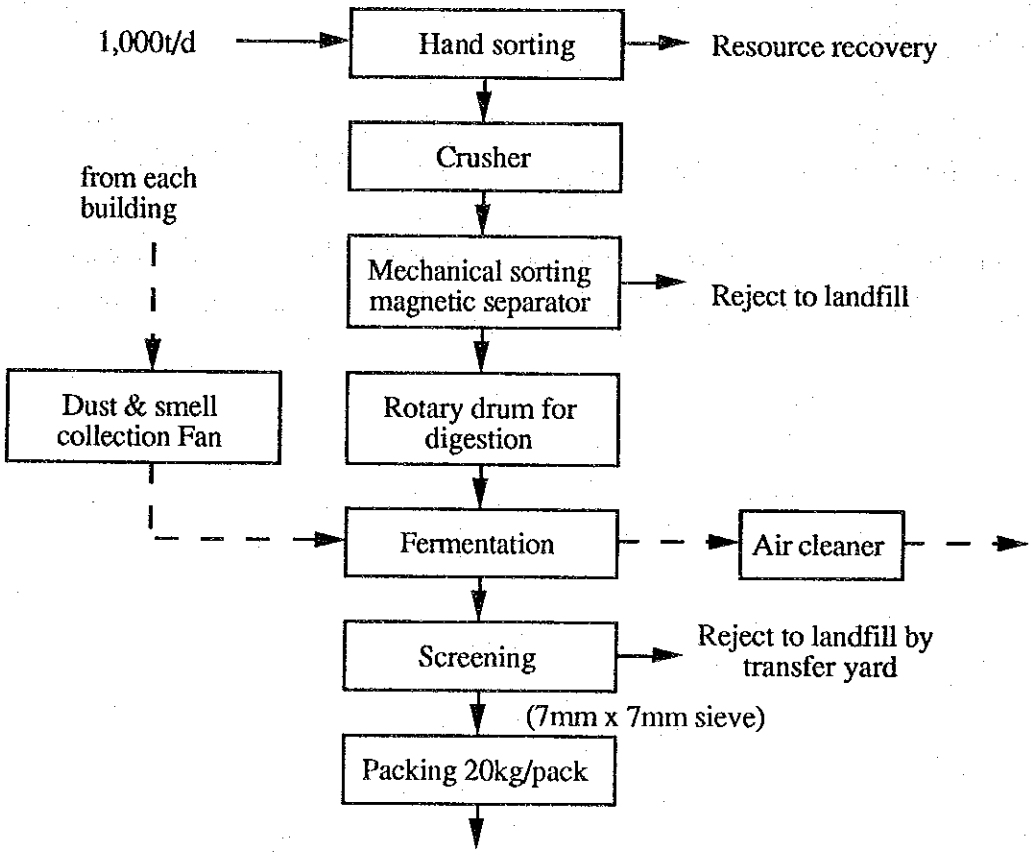
Recommendations

1. It is advisable for the BMA/DPC to selectively collect waste suitable for compost such as vegetable market waste, and use it as much as possible for composting.

2. If there is an offer from a contractor to take the responsibility for the plant operation and the right of selling final compost product, the BMA should accept such offer.

Table 4.3-1 Specification of New compost Plant

Capacity:	1000 t/d (20h continuous work)
Truck Scale:	30t (10kg sensitive) with computer printer
Reception Platform:	4 cars at a time; 3500m^3 pit with spot light equipment
Major Process:	



Control:	Local/Central control room with air conditioner
	ITV 8 points
Communication:	Inner telephone 10 set, Wirless phone 5 set
Equipment:	Bulldozer, shovel loader, truck, pick-up truck, typewriter, photo copy machine, microcomputer, 2 cars

Chapter 5 Evaluation of Private Contractors Regarding Final Disposal

5.1 Criteria

To evaluate the private contractors who tender for SWM work of the BMA, certain criteria are required. For the criteria, five of the following aspects should be covered;

1. Technical aspects of proposed final disposal plan,
2. Environmental considerations,
3. Cost,
4. Reliability of the company,and
5. Experience of similar work.

To ease evaluation of the contractors proposals and supervise their work, the Appendix of the master plan volume includes proposed technical guidelines to establish criteria and to rate Contractors potential performance.

5.2 Evaluation of Private Contractors who tendered for the Talang Project

In 1990, the BMA issued tender documents to employ a private contractor to construct a transfer station at Talang, and provide secondary transport from Talang to his proposed final disposal site, and to provide final disposal. In response with this, four private companies applied with documents such as transportation and disposal plan, detailed design of the proposed disposal site with proposed landfill method and estimated costs. Table 5.1-1 shows their proposed items.

According to their proposals, the private companies describe the necessity of soil covering, impervious work and leachate treatment, which are major items in the sanitary landfill method. However, the leachate treatment facility in their proposals were not adequate in terms of treatment ability.

The BMA does not have any standard format for the proposal, so each private company has to make his proposals in his own way. It makes it difficult for BMA to evaluate the proposals. This is one reason to suggest establishing a standard format and to provide technical guidelines.

Table 5.1-1 Main Items of the Documents (2)

ITEMS \ COMPANY		R Company	L Company	P Company	V company
Final disposal site sturcture	Chain link fence	———	———	———	———
	Structure of embankment	H=2.5m×2steps Slope=1:2	———	———	H=2.5m×2steps Out side 1:2 In side 1:1.5
	Internal structure	Depth=5.0m Slope=1:2	Depth=27m Slope=1:3	Depth=14m Slope=1:2	Depth=2m Slope=1:1.5
	Impervious material	NATURAL CLAY LAYER (1.2×10^{-7}~8.6×10^{-7}cm/s)	P.E.SHEET LINING 0.3mm CNPACTED CLAY 0.3m	Natural Clay Layer	Natural Clay Layer
	Leachate collection facility	———	Vinyl chloride pipe with crash stone	———	———
	Structure of gas out·let pipe	o300 Vinyl chloride pipe with crushed stone	o150 Vinyl chloride pipe with crushed stone	Porous pipe with crushed stone	———
	Leachate treatment facility	———	500 (m^3/d)	———	1,020 (m^3/d)
		Anaerobic pond (Depth=3.0m) Facultative pond (Depth=2.5m) Maturation pond (Depth=1.5m)	Anaerobic pond Aeration Tank Sedimation Tank Sludge Sump Sand dry bed Chlorination Tank Polishing Pond Pressure Sand Filter Activated Carbon Tank Control room and Stock room BOD 3,000 (Original)	Oxidation pond Chlorination	Facultative pond×2 Depth=2.5m Maturation pond ×2 Depth=1.5m

Note: ——— are not clarified

Table 5.1-1 Main Items of the Documents (1)

ITEMS \ COMPANY			R Company	L Company	P Company	V company
Main contents of final disposal site	Site location		①SOI RONGLOR HONGMANEE EKACHAIRL SAMUT SAKORN PROVINCE ②KROK SOMBOON SRIMAHAPOO PRAJEANBURI PROVINCE	NEAR MITR-MITREE ROAD MOO4 BANNCHADOO KOOH FANGNVA NONGJOK BANGKOK	MOO3 BAN-LVANG DONTOOM NAKORN PHATOM PROVINCE	①PHANOM THUAN KANCHA NABURI PROVINCE ②KAMPANG SAEN NAKORN PHATOM PROVINCE
	The distance from the transfer station		①150km ②170km	27.1km	105km	①170km ②110km
	The site area		①400RAI ②440RAI	482RAI (315RAI)	206RAI future(240RAI)	①450RAI ②250RAI
	Topographical condition of the site		Flat land	Hole (Old borrow pit)	Hole (Old borrow pit)	Flat
	Land fill volume	Solid waste	1. 1,500 2. 1,620 3. 1,740 4. 1,880 5. 2,020 (Tons/day)	1. 1,500 2. 1,650 3. 1,800 4. 1,980 5. 2,250 (Tons/day)	1. 1,500 2. 1,700 3. 1,900 4. 2,100 5. 2,400 (Tons/day)	1. 1,500 2. 1,620 3. 1,750 4. 1,890 5. 2,040 (Tons/day)
		Covering material	———	———	———	———
		Total (5 years)	3,197,400 (Tons) 7,993,500 (m³)	3,350,700 (Tons) 11,169,000 (m³)	3,504,000 (Tons)	3,212,100 (Tons) 7,137,800 (m³)
	Land owner		Company's own land	Leased land	giong to buy	giong to buy
	Completion of landfill		Agricultural space or recreation facilities	———	Trees will be planted all over the place	①Golf course ②Golf course
	Offerd price including ·Construction of T/S ·Toransportation ·Final disposal		288B/t	298B/t	169B/t	173B/t

Chapter 6 Environmental and Sanitary Conditions

6.1 Standards and Regulations for Environmental Conservation

1) Requirements Regarding the Environmental Impact Assessment

The Improvement and Conservation of National Environmental Quality Act was enacted in 1975. Environmental assessment was systematized by this act, which authorised:

1. The National Environmental Board (NEB) shall have the power to require government agencies, state enterprises, and other persons to submit documents on surveys of consequence affecting the environmental quality and documents or data concerning projects and schemes for its consideration.

2. Categories and projects of magnitude or activities by government agencies, state enterprises, or private organization, are required to prepare reports concerning the study of prevention of and remedy for the adverse effects on environmental quality during the construction period. These reports should be submitted to the National Environmental Board for consideration and approval.

The procedure for environmental assessment is shown in Fig.6.1-1, and types and sizes of projects or activities requiring environmental impact assessment reports are shown in Table 6.1-1.

2) Environmental Standards

Environmental standards concerning air quality and water quality are show in Table 6.3-2-8.

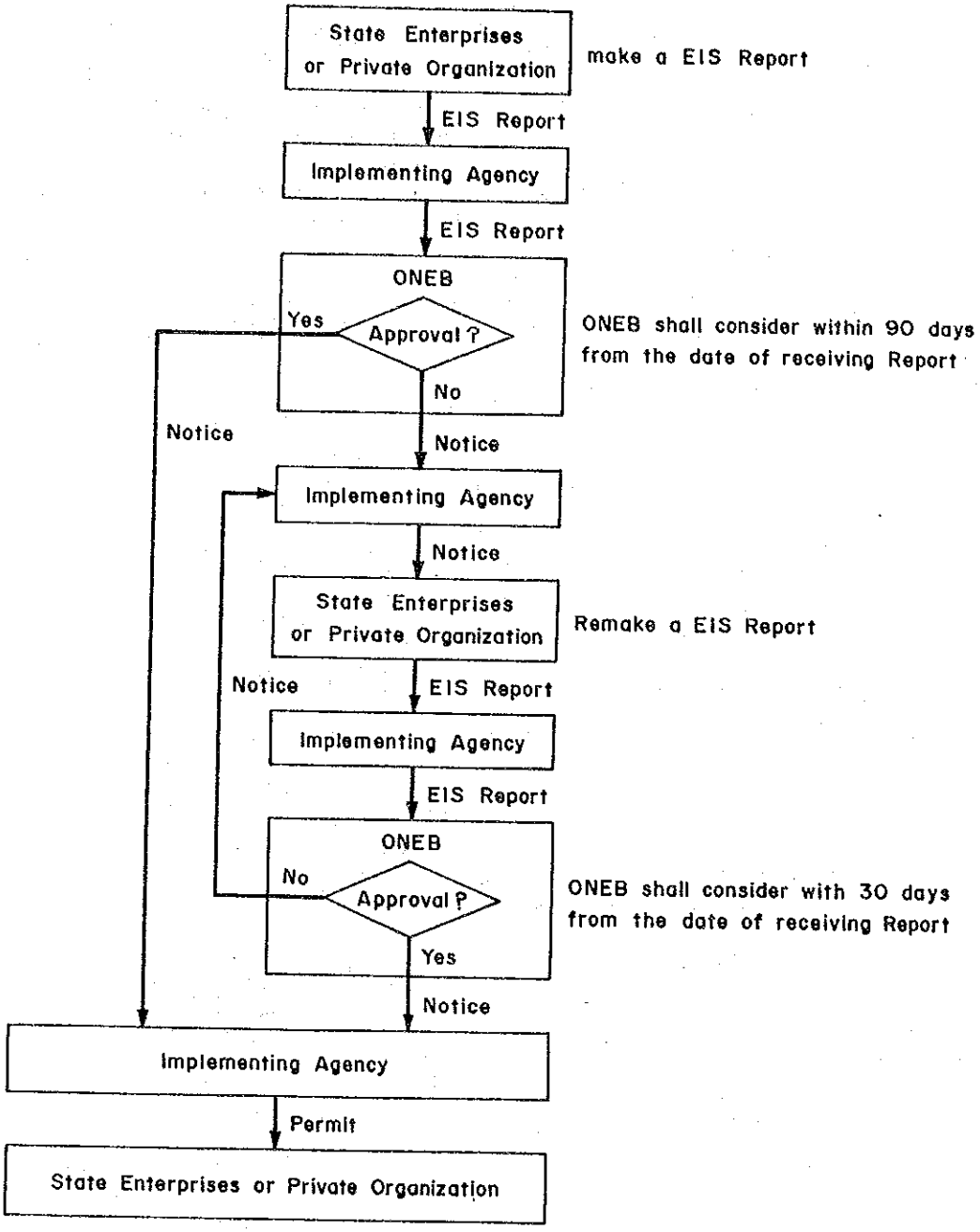


Fig.6.1-1 Procedure of Environmental Assessment Flow in Thailand

Table 6.1-1 Types and Sizes of Projects or Activities Requiring Environmental Impact Assessment (EIA) Reports

Items	Types of Projects or Activities	Sizes
1	Dam or Reservoir	storage volume greater than 100,000,000 cubic meters or storage surface area greater than 15 square kilometers
2	Irrigation	irrigated area greater than 80,000 rais (12,800 hectares)
3	Commercial Airport	all sizes
4	Hotel or Resort Facilities environmentally sensitive area such as areas adjacent to rivers coastal areas, lakes or beaches or in the vicinity of national parks	greater than 80 rooms
5	Mass Transit System and Expressway as defined by the Announcement of the Revolutionary Party No. 290, 24 November B.E. 2515	all sizes
6	Mining as defined by the Mineral Act No.1 B.E. 2510, No. 2 B.E. 2516 and No. 3 B.E. 2522	all sizes
7	Industrial Estate as defined by the Industrial Estate Authority of Thailand Act, B.E. 2522	all sizes
8	Commercial Port and Harbour	with capacity for vessels of greater than 500 ton-gross
9	Thermal Power Plant	Capacity greater than 10 MW.
10	Industries	
	(1) Petrochemical Industry	greater than 100 tons/day of raw materials required in production processes of oil refinery and/or natural gas separation
	(2) Oil Refinery	all sizes
	(3) Natural Gas Separation of Processing	all sizes
	(4) Chlor-Alkaline Industry requiring NaCl as raw material for production of Na_2CO_3, NaOH, HCl, Cl_2, NaOCl and Bleaching Powder	production capacity of each or combined product greater than 100 tons/day
	(5) Irons and/or Steel Industry	requiring from are and/or scrap iron as raw materials for production greater than 100 tons/day or using furnaces with combined capacity greater 5 tons/batch
	(6) Cement Industry	all sizes
	(7) Smelting Industry other than Iron and Steel	production capacity greater than 50 tons/day
	(8) Pulp Industry	Production capacity greater than 50 tons/day

Source : Notification of the Ministry of Science, Technology and Energy, B.E. 2524 issued under National Environmental Quality Act, B.E 2518 as amended in B.E. 2521, published in the Royal Government Gazette (Special issue), Vol. 98, Part 158, dated September 27, B.E. 2524 (1981)

Table 6.1-2 National Ambient Air Quality Standards

Pollutants	1-hr average value mg/m3	8-hr average value mg/m3	24-hr average value mg/m3	1-yr average value mg/m3	Methods of Measurement
Carbon Monoxide (CO)	50	20	–	–	Non-Dispersive Infrared Detection
Nitrogen Dioxide (NO_2)	0.32	–	–	–	Gas Phase Chemiluminescence
Sulfur Dioxide (SO_2)	–	–	0.30	0.10*	Pararosaniline
Suspended Particulate Matter (SPM)	–	–	0.33	0.10*	Gravimetric-High Volume
Photochemical Oxidant (O_3)	0.20	–	–	–	Chemiluminescence
Lead (Pb)	–	–	0.01	–	Wet Ashing

Note: * = Geometric mean value.

Sources: (1) Standards:Notification of Office of the National Environment Board, No.2, dated November 6, B.E. 2524, published in the Royal Government Gazette, Vol. 98, Part 197, dated December 1, B.E. 2524 (1981) P. 4322-4323.

(2) Methods of Measurement: Notification of the Ministry of Science, Technology and Energy, issued under National Environmental Quality Act B.E. 2518, B.E. 2521, published in the Royal Government Gazette, Vol. 98, Part 197, dated December 1, B.E. 2524 (1981) P. 4299-4306.

Table 6.1-3 Industrial Emission Standards

In order to avoid industrial nuisance problems, the intensity of smoke at the mouth of the stack shall not exceed 40 percent of total blackness by the Ringlemann scale except for the short periods of time during starting of operation, soot blowing, or other malfunctions of the soot control system.

Penalty : According to Factory Act No.2, B.E. 2518 (1975) which rules that violator are subjected up to one month imprisonment or fined not more than 10,000 baht or both.

Source: Notification of the Ministry of Industry No.4, B.E. 2514 (1971) issued under Factory Act B.E. 2512 (1969) dated August 11, B.E. 2514 (1971), published in the Royal Government Gazette, Vol. 86 (Special issue) dated August 14, B.E. 2514 (1971)

The Industrial Environment Division, Ministry of Industry has set up the emission guidelines for new industry or expansion or setting conditions after complaints. The proposed emission standards are shown as follows:

Table 6.1-4 Proposed Industrial Emission Standards by Ministry of Industry

No.	Substances	Sources	Proposed Standard Values
1	Particulate	– Boiler & furnace	
		Heavy oil as fuel	0.3 g/Nm^3
		Coal as fuel	0.5 g/Nm^3
		– Steel manufacturing	400 mg/Nm^3
		– Cement plant and calcium carbide plant	400 mg/Nm^3
		– Rock and gravel aggregate plants (production capacity more than 50,000 tons per year)	400 mg/Nm^3
		– Other source	500 mg/Nm^3
2	Smoke opacity	Boiler and Furnace	not exceed 40% Ringlemann scale
3	Aluminium	Furnace or smelter	(dust) 300 mg/Nm^3 (Al) 50 mg/Nm^3
4	Alcohol	any source	0.05 lb/min
5	Aldehyde	any source	0.05 lb/min
6	Ammonia	gas plant	25 ppm
7	Antimony	any source	25 mg/Nm^3
8	Aromatics	any source	0.05 lb/min
9	Asbestos	any source	27 µg/Nm^3
10	Arsenic	any source	20 mg/Nm^3
11	Beryllium	any source	10 µg/Nm^3
12	Carbonyls	Burning refuse	25 ppm
13	Chlorine	any source	20 mg/Nm^3
14	Ethylene	from production or by usage	0.03 lb/min
15	Ester	any source	0.05 lb/min
16	Fluorine	any source	0.3 lb/ton P_2O_5
17	Hydrogen Chloride	any source	200 mg/Nm^3
18	Hydrogen Fluoride	any source	10 mg/Nm^3
19	Hydrogen Sulphide	any source	100 ppm
20	Cadmium	any source	1.0 mg/Nm^3
21	Copper	any source	dust 300 mg/Nm^3 (Cu) 20 mg/Nm^3
22	Lead	any source	dust 100 mg/Nm^3 (Pb) 30 mg/Nm^3
23	Mercury	any source	0.1 mg/Nm^3
24	CO	any source	1,000 mg/Nm^3
25	SO_2	H_2SO_4 production	500 ppm
		Other activities:	
		– Bangkok and its vicinities	400 ppm
		– other area	700 ppm
26	NO_x	Combustion source	1,000 mg/Nm^3
		HNO_3 production and others	2,000 mg/Nm^3
27	Nitric acid	any source	70 mg/Nm^3
28	Organic Material	any source	0.01 ld/min
29	Phosphoric acid	any source	3 mg/Nm^3
30	Sulfur trioxide	any source also in combination with H_2SO_4	35 mg/Nm^3 as H_2SO_4
31	Sulfuric acid	any source	35 mg/Nm^3

Table 6.1-5 Surface Water Quality

Parameters	Units	Statistic	Standard values for class***				
			1	2	3	4	5
1. Temperature	°C	–	n	n	n	n	–
2. pH value	–	–	n	5–9	5–9	5–9	–
3. Dissolved oxygen	mg/l	P20	n	6	4	2	–
4. BOD (5 days, 20°C)	mg/l	P80	n	1.5	2.0	4.0	–
5. Coliform bacteria							
–Total coliform	MPN/100 ml	P80		5,000	20,000	–	–
– Fecal coliform	"	P80		1,000	4,000	–	–
6. NO_3–N	mg/l	Max. allowance	n	←	5.0	→	–
7. NH_3 –N	"	"	n	:	0.5	:	–
8. Phenols	"	"	n	:	0.005	:	–
9. Cu	"	"	n	:	0.1	:	–
10. Ni	"	"	n	:	0.1	:	–
11. Mn	"	"	n	:	1.0	:	–
12. Zn	"	"	n	:	1.0	:	–
13. Cd	"	"	n	:	0.005*,0.05**	:	–
14. Cr (hexavalent)	"	"	n	:	0.05	:	–
15. Pb	"	"	n	:	0.05	:	–
16. Hg (total)	"	"	n	:	0.002	:	–
17. As	"	"	n	:	0.01	:	–
18. CN	"	"			0.005		
19. Radioactivity							
– Gross ∝	Becqurel/l	"	n	:	0.1	:	–
– Gross β	"	"	n	:	1.0	:	–
20. Pesticides (total)	mg/l	"	n	:	0.05	:	–
– DDT	μg/l	"	n	:	1.0	:	–
– ∝BHC	"	"	n	:	0.02	:	–
– Dieldrin	"	"	n	:	0.1	:	–
– Aldrin	"	"	n	:	0.1	:	–
– Heptachlor & Heptachlor epoxide	"	"	n	:	0.2	:	–
– Endrin	"	"	n	←	none	→	–

Note : P = Percentile value
n = naturally
n′ = naturally but changing not more than 3°C
★ = when water hardness not more than 100 mg/l as $CaCO_3$
★★ = when water hardness more than 100 mg/l as $CaCO_3$
★★★ = Water Classification

Classifications	Objectives/Condition & Benificial usages
Class 1	Extra clean fresh surface water resources using for : (1) conservation, not necessary pass through water treatment processes require only ordinary process for pathogenic destruction (2) ecosystem conservation which basic living organisms can spread breeding naturally
Class 2	Very clean fresh surface water resources using for : (1) consumption which require the ordinary water treatment process before uses (2) aquatic organism conservation for living and assisting for fishery (3) fishery (4) recreation
Class 3	Medium clean fresh surface water resources using for (1) consumption but have to pass through an ordinary treatment process before uses (2) agriculture
Class 4	Fairly clean fresh surface water resources using for (1) consumption but require special water treatment process before uses, (2) industry (3) other activities
Class 5	The resources which are not classified in class 1–4 and using for (1) navigation

Source : Notification of the Ministry of Science, Technology and Energy (B.E. 2528 (1985.)), published in the Royal Government Gazette, Vol. 103, Part 60, dated April 15, B.E. 2529 (1986)

Table 6.1-6 Groundwater Quality Standards for Drinking Purpose

Properties	Parameters	Units	Standard values	
			Suitable allowance	Max. allowance
Physical	Colour	Platinum–Cobalt	5	50
	Turbidity	JTU	5	20
	pH	–	7.0–8.5	6.5–9.2
Chemical	Fe	mg/l	0.5	1.0
	Mn	"	0.3	0.5
	Cu	"	1.0	1.5
	Zn	"	5.0	15.0
	Sulphate	"	200	250
	Chloride	"	200	600
	Fluoride	"	1.0	1.5
	Nitrate	"	45	45
	Total hardness as $CaCO_3$	"	300	500
	Non Carbonate hardness as $CaCO_3$	"	200	250
	Total solids	"	750	1,500
Toxic	As	"	none	0.05
	Cyanide	"	none	0.2
	Pb	"	none	0.05
	Hg	"	none	0.001
	Cd	"	none	0.01
	Se	"	none	0.01
Bacterial	Standard Plate Count	colonies/ml	500	–
	Coliform Bacteria	MPN/100 ml	2.2	–
	E. Coli	"	none	–

Penalty : A licensee who does not comply with this notification shall be punished by fine not exceeding twenty thousand baht

Source : Notification of the Ministry of Industry No. 4 B.E. 2521 (1978) issued under in the Groundwater Act B.E. 2520 (1977), published in the Royal Government Gazette, Vol. 95, Part 66, dated June 27, B.E. 2521 (1978).

Table 6.1-7 Industrial Effluent Standards

Items	Units	Standard values	Remarks
BOD (5 days, at 20°C)	mg/l	20–60	Fishery canning Max. 100 Starch industry Centrifugal Max. 60 Sedimentation Max. 100 Noodle industry Max. 100 Tanning industry Max. 100 Pulp industry Max. 100 Frozen Food industry Max. 100
Suspended solids (SS)	mg/l	Depend on dilution ratios of wastewater and receiving water	Ratio 1/8 to 1/150 Max. 30 1/151 to 1/300 Max. 60 1/301 to 1/500 Max. 150
Dissolved solids (DS)	mg/l	Max. 2,000 or under office's consideration but not more than 5,000	If salinity of recieving water is higher than 2,000 mg/l, DS in the effluent should not be higher than 5,000 mg/l of the DS in the recieving water
pH	–	5–9	
Permaganate value	mg/l	Max. 60	
Sulfide as H_2S	"	Max. 1.0	
Cyanide as HCN	"	Max. 0.2	
Tar	"	none	
Oil & Grease	"	Max. 5.0	Refinery & Lubricant oil industry Max. 15.0
Formaldehyde	"	Max. 1.0	
Phenol & Cresols	"	Max. 1.0	
Free Chlorine	"	Max. 1.0	
Insecticides	"	none	
Radioactivity	Becquerel/l	none	
Heavy metals			
Zinc (Zn)	mg/l	Max. 5.0	Zinc industry Max. 3.0
Chromium (Cr)	"	Max. 0.5	Zinc industry Max. 0.2
Arsenic (As)	"	Max. 0.25	
Copper (Cu)	"	Max. 1.0	
Mercury (Hg)	"	Max. 0.005	Zinc industry Max. 0.002
Cadmium (Cd)	"	Max. 0.03	Zinc industry Max. 0.1
Barium (Ba)	"	Max. 1.0	
Selenium (Se)	"	Max. 0.02	
Lead (Pb)	"	Max. 0.2	
Nickel (Ni)	"	Max. 0.2	Zinc industry Max. 0.2
Manganese (Mn)	"	Max. 5.0	
Silver (Ag)	"	–	Zinc industry Max. 0.02

Penalty : A licensee for operation a factory who dose not comply with this notification shall be punished by fine not exceeding ten thousand baht.

Source : (1) Notification of the Ministry of Industry No.12, B.E. 2525 (1982) issued under the Factory Act B.E. 2521 (1978), published in the Royal Government Gazette, Vol. 99, Part 33, dated March 5, B.E. 2525 (1982).

(2) Notification of the Ministry of Industry No. 10, B.E. 2521 (1978) issued under the Factory Act B.E.2521,(1978), published in the Royal Government Gazette, Vol. 95, Part 132, dated November 28, B.E. 2521 (1978).

Table 6.1-8 Regulation of Industrial Pollution Control Facilities

1. The following industrial plants must have the supervisors and machine operators to take responsibility of the system of prevention of pollution, whose qualifications are specified in article 2.

1.1 An industrial plant discharging waste water at higher than 60 cubic meters/hour (with the exception of cooling water), or having the BOD load of influent at higher than 100 kilogram/day.

1.2 An industrial plant using heavy metals in the production process discharging waste water at higher than 50 cubic meters/day, and having the content of heavy metals in the discharge waste water at the following values :

(a) Zinc at higher than 250,000 milligrams/day
(b) Chromium at higher than 25,000 milligrams/day
(c) Arsenic at higher than 12,500 milligrams/day
(d) Copper at higher than 50,000 milligrams/day
(e) Mercury at higher than 250 milligrams/day
(f) Cadmium at higher than 1,500 milligrams/day
(g) Barium at higher than 50,000 milligrams/day
(h) Selenium at higher than 1,000 milligrams/day
(i) Lead at higher than 10,000 milligrams/day
(j) Manganese at higher than 250,000 milligrams/day

1.3 An industrial plant dealing with iron and steel :

(a) Using drying furnace or acids or other substances which may be polluting the environment in the production process, with production capacity of higher than 100 tons/day.
(b) Using steel smelters with the total capacity of 5 tons/batch.

1.4 An industrial plant producing Petrochemicals from the raw materials obtained as by-products of the Oil refinery in the production process at higher than 100 tons/day.

1.5 An industrial plant of any size separating or processing the natural gas.

1.6 An industrial plant producing chlor-alkali, using sodium chloride (NaCl) as raw material in the production of soda ash (Na_2CO_3) caustic soda (NaOH), hydrochloric acid (HCl), chlorine (Cl_2) and bleaching (NaOCl) each or several combined at higher than 100 tons/day.

1.7 An industrial plant of any size producing cement.

1.8 An industrial plant engaged in ore smelting or production of metals at higher than 50 tons/day.

1.9 An industrial plant producing paper pulp at higher than 50 tons/day.

1.10 An industrial plant of any size engaged in crude oil refinery

2. The supervisor, machine operators responsible for the system of pollution control, shall meet the following qualifications :

2.1 The supervisors are holders of bachelor degree in engineering, or science in chemistry, or other branches of study with experiences in the field of environment, and who has been approved by the Industrial Factory Department. In the case of an Engineering Consultant Firm, it must be operated by person(s) having the qualifications mentioned aboved.

2.2 The machine operators must be graduates of the secondary education, lower level, with the certification from the persons as mentioned in 2.1.

2.3 The persons stated in 2.1 and 2.2 must register themselves with the Industrial Works Department, and complying with the regulations and procedures as prescribed by the Industrial Works Department.

3. Factories mentioned in article 1.1 to 1.10 must arrange to make Poisonous Matter Analysis Reports and submit them to the Industrial factories Department every 3 months on the form and according to the procedures prescribed by the Industrial Factories Department. The analysis of the qualities of poisonous matter must be performed by a government analysis laboratory or a private analysis laboratory approved by the Industrial Factories Department in accordance with the regulations and procedures prescribed by the Industrial Factories Department.

Penalty : A licensee for operating a factory who does not comply with this notification shall be punished by fine not exceeding ten thousand baht.

Source : Notification of the Ministry of Industry No. 13 B.E. 2525 (1982), as amended in No. 22 B.E. 2528 (1985), issued under the Factory Act B.E. 2512 (1969), published in the Royal Government Gazette, Vol. 99, Part 89, dated June 29, B.E. 2525 (1982).

6.2 Data of Environmental Conditions

Basic data of environmental condition is shown in as follows:

- Climate	Table 6.2-1
	Fig. 6.2-1
-Groundwater	Table 6.2-2
-Air pollution	Table 6.2-3, 4
	Fig. 6.2-2

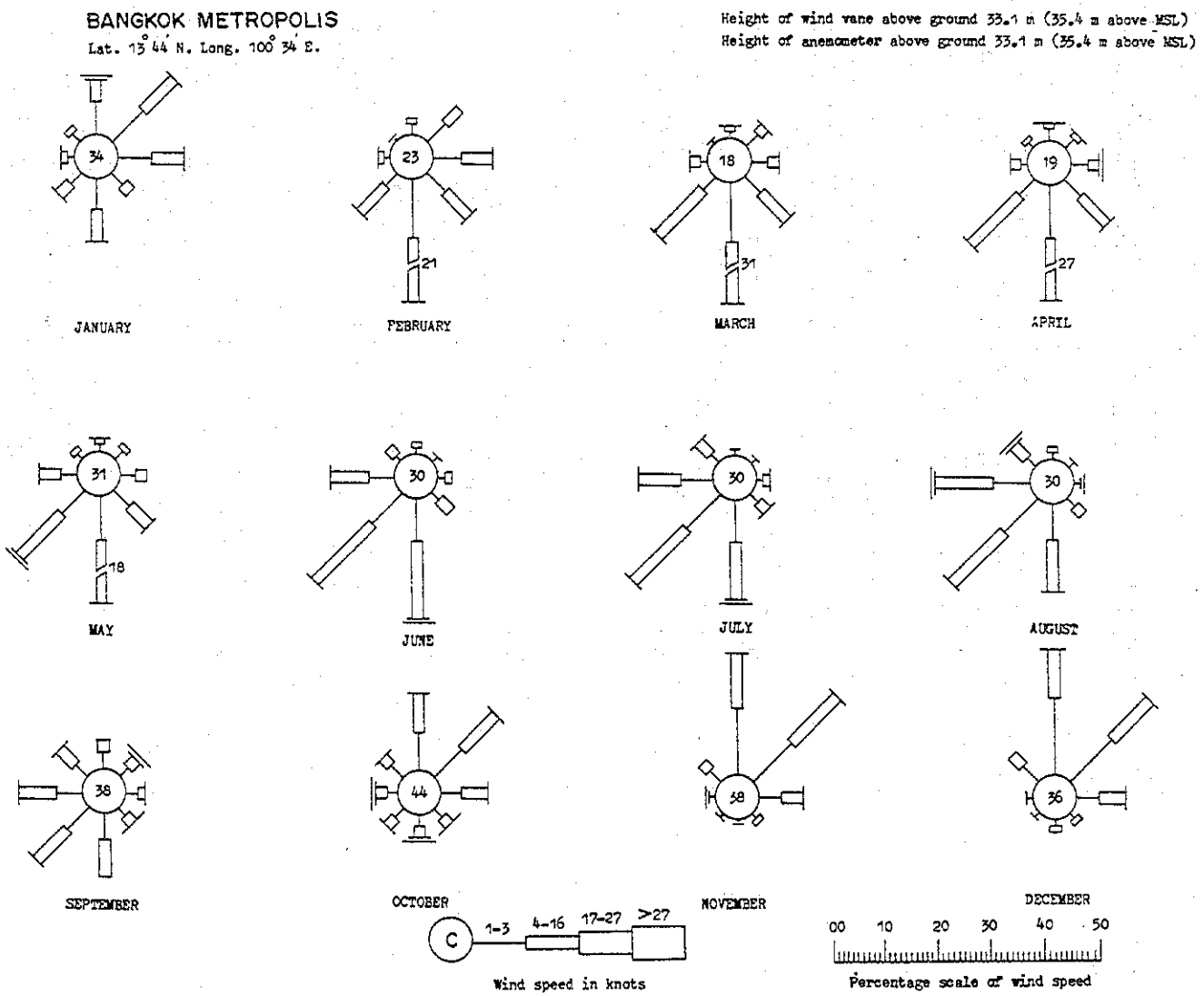
Table 6.2-1 Climatological Data in Bangkok, 1956-1985

Station	BANGKOK METROPOLIS	Elevation of station above MSL	2 meters
Index Station	48455	Height of barometer above MSL	20 meters
Latitude	13 44' N	Height of thermometer above ground	1.25 meters
Longitude	100 34' E	Height of wind vane above ground	33.10 meters
		Height of raingauge	1.00 meters

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Year
Pressure (+1000 or 900 mbs.)													
Mean	12.47	10.99	09.96	08.40	06.85	06.34	06.46	06.51	07.56	09.75	11.60	12.63	09.13
Ext. Max.	26.50	20.96	20.97	17.74	14.06	13.00	13.34	13.50	14.38	18.02	20.38	21.32	26.50
Ext. Min.	04.42	02.27	02.08	99.66	99.40	97.76	98.78	99.36	98.20	01.22	04.60	03.87	97.76
Mean daily range	4.81	4.80	4.85	4.83	4.46	3.80	3.75	3.93	4.39	4.43	4.28	4.51	4.40
Temperature (C)													
Mean	25.6	27.2	28.6	29.6	29.3	28.7	28.1	27.9	27.6	27.5	26.7	25.5	27.7
Mean Max.	31.9	32.8	33.9	34.9	34.2	33.1	32.6	32.4	32.0	31.8	31.5	31.4	32.7
Mean Min.	20.6	23.1	24.8	25.9	25.6	25.3	24.9	24.8	24.5	24.3	23.0	20.9	24.0
Ext. Max.	35.7	36.6	39.8	40.0	39.5	37.7	37.8	36.3	36.0	35.3	35.1	35.2	40.0
Ext. Min.	11.5	14.9	16.5	19.9	21.1	21.7	22.2	21.2	21.6	18.3	14.2	10.5	10.5
Relative Humidity (%)													
Mean	72.1	75.7	76.0	76.0	78.4	78.5	79.3	80.2	82.8	82.2	77.5	72.5	77.6
Mean Max.	90.6	92.2	91.6	90.7	92.2	91.5	91.8	93.2	94.8	94.3	92.5	90.0	92.1
Mean Min.	48.6	53.4	55.2	55.8	60.1	62.3	63.5	63.9	66.0	65.6	59.4	52.1	58.8
Ext. Min.	27.0	17.0	23.0	28.0	30.0	38.0	43.0	47.0	49.0	36.0	36.0	31.0	17.0
Dew Point (C)													
Mean	19.6	22.1	23.6	24.5	24.8	24.2	23.9	23.9	24.2	23.9	22.1	19.7	23.0
Evaporation (mm.)													
Mean-Pan	135.9	141.1	162.1	167.5	171.4	150.1	147.9	147.1	130.4	127.9	125.8	133.3	1760.5
Cloudiness (0-10)													
Mean	5.9	6.5	6.8	7.0	8.2	8.5	8.6	8.9	9.0	8.2	6.8	5.9	7.5
Sunshine Duration (hr.)													
Mean	276.6	252.5	270.0	256.0	222.4	178.5	169.1	159.4	152.6	202.0	242.6	266.1	2647.8
Visibility (km.)													
0700 L.S.T.	5.2	4.9	5.9	7.5	8.6	8.7	8.4	8.1	8.0	8.0	8.1	7.5	7.4
Mean	9.6	9.2	9.4	10.7	11.9	12.1	11.9	11.6	8.6	11.4	11.7	11.2	10.8
Wind (knots)													
Prevailing wind	NE	S	S	S	S	SW	SW	SW	SW	NE	NE	NE	-
Mean wind speed	2.6	4.1	5.0	4.6	3.8	3.8	3.5	3.6	2.7	2.3	2.3	2.4	-
Max. wind speed	31 NNE	37 N	48 ENE	52 E ESE	41 SSW	41 W	41 W NW WNW, S	43 E	44 SSW	40 NE	37 SE ESE	31 SE NNE	52 E ESE
Rainfall (mm.)													
Mean	9.3	29.1	26.2	66.4	189.9	156.1	158.7	204.6	339.4	239.3	48.3	9.7	1477.0
Mean rainy days	1.3	2.9	3.0	6.4	15.7	16.7	18.1	20.6	21.5	17.0	5.9	1.3	130.4
Greatest in 24 hr.	39.3	73.0	88.4	89.7	124.2	167.3	108.6	97.8	153.7	123.2	81.2	32.0	167.3
Day/Year	31/61	11/64	30/82	29/57	15/66	13/79	28/76	26/71	23/68	5/60	2/69	8/72	13/79
Number of days with													
Haze	19.1	15.9	16.3	9.3	2.9	1.3	0.8	0.8	1.0	2.2	6.3	11.8	87.7
Fog	3.5	1.2	0.4	0.0	0.1	0.0	0.1	0.0	0.0	0.1	0.3	0.7	6.4
Hail	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Thunderstorm	0.5	0.8	2.4	8.1	15.8	9.7	10.3	11.0	16.3	14.7	3.7	0.7	94.0
Squall	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.2

Remarks: Evaporation 1961 - 1985

source: Climatological Data of Thailand 30 years Period (1956-1985)
Meteorogical Department, Ministry of Communications



source: Wind Rose of Thailand 30 years Period (1951-1980)
Meteorogical Department, Ministry of Communications

Fig. 6.2-1 Wind Rose in Bangkok,1951-1980

Table 6.2-2 Characteristic of Aquifers in Bangkok

AGE	AQUIFER	Thickness (meters)	Lithology	Water-bearing Properties
LATE-PLEISTOCENE TO RECENT	1 BANGKOK (50-m zone)	± 50	Topmost clay is generally dark gray to black, limonitic lateritic in the upper portion. Coarse sand, gravel and pebble are subangular to rounded, moderately to well sorted; composed mostly of various types of fragments.	Yields considerable quantity of water of poor quality, brackish to salty and highly mineralized. Normally not developed for ground water resource.
	2 PHRA PRADAENG (100-m zone)	± 50	Separated from the Bangkok aquifer by a dark stiff clay bed. Gravel-sand is characteristically white to pale gray, subrounded to rounded, fairly well sorted; composed mostly of quartz, chert and other rock fragments; with carbonised woods and peats at the lower part. Clay lenses interbed in places.	Yields water of good quality only in the south and southwest of Bangkok; in other areas the aquifer yields brackish to salty water.
LOWER TO MIDDLE PLEISTOCENE ?	3 NAKHON LUANG (150-m zone)	± 50	Overlied by thick and hard clay bed. Sand-gravel layers which form the aquifer are rather thick (10-15 m). Fragments; mostly quartz, feldspar and quartzite; are subangular to subrounded, moderately to well sorted. Interbedding clays are whitish to yellowish to grayish brown, sandy and limonitic, non-plastic.	Has been heavily developed for public water supply. Yields 100-250 m^3/hr of water of exellent quality. Only in the south and southwest of Bangkok wells yield salty water due to salt water intrusion into the aquifer.
	4 NONTHABURI (200-m zone)	± 50	General characteristics of the formation are the same as the Nakhon Luang aquifer. It is consisted of rather uniform thick sands and gravels with minor sandy clay lenses. The formation can be divided into three units separated by leaky clay layers.	It is one of the most productive aquifers which yield up to 200 m^3/hr of water of exellent quality. The water has been extensively used for bottled drinking water and brewerage as well as domestic supplies.
	5 SAM KHOK (300-m zone)	± 100	The formation is consisted of sand, gravel and clay. Sand-gravel is yellowish brown to dirty brown, but may grade to white color, medium to very coarse grained, angular to sub-rounded, fairly well sorted, feldsparthic, calcareous due to limestone fragments in places; with interlayering clays. Both sand-gravel and clay beds are moderately to highly compacted.	Yields slightly less than those of the Nakhon Luang and Nonthaburi aquifers. Normally pennetrated by production wells in Northern Bangkok since shallower aquifers yield water of higher iron content.
	6 PHAYA THAI (350-m zone)	± 50	Consisted of sand gravel and clay . Sand and gravel are dirty brown, angular, sizes ranged from medium sand to gravel size, poorly to fairly well sorted; quartz and chert being major composition. Clay is brown to dark brown, compact, calcareous and lateritic.	Wells drilled in Central and Southern Bangkok yield brackish to salty water while those in Northern Bangkok produce fresh water. The aquifer is generally not popular due to its greater depth.
	7 THON BURI (450-m zone)	± 100	Separated from the upper formation by hard and compact clay. Sand and gravel beds are usually alternated layering with clay beds. Color is generally gray to brownish gray to occasional white sand layers.	No production wells ever constructed, but the packer tests of several test holes indicate that the water is fresh to slightly brackish or mineralized in places. The aquifer is not so productive as the above aquifers due to the presence of clay in many horizons.
PLIOCENE (?)	8 PAK NAM (550-m zone)	± 100	Separated from the upper formation by a leaky clay to sandy clay layer. Sand and gravel beds, generally thicker than that of the Thon Buri aquifer, are white to gray and well sorted. The clay is generally very compact, olive gray to dark gray, with carbonaceous matters.	The aquifer is very permeable and yield a considerable quantity of water of good quality. Water temperature is as high as 43°c It is, however, too deep to reach by domestic wells, except in areas where there is no alternative potential aquifer; i.e. the Southern Bangkok.

Note : Detail stratigraphic sections of Bangkok and adjacent areas and their water-bearing properties is after Chiamthaisong, 1980.

source: Mitigation of Groundwater Crisis and Land Subsidence in Bangkok Metropolitan Area Project, Department of Mineral Resources

Table 6.2-3 Air Quality Monitoring Stations

Station Number	Landuse
1. Office of the National Environmental Board	Urban Residential
2. Chankasem Teachers' College	Suburban Residential
3. Ban Somdet Teachers' College	Mixed
4. Rat Burana Post Office	Industrial
5. Queen Saovabha Memorial Institute	Commercial
6. The meteorological Department Sukhumvit	Urban Residential
7. Bangna Meteorological Office	Industrial
8. King Mongkut's Institute of Technology	Rural

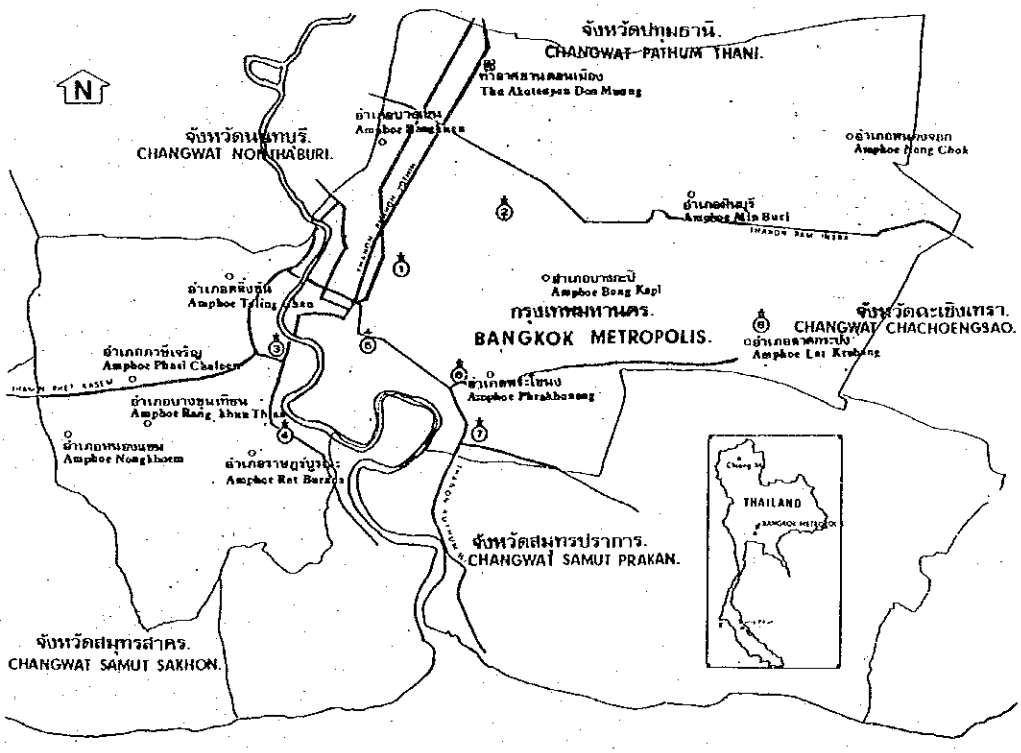


Fig. 6.2-2 Location of Air Quality Monitoring Stations in Bangkok

source: Office of the National Environmental Board

Table 6.2-4 Results of Ambient Air Quality (1)

CO Concentration (Milligram/cubicmeter) 1987
1 hour average

MONTH	STATION																	
	ONE8			CHANKASEM			BANSOMDEJ			SUKUMWIT			RATBURANA			BANGNA		
	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN
JAN	9.34	.73	.00	2.31	.95	.00	8.87	2.28	.00	3.39	1.01	.00	6.75	1.07	.00	4.80	1.05	.00
FEB	2.58	.32	.00	3.40	1.58	.00	10.39	1.16	.00	3.03	.57	.00	5.60	.63	.00	3.60	.55	.00
MAR	1.70	.37	.00	8.43	1.96	.00	4.97	1.09	.00	3.18	.73	.00	5.26	.61	.00	3.98	.79	.00
APR	2.64	.19	.00	16.55	1.11	.00	7.49	1.26	.00	2.33	.59	.00	10.70	.58	.00	4.47	.95	.00
MAY	3.98	.65	.00	4.16	.93	.00	3.26	.85	.00	1.84	.37	.00	3.28	.24	.00	2.30	.41	.00
JUN	8.18	.15	.00	4.16	1.09	.00				2.33	.41	.00	3.11	.17	.00	2.28	.41	.00
JUL	5.39	1.16	.00	5.52	1.25	.00	4.44	.92	.00	2.14	.57	.00	4.52	.26	.00	3.52	.77	.00
AUG	4.19	1.22	.00	3.89	.97	.00	3.73	.86	.00	2.33	.60	.00	5.94	.61	.00	3.52	.62	.00
SEP	5.57	1.46	.00	3.89	.96	.00	7.73	1.43	.00	12.98	.92	.00	5.60	1.14	.00	3.32	.73	.00
OCT	7.65	1.27	.00				11.34	1.99	.00	3.98	1.01	.00	5.55	1.31	.00	2.86	.70	.00
NOV	7.91	1.18	.00	5.80	1.56	.00	7.21	1.85	.00	3.39	.97	.00	8.61	1.80	.00	3.55	.70	.00
DEC	4.09	1.17	.00	8.28	1.12	.00	6.44	1.20	.00	4.63	.96	.00	5.46	1.68	.00	2.98	.43	.00

CO Concentration (Milligram/cubicmeter) 1988
1 hour average

MONTH	STATION																	
	ONE8			CHANKASEM			BANSOMDEJ			SUKUMWIT			RATBURANA			BANGNA		
	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN
JAN	6.90	.68	.11	6.16	1.44	.11	11.22	1.91	.11	4.18	.91	.11	19.91	1.59	.11	2.85	.37	.11
FEB	8.47	1.22	.11	3.99	.84	.11	9.96	1.50	.11	4.06	.75	.11	5.65	.87	.11			
MAR	16.66	1.10	.11	4.56	.70	.11	7.98	1.22	.11	4.06	.62	.11	6.04	.77	.11	2.00	.21	.11
APR	4.20	1.01	.11	3.71	.86	.11	13.82	1.46	.11	1.45	.30	.11	3.77	.91	.11	3.99	.60	.11
MAY	4.69	1.26	.11	4.73	.59	.11	9.94	1.29	.11	2.61	.36	.11	5.26	.88	.11	2.85	.48	.11
JUN	5.60	1.23	.11	3.99	.66	.11	9.83	1.00	.11	1.74	.35	.11	6.06	.89	.11	3.62	.73	.11
JUL	4.34	.91	.11	3.42	.74	.11	6.86	.77	.11	1.74	.36	.11	4.21	.82	.11	2.75	.60	.11
AUG	5.95	1.25	.11	3.99	.82	.11	11.30	1.70	.11	2.58	.42	.11	3.08	.53	.11	6.55	.62	.11
SEP	18.20	1.08	.11	13.11	.99	.11	21.24	2.91	.11	2.44	.43	.11	3.87	.96	.11	6.27	.89	.11
OCT	7.31	.99	.11	7.13	1.10	.11	14.69	1.38	.11	2.13	.38	.11	7.15	1.24	.11	7.98	1.22	.11
NOV	16.66	.99	.11	3.42	.66	.11	9.54	1.20	.11	1.18	.52	.11	4.49	1.31	.11	9.12	1.06	.11
DEC	3.82	1.70	.11	7.67	1.07	.11	8.22	1.66	.11	1.43	.58	.11	5.80	1.45	.11	13.20	1.46	.11

CO Concentration (Milligram/cubicmeter) 1989
1 hour average

MONTH	STATION																	
	ONE8			CHANKASEM			BANSOMDEJ			SUKUMWIT			RATBURANA			BANGNA		
	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN
JAN				4.71	2.45	.11				.98	.72	.11	12.25	6.95	.11			
FEB	6.03	2.60	.11							4.11	1.33	.11	5.25	2.90	.11			
MAR	6.25	2.48	.11	2.37	1.38	.11				3.53	.87	.11	1.78	.96	.11			
APR	2.87	2.10	.11	2.83	1.25	.11				1.87	.58	.11	2.60	1.55	.11			
MAY	4.48	2.67	.11							2.16	.85	.11						
JUN	12.66	3.59	.11	24.62	4.83	.11	19.78	3.60	.23	1.81	.92	.11	4.88	2.31	.11	19.75	4.19	.11
JUL	6.15	3.03	.11	27.25	5.15	.11	7.91	3.61	.17	1.81	.84	.11	4.00	1.64	.11	6.50	1.52	.11
AUG	5.45	3.64	.11	6.83	2.88	.11	5.65	3.32	.11	2.11	.85	.11	4.71	2.42	.11	3.47	2.03	.11
SEP	16.16	4.08	.11	10.68	3.18	.11	11.44	4.37	.11	2.27	1.36	.11	6.53	2.11	.11	7.67	3.08	.11
OCT	22.78	3.98	.11	11.96	4.87	.11	11.96	4.42	.11	3.65	1.38	.11	5.59	3.19	.11	7.90	2.94	.11
NOV	24.26	2.98	.11	12.43	3.51	.11	5.42	3.50	.27	14.88	1.57	.11	6.06	3.29	.11	5.74	2.99	.11
DEC	9.86	4.42	.11	11.55	5.59	.11	12.71	4.72	.28	8.28	4.64	.11	6.98	4.63	.11	8.37	4.12	.11

[1] ONE8 Standard 1 hour average = 50 ug/m^3

source: Office of the National Environmental Board

Table 6.2-4 Results of Ambient Air Quality (2)

NO2 Concentration mg/m^3

1 hour average

MONTH	station : ONE8									station : SAOWABHA					
	1987			1988			1989			1988			1989		
	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN
JAN				.004	.004	.004	.167	.041	.004				.159	.057	.017
FEB				.004	.004	.004	.131	.021	.002				.191	.045	.019
MAR	.094	.019	.006	.004	.004	.004	.067	.019	.002				.144	.058	.026
APR	.070	.019	.004	.011	.004	.004	.065	.014	.002				.130	.035	.019
MAY	.067	.021	.004	.007	.004	.004	.093	.022	.004				.093	.031	.019
JUN	.048	.007	.002	.004	.004	.004	.167	.012	.002						
JUL	.004	.004	.004	.080	.014	.004	.170	.025	.002	.100	.028	.009	.146	.034	.019
AUG	.004	.004	.004	.148	.030	.007	.085	.028	.002	.122	.020	.009	.080	.030	.009
SEP	.061	.004	.004	.165	.028	.004	.224	.032	.002	.026	.009	.009	.270	.043	.009
OCT	.091	.024	.004	.179	.037	.007	.203	.016	.002	.100	.026	.009	.146	.049	.009
NOV	.059	.007	.004	.148	.036	.004	.139	.039	.002	.109	.031	.009	.204	.061	.020
DEC	.004	.004	.004	.122	.045	.004	.168	.068	.024	.207	.040	.009	.179	.042	.009

* ONE8 Standard 1 hour average = 0.32 mg/m^3

SO2 Concentration mg/m^3

24 hours average

MONTH	station : ONE8					
	1988			1989		
	MAX	AVG	MIN	MAX	AVG	MIN
JAN	.021	.015	.013	.090	.038	.026
FEB	.025	.016	.013	.091	.038	.026
MAR	.022	.014	.013	.101	.042	.015
APR	.013	.013	.013	.086	.033	.013
MAY	.013	.012	.010	.181	.082	.013
JUN	.013	.013	.013	.085	.026	.013
JUL	.014	.013	.013	.154	.032	.013
AUG	.017	.013	.013	.021	.014	.013
SEP	.015	.013	.013	.024	.015	.013
OCT	.030	.013	.013	.052	.019	.013
NOV	.066	.031	.013	.056	.037	.022
DEC	.054	.028	.013	.038	.023	.013

* ONE8 Standard 24 hours average = 0.30 mg/m^3

SPM Milligram/cubicmeter

ANNUAL AVERAGE

YEAR	STATION						
	ONE8	CHANKASEM	BANSOMDEJ	SUKUMWIT	SAOWABHA	RATBURANA	BANGNA
1983	.10	.12	.11	.10	.09	.10	.12
1984	.10	.10	.11	.10	.10	.13	.14
1985	.09	.09	.12	.10	.09	.10	.10
1986	.08	.12	.12	.12	.11	.19	.11
1987	.09	.09	.12	.10	.13	.10	.10
1988	.07	.11	.12	.11	.12	.12	.12
1989	.10	.13	.13	.12	.14	.12	.14

* ONE8 Standard 1 year average : 0.10 mg/m^3

source: Office of the National Environmental Board

Table 6.2-4 Results of Ambient Air Quality (3)

O3 Concentration (mg/m^3)

1 hour average 1989

MONTH	ONEB		SAOWABHA	
	MAX	AVG	MAX	AVG
JAN	.07	.02		
FEB	.07	.02		
MAR	.07	.02		
APR	.10	.02		
MAY	.05	.01		
JUN	.04	.01		
JUL	.04	.01	.05	.01
AUG	.02	.00	.03	.01
SEP	.04	.01	.03	.01
OCT	.03	.01	.08	.01
NOV	.04	.01	.09	.01
DEC	.06	.01	.06	.01

ONEB standard 1 hour average : 0.20 mg/m^3

Lead Microgram/cubicmeter
ANNUAL AVERAGE

YEAR	STATION						
	ONEB	CHANKASEM	BANSOMDEJ	SUKUMWIT	SAOWABHA	RATBURANA	BANGNA
1983	.3874	.3494	.2962	.4158	.6663	.3547	.3180
1984	.2700	.3287	.2779	.3933	.3800	.2684	.5771
1985	.3175	.2904	.2666	.4442	.3481	.1911	.4095
1986	.3104	.3268	.2335	.4311	.3939	.2859	.3459
1987	.4789	.4570	.3650	.5636	.5473	.3413	.4598
1988	.3475	.3475	.3211	.4576	.4776	.3305	.3578
1989	.3926	.4078	.3315	.4799	.5272	.3097	.3496

ONEB = Office of the National Environment Board

** Ambiemt Air Quality Standards of Thailand
* 24 hrs. average value = 10 ug/m^3

source: Office of the National Environmental Board

6.3 Present Conditions

6.3.1 Collection and Haulage

1) Market Waste

In Bangkok, "market" is divided into two types by management body, BMA market and private market. The waste discharged from both types of market is collected by the BMA.

In BMA's market, the collection crews spend a lot of time on collecting the market waste because market workers throw their waste to the collection stations without using garbage bins or any other types of containers. The collection crews have to gather the scattered waste into bamboo baskets and carry them to collection vehicles.

The market waste consists mainly of food waste with a high moisture content. Therefore, the collection stations are a source of leachate and odor. The leachate remains in the collection stations or flows out without treatment. Odor brings rodents and flies at the collection stations.

2) Household waste

Household waste is collected by door to door collection, which is nearly 100% of coverage.

Apartment has two types of storage method such as:

i) Apartment house waste is carried to storage site by residents. This storage site is open dumping method, thereby odor and flies occur. The waste is scattered from the storage site by residents and dogs.

ii) Multistory apartment waste is carried to storage site through dust chute. The dust chute has some problems as follows.

- It is dangerous work for collecting crews.
- Poor environmental conditions for collection work
- Collection crews spend a lot of time collecting waste.

3) Haulage

The BMA uses large and small sizes of vehicle for haulage. The waste in the small size vehicles are transferred to larger size compactor vehicles on street or vacant ground. The waste is not scattered at this place. The collection vehicles, however, emit leachate and odor, because these collection vehicles do not have a leachate tank.

The collection vehicles spend a lot of time travelling to disposal sites due to traffic jams and flooding.

4) Collection Crew

The BMA provides collection crews with the following:

Working Uniform	2 sets/year
Working Boots	1 set/year

However, many collection crews do not wear the uniform and the boots. Because of unsanitary conditions and inconsistent use of gloves and the boots, they have high risk of contracting diseases.

The collection crews of the DPC have a physical examination by the BMA's doctors every six months, including blood analysis and lung and hearing tests. The number of patients of the collection crews and site workers is show in Table 6.3-1.

Table 6.3-1 Number of Patients (Collection Crew and Site Worker of the BMA)

Categories of Diseases	1985	1986	1987	1988	1989	TOTAL
Infections and Parasitic diseases	2	2	2	3	6	15
Neoplasms	1		5	6	1	13
Endocrine, Nutritional and Metabolic Diseases			1	2		3
Diseases of the Blood and Blood Forming Organs	1		1	2		4
Mental Disorders	1	1	1	2	2	7
Diseases of the Nervous System and Sense Organs			2	2	4	8
Diseases of the Circulatory System		2	2	2	2	8
Diseases of the Respiratory System	74	73	112	139	155	553
Diseases of the Digestive System	35	35	59	78	103	310
Diseases of the Genitourinary System		2	2	1	5	10
Complications of Pregnancy, Childbirth and the Puerperium		1		2	1	4
Diseases of the Skin and Subcutaneous Tissue						
Diseases of the Musculoskeleton system and Connective Tissue	6	9	10	9	10	44
Congenital Anomalies						
Certain Causes of Perinatal Morbidity and Mortality						
Symtoms and undefined Conditions		2		1	1	4
Accidents, Poisoning and Violence	29	15	21	30	54	149
Alcoholism	3	2	4	2	2	13
Total	152	144	222	281	346	1,145

District:	Phra Nakhon	Pom Prab	Phatum Wan	Sam Pam Thawong	Phaya Thai	Bang Rak
	Huai Khwang	Phra Khanong	Bang Kapi	Min Buri	Lad Kra Bang	Thon Buri
	Klong San	Bangkok Noi	Bangkok Yai	Bang Khun Thian	Nong Khaem	
	On Nut Compost Plant		Public Cleansing Service Division			
Except:	Dusit	Yannawa	Bang Khen	Nong Chok	Thaling Chan	
	Rat Burana	Pasi Charoen				

5) Complaints

The number of complaints to the DPC concerning environment and disposal sites is shown in Table 6.3-2. This data shows that complaints on waste are more frequent than complaints on other topics, indicating that uncollected waste exists in Bangkok. Odor also causes many complaints, which may include stench from the collection vehicles, collection stations and waste. Thus, from an environmental point of view, the collection and haulage systems have problems of odor and leachate.

Table 6.3-2 The Number of Complaints Concerning Environment and Disposal Sites Directed to the DPC.

YEAR	AIR	WATER	NOISE	ODOR	REFUSE	DISPOSAL SITE	OTHERS	TOTAL
1985	1			13	49		14	77
1986	2			26	65	3	3	99
1987	1	2		6	37	1	1	48
1988		2	1	30	43	1	11	88
1989	1			23	35		6	65
TOTAL	5	4	1	98	229	5	35	337

Source: Department of Public Cleansing, BMA

6.3.2 Treatment and Disposal

1) Compost Plant

There are three compost Plants in Bangkok as follows:

- On Nut 2 sites
- Nong Kheam 1 site

There is no complaint to the DPC about odor and noise from the compost plants. BMA has a plan to rebuild a compost plant in Ram Intra, which is located close to residences for workers.

2) Incineration Plant

There are three incineration plants in Bangkok as follows:

- On Nut 2 plants
- Nong Kheam 1 plant

These incineration plants do not have a pollution control facility.

3) Disposal Site

There are four disposal sites to treat the waste collected in Bangkok.

- On Nut (belongs to the BMA)
- Nong Kheam (belongs to the BMA)
- Ram Intra 2 site (belongs to private company)
- Nakhon Pathom (belongs to private company)

The disposal sites use an open dumping method except the Nakhon Pathom site. In recent years, houses have been developed near the final disposal sites, due to the rapid urbanization in Bangkok. Therefore, the problem of odor in nearby areas is getting worse.

At Nong Kheam, the number of complaint to the DPC's disposal plant office concerning odor is 20 to 30 per year.

There are treatment facilities for leachate from disposal sites at On Nut and Nakhon Pathom. The treatment system of leachate at On Nut is shown in a supporting report. Treatment facility of Nakhon Pathom is only two facultative ponds.

At Nong Kheam, there is canal for collecting leachate around the site. The canal can keep leachate. However, in rainy season, leachate over flows out side the boundary and rice fields.

Private disposal site at Ram Intra will be closed due to complaints concerning contaminated rice fields and odor from farmers.

The leachate without treatment diminishes through seepage into the ground and evaporation. The leachate is rich in organic matter and includes heavy metals, therefore, groundwater can be contaminated. The quality of leachate is shown in Table 6.3-3.

Each disposal sites are regularly sprayed with insecticide.

Table 6.3-3 Quality of leachate from disposal sites

Oct. 1988 - Aug. 1989

ITEM		NONG-KHEAM		ON-NUT	
		RANGE	AVERAGE	RANGE	AVERAGE
Temperature	C	24.5 - 30.4	28.6	25.8 - 33	29.8
pH		8.1 - 9.0	8.4	8.2 - 8.5	8.3
Alkalinity	mg/l	2,200 - 11,000	7,875	2,040 - 8,500	5,198
BOD	mg/l	108 - 268	222	48 - 682	258
COD	mg/l	2,040 - 10,041	6,201	2,400 - 3,840	2,850
T-KN	mg/l	224 - 897	735.6	224 - 1,625	681.8
Suspended-Solid	mg/l	69 - 238	121	76 - 1,177	276
Total Solid	mg/l	1,432 - 74,188	25,242	9,232 - 11,013	9,335
Volatile-Solid	mg/l	2,428 - 6,580	4,899	1,708 - 4,964	2,789
Sludge	mg/l	6,663 - 15,434	10,850	5,092.7 - 7,416	7,373

Source: Department of Public Cleansing, BMA

CHAPTER 7 Organizational and Institutional Framework

7.1 Historical Background of Solid Waste Management in Bangkok.

The solid waste management in Bangkok began in 1887 with an act prescribing the sanitary area of Bangkok. The Road Division of the Public Works Department, under the Ministry of the Interior, has a responsibility for maintaining the cleanliness of the city.

Thailand changed its administration to a democratic system in 1933, accordingly promoting the status of the local area into a municipality. This was done to allow local areas, needing their own management power, to contend with high density population and urbanization. As a result of this change,the solid waste management is under responsibility of the municipality. At the same time, the Public Cleansing Division was established under the municipality of Bangkok.

In 1963, the Ministry of Interior instructed the municipality of Bangkok to establish an office responsible for disposal of garbage and refuse. The office of Maintenance of Cleanliness was established under a ministerial regulation by the Ministry of Interior, consisting of three sections: Garbage Disposal Section, Night Soil Section and Compost Plant Section. The compost plant began operation in November 1963, with aiming at reducing waste volume and stabilizing waste quality as a process of the solid waste management.

In 1972, the Bangkok Metropolis was established under the Revolutionary Party. The Ministry of Interior arranged to transfer all solid waste management works to the Public Cleansing Section under the Public Works Office for a period. The Bangkok Metropolis created a new administration in 1974. The Public Cleansing Section was made independent of Public Works Office and established the Public Cleansing Bureau, which was the basis of the present organization and consisted of eight divisions: Office of Secretary, Sanitary Technology Division, Water Drainage System Control Division, Public Cleansing Service Division, Din Daeng Garbage Disposal Plant, Ram-Intra Garbage Disposal Plant, On-Nut Garbage Disposal Plant, and Thon Buri Garbage Disposal Plant. After that, the Water Drainage System Control Division was made independent as the Bureau of Sewage and Drainage and the other divisions were restructured in time to form the present organization of the Department of Public Cleansing.

7.2 The Present Organization and Institution for Solid Waste Management in Bangkok

7.2.1 Relevant Agencies and Their Responsibilities

Solid waste management is covered by several agencies in Bangkok. Fig. 7.2.1 shows relevant agencies for the solid waste management of Bangkok. Processes of the solid waste management can be sub-divided into three categories: collection and haulage, intermediate treatment and final disposal.

1) Collection and Haulage

The Sanitary Section of districts are responsible for collecting and hauling solid waste from households, offices, hotels, shops, markets and hospitals. The Department of Public Cleansing (DPC) is responsible for managing toxic and hazardous waste of hospitals, some markets and some factories. Canal waste is managed by the Department of Sewage and Drainage (DSD). Collection by the districts 85.2% of the total amount of collection in 1989.

2) Intermediate Treatment

Intermediate treatment, which employs only compost plans at present , is managed by the Garbage Disposal Division of the DPC. It operates On Nut and Nong Khaem disposal sites at present. The compost plant at Ram Intra disposal site is now closed due to the total closure of Ram Intra disposal site. On the other hand, hospital waste is specially incinerated in the attached furnace of the compost plants.

3) Final Disposal

Final disposal sites with the open dumping method are managed by the Garbage Disposal Division of the DPC. They are located in On Nut area of Phra Kanong district and Nong Khaem district. There is no leachate treatment system in final disposal sites at present.

Furthermore, there are several other tasks which are related to the solid waste management, such as vehicle management and production of fertilizer.

4) Vehicle Management

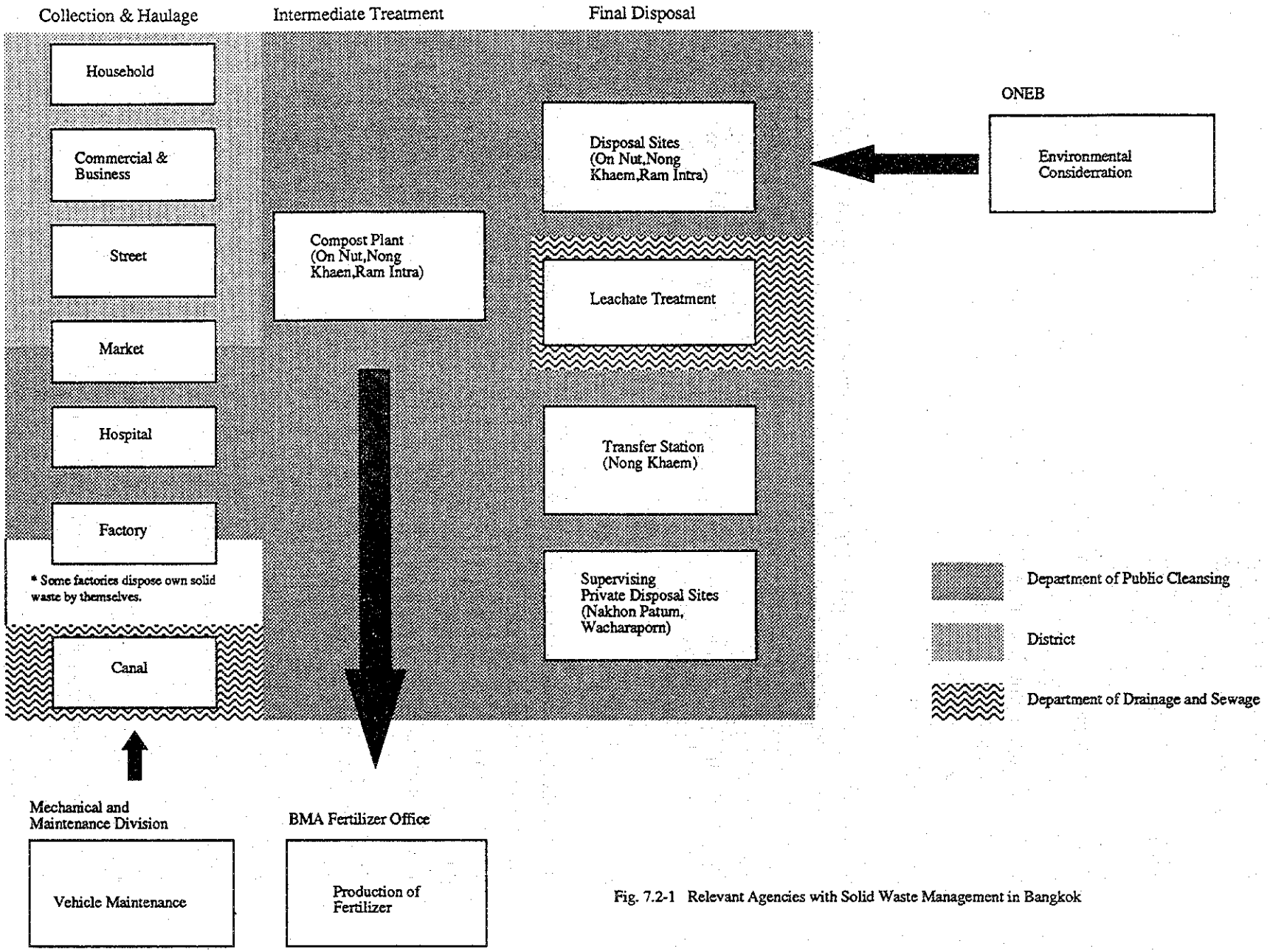


Fig. 7.2-1 Relevant Agencies with Solid Waste Management in Bangkok