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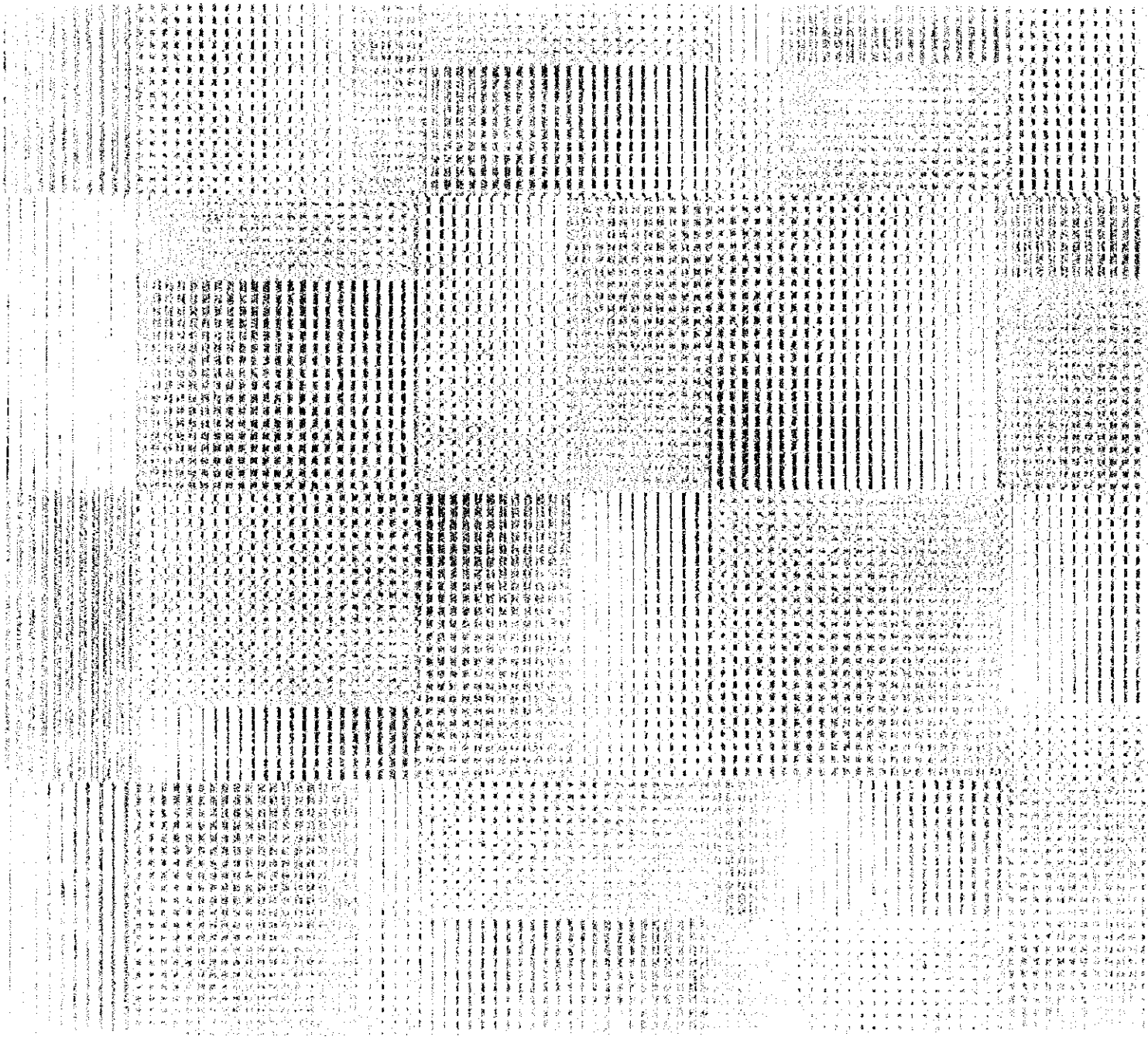
KINGDOM OF THAILAND

THE BANGKOK
SOLID WASTE MANAGEMENT AUTHORITY

FINAL REPORT (SUPPORTING REPORT)



KINGDOM OF THAILAND

THE BANGKOK SOLID WASTE MANAGEMENT STUDY

FINAL REPORT APPENDICES

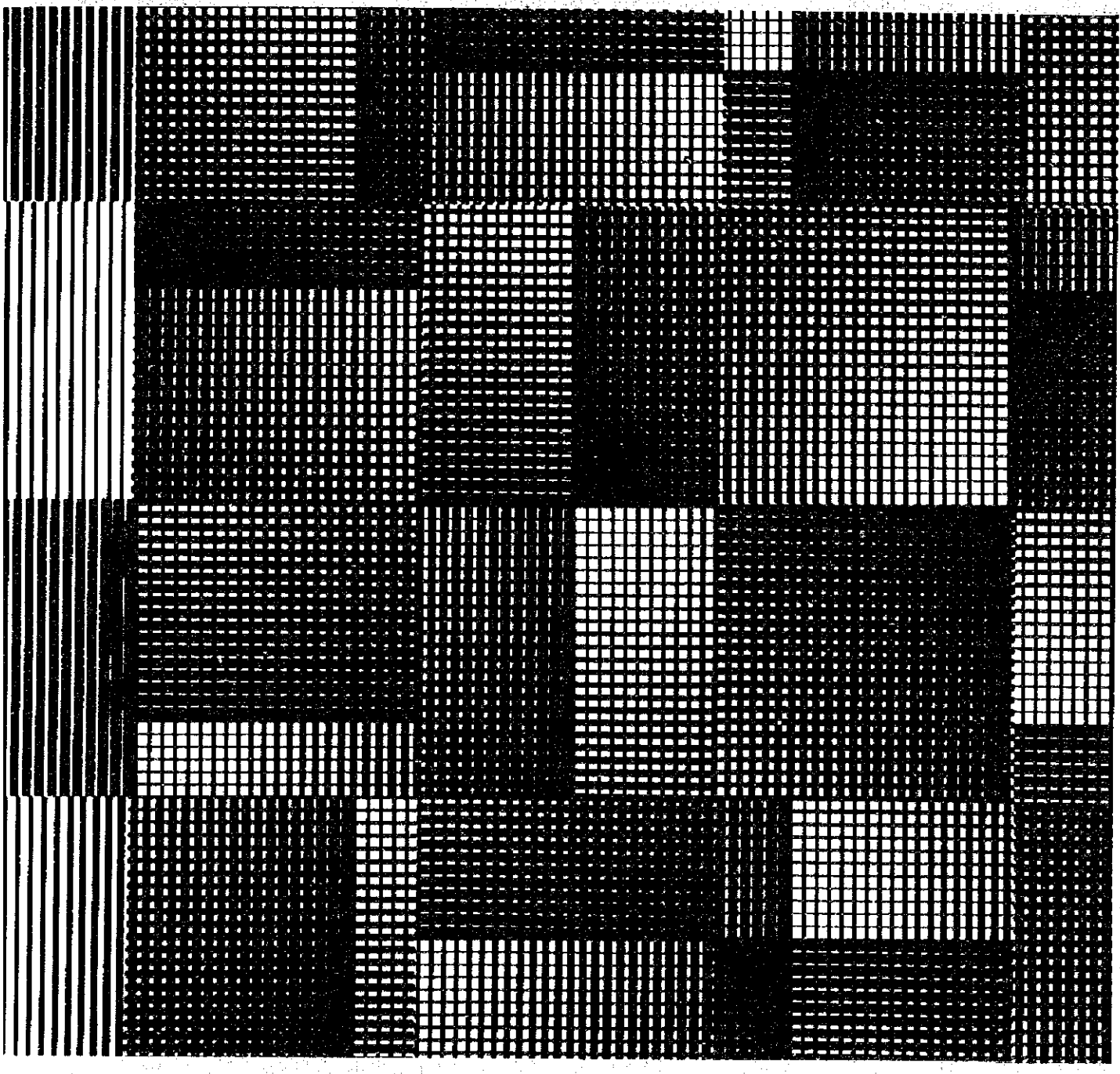


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TABLE OF CONTENTS

CONTENT

Page

Chapter 9 RECOMMENDATIONS FOR IMPLEMENTATION OF ADMINISTRATIVE ORGANIZATION AND SERVICES

LIST OF TABLES AND FIGURES

LIST OF TABLES

LIST OF FIGURES

Chapter 1 INTRODUCTION

Appendix 1.1 Concept of solid waste management

Waste is material discharged and discarded as unnecessary from each stage of daily human life activities.

For maintenance and improvement of the life activities, human society avails itself of natural resources as necessary. Material utilized for maintaining human life and social activity will be discarded and become waste when it is regarded as unnecessary in the value judgement of the person who uses it. The procedure to obtain materials from nature and utilize them in human society, then discard or store them in nature as unnecessary till they become a part of the environment is called environmental circulation cycle of material. This natural circulation cycle of material has certain quantitative limit and qualitative acceptability called environmental capacity and environmental acceptability, respectively. If either quantitatively or qualitatively excess waste is abandoned, nature becomes unable to cope with it, resulting not only in accumulation of excessive waste in nature but also destruction of the natural environment. This is what is called destruction of nature by waste or, more commonly, pollution. The ultimate solution for waste problems is to prevent the occurence of destruction of nature by waste in order to realize coexistence and coprosperity of nature and human society.

Urban waste problems of today are caused mainly by concentration of population and industries in cities, which through socio-economic activities generate tremendous volumes of waste. Most major cities in the world are facing serious urban waste problems. Strategies of the administrators-in-charge against the increasing volumes of urban waste have been developed in many cities. Such waste management administration has two objectives: one is the conventional and orthodox administrative approach to maintain and improve public health, in the other words, to prevent contamination of the sanitary environment by waste; and the other is the radical approach to suppress pollution caused by waste and, furthermore, to preserve the natural environment.

Based on the above-mentioned facts, the Study team has established the following concept of solid waste management:

Principle of Solid Waste Management

The solid waste management aims at accomplishment of the following objectives.

(1) Collection of solid waste in the urban areas to keep the city clean.

(2) Inactivation of solid waste (including harmless)

(3) Volume reduction

(4) Resource recovery

Principle and means of disposal

(1) It aims at completion of decomposition of solid waste for natural cycle.

(2) It aims at artificial expansion of receivable functions of nature.

- Securing of disposal facilities, and development and application of new disposal technique.

(3) It aims at control of restoration speed (speed-up or speed-down) of solid waste to soil.

(4) It aims at management of solid waste within a range of receivable functions of nature.

- The waste which cannot be received by the functions of nature (agricultural chemicals, nuclear substance and heavy metals, etc.) should be shielded.
- Restriction of production of materials which are difficult to be treated
- Thorough enforcement of PPP (thorough understanding of self-disposal responsibility of enterprisers)
- Control of production volume and quality according to disposal capacity

(5) It aims at recovery and reutilization of resources.

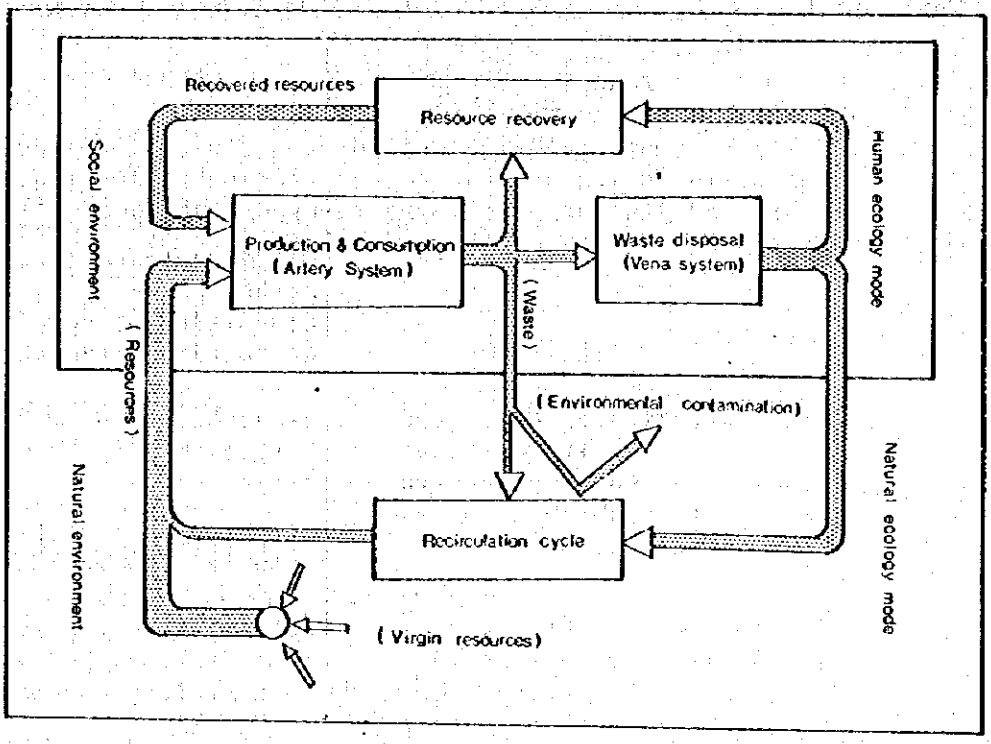
- Development and application of reutilization technique
- Production of products which can be reutilized
- Reduction of solid waste treating expense
- Saving and preservation of virgin resources

(6) In order to accomplish the above objectives, the following means should be employed.

- Application of physical, chemical and biological treatment
- Establishment and practice of social rules and agreement

Fig. AP 1.1 shows the relation between waste disposal and recirculation cycle described above.

Fig. AP 1.1 Waste disposal and recirculation cycle



Solid waste management system is composed of four systems: collection, transportation, intermediate treatment, and final disposal.

Depending upon the classification methods, the collection system is further divided into storage and discharge of solid waste at its generation point or, on the contrary, collection and transportation are united into one system.

In the Study, solid waste management system is regarded as consisting of the above four systems, and storage and discharge of solid waste are considered to be involved in the collection system.

Functions of each system are outlines in Table AP 1.1.

Table AP 1.1 Solid waste management system and its function

Subsystem		Function	Method (Example)
Solid waste management system	Collection	Collection of discharged solid waste, including actions to store and discharge solid waste at the generation point.	Door-to-door collection, station collection, hauled-type container collection. Mixed-waste collection method. Classified-waste collection method.
	Transportation	Transportation of collected solid waste to its destination. Transportation involves transfer stations which form transport junctions.	Transportation by trucks, barges, pipe line or train. Direct transportation. Transfer transportation.
	Intermediate treatment	Intermediate treatment of solid waste by physical, chemical or biochemical means to make the treated waste non-biodegradable, non-toxic and harmless, reduced in volume, and reutilizable.	Pulverization, selection, incineration, pyrolysis, methanation, composting, feed-making. Material recovery method. Energy recovery method. Material conversion method.
	Final disposal	Restoring of solid waste or residue from intermediate treatment to the natural environment as the final stage of solid waste management, by means of landfilling or disposal into water.	Anaerobic landfill, aerobic landfill. Unsanitary landfill method. Sanitary landfill method.

Appendix 1.2 History of solid waste management in Bangkok

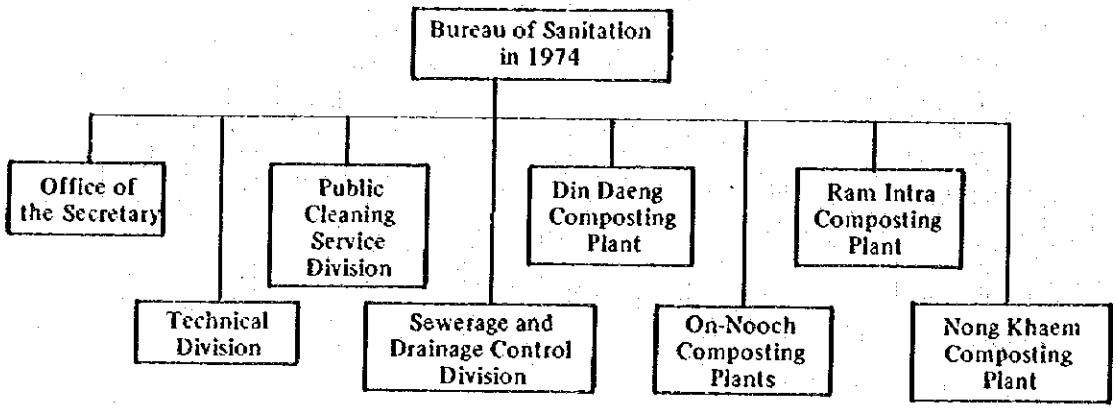
(1) History of Solid Waste Organization

The administrative work of the Bangkok Metropolitan Administration (BMA) is divided into Bureaus and districts, and their principal functions are as follows:

- Maintenance of law and order, and enforcement of city ordinance
- Providing and maintaining roads, water-ways and the drainage system
- Maintaining cleanliness and orderliness of the city
- Public health, family health and medical services
- Public facilities
- Administration of education
- Occupation promotion
- Preventing and abating public disaster
- Rehabilitating slums and provision of public housing
- Providing and controlling markets, ports and ferries
- Providing and controlling cemetaries and crematoriums
- Traffic engineering
- Developing and conserving the environment
- Providing and maintaining recreational centers
- Providing and controlling animal slaughtering
- Controlling animal husbandry
- Controlling orderliness and sanitation in public theatres and other public places
- Providing public utilities
- Public welfare
- Sport promotion
- Trade enterprises of Metropolitan Bangkok
- Other functions as ordered by the Prime Minister, the Cabinet or the Ministry of Interior, or as specified by law

BMA as the local city government carries out the function of maintaining the drainage system, flood protection, solid waste collection and disposal, night soil collection and treatment in the Bangkok Metropolitan area. The Bureau of Sanitation (BOS) has been responsible for these functions since 1974. The organization of the BOS in 1974 is shown in Fig. AP 1.2.

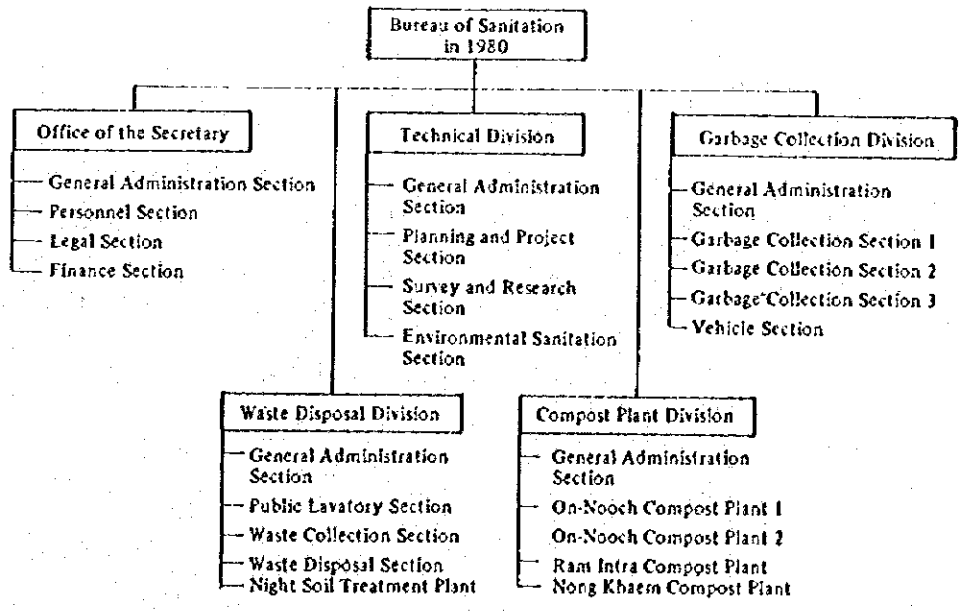
Fig. AP 1.2 Organization chart of Bureau of Sanitation



In 1977 the Bureau of Sewerage and Drainage was created by BMA which transferred the responsibility of maintaining drainage, flood protection and water pollution treatment to the Bureau. BOS with a current staff of about 2,100 persons is responsible for solid waste collection and disposal, mechanical street cleaning, night soil collection and treatment, and provision of collection vehicles.

In 1978 the administration of BMA adopted a policy to decentralize the responsibility of garbage collection to the districts. The reason was that the districts are thoroughly familiar with their own area and problems, and the BMA wanted to conserve its budget for garbage transportation. In the BOS today, the Garbage Collection Division has responsibility only for collection of garbage from markets, Government hospitals, procurement of collection vehicles, and operation of landfill disposal sites and compost plants. The collection of garbage from households, industries, public places, and street cleaning is done by the 24 districts. The organization chart of BOS in 1980 is shown in Fig. AP 1.3.

Fig. AP 1.3 Organization chart



(2) History of Solid Waste Collection and Transportation

The area now administered by Bangkok Metropolitan Administration (BMA) was previously called Bangkok province and Thonburi province. The administrative work of these two provinces was divided into Bangkok municipality, Thonburi Municipality and districts. Each district outside the municipality areas included a sanitation district (Sukhapiban). Bangkok and Thonburi municipalities collected the solid waste in their own areas of 238.56 sq.km. and 52.09 sq.km., respectively. In addition to collection of the solid waste in the municipal area, the sanitation districts also collected solid waste in areas where the number of people was over 20,000 per sq.km. These areas were 39.52 sq.km. in Bangkok province and 6.5 sq.km. in Thonburi province.

The container that most householders used to store their solid waste was the kerosine can, with a capacity of about 20 litres. In the early morning, householders placed their solid waste containers in front of their houses for collection. Occasionally garbage collectors would ring a bell when the garbage collection vehicle was passing, and householders would bring the garbage to the collection vehicle to be emptied. Most of the solid waste collection vehicles were hand carts with a body box, with a capacity of about 500 litres. With the growth of population and solid waste generation in the municipal areas of Bangkok and Thonburi, solid waste collection vehicles have changed from the hand carts with box body to non-compactor trucks in 1960, and to compactor trucks in 1976. For each truck, there is a driver and four garbage collectors. Collection takes place everyday of the year including Sundays and holidays. Household waste is collected by crewmen generally using bamboo baskets of various sizes. The crewmen put a bamboo basket on two-wheel trollies and pick up the garbage from house to house. These baskets are grouped at certain points, and then emptied into the trucks. This pick-up system is used for the following reasons: bamboo baskets are easy to acquire and their cost is low; trucks cannot enter all streets, since some are only 2 meters wide; a truck may have to unload at the dumping area or composting plant, yet the garbage collectors can remain in place and continue to collect and group the baskets at storage points. When the collection trucks return, they are loaded immediately.

In the markets, solid waste assembled in bulk in storage areas is loaded into bamboo baskets which are emptied into the trucks. The trucks make two or three collection trips, depending on the districts and the destination of the garbage.

The solid waste collection fee in Bangkok is the same as in the other provinces in Thailand. The fee depends on the amount of garbage generation and the characteristics of the location. For households, if garbage generation is less than 20 litre a day the collection fee is 4 Baht per month. This solid waste collection fee has been in effect since 1941.

(3) History of Solid Waste Disposal

Dumping on land or landfill was the method of solid waste disposal in Bangkok since 1935. This method of disposal caused many problems to householders near dumping sites. In 1951 the Bangkok Municipality Administrators decided to solve these problems by using another method. Since

Thailand is a country in which agriculture predominates and since the suburban areas of Bangkok are largely rice fields, the administration, following an observation and study tour abroad of solid waste disposal and analysis of the characteristics of solid waste in 1953, decided to use the recycling method of composting. In 1957, Bangkok Municipality Administration constructed a composting plant at Din Daeng. This plant was constructed by John Thompson Industrial Construction Ltd. of England. The cost of construction was 42,000,000.- Baht. The construction was finished in 1960 and the plant started to operate in 1961. The capacity of this plant is 320 ton or 1,100 cubic meters per day (8 hours operation).

The rate of increase of population and garbage generation in Bangkok and Thonburi province is higher than that in other provinces in Thailand. The capacity of Din Daeng composting plant was not sufficient to process the amount of garbage collected every day. Hence, in 1968 the Administration constructed four new composting plants at On-Nooch (two plants), Ram Intra, and Nong Khaem to serve the collection areas of nearby districts. The total capacity of these four composting plants is 1,120 tons a day.

In 1979, after the On-Nooch, Ram Intra and Nong Khaem composting plants started operation, the BMA decided to abandon the Din Daeng composting plant in accordance with the policy of the Prime Minister to clear that area and construct a youth center, recreation area and a housing project, since the Din Daeng composting plant was then surrounded by population settlements and other urban activities.

Dumping on land or the landfill method is another method of solid waste disposal in Bangkok. Currently, landfill sites are at Nong Khaem, On-Nooch, Tung Kru, Bung Tanode, and Bung Phrayasalum.

Cahpter 2 VOLUME AND PROPERTIES OF SOLID WASTE

Appendix 2.1 Solid waste disposal volume (1961 – 1981)

Table AP 2.1 Solid waste disposal volume

(Unit: m^3)

Fiscal Year	On-Nooch			Ram Intra	Nong Khaem		Ding Dang	Others	Total
	Compost No.1	Compost No.2	Landfill	Compost	Compost	Landfill			
1961							131,400		131,400
1962							121,409		121,409
1963							120,577		120,577
1964			649,697				329,397		979,084
1965			699,835				360,947		1,060,782
1966			795,526				351,995		1,147,521
1967			1,010,358				238,454		1,248,812
1968			939,310				374,191		1,313,501
1969			854,632				375,746		1,230,378
1970			1,004,201				337,151		1,341,352
1971			931,571				337,477		1,269,048
1972			834,489				416,054		1,250,543
1973			505,146	163,957		438,330	301,349		1,408,782
1974			486,276			499,022	335,575		1,320,873
1975			625,077			394,426	201,734		1,221,237
1976			848,018			344,560	236,979		1,429,557
1977			763,332	25,581		300,220	407,666	127,321	1,624,120
1978			756,328	313,601	159,380	325,174	110,180	92,629	1,810,867
1979	282,357	287,165	457,859	509,933	163,237	314,317		51,880	2,066,748
1980	491,476	493,011	207,986	480,168	155,505	568,635		46,740	2,443,521

(Unit: t)

Fiscal Year	On-Nooch				Ram Intra		Nong Khaem		Total
	Compost No.1	Compost No.2	Open Dump No.1	Open Dump No.2	Compost	Open Dump	Compost	Open Dump	
1981	88,887	89,756	107,051	31,347	70,138	22,591	36,541	224,656	670,967

Source: Technical Division, BOS

Appendix 2.2 Solid waste collection volume by month

Table AP 2.2-(1) Solid waste collection volume (1979)

(Unit: m^3)

District Name	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Mean	Total
Phra Nakhon	18,178	14,471	15,730	15,163	16,493	15,560	15,906	16,384	16,720	15,863	14,641	15,033	15,845	190,142
Pom Prap	9,293	7,750	8,623	8,508	9,133	7,777	8,609	9,496	9,366	9,360	9,215	9,855	8,915	106,985
Pathum Wan	10,917	9,638	10,977	10,718	10,597	10,181	10,235	10,442	10,248	10,620	10,446	11,423	10,537	126,442
Sam Phan Thawong	7,553	7,062	7,679	7,190	7,582	7,472	7,477	7,755	7,584	7,691	7,522	7,524	7,508	90,091
Bang Rak	8,378	8,391	8,857	8,428	8,906	8,267	7,877	8,711	8,967	9,233	10,752	9,314	8,840	106,081
Yannawa	17,858	13,344	12,692	13,631	11,160	11,452	11,689	12,388	12,712	13,601	12,839	14,328	13,141	157,694
Dusit	20,331	16,948	18,689	13,330	20,118	17,517	18,608	22,562	25,578	28,560	29,316	30,682	21,853	262,239
Phayathai	19,189	16,055	18,130	17,730	20,863	20,067	19,784	20,861	20,098	20,381	20,070	20,892	19,510	234,120
Huai Khwang	6,883	5,858	6,358	6,095	6,904	7,997	7,518	8,149	9,229	8,122	8,584	7,928	7,469	89,625
Phra Khanong	25,674	24,321	26,361	24,644	25,961	24,079	25,730	27,599	26,162	27,588	26,309	29,840	26,189	314,268
Bang Khen	8,986	9,156	12,096	12,999	11,128	11,160	12,573	12,845	10,034	12,946	11,751	12,047	11,477	137,721
Bang Kapi	6,900	6,327	7,048	7,701	8,731	8,205	8,346	8,549	8,600	7,828	8,036	7,913	7,849	94,184
Nong Chok	309	283	326	356	361	384	359	368	366	364	356	356	349	4,188
Minburi	2,399	2,383	2,458	2,494	2,490	2,332	2,303	3,371	2,967	2,752	3,133	4,247	2,777	33,329
Lat Krabang	1,323	1,352	1,229	1,259	901	1,087	985	1,182	1,104	1,108	1,608	1,394	1,211	14,532
Thonburi	7,403	6,501	7,402	6,898	7,423	7,188	7,144	7,286	7,255	7,631	7,532	7,766	7,286	87,429
Khlong San	9,189	9,056	9,361	9,577	10,148	10,317	10,347	10,338	10,738	9,915	10,921	11,021	10,077	120,928
Bangkok Noi	9,355	7,885	8,624	7,827	9,452	8,807	9,250	6,337	9,404	9,315	8,558	9,365	8,682	104,179
Bangkok Yai	3,574	3,148	3,447	3,178	3,548	3,317	3,382	3,416	3,261	3,432	3,482	3,403	3,382	40,588
Bang Khun Tian	3,454	3,122	3,378	3,141	3,458	3,114	3,206	3,975	3,539	3,378	3,692	4,148	3,467	41,605
Phasi Charoen	4,104	2,992	3,363	3,467	4,805	3,772	3,451	3,366	2,924	3,586	4,107	4,142	3,673	44,079
Rat Burana	4,240	3,229	5,220	4,079	4,410	3,939	4,264	5,995	4,889	5,073	5,409	5,320	4,672	56,067
Taling Chan	262	303	359	412	497	455	541	557	471	498	444	422	435	5,221
Nong Khaem	556	539	712	456	648	600	600	600	576	670	592	552	592	7,101
Subtotal	206,308	180,114	199,119	189,281	205,717	195,046	200,184	212,532	212,792	219,515	219,315	228,915	205,740	2,468,838

Source: Technical Division, BOS.

Note: The figures are those which the district offices reported according to the workers' estimation who collected the solid waste.

Table AP 2.2-(2) Solid waste collection volume (1980)

(Unit: m^3)

District Name	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Mean	Total
Phra Nakhon	15,575	14,714	15,638	15,775	15,211	15,862	16,486	16,024	16,303	21,415	15,576	15,451	16,169	194,030
Pom Prap	9,453	8,810	9,404	8,812	9,129	8,393	8,879	8,982	8,778	9,488	9,052	9,485	9,055	108,665
Pathum Wan	12,236	10,739	10,910	11,063	11,139	11,129	11,442	11,520	11,196	12,446	11,554	11,912	11,441	137,286
Sam Phan Thawong	7,634	7,187	8,270	7,400	7,470	6,628	7,172	7,597	7,826	7,038	6,974	7,319	7,376	88,515
Bang Rak	11,612	11,093	11,171	10,884	12,102	9,088	12,196	11,430	9,013	10,674	10,817	10,817	10,908	130,897
Yannawa	11,856	16,953	17,600	12,469	20,005	16,614	16,582	15,746	14,262	13,661	16,249	16,511	15,709	188,508
Dusit	31,243	29,887	33,314	32,451	34,229	33,163	34,059	33,006	34,255	32,699	33,177	33,463	32,912	394,946
Phayathai	19,415	19,150	19,621	19,066	20,167	19,986	19,740	19,761	19,095	19,309	19,805	20,182	19,608	235,297
Huai Khwang	8,160	7,691	8,879	9,118	8,185	9,373	9,118	8,821	8,456	8,651	7,649	8,596	8,558	102,697
Phra Khanong	26,244	27,365	29,219	26,694	26,607	26,909	27,899	24,777	26,861	27,393	28,006	28,524	27,208	326,498
Bang Khen	11,755	11,323	12,562	11,806	12,511	13,848	14,565	14,164	14,340	14,040	12,785	12,890	13,049	156,589
Bang Kapi	8,073	7,668	8,184	8,047	8,663	7,607	8,061	8,274	8,060	8,606	8,522	8,284	8,171	98,049
Nong Chok	366	347	373	362	368	368	368	368	358	369	357	371	381	4,575
Minburi	4,315	3,931	4,282	4,129	4,405	3,376	4,195	4,338	4,204	3,785	2,354	2,022	3,777	45,326
Lat Krabang	765	659	791	801	798	1,160	757	735	752	792	679	810	792	9,499
Thonburi	7,973	7,258	7,913	7,598	7,389	7,237	7,281	7,329	7,743	8,663	7,914	8,317	7,718	92,615
Khlong San	10,873	9,492	9,971	9,933	10,199	9,802	10,316	10,200	10,186	10,149	9,473	10,059	10,054	120,653
Bangkok Noi	9,893	9,534	9,769	9,636	9,887	9,524	10,125	9,771	10,617	11,380	11,082	11,698	10,243	122,916
Bangkok Yai	3,539	3,385	3,662	3,415	3,425	3,384	3,697	3,513	3,544	4,205	3,839	4,215	3,652	43,823
Bang Khun Tian	3,845	3,833	3,873	3,646	4,002	4,094	4,092	4,026	4,323	4,532	5,267	5,489	4,252	51,022
Phasi Charoen	3,941	3,718	4,389	4,342	4,326	4,337	4,447	4,553	4,253	4,196	4,667	5,062	4,353	52,231
Rat Burana	5,549	5,521	5,956	5,659	4,367	2,747	5,106	4,662	4,601	4,747	4,403	5,974	4,858	58,292
Taling Chan	942	1,088	988	1,089	975	869	784	775	889	668	824	950	903	10,841
Nong Khaem	596	684	1,168	1,005	448	974	1,172	1,192	1,536	1,256	1,206	1,246	1,040	12,483
Subtotal	225,853	222,030	237,907	225,200	236,007	226,472	238,539	231,564	231,451	240,162	232,221	238,847	231,854	2,786,253

Table AP 2.2-(3) Solid waste collection volume (Jan. - May 1981)

(Unit : m^3)

District Name	Jan.	Feb.	Mar.	Apr.	May
Phra Nakhon	17,559	15,334	15,010	14,500	21,625
Pom Prap	9,760	8,126	13,488	8,794	11,126
Pathum Wan	2,948	15,351	12,042	1,192	*
Sam Phan Thawong	7,136	6,376	7,226	7,106	7,226
Bang Rak	10,675	16,880	10,918	11,675	12,102
Yannawa	17,223	15,249	16,870	18,650	*
Dusit	32,425	29,560	33,110	32,310	*
Phayathai	19,856	20,519	21,519	20,443	22,885
Huai Khwang	8,317	7,760	9,279	9,084	10,406
Phra Khanong	27,617	26,152	29,224	27,638	28,614
Bang Khen	10,081	13,435	14,480	14,027	16,106
Bang Kapi	10,597	10,597	8,299	7,655	8,048
Nong Chok	369	513	490	603	*
Minburi	2,742	2,702	3,600	3,681	4,015
Lat Krabang	777	694	818	738	784
Thonburi	8,354	8,199	8,051	7,664	11,564
Khlong San	10,003	9,759	9,594	9,303	*
Bangkok Noi	11,709	10,442	10,442	9,939	*
Bangkok Yai	4,150	3,727	3,557	3,363	5,404
Bang Khun Tian	5,728	4,334	3,802	3,691	6,889
Phasi Charoen	5,745	5,200	5,134	4,549	5,767
Rat Burana	5,425	4,710	*	5,077	*
Taling Chan	927	656	920	854	856
Nong Khaem	245	549	950	666	242

Note: * means "unknown"

Table AP 2.3 Collection volume & number of trips by Garbage Collection Div. (1980 - 1981)

Month	Garbage from Markets			Garbage from Hospitals			Garbage from Others		
	No. of Source	No. of Trips	Collected Volume m^3	No. of Source	No. of Trips	Collected Volume m^3	No. of Source	No. of Trips	Collected Volume m^3
1980									
May	65	573	7,867.75	18	139	1,479.8	1	1	5.6
Jun.	69	649	9,371	18	151	1,643.8	17	25	57.4
Jul.	69	683	6,202.7	18	163	1,886.8	–	–	–
Aug.	61	595	9,352.8	18	110	1,464.4	1	5	29.2
Sep.	61	577	8,872.8	18	102	1,270	4	12	76.4
Oct.	60	592	9,936.5	18	102	1,302.4	3	27	256.6
Nov.	60	528	8,472.6	18	134	1,706	3	20	234.4
Dec.	60	557	8,985.6	18	136	1,628.2	1	7	50.8
Total		4,754	69,061.75		1,037	12,381.4		97	710.4
1981									
Jan.	69	670	6,932.7	20	151	1,690.3	1	3	10
Feb.	70	690	7,013.5	20	143	1,631.7	15	20	50
Mar.	65	573	7,713.7	20	147	1,620.9	–	–	–
Apr.	63	571	9,231.3	20	141	1,399.3	3	21	244.3
May	60	530	7,331.3	20	145	1,530	1	9	72.6
Jun.	70	731	9,723	20	147	1,600.7	–	–	–
Jul.	69	667	7,300.41	20	150	1,703	–	–	–
Aug.	61	580	9,001.7	20	143	1,530.6	13	20	43.1
Sept.	65	642	9,341.83	20	141	1,531	7	25	201.4
Oct.	63	590	11,014.5	20	147	1,624.5	1	9	70.4
Nov.	63	633	9,473.3	20	140	1,450	–	–	–
Dec.	65	671	8,413.1	20	160	1,810.7	15	40	193.6
Total	–	7,331	101,002	–	1,680	18,874	47	152	1,163

Source: Garbage Collection Division, BOS

Appendix 2.3 Generation unit of solid waste by industry

Table AP 2.4 Refuse generation unit

(1/8)

Kind of Industry	Production Rate A.	Capital (Unit: Baht) B.	Number of Workers C.	Refuse Generation Amount D.	Refuse Generation Original Unit		
					D/A	D/B (Unit: m^3/mln. Baht)	D/C
Civil Engineering Construction	-	-	-	-	-	-	-
Brewery	100 mln.L/month	558,105,283	1,200	2.5 m^3/d	0.5m^3/mln.L	0.004	0.002 m^3/wkr
"	60,000 boxes/month	35,000,000	310	-	-	-	-
Soft Drink Bottler	-	-	160	-	-	-	-
" " "	-	-	300	0.03 m^3/d	-	-	0.0001 m^3/wkr
Ice	-	-	6	0.05 m^3/d	-	-	0.008 m^3/wkr
Water Purifying	36,000 can/month	-	80	-	-	-	-
Rice Mill	13,910 kg/d	-	4	-	-	-	-
" "	27,820 kg/d	-	4	-	-	-	-
" "	26,180 kg/d	-	9	22 t/d	0.84 t/t	-	2.44 t/wkr
Flour Mill	-	100,000	25	0.025 m^3/d	-	0.25	0.001 m^3/wkr
" "	200 t/year	-	5	-	-	-	-
Noodle Factory	10,000~20,000 kg/month	2,000,000	300	0.4 m^3/d	0.0006m^3/unit	0.2	0.0013 m^3/wkr
Meat Processing & Product	500 kg/d	-	8	-	-	-	-
Meat Processing & Product	10,000 t/d	-	900	0.2 m^3/d	0.00002m^3/t	-	0.0002 m^3/wkr
Meat Processing & Product	1,000 t/d	-	154	-	-	-	-

(Cont'd) Table 2.4 Refuse generation unit

(2/8)

Kind of Industry	Production Rate A.	Capital (Unit: Baht) B.	Number of Workers C.	Refuse Generation Amount D.	Refuse Generation Original Unit		
					D/A	D/B (Unit: m^3/mln. Baht)	D/C
Fruit Products	100 jar/d	-	6	-	-	-	-
" "	-	-	20	1.5 m^3/d	-	-	0.075 m^3/wkr
" "	-	-	47	-	-	-	-
Dairy Products	-	-	7	-	-	-	-
Candy	-	2,000,000	90	0.6 m^3/d	-	0.3	0.0067 m^3/wkr
"	10 cartons/d	-	20	-	-	-	-
Tobacco	2,212 mln.pcs/month	-	5,619	109 m^3/d	0.049m^3/mil.pcs.	-	0.019 m^3/wkr
Feedstuff	3,000 t/month	6,810,000	70	-	-	-	-
Fertilizer	70 t/month	3,000,000	6	-	-	-	-
Food Products	3,000 pcs/d	-	400	8 m^3/d	0.0027 m^3/pcs	-	0.02 m^3/wkr
" "	1,500 cases/d	-	39	3 m^3/d	0.002 m^3/cases	-	0.077 m^3/wkr
" "	-	-	300	1 m^3/d	-	-	0.003 m^3/wkr
" "	1,000 m^3/month	-	17	1 m^3/d	0.024 m^3/m^3	-	0.059 m^3/wkr
Paper & Paper Production	650-750 t/month	-	212	-	-	-	-
Paper & Paper Production	20,000 packet/month	-	15	-	-	-	-
Paper & Paper Production	-	-	5	-	-	-	-

(Cont'd) Table AP 2.4 Refuse generation unit (3/8)

Kind of Industry	Production Rate A.	Capital (Unit: Baht) B.	Number of Workers C.	Refuse Generation Amount D.	Refuse Generation Original Unit		
					D/A	D/B (Unit: m^3/mln.Baht)	D/C
Paper & Paper Production	1,500 t/month	-	120	-	-	-	-
Paper and Paper Production	-	-	8	-	-	-	-
Printing & Publish-ing	20,000 pcs/d	-	39	-	-	-	-
" "	7,500 pcs/d	-	6	-	-	-	-
" "	-	-	398	2.5 m^3/d	-	-	0.006 m^3/wkr
Plastic Products	20 t/month	-	35	0.03 t/d	0.036 t/t	-	0.0009 t/wkr
" "	1,000 kg/d	-	100	0.1 m^3/d	0.1 m /t	-	0.001 m^3/wkr
" "	40 t/month	-	134	0.25 t/d	0.15 t/t	-	0.0019 t/wkr
" "	800 t/year	-	370	0.7 m^3/d	0.252 m^3/t	-	0.0019 m^3/wkr
" "	6,000 pcs/year	-	15	0.017 m^3/d	0.0008 m^3/pcs	-	0.001 m^3/wkr
Rubber Products	10,000 kg/month	-	135	-	-	-	-
" "	80,770 kg/month	-	307	-	-	-	-
" "	50 t/year	-	4	-	-	-	-
" "	30,000 pcs/month	-	80	0.4 m^3/d	0.0003 m^3/pcs	-	0.005 m^3/wkr
Agricultural Che-micals	20 t/month	-	45	0.01 t/d	0.012 t/t	-	0.0002 t/wkr

(Cont'd) Table AP 2.4 Refuse generation unit (4/8)

Kind of Industry	Production Rate A.	Capital (Unit: Baht) B.	Number of Workers C.	Refuse Generation Amount D.	Refuse Generation Original Unit		
					D/A	D/B (Unit: m^3/mln.Baht)	D/C
Adhesives (Glue)	120-160 t/month	1,600,000	50	0.25 m^3/d	0.035 m^3/t	0.156	0.005 m^3/wkr
Printing Ink	70-80 t/month	7,720,000	54	0.1 m^3/d	0.027 m^3/t	0.013	0.0019m^3/wkr
" "	60 t/month	-	25	0.1 m^3/d	0.04 m^3/t	-	0.004 m^3/wkr
Paint	60-80 t/month	-	17	0.1 m^3/d	0.029 m^3/t	-	0.0059 m^3/wkr
"	300 gal./d	-	8	-	-	-	-
Plastic & Water Paint	100-200 t/month	-	40	-	-	-	-
Paint	20,000 US.gal/month	-	40	0.016 m^3/d	0.00002 m^3/ US.gal.	-	0.0004 m^3/wkr
"	6,965 gal./month	-	12	0.1 m^3/d	0.0003 m^3/gal	-	0.008 m^3/wkr
Medicine & Cosmetic	-	-	10	1.5 m^3/d	-	-	0.15 m^3/wkr
" "	*	500,000	18	0.018 m^3/d	-	0.036	0.001 m^3/wkr
" "	-	-	250	3 t/d	-	-	0.012 t/wkr
" "		4,000,000	150	1.5 m^3/d	-	0.375	0.01 m^3/wkr
" "	-	-	12	-	-	-	- -
Oil & Coal Product	-	-	618	12.6 m^3/d	-	-	0.02 m^3/wkr

* Tablets: 70,000,000/mon; Capsules: 1,900,000/mon; Lotion: 100,000 bottles/mon.

(Cont'd) Table AP 2.4 Refuse generation unit (5/8)

Kind of Industry	Production Rate A.	Capital (Unit: Baht) B.	Number of Workers C.	Refuse Generation Amount D.	Refuse Generation Original Unit		
					D/A	D/B (Unit: m^3 /mln.Baht)	D/C
Tanning & Leather Products	*	-	730	15 m^3/d	-	-	0.021 m^3/wkr
Steel Manuf.	-	-	70	-	-	-	- -
Ceramic & Cement Products	81,000 kg/month	-	203	5.5 m^3/d	0.0016m^3/kg	-	0.027 m^3/wkr
Ceramic & Cement Products	1,800 t/month	-	60	0.1 m^3/d	0.0013 m^3/t	-	0.0017 m^3/wkr
Ceramic & Cement Products	1,800 m^3/month	-	250	-	-	-	- -
Ceramic & Cement Products	100 sets/month	-	12	0.035 m^3/d	0.008 m^3/set	-	0.003 m^3/wkr
Glass Products	70,329 t/year	405,313,732	1,112	10 m^3/d	0.052 m^3/t	0.025	0.009 m^3/wkr
" "	-	200,000	60	0.07 m^3/d	-	0.35	0.0012 m^3/wkr
" "	-	500,000	50	0.05 m^3/d	-	0.1	0.001 m^3/wkr
Non-ferrous	20,000 m/month	-	15	-	-	-	-
Metal Products	100 pcs/d	-	13	0.07 m^3/d	0.0007m^3/set	-	0.005 m^3/wkr
" "	350 pcs/d	-	65	-	-	-	-
Gilder	15,000 pcs/month	-	170	0.1 m^3/d	0.0002 m^3/pcs	-	0.0006 m^3/wkr
Metal Product	40-50 set/d	800,000	12	-	-	-	-

* 50% tanned leather: 410 million m^2; thick leather: 490,940 t/year; shoes: 520,330 pair/year; leather articles: 143,320 pcs.

(Cont'd) Table AP 2.4 Refuse generation unit (6/8)

Kind of Industry	Production Rate A.	Capital (Unit: Baht) B.	Number of Workers C.	Refuse Generation Amount D.	Refuse Generation Original Unit		
					D/A	D/B (Unit: m^3/mln.Baht)	D/C
Metal Products	300 pcs/month	-	10	-	-	-	-
" "	2,000 - 5,000 t/month	-	200	-	-	-	-
" "	-	600,000	10	-	-	-	-
" "	758,000 pcs/year	-	99	-	-	-	-
" "	10 ton/year	-	80	0.1 m^3/d	2.88 m^3/t	-	0.0013 m^3/wkr
General Machinery Manufacturer	80,000 pcs/month	10,000,000	100	-	-	-	-
General Machinery Manufacturer	300,000 pcs/month	51,196,200	150	8 m^3/d	0.0006 m^3/pcs	0.156	0.053 m^3/wkr
General Machinery Manufacturer	-	-	100	-	-	-	-
General Machinery Manufacturer	550 set/month	-	40	0.1 m^3/d	0.004 m^3/set	-	0.0025 m^3/wkr
Electrical Machinery Manuf.	20 set/month	-	30	0.004 m^3/d	0.004 m^3/set	-	0.0001 m^3/wkr
Electrical Machinery Manuf.	9,000 set/month	13,450,000	84	-	-	-	-
Electrical Machinery Manuf.	30 set/month	-	50	0.006 m^3/d	0.005 m^3/set	-	0.0001 m^3/wkr
Automobile & Bicycle Parts Manuf.	-	-	80	0.1 m^3/d	-	-	0.0013 m^3/wkr

(Cont'd) Table AP 2.4 Refuse generation unit (7/8)

Kind of Industry	Production Rate A.	Capital B.	Number of Workers C.	Refuse Generation Amount D.	Refuse Generation Original Unit D/A	D/B	D/C
Automobile & Bicycle Parts Manuf.	140,000 pcs/month	24,650,000	65	0.008 t/d	-	0.0003t/mln. Baht	0.0001 t/wkr
Automobile & Bicycle Parts Manuf.	5,500 set + 8,500 pcs/month	-	35	-	-	-	-
Automobile & Bicycle Parts Manuf.	Chain: 1 mln.t/year Wheel: 120,000 pcs/year	-	198	1 m^3/d	-	-	0.005 m^3/wkr
Gasoline Station	* 5 m^3/month	-	15	0.1 m^3/d	0.48 m^3/m	-	0.007 m^3/wkr
" "	* 7 m^3/month	-	6	0.01 m^3/d	0.034 m^3/m^3	-	0.002 m^3/wkr
Forwarding Agency	-	-	100	0.75 m^3/d	-	-	0.0075 m^3/wkr
" "	-	-	12	0.2 m^3/d	-	-	0.017 m^3/wkr
Railway Com.	** 900 person/d	-	136	11 m^3/d	0.012 m^3/per.	-	0.081 m^3/wkr
Road Transportation	** 151,000 person/d	-	604	0.5 m^3/d	0.003m^2/ 1,000 person	-	0.0008 m^3/wkr
Vehicle Repair Shop	-	-	10	-	-	-	-
Vehicle Repair Shop	-	-	10	0.1 m^3/d	-	-	0.01 m^3/wkr
Vehicle Repair Shop	40 set/month	-	80	0.015 t/d	0.009 t/set	-	0.0002 t/wkr

* Selling amount.
** No. of customers.

(Cont'd) Table AP 2.4 Refuse generation unit (8/8)

Kind of Industry	Production Rate A.	Capital B.	Number of Workers C.	Refuse Generation Amount D.	Refuse Generation Original Unit D/A	D/B	D/C
Laundry & Dry Cleaning	-	-	200	1 m^3/d	-	-	0.005 m^3/wkr
Gas Producing	40-50 t/month	-	16	0.04 m^3/d	0.021 m^3/t	-	0.0025 m^3/wkr
" "	-	-	-	-	-	-	-
Water Supply	800,000 m^3/d	-	170	sludge 40t/d	0.00005t/m^3	-	0.235 t/wkr
" "	600,000 m^3/d	-	120	-	-	-	-
" "	200,000 m^3/d	-	50	-	-	-	-

Source: Field Investigation Report, Oct. 1981 (Bangkok Solid Waste Management Study Phase II) (JICA)

Appendix 2.4 Estimation of the market waste volume

The volume of the market waste was estimated by using the generation unit of 17 liter per day per store and the number of the stores in the market in 24 districts.

Table AP 2.5 shows the number of the markets and the stores in them.

Estimated volumes of market wastes by district in 1982 is shown in weight in Table AP 2.6, when the bulk density is estimated 0.25 kg/L.

The volume of market wastes in 1980 is estimated as a little smaller than that in 1982, then the volume in 1980 is estimated at 135 tons per day.

Table AP 2.5-(1) Refuse generation volume from markets supervised by BMA (1981)

District	No. of Market	No. of Store	Refuse Generation Volume (m^3/d)
Phra Nakhon	3	1,657	28
Pom Prap	1	158	3
Bang Kapi	1	652	11
Dusit	2	187	3
Huai Khwang	1	575	10
Thonburi	1	197	3
Bangkok Noi	1	227	4
Bang Khun Tian	1	35	0.6
Rat Burana	1	114	2
Nong Chok	1	167	3
Minburi	1	96	1.6
Total	14	4,065	69.2

Estimated from the generation unit of 17 L/d. store

Table AP 2.5-(2) Refuse generation volume from private markets (April 1980)

District	No. of Market	No. of Store	Refuse Generation Volume
Phra Nakhon	10	3,708	63 m^3/d
Pom Prap	7	1,017	17 m^3/d
Pathum Wan	9	1,579	27 m^3/d
Yannawa	16	1,195	20 m^3/d
Bang Rak	4	679	12 m^3/d
Phayathai	14	2,142	36 m^3/d
Sam Phan Thawong	7	963	16 m^3/d
Bang Kapi	6	1,063	18 m^3/d
Phra Khanong	28	3,544	60 m^3/d
Bang Khen	16	2,815	48 m^3/d
Dusit	13	1,832	31 m^3/d
Huai Khwang	9	1,056	18 m^3/d
Khlong San	9	992	17 m^3/d
Thonburi	15	621	11 m^3/d
Bangkok-Noi	14	1,903	32 m^3/d
Bangkok-Yai	5	396	7 m^3/d
Bang Khun Tian	7	768	13 m^3/d
Phasi Charoen	5	724	12 m^3/d
Rat Burana	4	382	6 m^3/d
Nong Khaem	2	101	2 m^3/d
Lat Krabang	2	350	6 m^3/d
Minburi	1	98	2 m^3/d
Total	203	27,928	474 m^3/d

Estimated from the generation unit of 17 l/d. store.

Table AP 2.6 Market waste volume (1982)

(Unit: t/d)

District Name	Waste Volume	District Name	Waste Volume	District Name	Waste Volume
Phra Nakhon	22.8	Bang Khen	12.0	Phasi Charoen	3.0
Pom Prap	5.0	Bang Kapi	7.3	Rat Burana	2.0
Phathum Wan	6.8	Nong Chok	0.8	Taling Chan	
Sam Phan Thawong	4.0	Minburi	1.0	Nong Khaem	0.5
Bang Rak	3.0	Lat Krabang	1.5		
Yannawa	5.0	Thonburi	3.5		
Dusit	8.5	Khlong San	4.3		
Phayathai	9.0	Bangkok Noi	9.0		
Huai Khwang	7.0	Bangkok Yai	1.8		
Phra Khanong	15.0	Bang Khun Tian	3.5	Total	136.3

Estimated by the Study team

Appendix 2.5 Estimation of the solid waste volume from the slums

Most of solid waste generated in slums is left uncollected. The Slum Upgranding Office of National Housing Authority (SUO, NHA) has been promoting slum improvement activities in accordance with the Slum Improvement Program.

SUO estimated the number of slums in Bangkok city to be approximately 300 places with about 80,000 families.

The study team surveyed solid waste generation volume in a slum (Trok Tonmamuang, which is an improved slum), and obtained the solid waste generation unit of 0.77 kg/d.family. According to the Slum Improvement Program, the number of slums which may be improved but not cleared off are about 280 places, with nearly 67,700 households.

Estimated generation volume of slum waste in each district is shown in Table AP 2.7 and the total slum waste in Bangkok was estimated at 52 tons per day.

Table AP 2.7 Estimation of solid waste volume generated by slums in Bangkok

District Name	Number of Slums *1	Number of Households *1	Solid Waste Volume *2 (t/d)
Phra Nakhon	2	420	0.3
Pom Prap	3	600	0.5
Pathum Wan	7	2,160	1.7
Sam Phan Thawong	-		
Bang Rak	-		
Yannawa	32	8,120	6.3
Dusit	58	12,800	9.9
Phayathai	32	7,740	6.0
Huai Khwang	14	1,900	1.5
Phra Khanong	58	20,400	15.7
Bang Khen	14	2,300	1.8
Bang Kapi	3	510	3.9
Nong Chok			
Minburi			
Lat Krabang			
Thonburi	8	1,900	1.5
Khlong San	19	2,849	2.2
Bangkok Noi	20	4,800	3.7
Bangkok Yai	2	172	0.1
Bang Khun Tian	2	650	0.5
Phasi Charoen			
Rat Burana	3	350	0.3
Taling Chan			
Nong Khaem			
Total	277	67,652	52.1

Note *1 : Source: NHA. Excluding slums subject to slum clearance.
*2 : Estimated by the Study team.

Appendix 2.6 Estimation of percentage of uncollected solid waste

Table AP 2.8 Estimation of percentage of uncollected solid waste

District Name	Percentage of Uncollected Solid Waste (%)	Reason of Uncollection and Example of Uncollected Case	Manner of Disposal by Uncollected Houses
Phra Nakhon	0		
Pom Prap	0		
Pathum Wan	0		
Sam Phan Thawong	0		
Bang Rak	0		
Yannawa	60	Narrow path, houses in orchards, factories	
Dusit	20	- do -	Landfill
Phayathai	3	Narrow paths, slums	Throw into Khlongs
Huai Khwang	25	- do -	- do -
Phra Khanong	30	Narrow paths, houses in orchards	Landfill
Bang Khen	40	Narrow paths, houses in orchards	Landfill
Bang Kapi	50		
Nong Chok	40	Collection Workers are unwilling to collect solid waste discharged from factories since they do not store the waste at the specified places. Factories (*1)	Landfill into the low ground
Minburi	70	Difficult to collect. Residence, factories	- do -
Lat Krabang	70	Houses in orchards along the Khlong	- do -
Thonburi	40	- do -	- do -
Khlong San	40	Houses in orchard	Landfill
Bangkok Noi	60	Narrow paths, houses along river	Throw into river
Bangkok Yai	60	- do -	- do -
Bang Khun Tian	60	Same as (*1)	Landfill, incineration
Phasi Charoen	70	Houses in orchards	Landfill into the low ground
Rat Burana	3	Same as (*1)	
Taling Chan	5	Orchards	Landfill into the low ground
Nong Khaem	50	Same as (*1)	

Source: Interviews with the Sanitation Sections of the Districts.

Appendix 2.7 Method of estimation of solid waste generation volume

(Method-1) by utilizing land-use pattern

Using data of land-use pattern and generation unit by area of those districts which collect all areas in the districts and involve all types of major land-use patterns (Pathum Wan, Bang Rak, Dusit, Phayathai, Thonburi, and Bangkok Noi), an equation to relate generation unit by area with land-use patterns was formulated as follows:

$$g = 0.474x_1 + 0.611x_2 + 1.23x_3 + 0.487x_4 \quad \text{(Eq. 1)}$$

where, g : generation unit by area ($m^3/km^2 \cdot d$)

x_1 : land use, residential (%)

x_2 : land use, mixed use, high density (%)

x_3 : land use, mixed use, low density (%)

x_4 : land use, institutional (%)

The present land use is shown in Table AP 2.9.

(Method-2) by multiplying solid waste generation unit by population of areas

The equation for estimating the solid waste generation volume was established by analyzing the relation between the percentages of land-use type such as residential area, commercial area and industrial area in a district, population distribution, generation unit and so on.

$$G = [(g_1^\circ x_1 + g_2^\circ R_2 x_2 + g_3^\circ R_3 x_3) \cdot P_1 \cdot 10^{-5} + 0.487x_5] \cdot A \cdot 365$$

$$P_1 = (100P - P_4 x_4)/(x_1 + R_2 x_2 + R_3 x_3) \quad \text{(Eq. 2)}$$

where, G : solid waste volume generated in a district (m^3/year)

A : area of a district (km^2)

P_1 : population density in residential

P_4 : population density in agricultural area (person/km^2)

g_1° : generation unit in residential area
1.01 L/d·person

g_2° : generation unit in commercial area
1.17 L/d·person

g_3° : generation unit in industrial area
1.17 L/d·person

x_1 : share of a residential area in a district (%)

x_2 : share of a commercial area in a district (%)

x_3 : share of a industrial area in a district (%)

x_4 : share of agricultural and/or open space area in a district (%)

x_5 : share of institutional area in a district (%)

P : population density in a district (person/km^2)

R_2 : population density ratio of a commercial area to a residential area = 2.4

R_3 : population density ratio of an industrial area to a residential area = 1.0

Population densities by areas in 1979 are shown in Table AP 2.10.

(Method-3) by adding the generation volume in uncollected areas on to present collection volume

Population was estimated in the areas where solid waste collection was not yet carried out despite the areas being urbanized.

A figure obtained by multiplying the estimated population by the generation unit was regarded as uncollected volume, then solid waste generation volume was obtained by adding the uncollected volume to the present collection volume.

(Result of estimation)

Estimated volumes by the methods of 1 to 3 are shown in Table AP 2.11.

Table AP 2.9 Land use (1979)

District Name	Residential	Mixed Use High Density	Commercial	Institutional	Industrial	Agricultural Open Space
Phra Nakhon	6.5	0	31.0	15.7	0.14	32.5
Pom Prap	0	9.0	72.1	6.5	0.24	1.0
Pathum Wan	4.5	6.0	21.5	13.7	0	34.3
Sam Phan Thawong	0	0	45.9	0.4	0	27.2
Bang Rak	9.0	1.4	36.6	2.9	0	47.5
Yannawa	30	11	4	6	8	41
Dusit	31.9	1.7	4.9	20.5	10.7	19.6
Phayathai	46.7	3.6	12.7	17.1	0.02	12.4
Huai Khwang	54.7	0	10.3	0.03	0	34.9
Phra Khanong	28	2	2.5	1	3.5	63
Bang Khen	23.5	0	1.2	7.4	0.37	58.7
Bang Kapi	28.5	0	1.3	0.2	0.66	68.2
Nong Chok	2.2	0	0	0	0.04	97.5
Minburi	14.5	0	0.08	0.14	0.52	84.5
Lat Krabang	9.33	0	0.11	0.55	0.97	86.8
Thonburi	5.6	52.2	9.7	2.7	1.7	18.0
Khlong San	0	55.6	11.2	2.1	3.4	20.9
Bangkok Noi	45.0	3.5	5.1	2.9	0.41	34.4
Bangkok Yai	18.2	58.7	9.9	2.3	2.4	0.45
Bang Khun Tian	4.6	0	0.6	0.5	0.5	94
Phasi Charoen	19.2	0	1.43	0.13	2.63	75.1
Rat Burana	14.2	0	2.27	0	4.03	76.0
Taling Chan	5.09	0	0.07	0.06	0.07	94.7
Nong Khaem	15.1	0	0.42	0.09	2.05	81.5

Note *: Adapted from the data of DTCP (Department of Town and City Planning, Ministry of Interior) and the report of Comprehensive Study for Bangkok Suburban Transportation 1979, JICA.

Table AP 2.10 Population density by type of land use (in 1979)

1. Subdistricts where the most areas are open space or agricultural land.

(Unit : Person/km^2)

District	Subdistrict	Pop. density
Nong Chok	All subdistricts.	212
Minburi	All subdistricts except Minburi.	235
Lat Krabang	All subdistricts except Lat Krabang.	220
Taling Chan	Taveepatana, etc.	464
Bang Khun Tian	Takham, etc.	378
Mean		300

2. Subdistricts where the most areas are low density residential.

District	Subdistrict	Pop. density
Bang Rak	Silom	16,503
Dusit	Bang Sue	13,077
Bangkok Noi	Bangyeekhan	15,287
Phra Khanong	Klongtan	10,870
Mean		13,900

3. Subdistricts where the most areas are high density residential.

District	Subdistrict	Pop. density
Khlong San	Somdedh Chao Praya	26,870
Thonburi	Wat Kanlayanee Mit	32,256
	Hiran Rugee	38,007
	Bang Yeeroe	37,544
Mean		33,700

4. Subdistricts where the most areas are commercial.

District	Subdistrict	
Bang Rak	Mahaphoetaram	33,622
	Siphaya	18,975
	Suriyawong	39,615
Sam Phan Thawong	Sampanthawong	54,876
	Chakraward	58,882
Pom Prap	Pomprab	93,662
Mean		49,900

Note *: Derived from the populations and the areas of all subdistricts in Bangkok that were given by DTCP (Department of Town and City Planning, Ministry of Interior).

Table AP 2.11 Estimation of solid waste generation volume (Jan. - Dec., 1979)

(Unit : 1000 m^3)

District Name	Collection Volume	Estimated Generation Volume *				Generation Volume Determined by the Study Team
		A Method 1	B Method 2	C Method 3	D Dist. chiefs	
Phra Nakhon	159.7	-	-	-	-	161.3**
Pom Prap	111.5	-	-	-	-	112.5**
Pathum Wan	121.1	118.4	-	-	-	122.3**
Sam Phan Thawong	86.3	-	-	-	-	87.2**
Bang Rak	101.8	104.5	-	-	-	102.8**
Yannawa	143.9	282.7	148	161	340	215
Dust	203.6	262.8	-	-	251	250
Phayathai	220.6	239.3	-	-	229	240
Huai Khwang	78.3	-	60	91	105	100
Phra Khanong	312.3	-	308	347	447	350
Bang Khen	140.2	-	185	179	235	180
Bang Kapi	90.2	-	86	135	178	130
Nong Chok	4.1	-	7.9	5.1	6.8	7
Minburi	31.0	-	28	39	100	39
Lat Krabang	10.7	-	29	14	38	14
Thonburi	90.1	150.7	-	-	143	150
Khlong San	76.0	121	-	-	126	120
Bangkok Noi	106.9	265.0	-	-	265	265
Bangkok Yai	42.1	130	-	-	105	75
Bang Khun Tian	40.6	-	-	65	100	70
Phasi Charoen	46.7	-	81	64	155	70
Rat Burana	44.9	-	61	51	46	55
Taling Chan	5.0	-	21	15	5.4	15
Nong Khaem	6.9	-	28	13	13.6	14
Total	2,274.5	-	-	-	-	2,945.1

Estimated by the Study team.

* See Section 2.1.4(2)i), ii) and iii) for columns A, B and C; and for column D, the figures were derived from the estimated percentage of solid waste collection (the percentage of collection volume in generation volume) by the chiefs of Sanitation Sections.

** The figures were determined by assuming the collection ratio was 99%.

Appendix 2.8 Generation volume by district (1979)

Table AP 2.12 Generation volume by district (1979)

District Name	Collection Volume t/d	Solid Waste Collected Population 1,000 person	Collected Volume g/d. person	Generation Volume t/d	Solid Waste Generating Population 1,000 person	Generation Volume per Capita per day g/d. person
Phra Nakhon	122.9	123.7	994	124.1	124.9	990
Pom Prap	85.8	192.4	446	86.7	194.3	450
Pathum Wan	93.2	230.8	404	94.1	233.1	400
Sam Phan Thawong	66.4	77.4	858	67.1	78.2	860
Bang Rak	78.3	125.2	625	79.1	126.5	630
Yannawa	110.7	368.2	301	165.4	373	440
Dusit	156.7	370	423	192.4	462.2	420
Phayathai	169.7	463	366	184.7	514.2	360
Huai Khwang	60.2	161.3	374	77.0	192	400
Phra Khanong	240.3	370	649	269.3	484	550
Bang Khen	107.9	264	408	138.5	351	390
Bang Kapi	69.4	106.8	649	100.0	197	510
Nong Chok	3.2	9.7	325	5.4	20	250
Minburi	23.9	13.	1,830	30.0	33	910
Lat Krabang	8.2	17.7	464	10.8	27	410
Thonburi	69.3	154	450	115.4	256.7	450
Khlong San	58.5	85	687	92.3	140.9	650
Bangkok Noi	82.2	15.2	541	203.9	378.8	540
Bangkok Yai	32.4	96.6	335	57.7	97	610
Bang Khun Tian	31.2	149	210	52.3	170	310
Phasi Charoen	35.9	125	287	52.3	170	310
Rat Burana	34.5	74.8	462	39.2	103	380
Taling Chan	3.9	16.3	235	11.5	38	320
Nong Khaem	5.3	21.8	239	10.8	35	310
Entire city area	1,750	3,630.9	482	2,260	4,800	470

Estimated by the Study team.

Note: Generation volume in a day was obtained by dividing the annually generated volume by 365 days.

Appendix 2.9 Fluctuation of solid waste volume

Table AP 2.13 Fluctuation of household waste generation volume by day

	Year	Sun.	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.
Weight (g)	1979	365	331	310	311	305	290	374
	1980	363	289	271	283	256	266	-
Index average = 100	1979	112	101	95	95	94	89	115
	1980	126	100	94	98	89	92	-

Source (1) Interim Report of The Bangkok Sewerage & Solid Waste Disposal System Study in The Kingdom of Thailand (The First-Years Study for Solid Waste Disposal System), JICA, Feb, 1980.

(2) The Bangkok Solid Waste Management Study in Thailand, Field Investigation Report, JICA, Jan, 1981.

Fig. AP 2.1 Monthly fluctuation of solid waste collection volume and number of trips

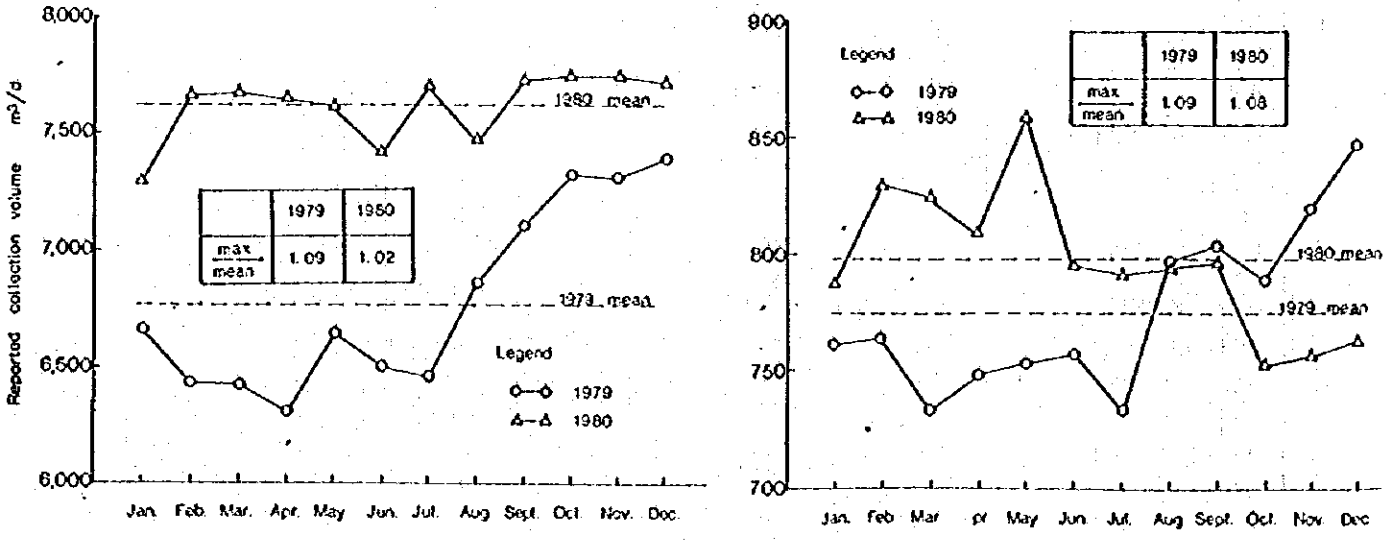
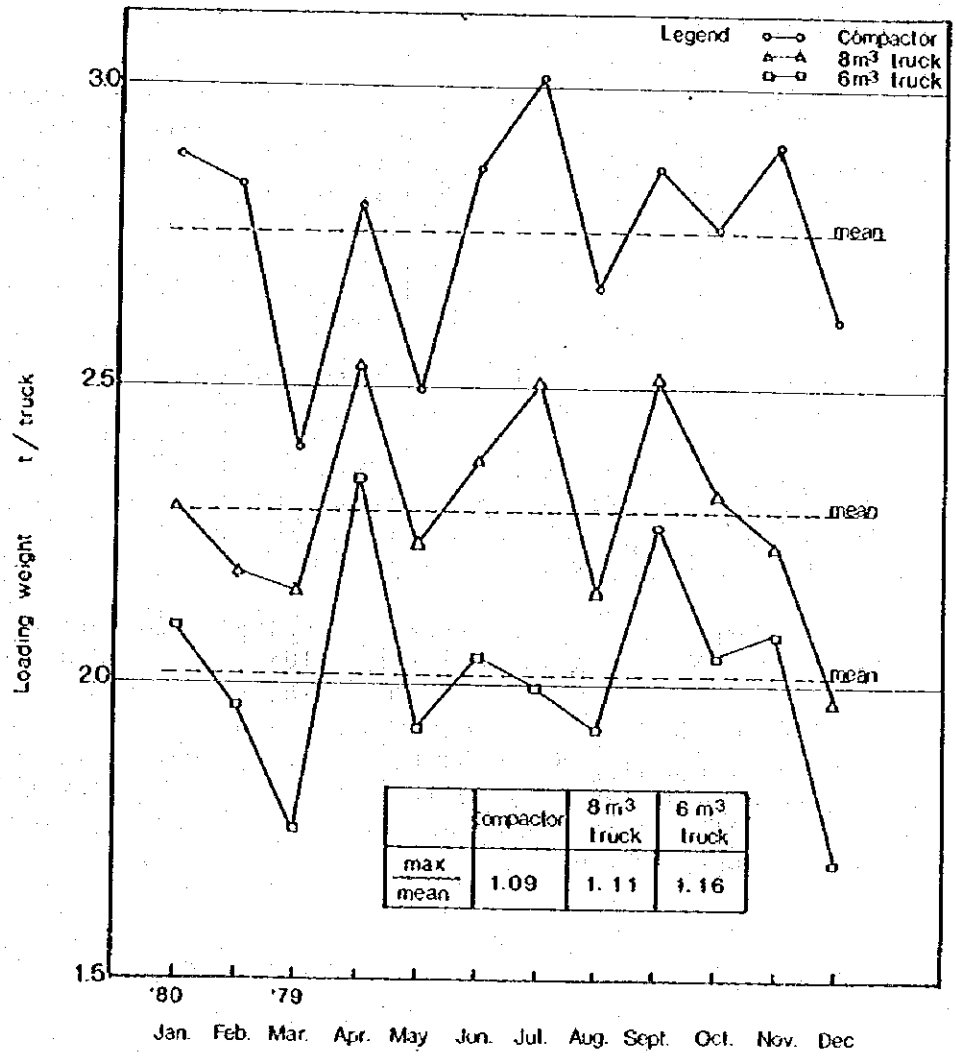


Fig. AP 2.2 Monthly fluctuation of loading weigh



Appendix 2.10 GPP and solid waste generation volume

Solid waste generation volume in the past is harder to estimate than the present volume. Therefore, using the present collection percentage collection volume and population of the present and of the past, a linear equation to express a relation between GPP and solid waste generation volume was formulated.

As a general tendency, solid waste generation volume per capita increases according with economic growth. Due to this tendency, the actual generation volume in the past must be smaller than the value calculated by multiplying the present generation volume by the ratio of the past population to the present population. Therefore, the actual generation volume in the past was conjectured to be smaller than estimated figures for the past generation volume (line-A) in Fig. AP 2.3 which was drawn on the basis of the population growth.

On the other hand, assuming that the percentage of solid waste collection (ratio of the collected volume to the generation volume) had increased year after year in the past, the actual generation volume in the past should be larger than the volume calculated by dividing the past collection volume by the collection percentage of 1979. Transition of the estimated solid waste generation volume in the past is drawn also in the Fig. AP 2.3 as a line-B.

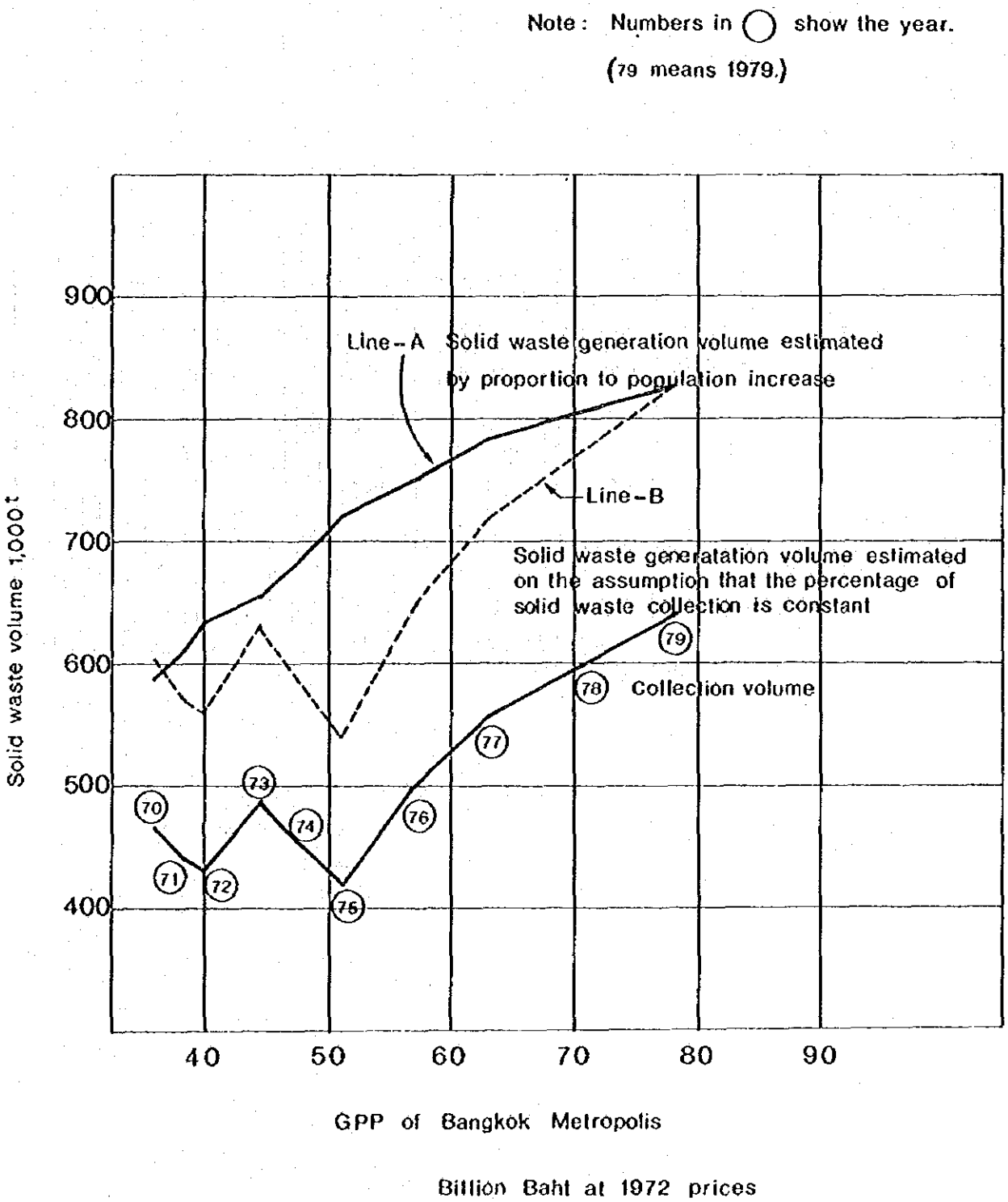
Fig. AP 2.3 shows that the percentage of solid waste collection had been dropping from 1970 till 1975, but has rapidly increased since 1976, and has regained the same level as in 1970 in the recent years. Assuming the collection percentages of the years 1970 and 1979 to be on the same level, intersection of line-A and line-B at the year 1970 was connected with a line to a point of the generation volume at the year 1979, and a linear equation to express the line was formulated as an equation to show a relation between GPP and solid waste generation volume.

$$G = 5.64(P-78.1) + 826$$

Where, G: solid waste generation volume per year (1,000 tons)

P: GPP, in billion Baht.

Fig. AP 2.3 Relation between solid waste generation volume and GPP



Appendix 2.11 Forecast of population by NESDB and other offices

Table AP 2.14 Population projections of Thailand

Year	High Fertility		Medium Fertility		Low Fertility	
	Thousand Persons	Annual Growth Rate(%)	Thousand Persons	Annual Growth Rate(%)	Thousand Persons	Annual Growth Rate(%)
1970	36,370					
		2.84		2.64		2.41
1975	41,869					
		2.83		2.46		2.00
1980	48,164		47,686		47,173	
		2.79		2.29		1.73
1985	55,373		53,851		52,087	
		2.73		2.11		1.54
1990	63,529		60,310		56,742	
		2.65		1.92		1.33
1995	72,675		66,951		61,237	
2000	82,828		73,614		65,413	

Source: The National Economic and Social Development Board.
The National Statistical Office.
The Institute of Population Studies, Chulalongkorn University, (1974)

Appendix 2.12 Forecast of the future population in Bangkok city

Population growth rate in Bangkok city has been always higher than that in the whole Thailand. It was mainly caused by social increase. The growth rate in Bangkok is, however, decreasing in recent years, showing a drop from more than 4% to a level of 2%. As natural increase has been in a range of 2%, slow-down of population increasing tendency in the late years in Bangkok city can be said caused by a sharp drop of social increase. In the year 1978, for example, population growth rate in Bangkok (2.7%) was attributed to natural increase (2.3%) and social increase (0.4%), while that for the whole Thailand (2.14%) was attributed to natural increase (1.96%) and social increase (0.18%).

The future population in Bangkok city was forecast on assumption that the population growth rate of Bangkok is larger by 10-30% than that of the whole Thailand. In recent years the population growth rate of Bangkok has been higher by 30 percent than that of whole Thailand, so that from 1980 to 1985, the population of Bangkok should be assumed to be higher by 30% than that of Thailand. But, it is recommended in 4th NESDP that the population concentration to Bangkok should be surpressed, so that the above mentioned 30% should be reduced to 25% in 1986 - 1990, 20% in 1991 - 1995 and 10% in 1996 - 2000.

Applying the following two method, the future population of each district in Bangkok city was forecast.

a. For the central districts, the annual change trend in the past was extended to the future and the population was forecast.

b. For the surrounding districts where the land-use pattern is thought to be remarkably changing, the future district population was forecast based on the change of the land use.

The index P defined below shows the change of population.

$$P = x_1 + 2.4x_2 + 0.02x_3$$

where, x_1 : Mixed use-low density area (%)

x_2 : Mixed use-high density area (%)

x_3 : Agricultural and/or open space (%)

The above equation was established by using the population density by type of land use (see Table AP 2.10).

Appendix 2.13 Forecast of the future percapita GPP of Bangkok

'e' is the ratio of Percapita GPP growth rate of Bangkok city to the growth rate of Thailand. The value of 'e' from 1975 till 1979 are shown in Table 2-23.

The mean value of 'e' in this period was 1.012, The 4th NESDP endeavored to rectify regional differences in economy.

Taking these circumstances into consideration, the change in the value of 'e' was estimated as 1.012 from 1980 to 1985, 1.006 from 1986 to 1990, and 1.000 from 1991 onwards.

The future Percapita GPP of Bangkok is forecast by the production of 'e' and Percapita GDP.

Table AP 2.15 Percapita GPP and percapita GDP

Year (i)	Percapita GPP (A_i)	Percapita GDP (B_i)	$e = \frac{A_i/A_{i-1}}{B_i/B_{i-1}}$
1975	11,725	4,860	
1976	12.493	5,180	0.9997
1977	13,321	5,413	1.0204
1978	14,444	5,917	0.9919
1979	15,622	6,171	1.0371
Mean			1.012

Sources: Per capita GPP and GDP were derived from Gross Regional and Provincial Product 2522 (NESDB)

Per capita GDP was determined from analogy with per capita GNP

Note : The prices are as of 1972
Source : Gross Provincial Product 2520 NESDB