JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

MINISTRY OF PUBLIC WORKS
REPUBLIC OF INDONESIA

The Study on the Solid Waste Management Improvement for Surabaya City in The Republic of Indonesia

FINAL REPORT

Volume 3

SUPPORTING REPORT I

(MASTER PLAN)

May 1993

Pacific Consultants International
EX Corporation

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All the Rupiah amounts including the projects costs shown in this report are indicated in 1992 price unless otherwise indicated. Those amounts are estimated partly based upon the foreign prices by applying dominant 1992 currency exchange rates, i.e.: US $ 1 = Rp 2,000 = ¥125 (¥1 = Rp 16)

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Abbreviations & English Translations

(in alphabetical order)

1.	ADIPURA	:	Noble City Award, an award presented by the Central Government to the local government for their efforts in sustainable improvement of the overall urban environmental quality.
2.	AMDAL	:	Environmental Impact Assessment system.
3.	ANDAL	:	Environmental Impact analysis.
4.	BAPEDAL	:	Environmental Impact Control Agency.
5.	BAPPEDA	:	Local development Planning Agency.
6.	BAPPENAS	:	National Development Planning Agency.
7.	Bina Marga	:	Directorate General of Highways, a name of a directorate general under the Ministry f Public works.
8.	Biro KLH	:	Provincial Bureau of KLH.
9.	BPPT	:	Technology Study and Application Agency.
10.	Cabang	:	Branch office for sanitary management at District Level.
11.	Camat	:	Chief of District.
12.	Cipta Karya	:	Directorate General of Human Settlements, a directorate general under the ministry of Public Works.
13.	CBD	:	Central business District.
14.	Depo	:	Waste transfer station with an administrative office.
15.	Dinas Kebersihan	:	Cleansing department.
16.	Dinas Marga	:	Road department.
17.	IUIDP	:	Integrated Urban Infrastructure Development Project.
18.	JATIM	:	East Jawa Province.
19.	JKT	:	Jakarta.
20.	KA ANDAL	:	Terms of Reference of ANDAL.
21.	Kampung	:	Unplanned low-income residential area naturally originated from villages and inhabited by people migrated from rural areas.
22.	Kecamatan	:	District, an administrative area.
23.	Kelurahan	:	Sub-District, and administrative area.
24.	KLH	:	Ministry of Population and Environment.
25.	KMS	:	Surabaya Municipality; Surabaya Municipal Government.
26.	LPA	:	Final Disposal site.
27.	LPS	:	open-dumping waste transfer station without administration office (literally means temporary disposal site).

28.	Lurah	:	Chief of sub-District.
29.	MCK	:	Public facilities for taking shower, washing, and toilet.
30.	Pasar	:	Traditional market.
31.	Pasukan Kuning	:	"Yellow Troop" (waste collection workers and street sweepers).
32.	PDAM	:	Water Supply Municipal Company.
33.	PEL	:	Preliminary Environmental Evaluation report.
34.	Perda	:	Municipal Regulations.
35.	PIL	:	Preliminary Environmental Information report.
36.	PLN	:	State Electric company
37.	Rayon	:	Working area f each Assistant to the Mayor.
38.	RT	:	Neighborhood unit.
39.	RW	:	Community Unit.
40.	SBY	:	Surabaya.
41.	SEL	:	Environmental Evaluation Study.
42.	SMA	:	Surabaya Metropolitan Area.
43.	SUDP	:	Surabaya Urban Development Plan.
44.	SWM	:	Solid Waste management

CHAPTER 1.

OUTLINE OF SURABAYA

CHAPTER 1. OUTLINE OF SURABAYA

1.1 Natural Conditions

1) Air Quality

"Surabaya Post Environmental Health Techinical Monitoring Association" and "Surabaya University Airlangga Study Center" are mesuring some parameters of air pollution on main streets in Surabaya, Madium, Gresik and other cities. Air quality is shown in Table 1.1-1.

According to this data, it is showed that SO_2 in Joyobono Station in Surabaya is 0.0375 mg/l which is under the Ambient Air Standards as well as other Areas. The average of dust in Surabaya is 1.044 mg/m3 which is under the Ambient Air Standards.

Table 1.1-1 Conditions of Air Quality in Surabaya and other Cities

[SO_2]

Location and City Name	Concentration of SO_2	
Joyoboyo Station	0.0375	mg/l
Gresik Station	0.122	mg/l
Sidoarjo	0.095	mg/l
Pasuruan	0.11	mg/l
Tulungagung	0.09	mg/l
Blitar	0.11	mg/l

[Dust]

Location and City Name	Concentration of Dust	
Surabaya	1.044	mg/l
Gresik	0.75	mg/l
Sidoarjo	0.366	mg/l
Pasuruan	1.78	mg/l
Malang	9.61	mg/l
Tulungagung	2.4	mg/l
Probolinggo	0.46	mg/l

source: Pemerintah Propinsi Daerah Tingkat I Jawa Timur,
Neraca Kependudukan Dan Lingkungan Hidup Daerah, 1990

2) Surface Water

Surabaya has two principal rivers, River Brantas and River Lamong. The Brantas (Surabaya) River streams from south to north in the center of Surabaya and its main stream and its tributary covers most part of Surabaya except north-western part. And, there are some channels connected to River Brantas. These channel accept waste water from urban life and is stagnated so the water quality is deteriorated. River Lamong is located on the west boundary of Surabaya and has numerous tributaries that covers northwestern part of coastal plain.

There are two water intakes for water supply by PDAM on the Brantas River, however, the surface water is used for agriculture, bathing, washing and fishing except drinking.

In rainy season, some areas are flooded which is covered whole Surabaya as Fig. 1.1-1.

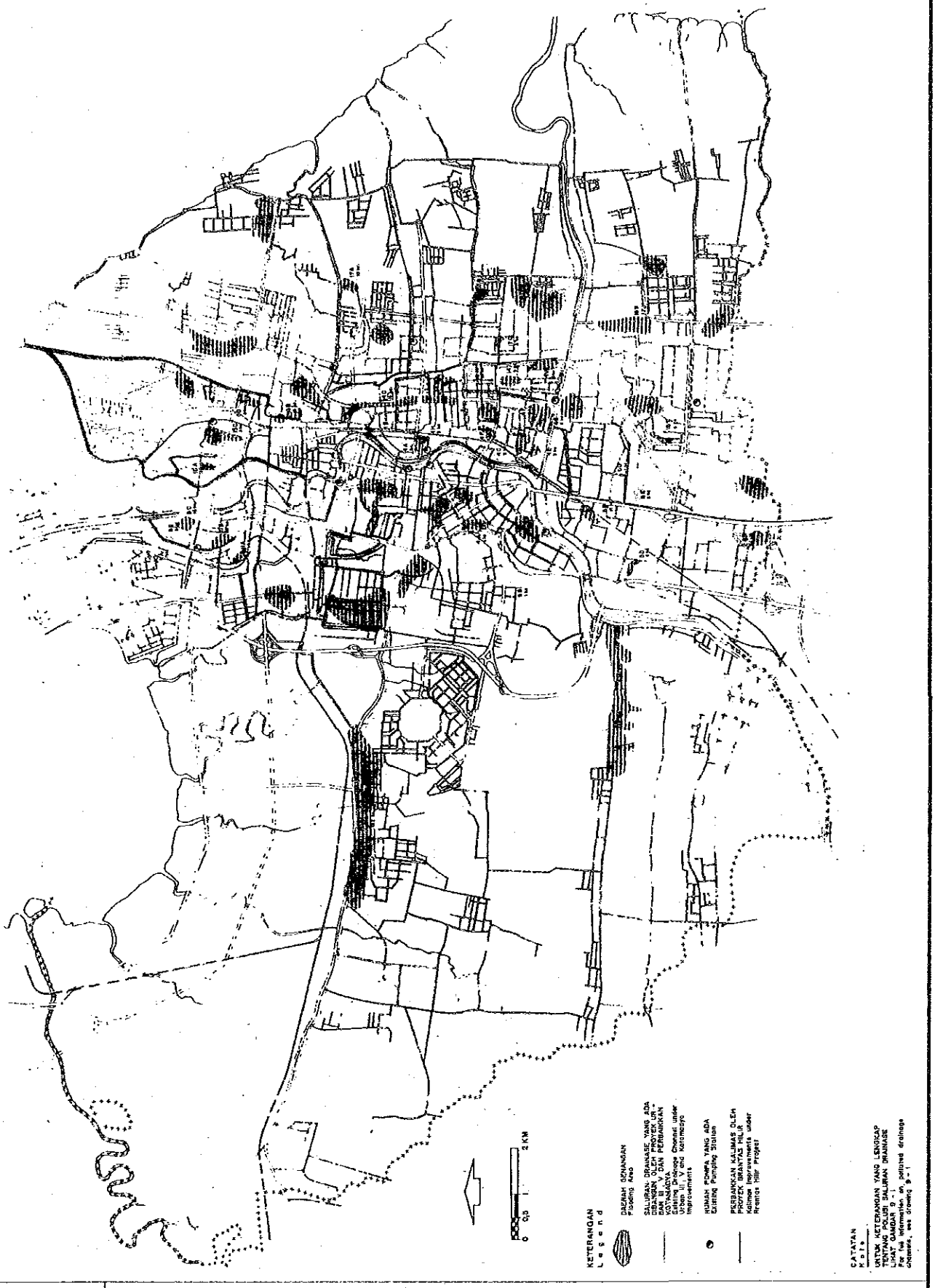

FIG. 1.1-1 FLOODING AREA IN SURABAYA

THE STUDY ON THE SOLID WASTE MANAGEMENT IMPROVEMENT FOR SURABAYA CITY

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1.2 Population

1.2.1 Present Population

The population of Surabaya was 2,473,272 in 1990 according to the census. The characteristics of the population of Surabaya may be summarized as follows:

1. About 60 % of the population live in the central part of Surabaya (consisting of 11 Kechamatans as indicated in Table 1.2-1, while the remaining 40 % live in the outskirts (8 Kechamatans).

2. The population has been increasing with an average increment of about 48,000 persons/year during the past 20 years since 1971. Consequently, the rates of annual growth have been declining. The average annual growth rate was 2.84 % year during the period 1971 - 1980, while it dropped to 2.06 %/year during the next decade 1980 -1990.

3. The population growth in the central part of Surabaya was negative (- 0.32 %/year) during the period 1980 - 1990, while the corresponding rate of the outskirts (such as Surabaya West and East) was 7.54 %/year during the same period, leading to the average growth rate of the whole Surabaya being 2.06 %/year.

4. It is said that about 10 % of the population is non-registered.

The census population by Kecamatan are shown in Table 1.2-1.

Table 1.2-1. Population by Kecamatan in Surabaya according to the Census

KECHAMATAN	1971	1980	ANNUAL AVERAGE GROWTH RATE (%) 1971 - 1980	1990	ANNUAL AVERAGE GROWTH RATE (%) 1980-1990
Surabaya Center (Sub-Total)	424,963	454,546	0.75	399,036	-1.29
1. Bubutan *	156,715	122,802	-2.63	109,214	-1.71
2. Simokerto *	101,965	112,470	1.10	98,107	-1.36
3. Tegalsari *	92,441	129,570	3.82	117,837	-0.94
4. Genteng *	73,842	89,704	2.19	73,878	-1.92
Surabaya North (Sub-Total)	305,534	431,062	3.90	458,501	0.62
5. Semampir *	98,114	162,131	5.74	166,496	0.27
6. Pabean Cantian*	40,762	101,711	10.69	88,416	-1.39
7. Krembangan *	144,890	125,511	-1.58	119,225	-0.51
8. Kenjeran	21,768	41,709	7.49	84,364	7.30
Surabaya East (Sub-Total)	303,544	439,984	4.21	665,756	4.23
9. Gubeng *	129,150	161,097	2.49	156,428	-0.29
10. Tambaksari *	127,913	163,598	2.77	188,225	1.41
11. Sukolilo	25,179	58,821	9.87	148,110	9.67
12. Rungkut	21,302	56,468	11.44	172,993	11.84
Surabaya South (Sub-Total)	465,760	545,421	1.77	660,780	1.94
13. Wonokromo *	217,203	171,845	-2.57	171,421	-0.02
14. Sawahan *	159,007	205,665	2.90	208,699	0.15
15. Wonocolo	40,884	86,234	8.65	140,614	5.01
16. Karangpilang	48,666	81,677	5.92	140,046	5.54
Surabaya West (Sub- Total)	67,845	146,496	8.93	289,199	7.04
17. Tandes	27,920	91,799	14.14	196,119	7.89
18. Benowo	15,659	23,157	4.44	35,986	4.51
19. Lakarsantri	24,266	31,540	2.96	57,094	6.11
T O T A L	1,567,646	2,017,509	2.84	2,473,272	2.06

Source : Statistic Office, KMS

Note : Kechamatans marked with asterisk (*) are located in the central part of Surabaya.

1.2.2 Future Population

During the past 20 years, the population of Surabaya has increased linearly with annual incremental population being more or less constant, instead of having grown exponentially with a constant annual growth rate.

It is, therefore, considered reasonable to assume that the future population will increase linearly rather than exponentially. It is projected that the population of Surabaya will increase by 45,500 persons annually judging from the fact that the past incremental population was 45,575 persons/year on average during the period 1980 - 1990. the projected population of Surabaya is shown in Table 1.2-2.

With the application of the linear model, the average annual growth rates will be 1.70 % between 1990 - 2000 and 1.4 % between 2000 - 2010.

Table 1.2-2 Projection of the Future Population of Surabaya 1990-2010

(unit: 1,000 person)

YEAR	POPULATION	YEAR	POPULATION
1990	2,473		
1991	2,519	2001	2,974
1992	2,564	2002	3,019
1993	2,610	2003	3,065
1994	2,655	2004	3,110
1995	2,701	2005	3,156
1996	2,746	2006	3,201
1997	2,792	2007	3,247
1998	2,837	2008	3,292
1999	2,883	2009	3,338
2000	2,928	2010	3,383

Population Projection by 5 Rayons

The population of each Rayon is estimated as shown in Table 1.2-2 by distributing the projected population of the whole Surabaya into 5 Rayons. It is assumed that the population of each rayon during 1990 - 2010 will increase, in principle, by a certain number of population same as the average annual incremental population exhibited in respective Rayon during 1980 - 1990.

Table 1.2-3 Projection of the Future Population by Rayon

RAYON	POPULA-TION IN 1990	ANNUAL AVERAGE INCRE-MENT 1990-2000	POPULA-TION IN 2000	ANNUAL AVERAGE INCRE-MENT 2000-2010	POPULA-TION IN 2010
Surabaya Center	399,000	-2,800	371,000	0	371,000
Surabaya North	459,000	2,700	486,000	2,500	511,000
Surabaya East	665,000	21,200	877,000	20,100	1,078,000
Surabaya South	661,000	10,900	770,000	10,200	872,000
Surabaya West	289,000	13,500	424,000	12,700	551,000
Total	2,473,000	45,500	2,928,000	45,500	3,383,000

Technical Note:

The population distribution to the 5 Rayons was made primary based upon the past population increase trend in respective Rayons during the period 1980 - 1990. An adjustment was made as to the population projection of Surabaya Center. The population of Surabaya Center decreased by 5,551 persons/year on average during the period 1980 -1990. However, it is assumed that the population of Surabaya Center will decrease by 2,800 persons/year for the period 1990 -2000. And thereafter, the population will remain unchanged. These assumptions were made by considering the following factors :

1. The population decrease in Surabaya Center is attributed to the development of the commercial area in Surabaya Center.

2. The speed of the population decrease would be slow down as the development in the area come to its completion, which may occur toward the year 2000.

3 With the stable condition where commercial development is completed, it can be assumed that there will be no further decrease in the population.

Population Projection by Kecamatan

The future populations at Kecamatan level are projected as shown in Table 1.2-4 by distributing the population already projected at Rayon level into 19 Kechamatans. Such distribution was made based upon average annual incremental population recorded in respective Kecamatan between 1980 - 1990. It is assumed that the population of each Kecamatan during 1990 - 2010 will increase, in principle, by a certain number of population same as the average annual incremental population exhibited in respective Kecamatan during 1980 - 1990.

Table 1.2-4 Projection of the Future Population by Kecamatan

KECHAMATAN	POPULA-TION IN 1990	ANNUAL AVERAGE INCRE-MENT 1990-2000	POPULA-TION IN 2000	ANNUAL AVERAG E INCRE-MENT 2000-2010	POPULA-TION IN 2010
Surabaya Pusat	399,000	-2800	371,000	0	371,000
1. Bubutan	109,000	-690	102,000	0	102,000
2, Simokerto	98,000	-730	91,000	0	91,000
3. Tegalsari	118,000	-590	112,000	0	112,000
4. Genteng	74,000	-790	66,000	0	66,000
Surabaya Utara	459,000	2700	486,000	2,500	511,000
5. Semampir	167,000	240	169,000	190	170,000
6. Pabean Cantian	88,000	-660	82,000	-330	79,000
7. Krembangan	20,000	-310	116,000	-150	115,000
8. Kenjeran	84,000	3430	119,000	2790	147,000
Surabaya Timur	666,000	21200	878,000	20,100	1,079,000
9. Gubeng	156,000	-230	154,000	-110	153,000
10. Tambaksari	189,000	2290	211,000	2160	233,000
11. Sukolilo	148,000	8310	231,000	7840	310,000
12. Rungkut	173,000	10830	282,000	10210	383,000
Surabaya Selatan	661,000	10,900	770,000	10,200	872,000
13. Wonokromo	171,000	-20	171,000	-10	171,000
14. Sawahan	209,000	280	212,000	260	214,000
15. Wonocolo	141,000	5130	192,000	4800	240,000
16. Karangpilang	140,000	5510	195,000	5150	247,000
Surabaya Barat	289,000	5510	424,000	12,700	551,000
17. Tandes	196,000	9870	295,000	9,280	388,000
18. Benowo	36,000	1210	48,000	1,140	59,000
19. Lakarsantri	57,000	2420	81,000	2,280	104,000
TOTAL	2,473,000	45,500	2,928,000	45,500	3,383,000

Technical Note:

Some adjustments were made in the population estimation of the 8 Kecamatans which exhibited the minus growth during 1980 - 1990 (Refer to Table 1.2-1). It is projected that the population of those 8 Kecamatans for 1990 - 2000 will annually decrease by one half of the average annual decreases recorded between 1980 - 1990. Then, for the period 2000 - 2010, it is projected the population in the 4 Kecamatans (in Surabaya Center) out of those 8 Kecamatans will remain unchanged, while the population of the remaining 4 Kecamatans (2 in Surabaya North, 1 in Surabaya East and 1 in Surabaya South) will annually decrease by one quarter of the average annual decreases recorded between 1980 - 1990.

1.3 Economic Activity

The economy of Surabaya has been growing rapidly. During the past 5 years (from 1985 to 1990), real GDP of Surabaya has increased by 57 % as shown in Table 1.3-1, or 9.5 % increase on annual base. The corresponding percentages of real GDP per capita are 41 % and 7 % respectively during the same period. In 1990, GDP per capita was Rp 1,677,410/year as shown in Table 1.3-2, while the income per capita was Rp 1,367,090/year as shown in Table 1.3-3.

Surabaya is a commercial city. As shown in Table 1.3-4, service industries such as trade, hotel, restaurant, banking, transportation, communication, etc. shared as much as 69.5 % of the GDP of Surabaya in 1989, while the manufacturing and primary industries shared 29.3 % and 1.2 % only, respectively. Annual inflation was 8.1 % on average during 1983 - 1990 as shown in Table 1.3-5.

Table 1.3-1 Gross Domestic Product (GDP) in Surabaya 1985-1990

(in billion Rupiahs)

Year	Nominal GDP	Real GDP [base-year 1985]	
1985	1,948	1,948	(100%)
1986	2,098	2,008	(103%)
1987	2,444	2,201	(113%)
1988	2,896	2,484	(128%)
1989	3,499	2,798	(144%)
1990	4,122	3,062	(157%)

Source: Processed from *Pendapatan Regional Kotamadya Surabaya 1985-1990*

Table 1.3-2 GDP Per Capita in Surabaya 1985-1990

(in thousand Rupiahs)

Year	Nominal GDP Per Capita	Real GDP Per Capita [base-year 1985]	
1985	877.73	877.73	(100%)
1986	926.27	879.59	(102%)
1987	1,057.18	944.74	(108%)
1988	1,227.46	1,044.61	(119%)
1989	1,453.15	1,152.71	(131%)
1990	1,677.41	1,236.39	(141%)

Source: Processed from *Pendapatan Regional Kotamadya Surabaya 1985-1990*

Table 1.3-3 Income Per Capita in Surabaya 1985-1990

(in thousand Rupiahs)

Year	Nominal Income Per Capita	Real Income Per Capita [base-year 1985]	
1985	739.93	739.93	(100%)
1986	779.49	746.01	(101%)
1987	884.46	802.44	(108%)
1988	1,026.56	889.20	(120%)
1989	1,186.62	970.89	(131%)
1990	1,367.09	1,029.42	(139%)

Source: Processed from *Pendapatan Regional Kotamadya Surabaya 1985-1990*

Table 1.3-4 Gross Regional Domestic Product (GRDP) by Sector based upon 1989 Price

(million Rupiahs)

No.	Sector		1989 (%)
A	Primary Industries		1.2
	1) Agriculture	1.1	
	2) Mining	0.1	
B	Manufacturing Industries		29.3
	3) Industry & Processing	17.5	
	4) Electricity, Gas & Water Supply	2.8	
	5) Construction	9.0	
C	Service Industries		69.5
	6) Trade, Hotel & Restaurant	20.6	
	7) Transportation & Communication	14.3	
	8) Bank & Financial Institution	16.5	
	9) Services	6.9	
	10) House Rent	5.5	
	11) Governmental & Defense	5.7	
Gross Regional Domestic Product		100.0	100.0

Source: *Surabaya Dalam Angka 1990*

Table 1.3-5 Inflation Rate in Surabaya 1983-1990

Year	Food	Housing	Clothing	Services	General
1983	7.95	12.47	5.48	14.30	12.10
1984	4.89	10.75	4.42	10.58	7.82
1985	2.31	8.45	2.97	3.66	4.53
1986	14.26	3.42	6.28	6.09	8.48
1987	10.68	7.10	14.50	8.05	9.26
1988	9.11	5.23	4.35	3.88	6.46
1989	5.17	10.17	5.55	5.96	6.73
1990	13.60	15.55	6.16	9.92	9.69
Average	8.50	9.14	6.21	7.81	8.13

Source: *Surabaya Dalam Angka 1990*

1.4 Environmental Sanitation

1.4.1 Responsible Bodies

Concerning the administrative subject related to environmental sanitation, various authorities are assigned to the relevant field as follows:

1) *Solid Waste Management*

The major responsible body is Dinas Kebersihan, KMS who covers the most part of solid waste management in volume with a few exception managed by the other authorities such as :

1. Minor road sweeping (by RW/RT)
2. Highway sweeping (by Dinas Marga)
3. Hazardous industrial waste (by Generator Itself)
4. Port Area (by Port Authority)

2) Water Supply

Water supply is solely provided by PDAM Surabaya. The pipe network covers most urbanized area and small reservoir tanks are distributed in the rural area. Either system can satisfy the demand of the water for daily life at least for drinking use.

Though the number of registered client of water supply stays around 150 thousand out of about 500 thousand households in total in Surabaya, most people without piped water terminal buy their drinking water from some neighboring PDAM clients.

For the other use than drinking, a certain people who live near the river use the river water directly for their daily life.

3) Waste Water

Waste water including sludge from night soil pit is removed by PDAM and RW/RT and disposed at the treatment plant operated by Dinas Kebersihan in Keputih. But, the capacity of the plant is not enough to accept all the sludge from night soil pit, sot that some part of sludge removed is discharged into Wonorejo River directly at the specific site where installed a special discharge facility.

There is no public sewage system at present, therefore the waste water is usually discharged from individual sources to public water body.

4) Control on Ambient Quality of Air and Water

Ambient air quality is regulated by Biro KLH JATIM with the emission gas standard. Ambient water quality is also regulated by Biro KLH JATIM with the effluent standard and the water quality standard for public water body.

As the comprehensive control on environmental situation, AMDAL is applied to those projects which are liable to affect the environment by AMDAL Commission.

1.4.2 Present Situation

1) Solid Waste

KMS has been awarded ADIPURA prize for five successive years by the national government of Indonesia. The prize is established to admire the excellent local body for its cleansing activity and attainment. KMS is actually kept clean on the ground particularly in downtown zone.

2) Air Quality

There seemed to be no prevailing air pollution reported.

3) Water Quality

In residential area, household waste water is discharged to rivers through open conduits without any treatment, and it brings a lot of organic pollutant to the river. In industrial area, hazardous chemicals and heavy metals may be probably discharged because laws and standards specifying the obligation to build the industrial waste water treatment facilities have not been enforced yet.

A row of floating foam can be seen on the surface of Surabaya River almost once a week, which is suggested to be caused by the excessive concentration of detergent or some other surface active substances.

The ground water in Surabaya is said to be too saline to use it for drinking water, and most people who use the well water limit the purpose of utilization to the miscellaneous use only. The high salinity of groundwater is also recognized in the survey at both Keputih and Lakarsantri by the Study Team.

The actual situation of water quality in public water body cannot be known because of the lack of available monitoring data, however, the major rivers are supposed to be polluted by organic more seriously than the upstream of their estuaries judging from the result of the survey conducted by the Study Team in 1992.

4) Wild Life

The territory of KMS is already developed by human activity so there are very few areas where the wild life has been preserved as its natural condition. In dry field, most area are utilized as farm land, urban area and other productive land, consequently it is very rare natural forest or secondary forest area are preserved. In wet field, most area are utilized as fish pond or salt farm, and after reclaiming utilized as a part of urban area except the coastal zone which is covered with mangrove bush.

Most of mangrove bush is included in the designated green area by a long term city plan "Surabaya 2,000".

The designation of green area requires a series of specific permission for development, so that the wild life there may be kept the present level better than the other area.

1.5 City Planning

1.5.1 Current Land Use

The current land use of Surabaya is shown in Table 1.5-1.

According to the City Planning Department of Surabaya Municipality, Surabaya City has an area of approximately 350 km^2. Organized housing area and unorganized housing area are the dominant land use that occupy 40 % of total area. And the next dominant uses are Swamp/Fish Pond and Dry/Wet Field that occupy 23 % and 26% respectively, of the total area of Surabaya. The housing area is distributed on both sides of River Brantas. Swamp/Fish Pond area are along the east coast and the west coast of Surabaya. Dry/Wet Field area distributed in the peripheral part of the City.

Table 1.5-1 Current Land Use in Surabaya

unit: ha

Kecamatan	Categories	Organized Housing	Unorganized Housing	Industry/ Warehouse	Public Facility	Wet Field/ Dry Field	Swamp/ Fish Pond	Total
Surabaya Timur	Sukolilo	552	532	0	125	839	1,366	3,414
	Kenjeran	39	729	6	25	457	156	1.412
	Tambak Sari	156	1,339	11	52	115	0	1.673
	Simokerto	56	171	9	41	0	0	277
	Gubeng	274	345	4	1,022	0	0	1,645
	Rungkut	420	416	311	45	944	1,654	3,790
	Total area	1,497	3,532	341	1,310	2,355	3,176	12,211
	Ratio (%)	12.3	28.9	2.8	10.7	19.3	26.0	100
Surabaya Utara	Semampir	72	923	396	124	0	216	1,731
	Pabean Cantikan	82	214	96	101	0	0	493
	Bubutan	28	262	20	71	0	287	668
	Krembangan	216	176	40	182	97	100	811
	Tandes	419	843	242	44	387	1,657	3,592
	Benowo	20	194	0	1	1,967	2,533	4,715
	Total area	837	2,612	794	523	2,451	4,793	12,010
	Ratio (%)	7.0	21.7	6.6	4.4	20.4	39.9	100
Surabaya Selatan	Lakarsantri	0	619	0	5	2,605	0	3,229
	Karang Pilang	179	1,533	25	260	1,535	0	3,532
	Wonocolo	462	567	10	110	295	0	1,444
	Wonokromo	119	293	44	140	0	0	596
	Sawahan	91	911	1	190	0	0	1,193
	Tegal Sari	144	262	0	47	0	0	453
	Genteng	0	229	0	133	0	0	362
	Total area	994	4,414	80	885	4,435	0	10,809
	Ratio (%)	9.2	40.8	0.7	8.2	41.0	0.0	100
Surabaya City	Total area	3,329	10,558	1,215	2,718	9,241	7,969	35,030
	Ratio (%)	9.5	30.1	3.5	7.8	26.4	22.7	100

Source : City Planning Department, Municipality of Surabaya, "Land Use Map in Municipality of Surabaya, 1990

1.5.2 Traffic Conditions

1) Road

The road network in Surabaya consists of the following five (5) classes as shown in Fig. 1.5-1.

1. Toll road
2. National road
3. Provincial road
4. Municipal road
5. Other road

The total length of the road is 830 km in Surabaya as shown in Table 1.5-2. The asphalt paved roads occupies 78% of total length, and 63% of asphalt paved road is maintained in good condition.

Table 1.5-2 Length of Road Surface Types in Surabaya, 1990

Unit: km

Road Types	Road Length	Percentage (%)
Material types of road		
Asphalt	648.38	78.1
Stone	9.76	1.2
Soil	171.88	20.7
Total	830.02	100.0
Surface conditions of asphalt roads		
Good	407.68	62.9
Moderte	220.18	34.0
Damage	17.25	2.7
Seriously Damage	3.27	0.5
Total	648.38	100.0

Source: Surabaya Dalam Angka, Kantor Statistik, Kotamadya Surabaya, 1990

There are four public bus terminals in Surabaya which is used for the inter-city and the long distance person trip as follows:

- Joyoboyo Station (for inter-city and long distance)
- Jembatan Merah Station (for inter-city and long distance)
- Bratang Station (for inter-city)
- Surabaya Station (for night bus, long distance and inter-city, opened 1991)

Number of passengers who utilized the bus terminals except Surabaya Station is shown in Table 1.5-3.

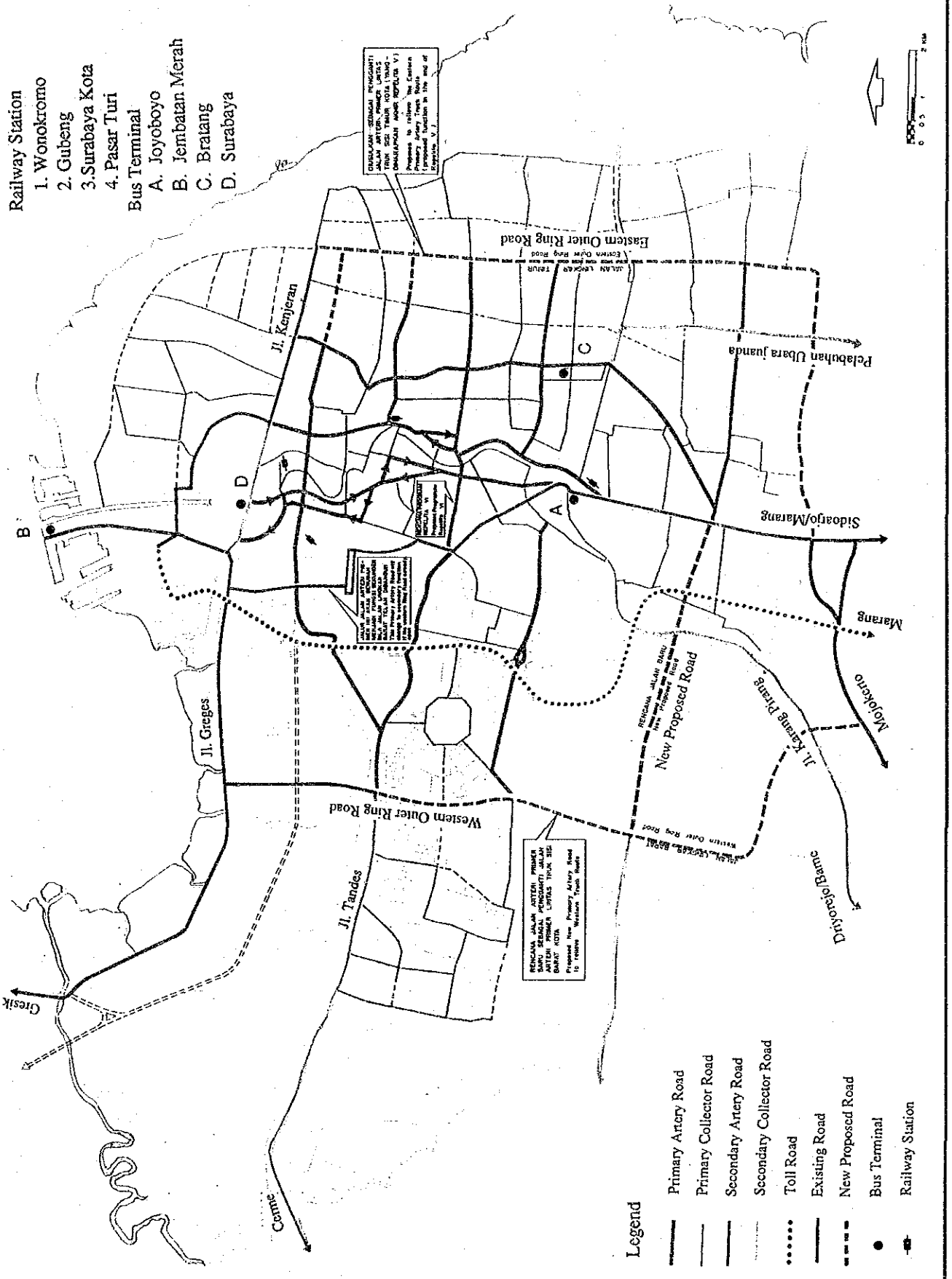

FIG. 1.5-1 ROAD NETWORK IN SURABAYA

THE STUDY ON THE SOLID WASTE MANAGEMENT IMPROVEMENT FOR SURABAYA CITY

Table 1.5-3 Number of Arrival and Departure of Bus and Passenger, 1986-1990

Unit: 1,000 trips

Station Name	Year	Vehicle		Passenger	
		Arrival	Departure	Arrival	Departure
Joyoboyo Bus Station	1986	6,689	6,099	49,526	53,347
	1987	6,002	6,008	51,688	69,902
	1988	6,229	6,319	46,022	64,874
	1989	6,940	6,943	49,446	70,135
	1990	7,062	7,064	51,954	71,998
Jembatan Merah Bus Station	1986	3,266	3,271	25,422	28,017
	1987	3,570	3,606	32,385	36,525
	1988	3,579	3,679	32,524	33,340
	1989	3,776	3,776	24,649	31,794
	1990	3,760	3,761	23,511	30,887
Bratang Bus Station	1986	632	662	4,332	5,507
	1987	680	717	4,356	7,447
	1988	685	801	4,277	7,309
	1989	808	816	4,926	7,514
	1990	743	749	4,596	6,990
Total	1986	10,587	10,032	79,280	86,871
	1987	10,252	10,331	88,429	113,874
	1988	10,493	10,799	82,823	105,523
	1989	11,524	11,535	79,021	109,443
	1990	11,565	11,574	80,061	109,875

Source: Surabaya Dalam Angka, Kantor Statistik, Kotamadya, 1990

The fluctuation pattern of road traffics depends on the operation hours of offices, markets, and commercial areas. The pattern is described as follows:

1. The maximum peaks of the most roads (Particularly of the arterials leading to the city center) appear during 7 a.m. to 8 a.m. The next peak appears around 4 to 6 p.m. The worst traffic peak occurs at Saturday midday of the week when both governmental sectors and business sectors finish their daily work at the same time, and the traffics from the both sectors are combined with the shopping traffics.

2. One-way road links generally have only one major peak in a day. The time and the magnitude of the peak depends on the function of the road and the traffic flow direction.

3. The average peak hour traffic is considered to be 8.3% of daily traffics.

An index to describe the traffic congestion is defined by the rate of actual traffic volume to the capacity of the road: it is called as the congestion ratio. The ratio was presented in the study of "A Transportation Strategy for Surabaya 1990-2000" for 116 points in the road network of the central business district in Surabaya. The peak traffic volume of 25 points proved exceeding the congestion ratio of 0.9 that means a

critical point over which a traffic jam may happen. The location of the congested road is shown in Fig. 1.5-2. Most cases of traffic congestion are caused by parking vehicles, roadside trading, Bus/Bemo stop and U-turn vehicles besides excessive vehicle concentration.

2) Railway

There are three trunk railway lines coming to Surabaya. These lines are named Northern Line, Southern Line and Eastern Line as shown in Fig. 1.5-3.

There are four railway stations for passenger and three for freight. Number of passenger and weight of freight are recorded at these stations as shown in Table 1.5-4 and 1.5-5.

Table 1.5-4 Number of Railway Passenger in Surabaya (1986-1990)

Unit: 1,000 trips/y

Station Name / Year	SBY Kota	Pasar Turi	Gubeng	Wonokromo	Total
1986	609	479	634	629	2,352
1987	576	577	642	653	2,449
1988	612	685	611	634	2,542
1989	646	627	638	668	2,579
1990	683	626	723	711	2,742

Source: Surabaya Dalam Angka, Kantor Statistik, Kotamadya Surabaya, 1990

Table 1.5-5 Amount of Railway Freight Handled in Surabaya (1986-1990)

Unit: 1,000 ton/y

Station Name	Pasar Turi		Kalimas		Benteng		Total	
Year	Inward	Outward	Inward	Outward	Inward	Outward	Inward	Outward
1986	64	53	81	229	1	572	145	854
1987	45	57	76	282	2	627	124	967
1988	64	82	49	252	1	621	114	954
1989	117	141	26	272	3	742	146	1,551
1990	102	127	36	185	1	745	140	1,057

Source: Surabaya Dalam Angka, Kantor Statistik, Kotamadya Surabaya, 1990

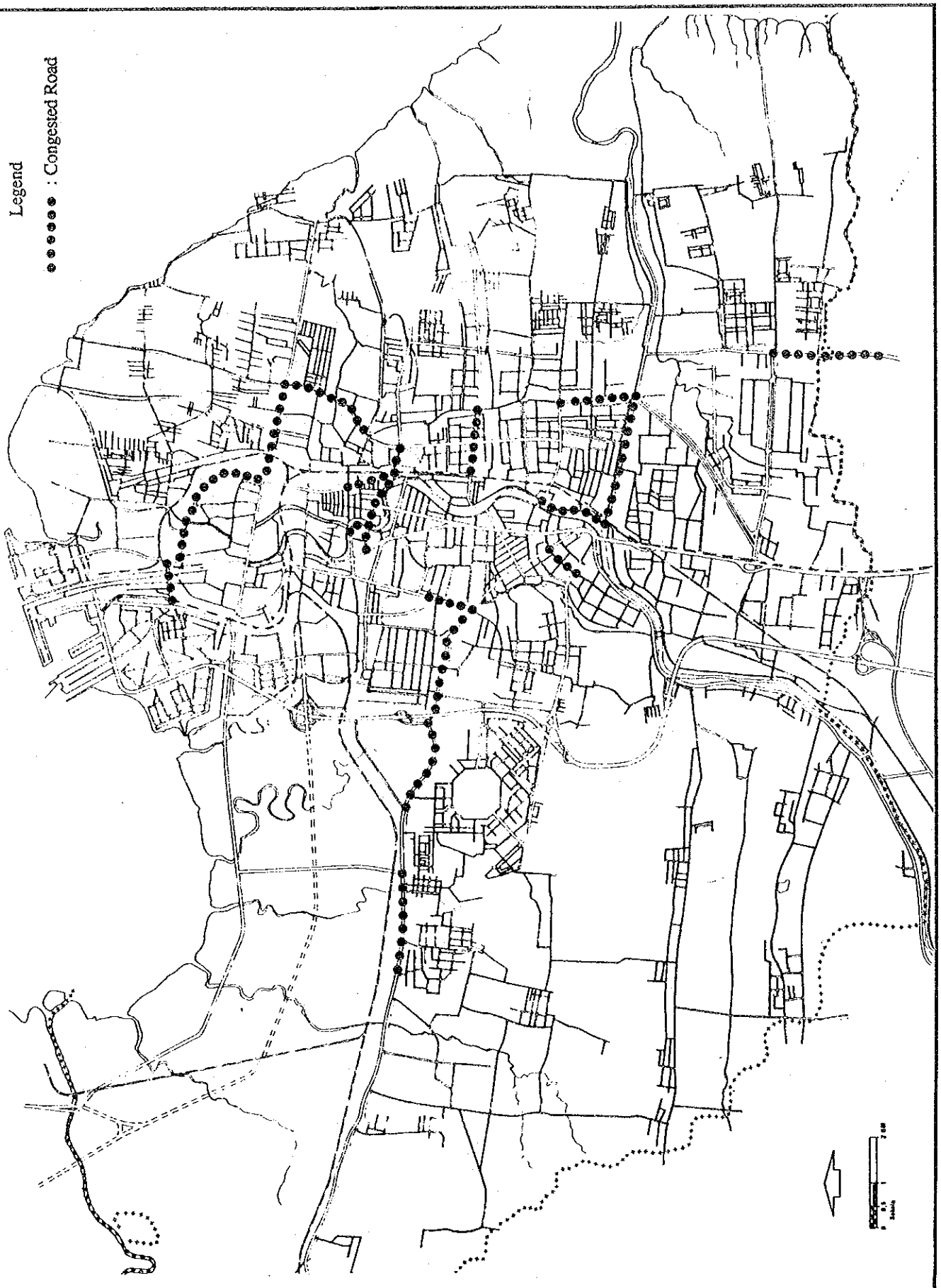

FIG. 1.5-2 LOCATION OF CONGESTED ROAD AT PEAK HOURS

THE STUDY ON THE SOLID WASTE MANAGEMENT IMPROVEMENT FOR SURABAYA CITY

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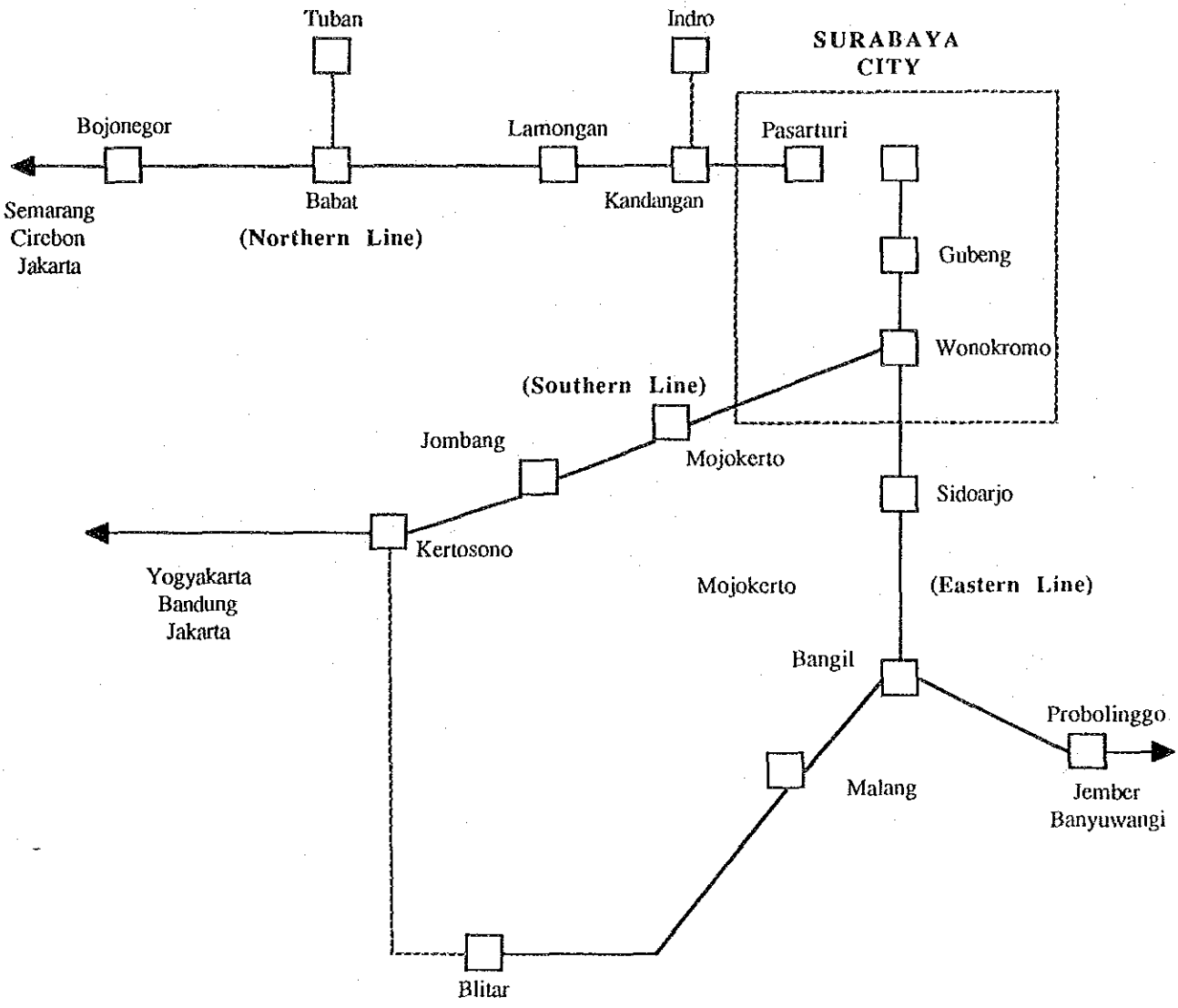

FIG. 1-5-3 SCHEMATIC RAILWAY LINES IN EAST JAVA

3) Intra-city Public Transport

The present intra-city public transport system consists of Damri Buses, Bemos and Becaks. The share of each mode are presented in Table 1.5-6. The total passenger trips was counted at 657 thousand per day in the city, and it exceeded the number of the average inter-city passenger trips of 528 thousand per day (Bus 520,000 Trips/day + Railway 8,000 trips/day).

Buses are operated by a semi-governmental enterprise, Damri, through north-south trunk lines with many prescribed bus stops.

Bemo operates among 26 fixed terminals which are located in the peripheral area of the city. The routes of Bemo are fixed but no prescribed stations are installed. The Bemo is operated by private companies.

Becaks serve almost all the urbanized area including those area where it is hard to utilize Bus/Bemo system.

Table 1.5-6 Passenger Trips by Public Transport in Surabaya

Public Transport Type	Total No. of Vehicles	Seats per Vehicle	Daily Vehicle Trips	Daily Person Trips
City Buses	231	48/54	2,139	110,061
Bemos	3,050	10	24,400	417,444
Becaks	39,801	2	199,005	129,353
Total	43,083		225,544	656,858

Source: A Transportation Strategy for Surabaya 1990-2000, CIPTA KARYA, 1991

1.6 Organization of Surabaya Municipal governent

The organizational structure of Surabaya Municipal Government (KMS) is shown in Fig. 1.6-1. There aare 16 Department carrying out development and public service affairs in Surabaya Municipality; one of which is CLEANSING Department. At municipal level, administrative affairs are done by the Municipal Secretariat, of which the organizational structure is shown in Fig. 1.6-2.

KMS has 8,985 employees in total as of the end of 1991. this figure includes employees working at 19 District offices and 163 sub-District offices. the breakdonw of the total employees is shown in the following table.

Table 1.6-1 Number of Employees in KMS

No.	Type of Employee	Sub-Total	Total
1	Employees of Central Government temporarily dispatched to KMS:		985
	a. Permanent Civil Servant	984	
	b. Candidate Civil Servant	1	
2	Employees of Central Government permanently staying at KMS:		844
	a. Permanent Civil Servant	840	
	b. Candidate Civil Servant	4	
3	Pure Employees of KMS:		6,002
	a. Permanent Civil Servant	5,881	
	b. Candidate Civil Servant	121	
4	Honorarium Employees of KMS:	843	843
5	Honorarium Army in charge of KMS	311	311
	GRAND TOTAL	**8,985**	**8,985**

Since 1991, in parallel with the development progress f Surabaya City, the Major has been assisted by 5 Assistants, 19 *Camat*(Chief of *Kecamatan*/District), and 163 ILurah (Chief of *Kelurahan*/Sub-District). Each Assistant to Mayor is responsible for one *Rayon* (administrative working area comprising several districts). In addition, every sub-District has minimum 3 non-administrative community units called RW [*Rukun Warga*], and every RW is divided into minimum 3 neighborhood units named RT [*Rukun Tetanga*]. Generally, one RT comprises maximum 75 households. The totalnumber of RW and RT in surabaya Municipality is 1,224 and 7,711 respectively.

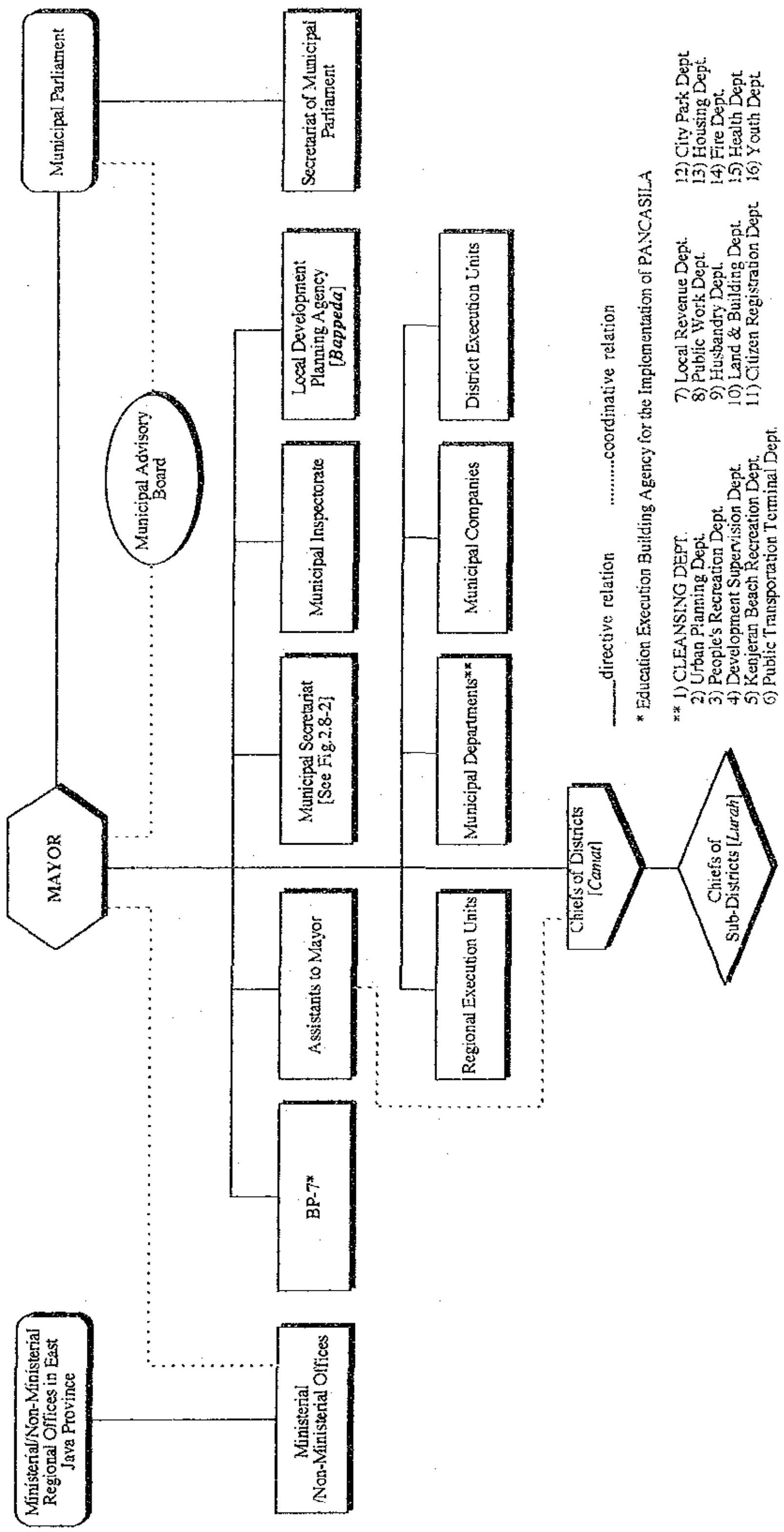

FIG. 1.6-1 ORGANIZATIONAL STRUCTURE OF SURABAYA MUNICIPAL GOVERNMENT

THE STUDY ON THE SOLID WASTE MANAGEMENT IMPROVEMENT FOR SURABAYA CITY

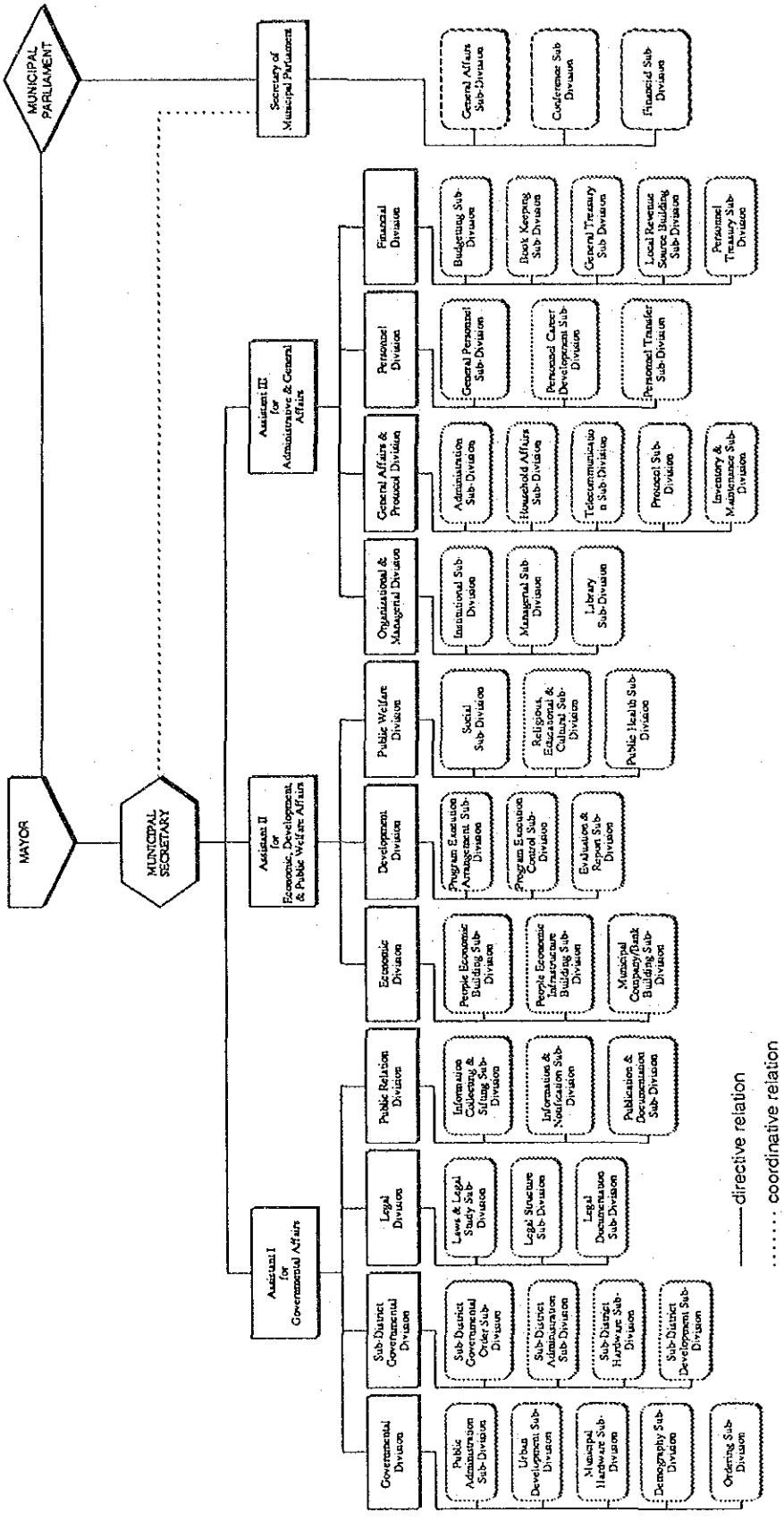

FIG. 1.6-2 ORGANIZATIONAL STRUCTURE OF SURABAYA MUNICIPAL SECRETARIAT

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CHAPTER 2.

EXISTING SOLID WASTE MANAGEMENT CONDITIONS IN SURABAYA

CHAPTER 2. EXISTING SOLID WASTE MANAGEMENT CONDITIONS IN SURABAYA

2.1 Present Situation of Waste Amount

2.1.1 Introduction

Per Capita Waste Discharge Survey and Disposed Amount Survey (Truck Count Survey and Truck Weight survey at final disposal site) were conducted to grasp the present situation of waste amount at collection process and at final disposal site of Surabaya City. These fundamental surveys were conducted twice in the study period which specified as rainy season (March, 1992) and dry season (May, 1992), in order to examine seasonal change of waste amount.

The purpose of each survey are described as follows:
Per Capita Waste Discharge Survey

- To grasp per capita waste amount discharged at residential, market and commercial area.

Waste Amount Survey (at final disposal site)

- To grasp present volume and weight of waste disposed at the final disposal site.

2.1.2 Estimated Waste Amount at Collection Process

In order to estimate present waste amount at collection process, Per Capita Waste Discharge Amount are obtained by the survey at the selected Depo/LPS of the study area. The survey are executed at each represented location of these following classified groups.

- High income residential area	1 point
- Middle income residential area	1 point
- Low income residential area	1 point
- Market	5 points
- Commercial area	4 points
- Total	12 points

The selected points that represent above mentioned group are listed at Table 2.1-1 and shown in Figure 2.1-1.

Table 2.1-1 List of Survey Points of Per Capita Waste Discharge

No.	Land Use Type	Kelurahan	Kecamatan	Name of Survey Point
I	RESIDENTIAL			
1	Depo Manyar (High Income)	Manyar Sabrangan	Sukolilo	Jl. Manyar Kertoarjo Indah Jl. Manyar Kertoarjo I Jl. Manyar Kertoarjo II
2	Depo Kangean (Middle Income)	Gubeng	Gubeng	Jl. Gubeng Kertajaya I, IA, IB, IDKA, ID Jl. Gubeng Kertajaya IIIA, IIIB, IIIC, IIIF
3	Depo Kintamani (Low Income)	Wonokromo	Wonokromo	Jl. Karang Rejo IV, VI, VIB, IX Jl. Karang Rejo X, XIII, XIV Jl. Pulo Wonokromo
II	MARKET	Wonorejo	Tegalsari	Pasar Kupang
		Ampel	Semampir	Pasar Pegirian
		Jagir	Wonokromo	Pasar Wonokromo
		Keputran	Tegalsari	Pasar Keputran
		Bubutan	Bubutan	Wijaya Shopping Centre
III	COMMERCIAL	Alon-alon Contong	Bubutan	Jl. Baliwerti, Gembongan, Praban
		Genteng	Genteng	Jl. Genteng Besar
		Kapasari	Genteng	Jl. Kalianyar
		Bongkaran	Pabean Cantikan	Jl. Slompretan

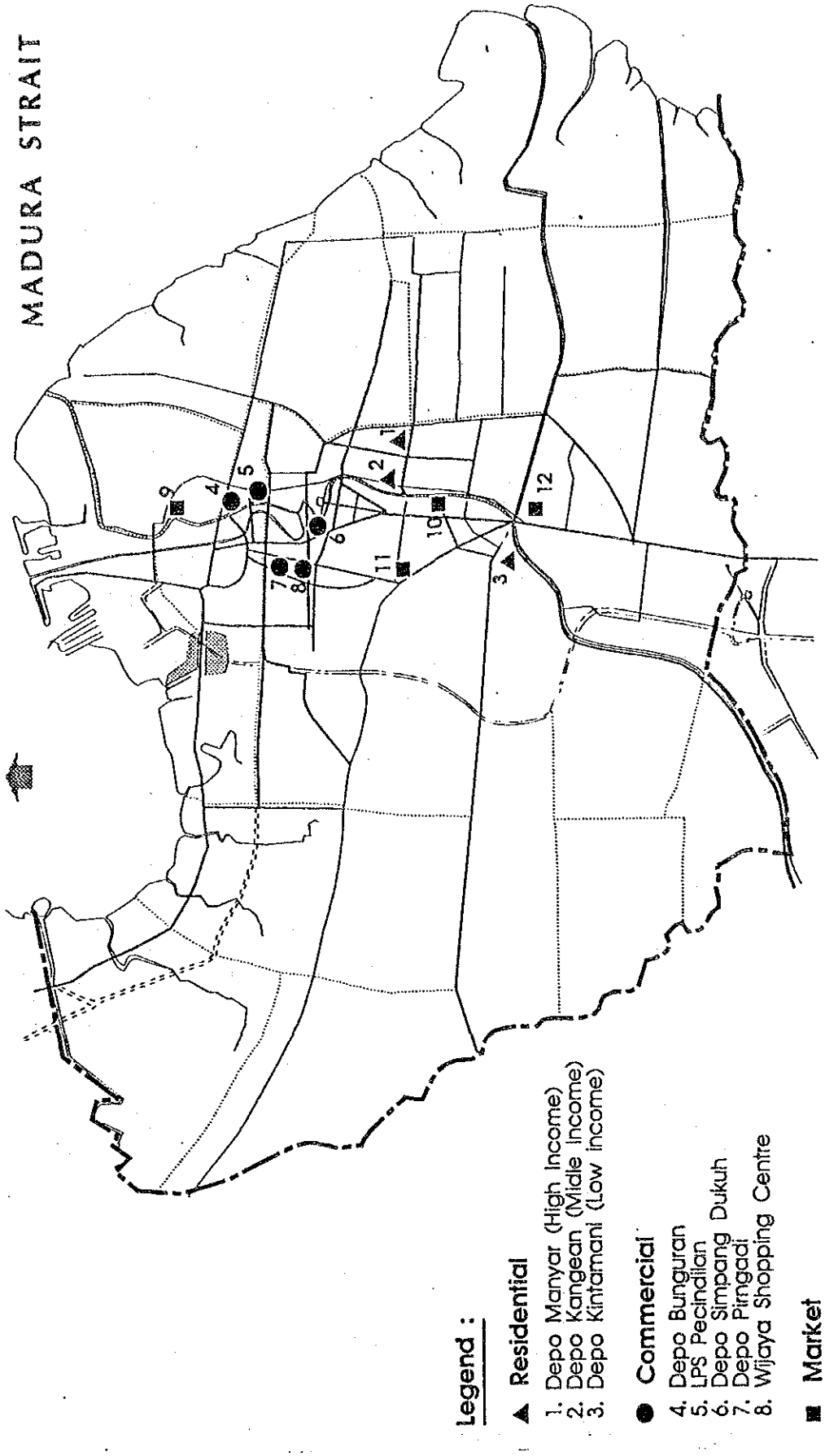


FIG. 2.1-1 LOCATION OF SURVEY POINTS FOR PER CAPITA WASTE DISCHARGE

THE STUDY ON THE SOLID WASTE MANAGEMENT IMPROVEMENT FOR SURABAYA CITY

1) Domestic Waste

According to the level of household, residential area is classified into three (3) classes as High, Middle and Low by referring to the output of "Household Survey Analysis" of IUIDP Report. Per capita waste discharge amount are obtained for each level as described in the following section.

a. Per Capita Waste Discharge Amount

Survey result of per capita waste discharge amount is shown in Table below.

Table 2.1-2 Survey Result of Per Capita Waste Discharge Amount

	Weight (kg/cap/day)		Volume (liter/cap/day)	
	Rainy Season	Dry Season	Rainy Season	Dry Season
High	0.83	0.72	4.35	2.86
Middle	0.77	0.60	2.60	2.49
Low	0.48	0.40	1.43	1.24
Average	0.50	0.45	1.6	1.5

Note: Average is assumed considering the composition of high, middle and low classes is 5%, 10% and 85% respectively.

b. Estimated Domestic Waste Amount

According to the result of per capita waste discharge survey, the waste discharge in residential area is estimated as shown in Table 2.1-3.

Table 2.1-3 Estimated Domestic Waste Amount

Year	Registered Population (1,000 person)	Weight (ton/day)		Volume (m^3/day)	
		Rainy Season	Dry Season	Rainy Season	Dry Season
1990	2,250	1,125	1,012	3,600	3,375
1992	(+3.7%)	1,168	1,048	3,733	3,500

Note: Increment of registered population is assumed at 3.7% by referring to the increment rate of census population between 1990 and 1992.

c. Waste Density

Waste density of residential area are calculated as follows :

Waste Density (ton/m^3) = Total Weight (ton/day) / Total Volume (m^3/day)

Table 2.1-4 Domestic Waste Density of Handcart Measure

	Total Weight (1)	Total Volume (2)	Waste Density (1)/(2)
Rainy Season	1,168	3,733	0.312
Dry Season	1,048	3,500	0.299

2) Market Waste

a. Unit Waste Discharge Amount

Five (5) represented markets were selected for per capita discharge amount survey. Results of the survey is shown in following table. These five (5) markets have different location, scale, and article for sale, therefore, the area (square meter), which is common unit for each market, was used as the parameter for calculating the unit waste discharge amount of the market.

Table 2.1-5 Unit waste Discharge amount for Sampled market

	Name of Market	Area (m^2)	Weight (kg/m^2/day)		Volume (liter/m^2/day)	
			Rainy Season	Dry Season	Rainy Season	Dry Season
1.	Wijaya shopping center	10,000	0.06	0.02	0.29	0.17
2.	Pasar Keputran	17,157	1.44	1.03	4.08	4.22
3.	Pasar Pegirian	4,140	0.83	0.81	2.41	2.72
4.	Pasar Wonokromo	14,276	1.06	0.87	2.78	2.51
5.	Pasar Kupang	3,000	0.49	0.40	1.80	1.61

The unit waste discharge of market is represented by the average of intermediate values excluding the maximum and the minimum as shown below:

Rainy Season Weight = 0.93 kg/m^2/day
Volume = 2.64 liter/m^2/day

Dry Season Weight = 0.72 kg/m^2/day
Volume = 2.60 liter/m^2/day

b. Estimated Market Waste Amount

According to the data obtained from Market Department of municipal government of Surabaya, the total area of market in Surabaya City is 313,124.57 m^2 as of 1992. Therefore, market waste amount of whole Surabaya City is calculated as follows:

	Total Weight(ton/day)	Total Volume(m^3/day)
Rainy Season	291	827
Dry Season	225	814

c. Market Waste Amount by Area

Estimated market waste amount by 19 kecamatan is described in the Table below.

Table 2.1-6 Market Waste Amount by Area

Name of Kecamatan	Area (m^2)	Weight (ton/day) Rainy Season	Weight (ton/day) Dry Season	Volume (m^3/day) Rainy Season	Volume (m^3/day) Dry Season
Genteng	31,906.00	29.67	22.97	84.23	82.96
Tegalsari	14,741.50	13.71	10.61	38.92	38.33
Bubutan	3,599.00	3.35	2.59	9.50	9.36
Simokerto	13,306.00	12.37	9.58	35.13	34.60
Krembangan	6,647.00	6.18	4.79	17.55	17.28
Semampir	6,245.12	5.81	4.50	16.49	16.24
Pabean Cantikan	17,513.20	16.29	12.61	46.23	45.53
Kenjeran	4,300.00	4.00	3.10	11.35	11.18
Tambaksari	40,196.75	37.38	28.94	106.12	104.51
Gubeng	30,955.00	28.79	22.29	81.72	80.48
Sukolilo	5,171.00	4.81	3.72	13.65	13.44
Rungkut	4,338.00	4.03	3.12	11.45	11.28
Sawahan	14,809.00	13.77	10.66	39.10	38.50
Wonokromo	24,133.00	22.44	17.38	63.71	62.75
Wonocolo	14,002.00	13.02	10.08	36.97	36.41
Karang Pilang	11,921.00	11.09	8.58	31.47	30.99
Tandes	63,467.00	59.02	45.70	167.55	165.01
Lakarsantri	5,847.00	5.46	4.23	15.51	15.27
Total	**313,124.57**	**291.21**	**225.45**	**826.65**	**814.12**

Note: Market waste by area is calculated as following formula:
Weight or Volume = (Unit Weight or Unit Volume) x Area

	Rainy Season	Dry Season
Unit Weight	0.93 kg/m^2/day	0.72 kg/m^2/day
Unit Volume	2.64 liter/m^2/day	2.60 liter/m^2/day

d. Waste Density

Waste density of market is calculated as follows:

Waste Density (ton/m^3) = Total Weight (ton/day) / Total Volume (m^3/day)

	Total Weight (1)	Total Volume (2)	Waste Density (1)/(2)
Rainy Season	291	827	0.352
Dry Season	225	814	0.276

3) Commercial Waste

a. Unit Waste Discharge Amount

The survey are conducted at four (4) selected commercial area which represent those similar in Surabaya City. Result of the survey is summarized as shown in Table below.

Table 2.1-7 Unit Waste Discharge Amount for Sampled Commercial Area

Name of Area	Nos. of Shop	Weight (kg/shop/day)		Volume (liter/shop/day)		Type of Commercial
		Rainy Season	Dry Season	Rainy Season	Dry Season	
Jl. Slompretan						Office
Jl. Bongkaran	195	1.64	1.49	10.6	11.2	Textile shop
Jl. Baliwerti						Building Materials,
Jl Bubutan	129	2.07	1.61	13.4	12.6	Furniture shop
Jl. Kalianyar						Fruits shop
Jl. Kapasari	125	5.28	4.11	30.0	23.3	Restaurant
Jl. Genteng	70	5.95	5.59	31.4	30.9	Food shop

As shown in the Table 2.1-7, different commercial type and location are selected, therefore, weighted average is taken by the number of shop surveyed (total 519 shops). The result of average Unit waste discharge of commercial area is:

Rainy Season Weight = 3.20 kg/shop/day
Volume = 18.8 liter/shop/day

Dry Season Weight = 2.70 kg/shop/day
Volume = 17.1 liter/shop/day

b. Estimated Commercial Waste Amount

In order to grasp the total number of commercial shop in Surabaya City, a statistic book as of 1990 is referred to at first. The book shows the number of shops at 4,908 in 1990, whereas, it was recorded 9,090 shops in 1982. It is hard to believe that the number of shop has decreased for this decade in spite of economic growth. On the other hand, PDAM of Surabaya City has the number of shops whose water are supplied from this enterprise: the total number is 12,364 shops as of 1992. This figure seems more suitable than that given by the statistic book, therefore the number from PDAM is adopted for the estimation of total commercial waste discharge.

	Total Weight (ton/day)	Total Volume (m^3/day)
Rainy Season	40	232
Dry Season	33	212

c. Commercial Waste Amount by Area

To estimate the number of shop in each 19 kecamatan, population of each kecamatan are used to assign the total shop number for each Kecamatan. Waste amount by area is estimated according the number of shop as shown in Table below.

Table 2.1-8 Commercial Waste Amount by Area

	Weight (ton/day)		Volume (m^3/day)	
Name of Kecamatan	Rainy Season	Dry Season	Rainy Season	Dry Season
Genteng	1.20	1.01	6.95	6.38
Tegalsari	1.90	1.78	11.05	11.29
Bubutan	1.20	1.59	10.30	10.11
Simokerto	1.60	1.63	9.20	10.36
Krembangan	2.00	1.73	11.20	11.01
Semampir	2.70	2.29	15.60	14.51
Pabean Cantikan	1.45	1.37	8.30	8.67
Kenjeran	1.40	1.07	7.91	6.80
Tambaksari	3.03	2.86	17.70	18.16
Gubeng	2.53	2.12	14.70	13.48
Sukolilo	2.40	1.58	13.90	10.03
Rungkut	2.80	1.56	16.24	9.89
Sawahan	3.40	2.99	19.60	18.97
Wonokromo	2.80	2.56	16.10	16.27
Wonocolo	2.30	1.73	13.20	10.95
Karang Pilang	2.30	1.71	13.13	10.85
Tandes	3.20	2.51	18.40	15.93
Benowo	0.60	0.47	3.36	2.99
Lakarsantri	1.00	0.81	5.36	5.16
Total	39.81	33.37	232.20	211.81

d. Waste Density

Waste density of commercial waste is calculated as follows :

Waste Density (ton/m^3) = Total Weight (ton/day) / Total Volume (m^3/day)

	Total Weight (1)	Total Volume (2)	Waste Density (1)/(2)
Rainy Season	40	232	0.172
Dry Season	33	212	0.156

4) Estimated waste amount at collection process (Conclusion of Per Capita Waste Discharge Survey)

According to the result obtained in section a. to c. mentioned above, estimated waste amount at collection process are summarized as follows :

Table 2.1-9 Estimated Waste Amount at Collection Process

Type of Waste	Weight (ton/day)		Volume (m^3/day)	
	Rainy Season	Dry Season	Rainy Season	Dry Season
Domestic	1,168	1,048	3,773	3,500
Market	291	225	827	814
Commercial	40	33	232	212
Total	1,499	1,306	4,832	4,526

Average waste density is calculated as follows :

Waste Density (ton/m^3) = Total Weight (ton/day) / Total Volume (m^3/day)

	Total Weight (1)	Total Volume (2)	Waste Density (1)/(2)
Rainy Season	1,499	4,832	0.310
Dry Season	1,306	4,526	0.288

2.1-3 Estimated Waste Amount at Final Disposal Site

1) Basic Data Obtained at Final Disposal Site

To obtain the basic data at Final Disposal site, truck count survey and truck weight survey are conducted.

a. Count survey

Count survey is conducted to know the number of truck, the volume of waste carried and the origin of waste at three final disposal sites and incinerator simultaneously. The outline of survey is summarized as follows :

- Period
  12 March to 18 March (1 week) for rainy season.
  10 April to 16 April (1 week) as supplementary survey
  15 May to 22 May (1 week) for dry season

- Survey hours
  16 hours (7:00 am to 11:00 pm)

- Location surveyed
  Kenjeran, Lakarsantri, Keputih, and Incinerator (Keputih)

- Item surveyed
  Truck Number, Volume of waste carried by each vehicles, Waste origin.

b. Weight survey

Weight survey is conducted with a portable Truck Scale to measure the weight of waste loaded by each vehicle. 814 samples are collected by the rainy season survey and 894 samples by dry season survey.

The main contents of survey are summarized as below :

- Period
  21 March to 1 April for rainy season
  15 May to 23 May for dry season

- Survey Hours
  11 hours (7:00 am to 6:00 pm)

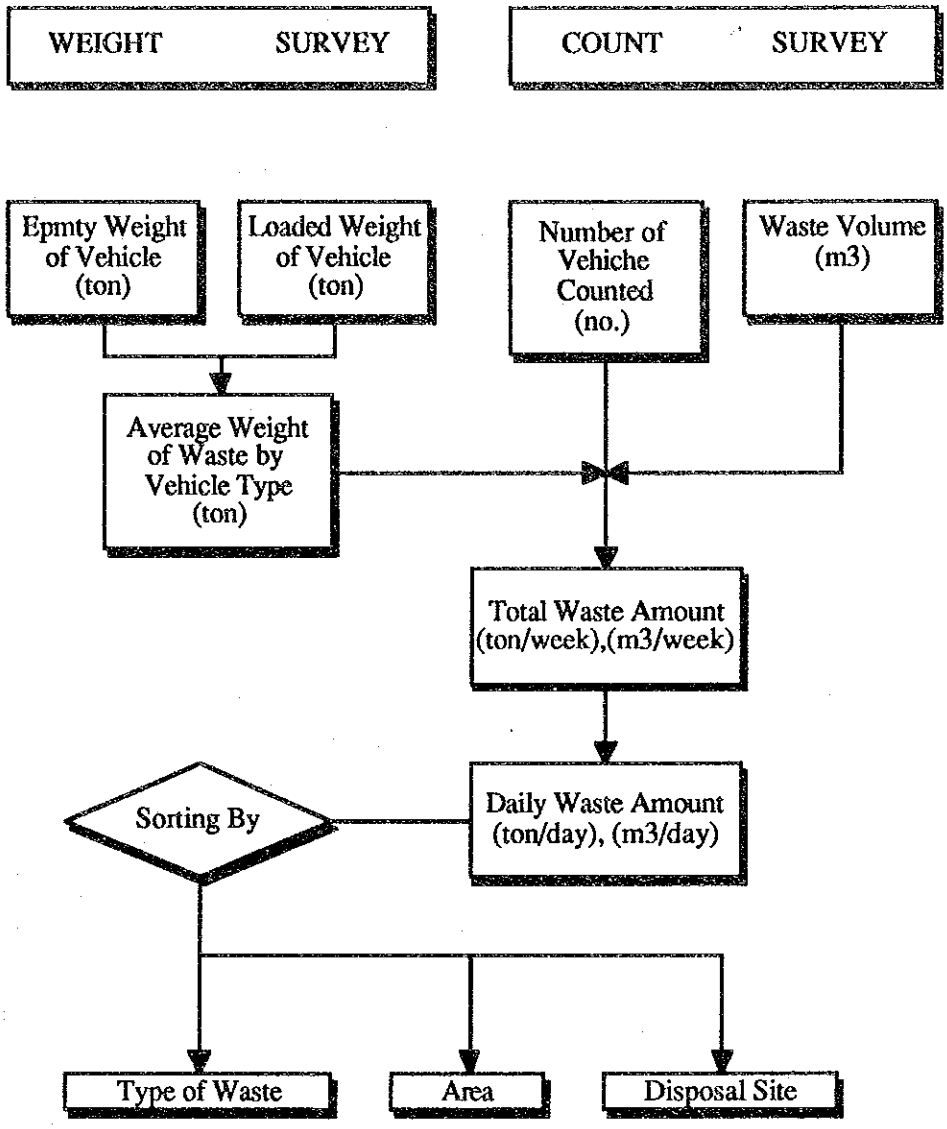
- Location surveyed
  Kenjeran and Lakarsantri

- Item surveyed
  Truck Number, Weight of waste loaded by each vehicle, Loading rate

c. Estimated Waste Amount at Final Disposal Site

Waste amount are estimated by the basic data obtained from the survey. Average loaded weights for 9 kinds of vehicles are calculated by the data of weight survey. These average load of waste are combined with the number of vehicles counted at each site. Thus, waste amount is estimated in weight. The flow chart of this estimation is shown in Figure 2.1-2.

Figure 2.1-2 Flow Chart of Estimation on Disposed Waste Amount



2) Waste Amount at Each Disposal Site

The total number of vehicle which recorded by the count survey are shown are shown in the Table below.

Table 2.1-10 Vehicle Number Arrived

(Rainy Season)

Date	Kenjeran	Keputih	Lakarsantri	Incinerator	Total
Mar-12	165	0	69	76	310
Mar-13	189	0	83	73	345
Mar-14	189	5	60	76	330
Mar-15	181	9	57	-	247
Mar-16	170	10	72	73	325
Mar-17	192	11	88	74	365
Mar-18	215	12	76	74	377
Total	1,301	47	505	446	2,299

(Dry Season)

Date	Kenjeran	Keputih	Lakarsantri	Incinerator	Total
May-15	175	35	71	55	336
May-17	136	68	66	-	270
May-18	168	35	68	53	324
May-19	148	51	68	54	321
May-20	142	49	81	59	331
May-21	138	58	64	59	319
May-22	131	61	63	58	313
Total	1,038	357	481	338	2,214

Based on the result of count survey and weight survey, waste amount brought and unloaded is estimated as shown in the Table below.

Table 2.1-11 Waste Amount Transported

Disposal Site	Weight (ton/day)		Volume (m^3/day)		Share of Site (%)	
	Rainy Season	Dry Season	Rainy Season	Dry Season	Rainy Season	Dry Season
Kenjeran	564	396	1,589	1,439	60	52
Lakarsantri	177	141	534	528	19	19
Keputih	7	98	22	390	1	13
(Subtotal of Landfill)	(748)	(635)	(2,145)	(2,357)	(80)	(84)
Incinerator	194	121	515	382	20	16
Total	942	756	2,660	2,739	100	100

Note : In rainy season, Keputih was closed due to the bad condition of entrance way

Waste Density is calculated as follows:
Waste Density (ton/m^3) = Total Weight (ton/day) / Total Volume (m^3/day)

	Total Weight (1)	Total Volume (2)	Waste Density (1)/(2)
Rainy Season	942	2,660	0.354
Dry Season	756	2,739	0.276

3) Waste Amount Sorted by Type of Waste

During count survey in April, waste origin were recorded for all vehicles which counted at each site. As a result, each origin of waste such as road, factory, public space, and others are identified. The item of "Others" should be derived from residence, market, and commercial area, therefore, waste amount of these items are estimated by results of consisting ratio of per capita waste discharge survey. The results are shown in the Table below.

Table 2.1-12 Waste Amount by Origin of Waste

Origin of Waste	Weight (ton/day) Rainy Season	Weight (ton/day) Dry Season	Volume (m^3/day) Rainy Season	Volume (m^3/day) Dry Season
Residence	638.7	548.3	1,731.0	1,966.1
Market	154.2	109.9	416.0	394.2
Commercial	16.1	16.2	44.0	58.0
Road*	106.0	46.5	328.0	155.4
Factory	17.0	31.1	98.0	140.6
Public Space	10.0	3.6	43.0	24.4
Total	942.0	755.6	2,660.0	2,738.7

*Note: Item "Road" includes the waste generated at roadside office buildings and households.

5) Waste Amount by Disposal Site

The Table 2.1-13 indicates waste amount of each origin according to Disposal Site.

Table 2.1-13 (1) Waste Amount by Disposal Site (Rainy Season)

Weight (Rainy Season)

Final Disposal Site	Residential	Market	Commercial	Road*	Factory	Public Space	Total (ton/day)
Kenjeran	409.5	99.0	10.0	28.0	8.0	9.5	564.0
Lakarsantri	125.5	30.0	3.0	15.0	3.0	0.5	177.0
Keputih	0.7	0.2	0.1	0.0	6.0	0.0	7.0
Incinerator	103.0	25.0	3.0	63.0	0.0	0.0	194.0
TOTAL	638.7	154.2	16.1	106.0	17.0	10.0	942.0

Volume (Rainy Season)

Final Disposal Site	Residential	Market	Commercial	Road*	Factory	Public Space	Total (m3/day)
Kenjeran	1,111.0	267.0	28.0	90.0	51.0	42.0	1,589.0
Lakarsantri	359.0	86.0	9.0	53.0	26.0	1.0	534.0
Keputih	0.8	0.2	0.0	0.0	21.0	0.0	22.0
Incinerator	260.0	63.0	7.0	185.0	0.0	0.0	515.0
TOTAL	1,730.8	416.2	44.0	328.0	98.0	43.0	2,660.0

Table 2.1-13 (2) Waste Amount by Disposal Site (Dry Season)

Weight (Dry Season)

Final Disposal Site	Residential	Market	Commercial	Road*	Factory	Public Space	Total (ton/day)
Kenjeran	305.6	61.3	9.0	8.3	8.6	2.7	395.5
Lakarsantri	99.4	19.9	2.9	11.4	7.2	0.2	141.0
Keputih	66.3	13.3	2.0	0.5	15.3	0.6	98.0
Incinerator	77.2	15.5	2.3	26.3	0.0	0.0	121.3
TOTAL	548.5	109.9	16.2	46.5	31.1	3.6	755.8

Volume (Dry Season)

Final Disposal Site	Residential	Market	Commercial	Road*	Factory	Public Space	Total (m3/day)
Kenjeran	1,102.0	220.9	32.5	25.4	36.9	20.7	1,438.4
Lakarsantri	364.1	73.0	10.7	41.7	38.0	0.9	528.4
Keputih	259.9	52.1	7.7	1.4	65.7	2.9	389.7
Incinerator	240.1	48.2	7.1	86.9	0.0	0.0	382.3
TOTAL	1,966.1	394.2	58.0	155.4	140.6	24.5	2,738.8

*Note: Item "Road" includes the waste generated at roadside office buildings and households.

6) Waste Amount by Area

Waste amount by area is estimated as shown in the Table 2.1-14 and Table 2.1-15.

Table 2.1-14 Waste Amount by Area (Rainy Season)

Kecamatan	Weight (ton/day)	Volume (m^3/day)
Genteng	40.8	118.1
Tegalsari	43.8	121.0
Bubutan	62.8	173.1
Simokerto	28.4	81.9
Krembangan	42.6	119.4
Semampir	52.0	142.6
Pabean Cantikan	54.0	152.9
Kenjeran	25.9	80.4
Tambaksari	74.2	203.0
Gubeng	112.0	309.2
Sukolilo	54.8	154.0
Rungkut	51.9	149.3
Sawahan	60.0	165.7
Wonokromo	66.8	186.7
Wonocolo	41.8	124.7
Karangpilang	61.5	190.3
Tandes	58.1	157.1
Benowo	3.2	9.9
Lakarsantri	7.4	20.7
TOTAL	942.0	2,660.0

Table 2.1-15 Waste Amount by Area (Dry Season)

Kecamatan	Weight (ton/day)	Volume (m^3/day)
Genteng	21.3	95.9
Tegalsari	56.9	199.1
Bubutan	44.3	167.4
Simokerto	47.0	154.4
Krembangan	24.0	86.3
Semampir	41.8	146.7
Pabean Cantikan	49.2	171.0
Kenjeran	8.3	34.9
Tambaksari	48.2	194.6
Gubeng	84.7	303.0
Sukolilo	25.8	98.0
Rungkut	60.9	214.0
Sawahan	46.6	142.6
Wonokromo	73.3	260.6
Wonocolo	23.6	86.7
Karangpilang	42.5	170.3
Tandes	42.7	159.4
Benowo	8.1	33.0
Lakarsantri	6.6	20.9
TOTAL	755.8	2,738.8

7) Waste Disposed to the Final Disposal Site during Non-surveyed Hours

The vehicle count survey was conducted for one week by 16 hours (7:00 to 23:00), however, the vehicles arrived at the final disposal site during the remaining 8 hours (23:00 to 7:00) were not recognized.

Considering the result of interview to some specific generation sources, following two kinds of vehicles were supposed to arrive at the final disposal site in midnight hours or early morning, one was the vehicle from port area and the other was KMS vehicle that worked in two shift system.

To estimate the total waste amount arrived at the final disposal sites, these two sources of vehicle are considered to be the additional vehicles to the observed ones.

a. Waste from Port Area

As described in section **4),a.,(2),(v)**, the waste amount of port area is estimated at 42 ton/day and the trip number of vehicle is estimated at 10 times a day. Out of 10 trips a day only two vehicles were observed in the count survey in average. Remaining eight trips were supposed to arrive at the final disposal site during the non-surveyed hours or other place. The amount of waste that arrived during not counted time is estimated at about 17 ton/day as 40 % of 42 ton/day carried by the whole 10 trips.

b. Waste carried by KMS vehicle

In order to estimate the number of vehicle arrived at the final disposal sites during the non-surveyed hours, vehicle operation record was prepared at the workshop of KMS in Asemrowo.

Based on the operation record and interview survey, following three facts were found.

- Average number of trip to the final disposal site is about 6 trips a day.
- Eight (8) vehicles are operated in two shift system.
- Trip number of two shift vehicles is 10 to 15 times a day, namely 12.5 in average.

The result of the count survey for the vehicles designated to work in two shift system is shown in Table below.

Table 2.1-16 Observed Trip Number of Designated 2 Shift Vehicle

Plate No.	Observed Trip Number (Trips/day)							(trips/week)	Average (trips/day)
9653	5	-	-	7	5	6	6	29	5.80
9656	**8**	**5**	**10**	**7**	**8**	**5**	**6**	**49**	**7.00**
9657	**12**	**6**	**11**	**11**	**13**	**10**	**12**	**75**	**10.71**
9670	**12**	**8**	**12**	**13**	**10**	**11**	**11**	**77**	**11.00**
9687	**14**	**19**	**7**	**8**	**16**	**10**	**18**	**92**	**13.14**
9688	**10**	**9**	**10**	**8**	**7**	**7**	**7**	**58**	**8.29**
9692	4	2	4	5	4	3	3	25	3.57
9693	4	1	6	5	4	3	3	26	3.71

According to the observed trip number, it can be thought that only five vehicles (9656, 9657, 9670, 9687, 9688) are actually operated in two shift system. Assuming that average trip number of two shift vehicles is 7.0 or 12.5, the number of vehicles arrived from 23:00 to 7:00 is estimated at about 21 trips a day as shown in Table below.

Table 2.1-17 Presumed Trip Number during Non-Survey Hours

Plate No.	Observed Trip Number from 7:00 to 23:00 (trips/day)	Presumed Trip Number from 23:00 to 7:00 (trips/day)	Total Trips (trips/day)
9653	5.80	1.2	7.0
9656	7.00	5.5	12.5
9657	10.71	1.3	12.5
9670	11.00	1.5	12.5
9687	13.14	0	12.5
9688	8.29	4.2	12.5
9692	3.57	3.4	7.0
9693	3.71	3.3	7.0
Total		20.4 = 21	-

The weight of waste carried by 21 vehicles mentioned above can be estimated by using, average weight per vehicle as shown in Table 2.1-18 because these 21 vehicles are not identified their types.

Table 2.1-18 Average Loaded Weight per Truck

Survey Time	Total weight	Number of vehicle	Average weight
Rainy Season	942 ton/day	328 truck/day	2.9 ton/truck
Dry Season	756 ton/day	316 truck/day	2.4 ton/truck
	Average weight per truck		**2.65 ton/truck**

As a conclusion, the waste amount is estimated at 55 ton/day.

c. Total Amount Delivered during Non-Surveyed Hours

Total amount of the waste delivered to the final disposal site during non-surveyed hours is estimated as follows:

Highrise Office Building	6 ton/day
Waste from Port Area	17 ton/day
Waste by KMS 2 Shift Vehicles	55 ton/day
Total	78 ton/day

2.1.4 Present Situation

1) Amount of Generation and Treatment

Based on the result of the survey described in Section 2) and 3), the present situation of waste amount is examined by following 3 stages, namely Summary of sources, identification of specific sources, and Summary of treatment.

a. Summary of Sources

Result of per capita waste discharge survey is used for estimating household, market, and commercial waste amount. The remaining waste from hotels, highrise office buildings, street, factory, public space, medical facilities and port facilities are estimated by the result of waste amount survey at the final disposal site and the interview survey to the generators.

The result of estimation are summarized in Table below:

Table 2.1-19 Amount of Source

	Source Item	Amount (ton/day) Rainy Season	Dry Season	Source Data
1	Household	1,168	1,048	Per capita survey
2	Market	291	225	Per capita survey
3.1	Commercial	40	33	Per capita survey
3.2	Hotel	21	21	Hearing
3.3	Highrise Office Building	11	11	Hearing
4	Street	106	46	Amount survey at disposal site
5	Factory	79	93	Amount survey at disposal site
6	Public Space	10	4	Amount survey at disposal site
7	Medical	5	5	Health Dept. KMS
8	Port Waste	17	17	Hearing
	Total Generate	1,748	1,503	

b. Identification of Specific Sources

There are 6 kinds of waste sources identified that correspond to each specific collection activity. Each kind of waste is estimated as follows :

i) Waste Not Collected

Concerning the waste collection rate for each kecamatan, the figure is reported in "Answers Explanation of Questionnaire for ADIPURA 1992". Based on the report, collection rate of household waste is calculated totally at around 77.5%.

Table 2.1-20 Estimate of Non-collected Household Waste

Waste Source	Generated Amount	Collection Rate (Ave.)	Collected Amount	Non Collected
Household	1,168 (Rainy)	77.5%	905	263
	1,048 (Dry)	77.5%	812	236

ii) Collected at Depo/LPS

Waste collected at Depo/LPS is classified into four waste sources which are households, market, commercial and hotels. Waste origin is recorded for each vehicles in the waste amount survey at final disposal sites. Waste discharged from hotels is also collected at Depo/LPS, however, the waste was not identified through the waste amount survey because it was completely mixed with the other wastes and was impossible to discriminate

from the others. Therefore the amount of waste from hotels is estimated by hearing survey conducted independently at around 21 ton/day in total.
Summary of incoming waste amount at Depo/LPS is shown in Table below.

Table 2.1-21 Estimate of Incoming Waste at Depo/LPS

(unit: ton/day)

Source	Rainy Season	Dry Season	Average
Household (survey time)	(639)	(548)	(594)
Household (midnight)	(55)	(55)	(55)
Household (subtotal)	694	603	649
Market	154	110	132
Commercial	16	16	16
Hotels	21	21	21
Factories	2	2	2
Total	887	752	820

Outgoing waste from Depo/LPS is summarized as shown in Table below.

Table 2.1-22 Estimate of Outgoing Waste from Depo/LPS

(unit: ton/day)

Destination	Rainy Season	Dry Season	Average*
Landfill Site	737	638	695
Incinerator	126	90	101
Recycle	19	19	19
Unauthorized Disposal	5	5	5
Total	887	752	820

*: not equal to the mean value of Rainy and Dry season because the amount of incineration is estimated at 150 ton/day independently.

iii) Medical Waste

According to the result of hearing at Health Dept. of KMS, medical facilities generate the waste of 5 ton/day in average. All medical wastes are carried directly to the incinerator by using the exclusive containers since June, 1992.

iv) Waste Discharged at Major Commercial Building

Since the waste is mixed with road waste, the waste amount survey could not identify the waste from office buildings. In order to grasp the amount of waste discharged at major office building, a hearing survey was conducted for several multistoried buildings. As a

result it was found the discharged waste is carried directly to the final disposal site and its amount is estimated at about 11 ton/day.

v) Waste Discharged form Port Area

Waste collection in the Port Area (Northern part of Surabaya City) is not undertaken by KMS. General Enterprise of III Port of Tanjung Perak Branch Office is the responsible agency to manage port area including waste collection service. The Office entrusts the waste collection in the area to a private company. This collection is not carried out by KMS, but the amount of waste discharged at port area should be considered in this study since the waste is brought into the final disposal site managed by KMS.

According to the data from the agency, total amount of waste is estimated at 42 ton/day in average and 60 % of total amount is regarded as the waste discharged from households. Therefore, the waste discharged from the Port Area is estimated as follows:

Household Waste	25 ton/day
Harbor Waste	17 ton/day
Total	42 ton/day

c. Summary of Treatment

i) Incinerator

As shown in the Table 2.1-11 the disposed amount at incinerator is calculated at 194 ton/day in rainy season and 121 ton/day in dry season.

ii) Disposal

The amount of incoming waste to landfill sites is estimated at 835 ton/day in rainy season and 721 ton/day in dry season as shown in Table below.

Table 2.1-23 Estimate of Incoming Waste at Landfill Site

(unit: ton/day)

Sources	Rainy Season	Dry Season	Average*
Depo/LPS	737	638	695
Port (household)	(5)	(5)	(5)
Port (others)	(17)	(17)	(17)
Port (subtotal)	22	22	22
Street	43	20	32
Highrise Office	6	6	6
Factory	17	31	24
Public Space	10	4	7
Total	835	721	786

*: not equal to the mean value of Rainy and Dry season because the amount of incineration is estimated at 150 ton/day independently.

Consequently, total waste amount disposed at the final disposal site is 825 ton/day in rainy season and 711 ton/day in dry season and 776 ton/day in Average.

iii) Unauthorized Disposal

Count and hearing survey is conducted to the truck driver coming to the unauthorized disposal site near Asemrowo. According to the survey result, disposed waste amount at the site is estimated at approximately 90 ton/day.

iv) Recycling

Amount of recycling is estimated at 190 ton/day according to the hearing survey.

2) Balance of Solid Waste

Based on the amount examined hitherto, the balance of solid waste is assumed as shown in Fig. 2.1-3 to Fig. 2.1-5. The balance shows among the total generation of 1,748 ton/day in rainy season and 1,503 ton/day in dry season, 1,200 ton/day in rainy season and 1,020 ton/day in dry season are disposed soundly as shown in Table below.

Table 2.1-24 Waste Amount by Disposal Type

Item	Amount (ton/day)			Ratio (%)		
	Rainy Season	Dry Season	Average	Rainy Season	Dry Season	Average
Landfill	(825)	(711)	(776)	(47)	(47)	(48)
Incineration	(194)	(121)	(150)	(11)	(8)	(9)
Disposed (subtotal)	1,019	832	926	58	55	57
Non Collected	263	236	249	15	16	15
Recycled	190	190	190	11	13	12
Unauthorized Disposal	90	90	90	5	6	6
Unidentified Disposal	186	155	171	11	10	10
Total	1,748	1,503	1,626	100	100	100

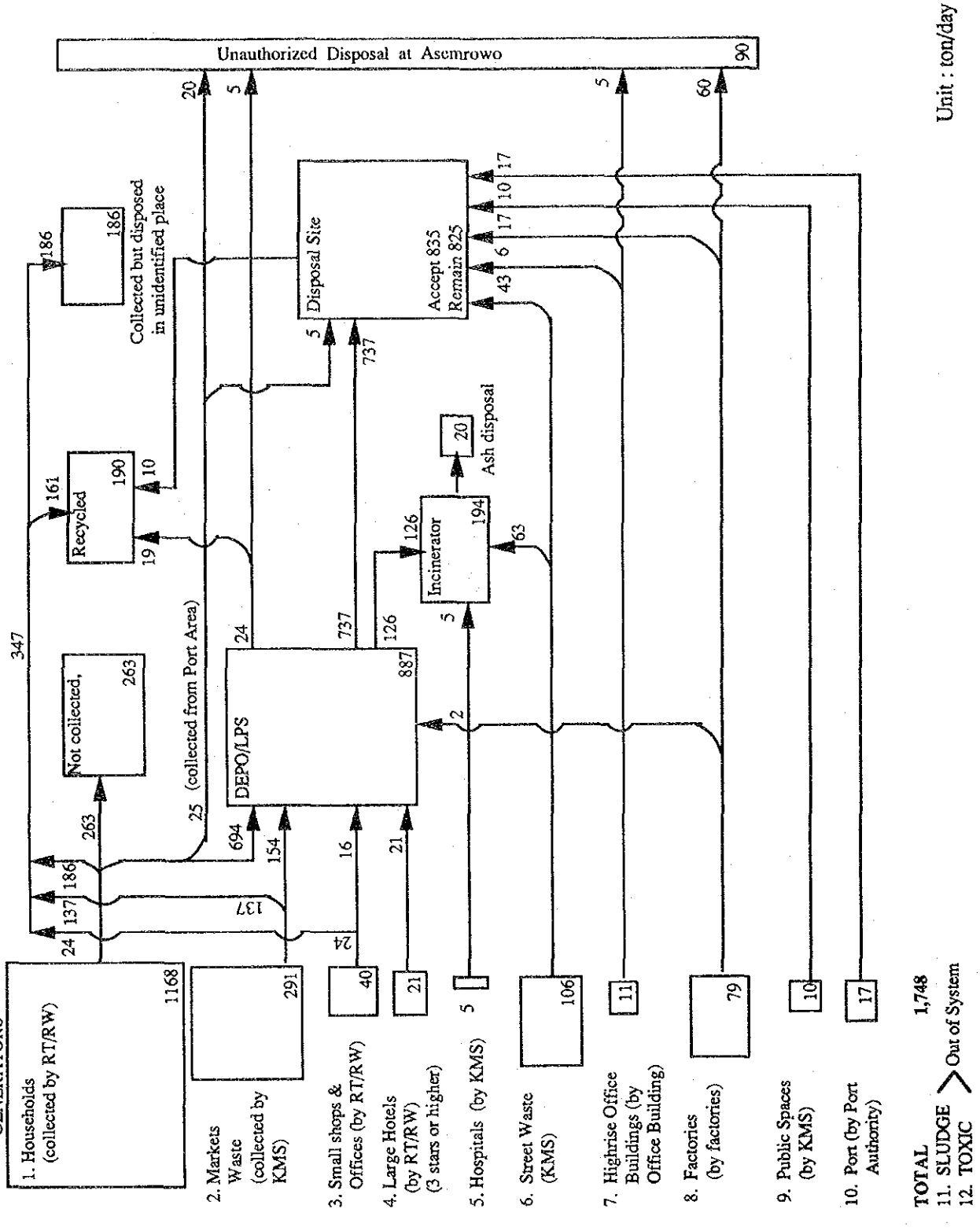


FIG. 2.1-3 DAILY AVERAGE IN RAINY SEASON

THE STUDY ON THE SOLID WASTE MANAGEMENT IMPROVEMENT FOR SURABAYA CITY

FIG. 2.1-4 DAILY AVERAGE IN DRY SEASON

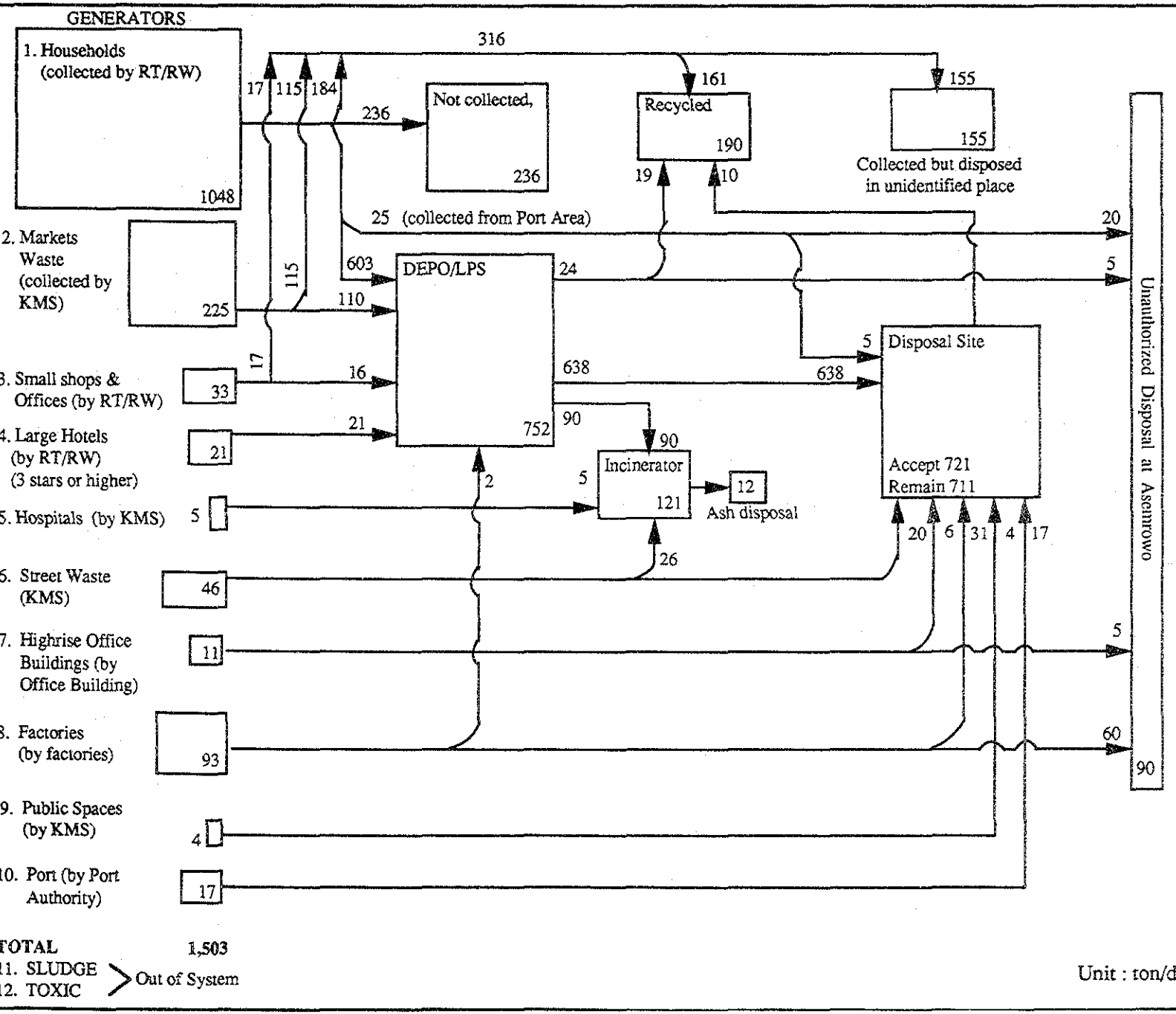
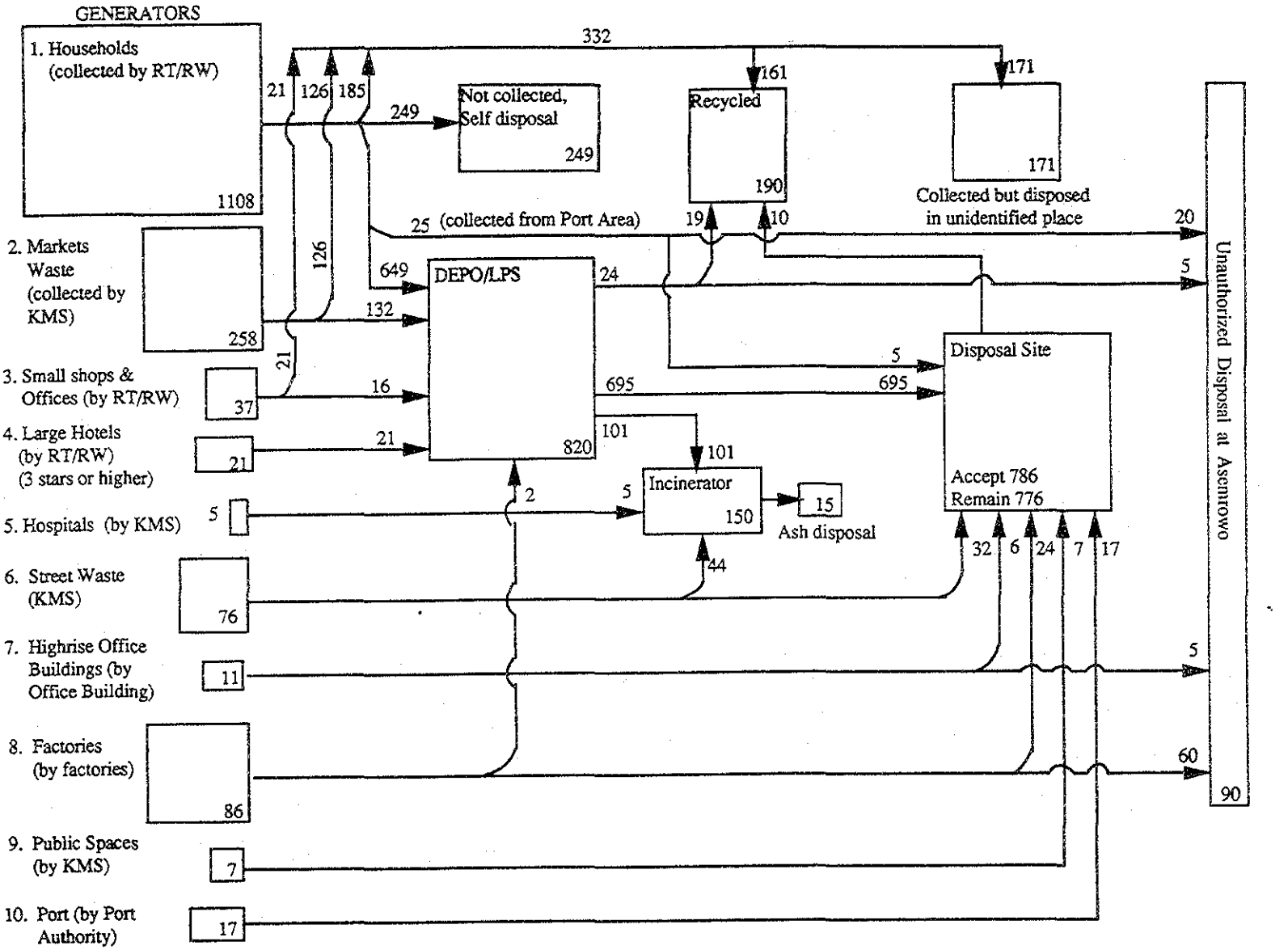


FIG. 2.1-5

DAILY AVERAGE THOROUGHOUT THE YEAR



2.2 Present Situation of Waste Quality

2.2.1 Objective

The survey is planned to grasp the existing situation of the waste quality discharged every day in Surabaya, because there is no data available for the purpose.

The object of the survey is to know the following items of waste quality:

1. Physical composition
2. Chemical composition
3. Diversity by the type of generation source
4. Diversity by season

To attain the objective, the survey area was selected according to the specified land use classification based on the suggestion of Dinas Kebersihan, KMS as shown in Table below.

Table 2.2-1 Distribution of Survey Points

Area		Number of Sample (Rainy Season)	Number of Sample (Dry Season)
a) Residential area	High	4	4
b)	Middle	4	4
c)	Low	4	4
d) Market		4	4
e) Commercial District		4	4
f) Incinerator		1	3
Total		21 samples	23 samples

These samples were collected at 21 points as shown in Table 2.2-2 and Fig. 2.2-1, and the sampling was conducted twice, in March as the rainy season and in May as the dry season, at the same point.

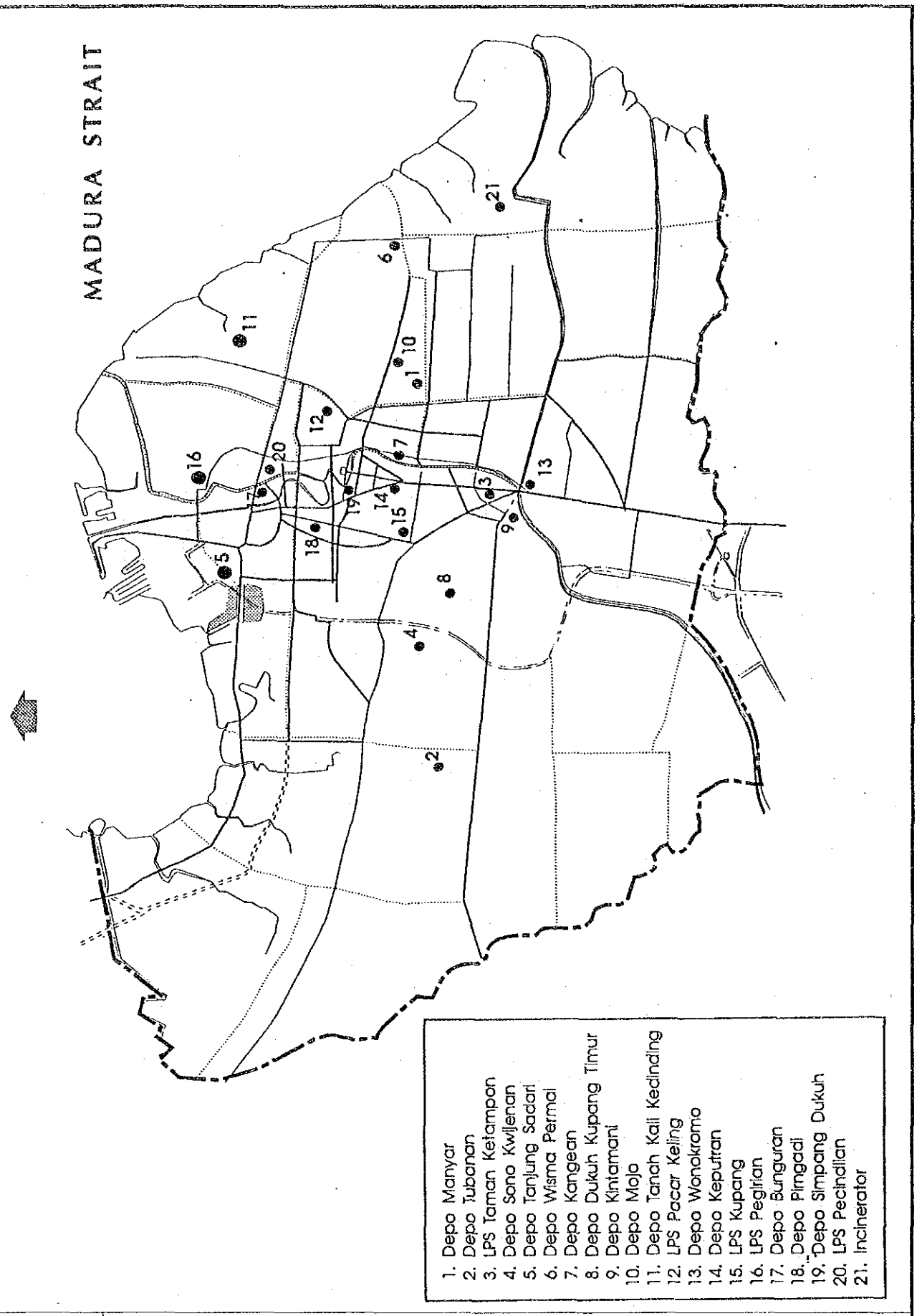


FIG. 2.2-1 LOCATION OF WASTE QUALITY SURVEY

THE STUDY ON THE SOLID WASTE MANAGEMENT IMPROVEMENT FOR SURABAYA CITY

Table 2.2-2 List of Sampling Points

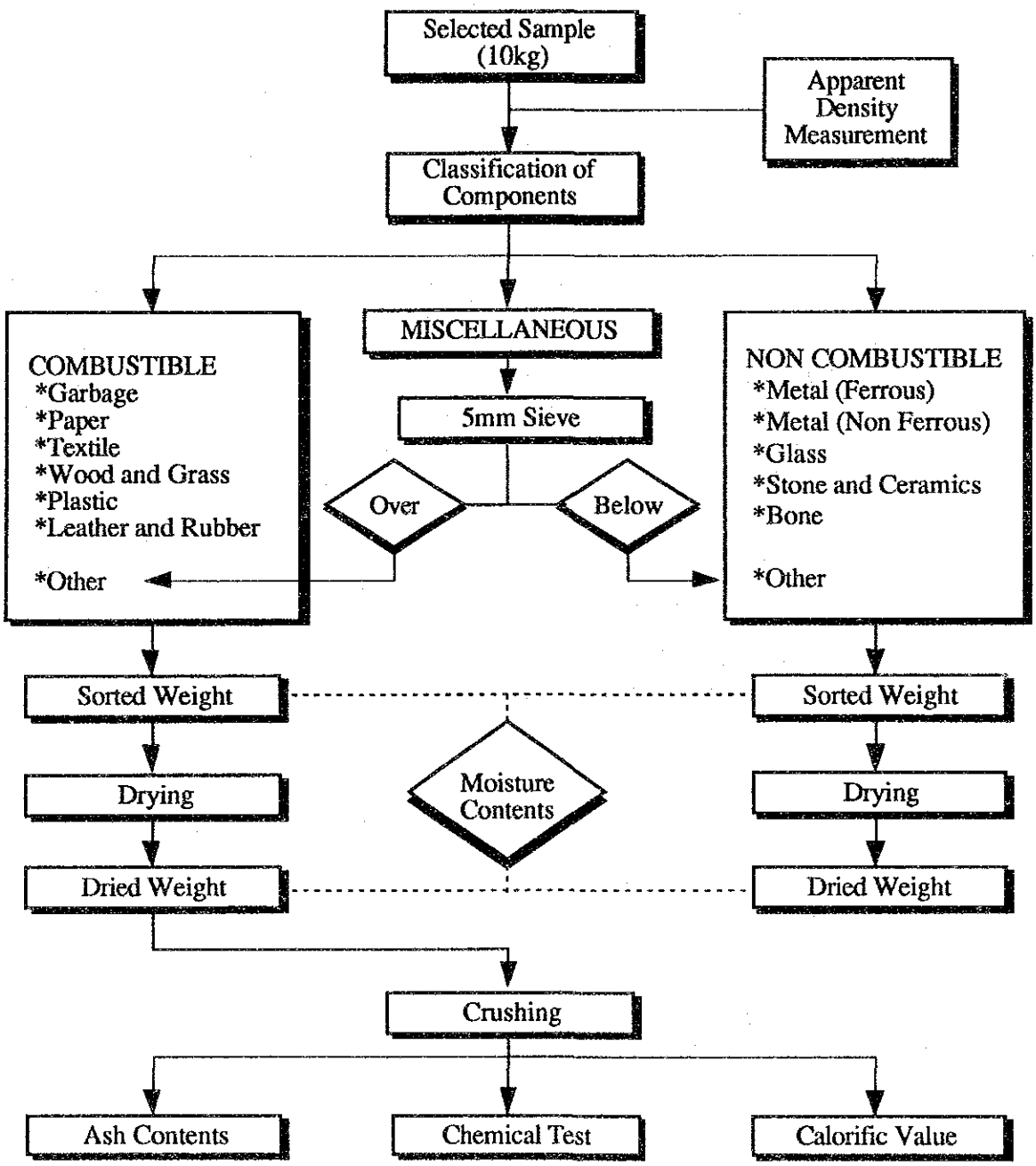
No	District	Name of Depo/LPS	Area
1	Manyar Kertoarjo	Depo Sukadami	Residential (High Income)
2	Darmo Permai	Depo Tubanan	Residential (High Income)
3	Kawasan Darmo	LPS Taman ketampon	Residential (High Income)
4	Darmo Satelit	Depo Sonokwijenan	Residential (High Income)
5	Krembangan	Depo Tanjung Sadari	Residential (Middle Income)
6	Sukolilo	Depo Wisma Permai	Residential (Middle Income)
7	Gubeng	Depo Kangean	Residential (Middle Income)
8	Sawahan	Depo Dukuh Kupang Timur	Residential (Middle Income)
9	Wonokromo	Depo Kintamani	Residential (Middle Income)
10	Darmahusada	Depo Mojo	Residential (Low Income)
11	Kenjeran	Depo Tanah Kali Kedinding	Residential (Low Income)
12	Tambaksari	LPS Pacar Keling	Residential (Low Income)
13	Wonokromo	Depo Wonokromo	Market
14	Keputran	Depo Keputran	Market
15	Kupang	LPS Kupang	Market
16	Pegirian	LPS Pegirian	Market
17	Kembang Jepun	Depo Bunguran	Commercial
18	Bubutan	Depo Pirngadi	Commercial
19	Genteng	Depo Simpang Dukuh	Commercial
20	Undaan	LPS Pecindilan	Commercial
21	Incinerator	indefinete	Road or Others

2.2.2 Method of Survey

1) Physical Analysis

Flow chart of physical analysis and sample processing for chemical analysis is shown in Figure 2.2-2.

Fig. 2.2-2 Flow Chart of Sample Processing



a. Sampling

In each sampling point, approximately 200 kg of sample was collected from every cart coming to the selected Depo, then the final sample of 10 kg was taken out from the whole sample which has been mixed enough at the place.

b. Apparent density measurement

Apparent density is measured by the weight of waste collected by 40 liter bucket.

c. Classification (physical composition)

The waste samples are classified into the following components.

COMBUSTIBLE COMPONENTS

* Garbage
* Paper
* Textile
* Wood & grass
* Plastic
* Leather & rubber
* Other

NON COMBUSTIBLE COMPONENTS

* Metal (ferrous & non ferrous)
* Glass
* Stone & ceramics
* Bone
* Other

MISCELLANEOUS

Undistinguished samples are screened by 5 mm sieve, then classified into two components namely, more than 5 mm as Combustible and less than 5 mm as Non Combustible.

d. Sample drying

After classifying, the waste samples are dried up by following 3 stages :

Stage 1	60 °C - 70 °C (1 day)
Stage 2	80 °C - 90 °C (1 day)
Stage 3	100 °C - 105 °C (2-3 days)

e. Moisture content

Moisture contents is calculated by subtracting dry weight from wet weight.

f. Sample crushing

After drying, the sample weight are measured, then each component of dried combustible samples are crushed to prepare the samples for the chemical analysis.

2) Chemical Analysis

Chemical analysis is conducted to get the information on the following items:

1. Four major components, namely:
   (a) Moisture content
   (b) Combustible content
   (c) Ash content
   (d) Plastics

2. Calorific Value

3. Elemental composition about six principal elements, namely:
   (a) Carbon
   (b) Hydrogen
   (c) Nitrogen
   (d) Sulfur
   (e) Chlorine
   (f) Oxygen

To proceed the chemical analysis, 13 types of waste sample which have been already dried and crushed, are blended again according to the original composition in dry basis.

All the process of chemical analysis were carried out at the Water Supply and Environment Training Center in Bekasi under the cooperation with the staff of the Center.

a. Four Major Components

Out of four major components, moisture content and plastics content have been already measured in the process of physical analysis, therefore the ash content is to be measured directly by using a muffle furnace. The fourth component of combustible content is calculated as the remainder subtracted the weight of ash and water from the original sample weight.

Combustible component is eliminated by heating in the muffle furnace at the temperature of 800 °C for three hours . On finishing the heating, cool the ash on the metal plate and successively in the desiccator for 20 minutes, then measure the weight of ash. Thus the four major components are quantified.

b. Calorific Value

A bomb type calorimeter is applied to measure the calorific value of sample waste.
Taking a 1g sample, put it into the bomb and fill the bomb with oxygen at the pressure of 30 kg/cm^2.

Then the sample is ignited and burnt completely as it is contained in the bomb. After the combustion the heat amount generated can be known by measuring the rise of water temperature that surrounds the bomb.

c. Elemental Composition

An automatic element analyzer is used for measuring the content of major elements, namely carbon, sulfur, hydrogen and chlorine. These elements are extracted out of exhaust gas in the form of compound, and quantified by chemical analysis method.

The nitrogen content alone is quantified by using a Kejerdar flask, a specially designed for this analysis exclusively.

Based on the results of five elements' measurement, the oxygen content can be calculated as the remainder of combustible component stated above.

2.2.3 Results of Survey

1) Physical Composition

The results of the physical composition analysis are summarized in Table 3.2-27 and 3.2-28.

The content of combustible in wet basis (non-processed condition) was 96% for rainy season and 93% for dry season, on the other hand, in dry basis, it was 89% for rainy season and 86% for dry season. The results shows that the most part of waste consists of combustibles and the seasonal fluctuation is no bigger than 3% in average.
The main component of waste was garbage with the share of 53 to 56% in wet condition.

Plastics, papers and textile have on the contrary smaller rate, namely 8.15% (plastics), 11 to 14% (papers) and 2% (textile) in wet condition. Non combustible waste consists of mainly glasses as well as stone/ceramics, and metal content is very poor.

In the commercial area, the share of papers is much higher than the other sources. On the other hand, market area shows the highest share of garbage and the lowest share of paper and plastics among all the generation sources surveyed. The waste from incinerator seems to have the similar composition to the household waste.

The waste from road sweeping has the largest share of wood/glass and stone/ceramics which are supposed to be derived from the maintenance of roadside trees and street sweeping.

Table 2.2-3 Physical Composition of Waste (Rainy Season)

(Wet Basis Wt.%)

Source / Classification	Residential				Market	Commercial	Incinerator	Average
	High	Middle	Low	Mean				
(Combustible)								
Paper	14.24	11.51	12.12	12.62	5.14	23.74	17.29	13.54
Textile	1.26	1.53	2.61	1.80	0.27	3.64	1.77	1.85
Garbage	48.87	51.77	56.14	52.26	61.93	47.42	46.91	52.93
Wood/Grass	22.25	20.92	15.48	19.55	28.74	9.15	15.96	19.15
*Plastics	7.24	8.94	7.64	7.94	2.75	9.73	16.41	7.70
*Leather/Rubber	1.35	0.29	0.30	0.65	0.17	0.22	0.19	0.45
Others	0.06	0.19	0.14	0.13	0.19	0.11	0.00	0.13
Sub Total	95.27	95.15	94.43	94.95	99.19	94.01	98.53	95.75
(Non combustible)								
Metal (Ferrous)	1.01	0.47	1.09	0.86	0.27	1.45	0.09	0.82
Metal (Non-Ferrous)	0.13	0.07	0.07	0.09	0.00	0.11	0.11	0.08
Glass	1.70	0.22	0.76	0.89	0.20	2.97	0.11	1.12
Stone/Ceramics	1.17	2.97	3.20	2.45	0.27	0.65	0.76	1.61
Bones	0.72	1.12	0.45	0.76	0.07	0.81	0.40	0.62
Others	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sub Total	4.73	4.85	5.57	5.05	0.81	5.99	1.47	4.25
Total	100	100	100	100	100	100	100	100

Note 1: * Unsuitable waste for Combustion
2: Residential, Market and Commercial Wastes are described as the average of four (4) measured values.

(Dry Basis Wt.%)

Source / Classification	Residential				Market	Commercial	Incinerator	Average
	High	Middle	Low	Mean				
(Combustible)								
Paper	17.56	14.16	13.32	15.01	8.01	23.93	26.45	15.92
Textile	1.73	2.06	3.73	2.51	0.70	4.53	2.90	2.57
Garbage	34.70	41.33	43.00	39.68	56.42	31.83	31.49	40.98
Wood/Grass	21.27	18.11	13.21	17.53	23.95	10.81	14.49	17.33
*Plastics	9.94	10.87	11.73	10.85	6.49	14.39	20.41	11.14
*Leather/Rubber	2.47	0.72	0.73	1.31	0.77	0.44	0.25	0.99
Others	0.10	0.34	0.23	0.22	0.43	0.17	0.00	0.24
Sub Total	87.77	87.59	85.95	87.10	96.77	86.10	95.99	89.17
(Non combustible)								
Metal (Ferrous)	2.84	1.26	2.60	2.23	1.07	3.33	0.25	2.13
Metal (Non-Ferrous)	0.26	0.17	0.19	0.21	0.00	0.28	0.30	0.19
Glass	4.41	0.64	2.02	2.36	0.79	7.25	0.30	2.89
Stone/Ceramics	3.27	8.02	8.30	6.53	1.15	1.69	2.02	4.37
Bones	1.45	2.32	0.94	1.57	0.22	1.35	1.14	1.25
Others	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sub Total	12.23	12.41	14.05	12.90	3.23	13.90	4.01	10.83
Total	100	100	100	100	100	100	100	100

Table 2.2-4 Physical Composition of Waste (Dry Season)

(Wet Basis Wt.%)

Source / Classification	Residential				Market	Commercial	Incinerator	Road Sweeping	Average
	High	Middle	Low	Mean					
(Combustible)									
Paper	14.21	11.78	11.54	12.51	2.86	17.71	10.03	9.11	11.37
Textile	1.16	2.87	1.92	1.98	0.37	2.77	5.08	0.09	2.03
Garbage	50.39	54.03	51.55	51.99	78.51	48.38	50.50	53.14	55.89
Wood/Grass	20.25	17.11	16.48	17.95	1.11	11.44	17.44	21.05	15.72
*Plastics	8.10	6.33	8.70	7.71	2.62	11.90	8.91	4.33	7.51
*Leather/Rubber	0.79	0.15	0.60	0.51	0.06	1.35	0.93	0.73	0.63
Others	0.08	0.08	0.07	0.08	0.01	0.02	0.16	0.01	0.06
Sub Total	94.98	92.35	90.86	92.73	95.54	93.57	93.05	88.46	93.215
(Non combustible)									
Metal (Ferrous)	0.69	0.69	0.77	0.72	0.10	1.30	0.82	1.23	0.74
Metal (Non-Ferrous)	0.12	0.14	0.35	0.20	0.00	0.23	0.05	0.16	0.16
Glass	0.11	1.35	1.68	1.05	0.03	0.42	0.49	0.37	0.68
Stone/Ceramics	2.93	5.20	5.74	4.62	4.02	2.94	4.94	9.37	4.46
Bones	1.17	0.27	0.53	0.66	0.31	1.54	0.65	0.41	0.74
Others	0.00	0.00	0.07	0.02	0.00	0.00	0.00	0.00	0.00
Sub Total	5.02	7.65	9.14	7.27	4.46	6.43	6.95	11.54	6.79
Total	100	100	100	100	100	100	100	100	100

Note 1: * Unsuitable waste for Combustion
2: Residential, Market and Commercial Wastes are described as the average of four (4) measured values.
3: Incinerator waste is described as the average of two (2) measured values.

(Dry Basis Wt.%)

Source / Classification	Residential				Market	Commercial	Incinerator	Road Sweeping	Average
	High	Middle	Low	Mean					
(Combustible)									
Paper	19.59	12.71	13.26	15.19	5.90	21.40	9.20	13.84	14.07
Textile	1.78	3.60	2.87	2.75	0.48	3.92	7.23	2.84	2.95
Garbage	37.78	42.48	37.54	39.27	65.64	32.76	37.24	42.63	42.70
Wood/Grass	18.53	16.05	15.21	16.60	12.09	12.58	19.63	15.54	15.33
*Plastics	11.45	8.80	11.92	10.72	3.88	14.25	11.16	9.96	10.15
*Leather/Rubber	1.11	0.32	1.22	0.88	0.16	2.78	1.70	1.18	1.17
Others	0.12	0.11	0.11	0.11	0.01	0.05	0.19	0.09	0.09
Sub Total	90.36	84.07	82.13	85.52	88.16	87.74	86.35	86.08	86.46
(Non combustible)									
Metal (Ferrous)	1.15	1.37	1.54	1.35	0.26	2.59	1.65	1.46	1.41
Metal (Non-Ferrous)	0.24	0.27	0.68	0.40	0.00	0.46	0.10	0.31	0.31
Glass	0.25	3.01	3.41	2.22	0.06	0.90	1.05	1.45	1.48
Stone/Ceramics	6.09	10.87	11.29	9.42	10.85	5.91	9.78	9.48	9.09
Bones	1.91	0.41	0.78	1.03	0.67	2.40	1.07	1.19	1.22
Others	0.00	0.00	0.17	0.06	0.00	0.00	0.00	0.03	0.03
Sub Total	9.64	15.93	17.87	14.48	11.84	12.26	13.65	13.92	13.54
Total	100	100	100	100	100	100	100	100	100

2) Apparent Density

The average apparent density is 0.34 Kg/liter as shown in Table 2.2-5. The highest density is observed in incinerator and the lowest is in high residential area. In residential area, there is descending tendency of the density in inverse proportion to the income level. Apparent density appeared to decrease in dry season by 5% in average.

Table 2.2-5 Apparent Density Measured in Quality Survey

(Kg/l, Wet Basis)

Source / Season	Residential			Market	Commercial	Incinerator	Road Sweeping	Average
	High	Middle	Low					
Rainy	0.255	0.332	0.362	0.322	0.413	0.421	-	0.341
Dry	0.252	0.323	0.331	0.373	0.341	0.418	0.402	0.335

3) Moisture Content

The moisture content of waste by each component and by generation source is summarized in Table 2.2-6 and Fig. 2.2-3. Overall average of moisture content are 67% in rainy season and 56% in dry season. This shows about 10% decrease in dry season from rainy season in average moisture content. Among the various generation sources, the market generates the waste with the highest moisture content, higher than the average by about 10%. Among the 13 kinds of waste components, garbage has the highest moisture content, higher than the average by 8 to 10%. At the same time, the garbage is recognized to contribute to raise the moisture content of the whole waste due to its biggest share in physical composition. At the incinerator, the samples were taken out twice from the same pile that was dumped into the pit on the same day : one was taken just after the waste was dumped and the other was taken three days after.

According to the comparison of the moisture content of these two samples, it is found that the waste kept for three days in the pit has smaller moisture content than that of fresh waste by about 5%. This shows that the three day storing of waste in the pit has an effect of moisture reduction, in other word, an effect of increase of calorific value.

Table 2.2-6 Moisture Content

(Rainy Season) (unit: Wt.%)

Source / Classification	Residential High	Residential Middle	Residential Low	Market	Commercial	Incinerator	Average
(Combustible)							
Paper	60.84	59.25	59.24	62.22	59.45	46.15	59.53
Textile	59.60	59.60	45.34	41.54	49.57	42.50	50.72
Garbage	77.02	72.99	71.39	78.69	75.39	76.37	75.16
Wood/Grass	71.80	70.97	66.68	75.71	55.40	68.06	68.14
*Plastics	57.51	58.61	43.46	39.56	42.55	56.22	48.71
*Leather/Rubber	27.03	10.83	20.24	2.27	22.87	54.55	18.45
Others	41.67	37.50	33.01	15.15	29.95	-	31.46
Sub Total	71.01	69.28	66.35	77.76	65.49	65.71	69.58
(Non combustible)							
Metal (Ferrous)	20.81	6.25	4.93	5.27	10.83	0.00	9.16
Metal (Non-Ferrous)	33.20	10.00	0.00	-	0.00	0.00	10.16
Glass	4.69	8.34	4.03	2.38	9.78	0.00	5.57
Stone/Ceramics	7.49	9.81	9.12	3.57	4.17	6.98	6.84
Bones	33.45	30.63	30.63	14.29	48.85	0.00	30.07
Others	-	-	-	-	-	-	-
Sub Total	15.64	11.98	9.13	7.21	12.94	3.64	11.01
Total	68.52	66.60	63.13	77.20	62.32	64.80	67.42

* Unsuitable Waste for Combustion

(Dry Season) (unit: Wt.%)

Source / Classification	Residential High	Residential Middle	Residential Low	Market	Commercial	Incinerator Fresh	Incinerator 3 day after	Road Sweeping	Average
(Combustible)									
Paper	42.40	51.95	45.85	29.58	42.70	56.00	56.00	55.00	44.21
Textile	31.23	40.53	30.93	38.29	32.34	35.63	28.57	30.00	34.24
Garbage	67.65	64.57	65.51	74.20	68.35	66.81	62.65	62.59	67.53
Wood/Grass	59.10	57.37	56.54	58.64	47.41	35.90	56.96	53.68	54.90
*Plastics	38.51	33.88	36.00	48.86	40.44	38.89	40.91	36.84	39.46
*Leather/Rubber	17.93	6.67	2.38	7.72	5.83	0.00	10.81	6.25	7.79
Others	24.44	37.91	11.33	25.00	5.00	45.95	-	0.00	20.03
Sub Total	58.93	58.95	57.38	71.18	55.69	56.33	54.86	57.92	59.90
(Non combustible)									
Metal (Ferrous)	24.20	7.90	4.28	4.69	3.33	0.00	0.00	0.00	7.72
Metal (Non-Ferrous)	14.17	7.29	4.20	-	6.05	12.50	0.00	5.56	6.30
Glass	0.66	8.33	0.56	0.00	1.92	0.00	9.38	0.00	2.40
Stone/Ceramics	3.01	5.27	7.02	4.18	1.53	5.48	3.40	3.89	4.21
Bones	25.60	29.48	30.09	17.04	28.28	40.00	10.53	33.33	25.24
Others	-	-	0.00	-	-	-	-	-	-
Sub Total	14.66	5.91	6.93	4.76	11.07	7.99	3.38	4.42	8.22
Total	56.62	54.82	52.82	68.46	52.79	54.59	49.98	51.75	56.45

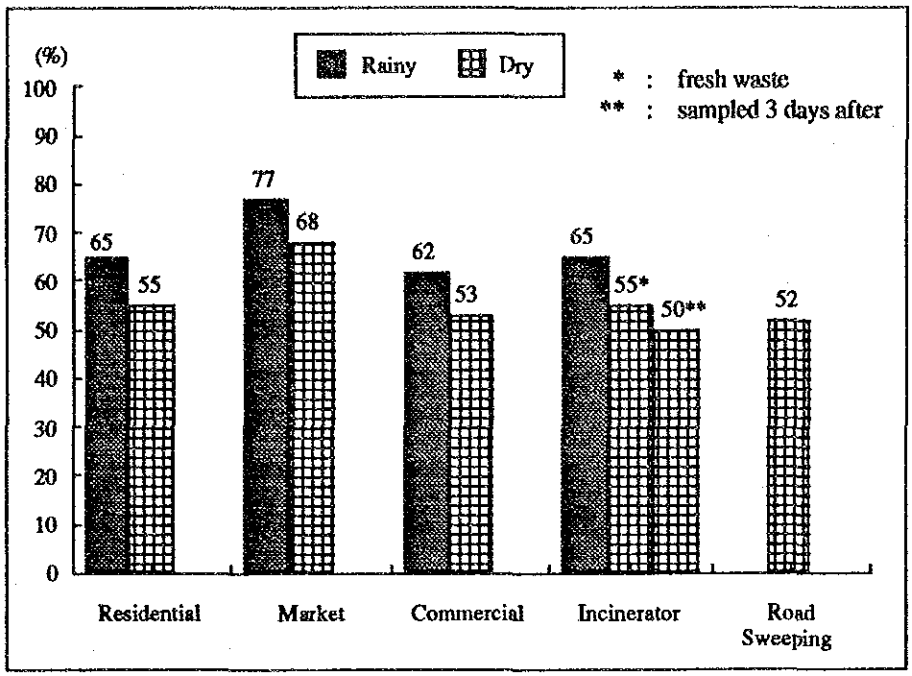


Fig. 2.2-3 Comparison of Moisture Content

suibun-hikaku

4) Chemical Analysis

a. Four Major Components

Four major components are defined by decomposing the combustible content of the three major components into plastics and other combustibles.

Four major components are summarized in Table 2.2-7. Among four components, moisture is a dominant one which shares about 2/3 in average of rainy season. The rest two solid components namely ash and combustible including plastics share of 1:3 respectively in average, and the rate between ash and combustible is almost 1:2.

Out of four major composition, namely moisture, combustible and plastics, the former three are defined as the three major composition. In comparison with the other cities, Jakarta and Tokyo, the characteristics of Surabaya can be found that the moisture content is apparently larger than the others as shown in Fig. 2.2-4.

Table 2.2-7 Four Major Components

Rainy Season (unit : wt. %)

Component	Household waste			Market Waste	Commercial Waste	Incinerator Waste	Average	
	High	Middle	Low				Overall	Without Market
Moisture	68.52	66.60	63.13	77.20	62.32	64.80	67.10	65.08
Ash	10.14	10.92	12.07	5.72	11.84	8.59	9.88	10.71
Combustible	21.34	22.48	24.80	17.08	25.84	26.61	23.02	24.21
Plastics	3.51	3.30	4.15	1.49	4.87	6.17	3.91	4.40
Others	17.83	19.18	20.65	15.59	20.97	20.44	19.11	19.81
Total	100	100	100	100	100	100	100	100

Dry Season (unit : wt. %)

Component	Household waste			Market Waste	Commercial Waste	Incinerator Waste	Street Waste	Average	
	High	Middle	Low					Overall	Without Market
Moisture	56.65	54.81	52.82	68.46	52.79	52.29	51.75	55.60	53.52
Ash	13.48	16.14	17.82	9.81	13.82	14.21	20.11	15.11	15.93
Combustible	29.87	29.05	29.36	21.73	33.39	33.50	28.14	29.29	30.55
Plastics	4.76	3.64	5.27	1.07	6.83	5.09	2.88	4.22	4.74
Others	25.11	25.41	24.09	20.66	26.56	28.41	25.26	25.07	25.81
Total	100	100	100	100	100	100	100	100	100

Composition	Rainy Season (%)		
	Surabaya	Jakarta	Japan
Moisture	67.1	63.4	45.2
Ash	9.9	8.5	7.5
Combustible	23.0	28.1	47.3
TOTAL	100	100	100

Composition	Rainy Season (%)		
	Surabaya	Jakarta	Japan
Moisture	55.6	54.0	44.4
Ash	15.1	18.2	7.8
Combustible	29.3	27.7	47.8
TOTAL	100	99.9	100

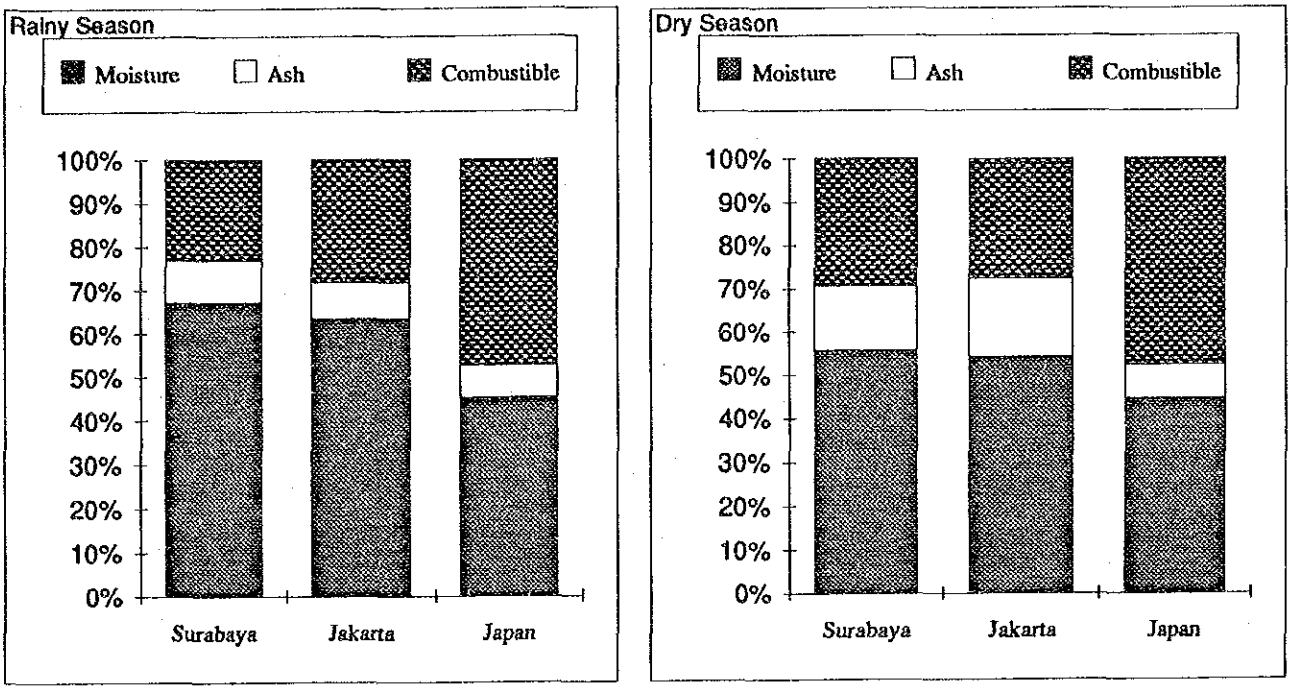


Fig. 2.2-4 Comparison of Four Major Components

b. Elemental Composition

The content of 6 major element is summarized in Table below.

Table 2.2-8 Elemental Composition

(Rainy Season) (unit : wt. %, wet basis)

Source	Residential			Market, Wono Kromo	Commercial, Bungran	Incinerator	Average	
Element	High, Darmo Permai	Middle, Sawahan	Low, Tambak sari				Overall	Without market
C	12.65	13.34	15.88	7.44	14.91	15.46	13.28	14.43
H	1.64	1.64	2.03	0.82	1.98	2.10	1.70	1.88
N	0.25	0.26	0.32	0.26	0.39	0.41	0.31	0.33
S	0.014	0.024	0.018	0.015	0.010	0.024	0.02	0.02
Cl	0.024	0.040	0.080	0.049	0.035	0.057	0.05	0.05
O	6.762	7.176	6.472	8.496	8.515	8.559	7.66	7.50
Combustible Total	21.34	22.48	24.80	17.08	25.84	26.61	23.02	24.21

(Dry Season) (unit : wt. %, wet basis)

Source	Residential			Market, Wono Kromo	Commercial, Bungran	Incinerator	Road	Average	
Element	High, Darmo Permai	Middle, Sawahan	Low, Tanbak sari				Sweeping	Overall	Without Market
C	19.18	17.98	17.66	8.48	24.42	19.47	13.18	17.20	18.65
H	2.73	2.54	2.35	1.08	3.48	2.77	1.59	2.36	2.58
N	0.45	0.39	0.38	0.31	0.65	0.50	0.42	0.44	0.46
S	0.027	0.028	0.011	0.003	0.037	0.038	0.028	0.02	0.03
Cl	0.055	0.067	0.083	0.047	0.064	0.062	0.038	0.06	0.06
O	7.428	8.045	8.876	11.810	4.739	10.660	12.884	9.21	8.77
Combustible Total	29.87	29.05	29.36	21.73	33.39	33.50	28.14	29.29	30.55

To Compare the result with Tokyo, the average composition excluding market waste which is not suitable for incineration is shown in Table 2.2-9. According to the Table, the significant difference is in the content of Cl. Fuel indexes are about 1.2.

Table 2.2-9 Comparison of Elemental Composition

(unit : wt.%)

Element	Surabaya		Tokyo
	Rainy	Dry	(as of 1988)
C	41.32	40.13	43.67
H	5.38	5.55	6.22
N	0.95	0.99	0.86
S	0.06	0.06	0.04
Cl	0.14	0.13	0.77
O	21.48	18.87	35.54
Ash	30.67	34.27	12.90
Total	100	100	100
Fuel Index	1.20	1.24	1.12

Note 1) Fuel Index is defined by the following equation:

$$F.I. = 1 + 3 \times \frac{H}{C} - \frac{3}{8} \times \frac{(O - S)}{C}$$

where H : hydrogen percentage in weight in solid content
C : carbon percentage in weight in solid content
O : oxygen percentage in weight in solid content
S : sulfur percentage in weight in solid content

Note 2) Ash content shown in Table 2.2-9 does not include incombustible substances.

c. Calorific Value

The calorific values of the waste from various sources are summarized in Table 2.2-10. Overall averages excluding market waste are almost same as the average of household waste for each season, and the values are 1,050 Kcal/kg for rainy season and 1,300 Kcal/kg for dry season. The difference between rainy season and dry was proved large, namely the value in dry season is bigger than that of rainy season by around 24% in average.

Among the various generation sources, Market generates such waste as has a remarkably low calorific value that is insufficient to sustain the spontaneous combustion. The remarkably low calorific value is thought to be brought about by its large moisture content mainly held by dominant garbage content.

Table 2.2-10 Low Calorific Value by Calorimeter

(unit : Kcal/kg)

Source / Season	Residential			Market	Commercial	Incinerator	Road	Average
	High	Middle	Low	Wonokromo	Bungran		Sweeping	(weighted)
	Darmo Permai	Sawahan	Tambaksari					
Rainy	880	970	1,050	300	1,150	1,250	-	1,050
Dry	1,480	1,450	1,210	450	1,550	1,390	1,180	1,300

Note 1) Calorific values obtained by the measurement by calorimeter are examined through the other evaluation methods as shown below, and confirmed the values stand for the probable characteristics of sample wastes:

Comparison of calorific values obtained in various evaluation methods.

Rainy Season (unit : Kcal/kg)

Evaluation Method	Household waste			Market Waste	Commercial Waste	Incinerator Waste	Simple* Average
	High	Middle	Low				
Four Major Component Eq.	670	730	860	360	960	1,020	850
Four Major Component Eq. by Hirayama	700	760	890	370	1,000	1,080	890
Calorimeter	880	970	1,050	300	1,150	1,250	1,060
Dulong's Eq.	790	820	1,090	60	1,110	1,100	980
Steuer's Eq.	870	920	1,210	150	1,200	1,210	1,080

Dry Season (unit : Kcal/kg)

Evaluation Method	Household waste			Market Waste	Commercial Waste	Incinerator Waste	Street Waste	Simple* Average
	High	Middle	Low					
Four Major Component Eq.	1,170	1,110	1,190	600	1,150	1,370	1,060	1,180
For Major Component Eq. by Hirayama	1,210	1,140	1,230	610	1,210	1,410	1,080	1,210
Calorimeter	1,480	1,450	1,210	450	1,550	1,390	1,180	1,380
Dulong's Eq.	1,590	1,430	1,320	150	2,020	1,580	660	1,430
Steuer's Eq.	1,710	1,560	1,460	270	2,200	1,720	830	1,530

* : Market wastes are excluded

Note 2) Four major component equation

$$Hu = 45B + 80R - 6W$$

where Hu : low calorific value (Kcal/kg)

B : combustible percentage other than plastics in dry condition in weight (%)

R : plastics percentage in dry condition in weight (%)

W : moisture content (5)

Note 3) Four major component equation by Hirayama

$$Hu = 45B + 88.45R - 6W$$

Note 4) Dulong's equation

$$Hu = 8,100C + 34,200 (h - \frac{O}{8}) + 2,500S - 600 (9h + W) \quad (Kcal/kg)$$

where C : carbon content in wet condition (kg/kg)
h : hydrogen content in wet condition (kg/kg)
O : oxygen content in wet condition (kg/kg)
S : sulfur content in wet condition (kg/kg)
W : moisture content (kg/kg)

Note 5) Steuer's equation

$$Hu = 8,100 (C - \frac{3}{8} O) + 5,700 \times \frac{3}{8} O + 34,500 (h - \frac{O}{16}) + 2,500S - 600 (9h + W) \quad (Kcal/kg)$$

2.2-4 Projection of future Waste Quality

1) Physical Composition

a. Projection

The future waste quality is projected for household wastes and market wastes which are generated in comparably large amount. The next large amount of waste source is street wastes which have the similar composition and moisture content to household wastes. Therefore the future waste quality of street waste can be projected by referring to the household waste. The other minor wastes are assumed unchanged their quality even in the future.

The projected physical compositions are shown in Table 2.2-11 to 2.2-15 by type of waste and season.

Table 2.2-11 Projection of Household Waste Composition (Rainy Season)

(Unit: wt.%)

Classification	1992		2000		2010		Moisture Content
	Content	Annual Growth	Expanded Share	Content	Expanded Share	Content	
	%	%	%	%	%	%	%
Recyclable							
Paper	12.62	+1	13.67	13.27	15.10	14.08	59.78
Plastics	7.94	+2	9.30	9.03	11.34	10.58	53.19
Metal	0.95	+1	1.03	1.00	1.14	1.06	12.53
Glass	0.89	+2	1.04	1.01	1.27	1.19	5.68
Sub total	22.40		25.04	24.32	28.84	26.90	-
Non-Recyclable							
Textile	1.80	1.80	1.80	1.75	1.80	1.68	54.85
Wood/Grass	19.55	±0	19.55	18.99	19.55	18.23	69.82
Garbage	52.26	±0	52.26	50.75	52.26	48.74	73.80
Other Combustible	0.78	+1	0.84	0.82	0.93	0.87	28.38
Other Non Combustible	3.21	+1	3.48	3.38	3.84	3.58	20.19
Sub total	77.60		77.93	75.68	78.38	73.10	-
TOTAL	100		102.97	100	107.08	100	
Moisture Content	66.1%		65.5%		64.8%		

Table 2.2-12 Projection of Household Waste Composition (Dry Season)

(Unit: wt.%)

Classification	1992		2000		2010		Moisture Content
	Content	Annual Growth	Expanded Share	Content	Expanded Share	Content	
	%	%	%	%	%	%	%
Recyclable							
Paper	12.51	+1	13.55	13.14	14.96	13.91	46.73
Plastics	7.71	+2	9.03	8.76	11.01	10.24	24.25
Metal	0.92	+1	1.00	0.97	1.10	1.02	10.34
Glass	1.05	+2	1.23	1.19	1.50	1.39	3.18
Sub total	22.19		24.81	24.06	28.58	26.57	-
Non-Recyclable							
Textile	1.98	±0	1.98	1.92	1.98	1.84	34.23
Wood/Grass	17.95	±0	17.95	17.41	17.95	16.69	57.67
Garbage	51.99	±0	51.99	50.42	51.99	48.34	65.91
Other Combustible	0.59	+1	0.64	0.62	0.71	0.66	16.78
Other Non Combustible	5.30	+1	5.74	5.57	6.34	5.90	16.75
Sub total	77.81		78.30	75.94	78.97	73.43	-
TOTAL	100		103.10	100	107.54	100	
Moisture Content	54.7		53.4		52.3		