Annex B

Waste Amount and Composition Survey

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B Waste Amount and Composition Survey

Waste Amount and Composition Survey (WACS) is actually divided into two parts, i.e.,

- Waste Amount Survey, and
- Waste Composition Survey.

Objectives, methodologies and results are separately described in each part and findings are discussed together in the subsequent section.

B.1 Waste Amount Survey

a. Objectives

The objectives of Waste Amount Survey is to know current waste generation ratios of households, commercial entities, institutions, markets and street sweeping in the Study Area. Knowledge of the waste generation ratio is essential for the development and design of integrated solid waste management systems.

The data of waste generation ratios obtained in this survey is then applied to elaborate the waste stream that is used to comprehend the current flow of waste and to make future projections in the Study Area.

b. Methodology

b.1 Wastes Targeted

The survey covers household, commercial, institutional, market and street sweeping wastes. Waste generation sources were selected through consultation with a local contractor in order to reflect the present situation of the Study Area to the survey.

The wastes except market waste were weighed by spring balance at generation sources, and the market waste was weighed by weighbridge.

b.2 Questionnaire Survey

Questionnaire survey was also conducted to know the number of residents in houses, the number of employees in commercial and institutional entities, the number of stalls in markets, and conditions of recycle of these waste generation sources.

b.3 Survey Schedule

The survey was conducted in the dry season from 4th to 11th February 2000 for 8 consecutive days. The first day of the survey was used as a trial run. Then, the sources had a chance to discharge waste accumulated before the survey started, and the sources and surveyors could get used to the survey.

b.4. Waste Generation Sources

Table B-1 shows the categories, the number of waste generation sources, the survey days and the number of samples in each category. The categories were 8, the waste generation sources were 79, and the total number of samples was 553.

Table B-1: Number of Sources and Samples

Category		Number of sources	Survey days	Number of samples
Residential	High	20	7	140
	Middle	20	7	140
	Low	20	7	140
Commercial	Restaurant	5	7	35
	Other	5	7	35
Institutional		5	7	35
Market		2	7	14
Street sweeping		2	7	14
Total		79	-	553

Households were categorized into 3 groups according to income level, i.e., high, middle, and low income, in order to reflect living conditions in the Study Area, and the sources were distributed in 9 municipalities. Classification of income level was not based on actual income. It was based on observation on houses and areas where sources are located.

Table B-2: Classification households by Income Level

Income level	Status (price of house)
High	More than 500,000 colons
Middle	Between 150,000 and 500,000 colons
Low	Less than 150,000 colons

Table B-3: Distribution of Sources (Households)

Municipality	High income	Middle income	Low income	Total
San Salvador	14	10	8	32
Mejicanos	-	1	2	3
Ciudad Delgado	-	1	1	2
Ayutuxtepeque	-	-	1	1
Nueva San Salvador	3	3	-	6
Antigo Cuscatlan	3	4	-	7
Soyapango	-	1	5	6
Ilopango	-	-	2	2
Apopa	-	-	1	1
Total	20	20	20	60

Commercial entities were divided into two groups, i.e., restaurant and other, due to the difference of amount and character of waste generated from them. Schools, public institutions were chosen as waste generation sources of the institutional waste. Municipal markets (San Miguelito, San Jacinto) were selected to obtain the market waste as such municipal markets are one of major subjects of each municipality's collection service. Manually swept streets were chosen as sources of street sweeping waste because the manual sweeping method dominates street sweeping in AMSS.

c. Results

c.1 Residential Waste

140 samples for each income level, 420 samples in total, were obtained for the 7days. Those were statistically analyzed as below. Consequently, generation ratio for each income level was estimated as shown in Table B-4.

Waste generation ratio of 95% reliable value calculated by the following formula.

$$R_{95} = \overline{x} \pm 1.96 \left(\frac{\sigma}{\sqrt{n}} \right)$$

where R_{95} : 95% reliable value
$\overline{x}$: mean value
σ : standard deviation
n : number of sample

Table B-4: Estimation of Waste Generation Ratio

Item	High Income	Middle Income	Low Income
Mean value (g/person/day)	600.8	542.0	418.7
95% reliable value (g/person/day)	±102.8	±124.4	±100.2
Maximum value (g/person/day)	703.6	666.4	518.9
Minimum value (g/person/day)	498.0	417.6	318.5

Based on the results above, generation ratios with 95% reliable ranges were estimated as below.

Table B-5: Waste Generation Ratio of Residential Waste

Category	Waste generation ratio (g/person/day)
High income	600 (500 to 700)
Middle income	540 (420 to 670)
Low income	420 (320 to 520)

c.2 Commercial, Institutional, Market and Road Sweeping Wastes

The following table show the waste generation ratios of commercial, institutional, market and road sweeping wastes.

Table B-6: Waste Generation Ratio of Commercial, Institutional, Market and Road Sweeping Wastes

Category		Waste generation ratio	
Commercial	Restaurant	466	g/seat/day
	Other	482	g/employee/day
Institutional		196	g/employee/day
Market		1,674	g/stall/day
Street Sweeping		198	g/m/day

c.3 Questionnaire

As for recycling, 23% of households separates their waste for recycling (14 houses out of 60 houses; high income 6, middle 2, low 6) and 77% does not separate it (46 houses; high 14, middle 18, low 14). Out of 14 households separating their waste, 6 houses separate papers, 5 houses plastics, 8 houses cans, 7 houses organic and 4 houses bottles.

All (5) restaurants do not separate waste. One other commercial entity separates. Also, one institution separates. All (2) markets do not separate waste for recycling.

Note: The survey dealt with all waste including the waste that the households, commercial and institution usually separate for recycling.

B.2 Waste Composition Survey

a. Objectives

The objective of Waste Composition Survey is to obtain data of physical and chemical properties of wastes generated in the Study Area. The study focused on determining the following:

- bulk density
- physical composition (wet base)
- moisture content
- carbon and nitrogen content

a.1 Bulk Density

The bulk density is necessary to assess the total volume of waste that must be managed. Bulk density is important for planning the type and number of collection vehicles, the number and size of containers, and landfill capacity.

a.2 Physical Composition (wet base)

Physical composition of waste is necessary for current and future planning of SWM. Variations in composition affect the feasibility of the introduction of intermediate treatment technologies.

Composition rates of recyclable materials, such as plastic and metals, are used to assess the feasibility of recycling programs. Also, ratio of organic composition is crucial when planning of composting is required.

a.3 Moisture Content

Moisture content, along with the bulk density, is important for the design of collection and disposal of municipal SW. Further, knowledge of moisture content of municipal SW is necessary when analyzing potential of biological treatments such as composting.

a.4 Carbon and Nitrogen Contents

Information of carbon and nitrogen contents is crucial to plan biological treatments. Proportion of their contents affects activities of microorganisms that decompose waste.

b. Methodology

b.1 Waste Targeted

Wastes of all 8 categories were subjects of physical composition and moisture content analyses. Carbon and nitrogen contents were analyzed for residential (middle income as the representative of residential waste), restaurant and market wastes that are potential subjects of composting. Table B-7 shows the waste targeted and the number of samples.

Table B-7: Number of Samples of Waste Composition Survey

Category		Samples per day	Survey days	Bulk density	Physical composition	Moisture content	Carbon/ nitrogen content
Residential	High	1	7	7	7	7	-
	Middle	1	7	7	7	7	7
	Low	1	7	7	7	7	-
Commercial	Restaurant	1	7	7	7	7	7
	Other	1	7	7	7	7	-
Institutional		1	7	7	7	7	-
Market		1	7	7	7	7	7
Street sweeping		1	7	7	7	7	-
Total		-	-	56	56	56	21

b.2 Sampling

The wastes used in the Waste Amount Survey were used for the Waste Composition Survey. Wastes from each source were gathered and mixed by category and one sample was extracted from each category by using waste reduction method.

Reduction Method

Step1 Mixing: Wastes from each source is mixed every category. When the waste contained large particles (e.g., cardboard, textiles, etc.) those items are cut into smaller pieces and mixed again. Cutting the waste into smaller pieces is carried out to obtain an even mixture.

Step2 Dividing: Once the waste is mixed well, it is divided into four segments of approximately the same size.

Step3 Reduction: The two segments of waste diagonally opposite each other are removed and the remaining waste is mixed again.

Step4 The above steps are repeated till the volume of the remaining waste is reduced in size to approximately 50 liters.

Step5 The waste sample is then put into a calibrated plastic bucket and dropped 3 times from a height of 30 centimeters. Then, volume and weight are recorded.

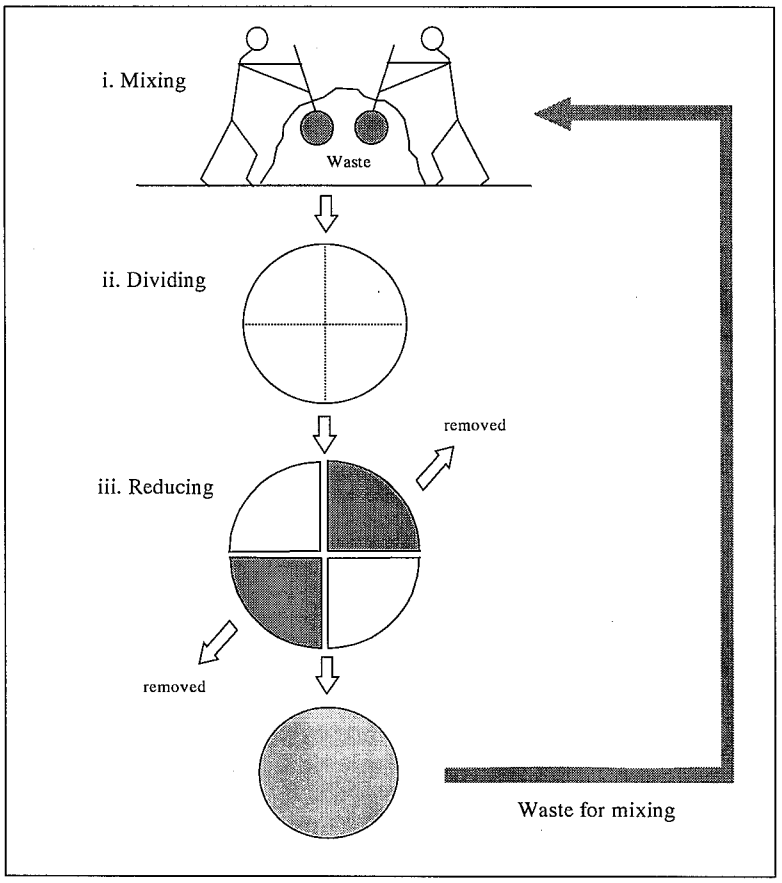

Figure B-1: Mixing, Reduction, and Separation of Waste Samples (Reduction method)

b.3 Bulk Density

Subsequently the bulk density of the waste sample was calculated with the following formula.

$$\text{Bulk density} = \frac{\text{Net Weight of Waste}}{\text{Volume of Waste}}$$

b.4 Physical Composition (wet base)

The physical composition was measured in the "wet base" (as discarded state, before the waste had a chance to dry). The above samples were divided into the following 10 components, and the weight of each was measured.

- food waste
- papers
- textiles
- grass, wood, bamboo
- plastics
- rubber and leather
- metals
- bottles, glass
- ceramics and soil
- other

b.5 Moisture Content

After drying out for 48 hours in dryer, the samples were weighed again, and the moisture content was calculated by the following formula.

$$\text{Moisture Content}(\%)=\frac{\text{Original Weight}-\text{Dry Weight}}{\text{Original Weight}}\times 100$$

b.6 Carbon and Nitrogen Contents

Combustible compositions of the dried wastes were mixed and crushed, then samples were taken for the analysis of carbon and nitrogen contents. Carbon content was analyzed by Walker and Black method, and Kjeldahl method was used for nitrogen content.

c. Results

c.1 Bulk Density

Table B-8 shows bulk density of the wastes.

Table B-8: Bulk Density of Wastes

Category		Bulk density (g/liter)
Residential	High income	198
	Middle income	202
	Low income	207
Commercial	Restaurant	353
	Other	60
Institutional		85
Market		335
Road sweeping		172

c.2 Waste Composition (wet base)

Table B-9 shows composition of residential waste and Table B-10 shows of restaurant, other commercial, institutional, market and road sweeping wastes.

Table B-9: Composition of Residential Waste

Unit: %

Composition	High income	Middle income	Low income
Combustible	95.5	94.4	93.4
Food waste	59.5	57.6	66.0
Papers	18.5	13.0	13.1
Textiles	1.2	1.1	2.5
Grass, wood, bamboo	2.7	16.8	4.0
Plastics	12.1	5.8	7.8
Rubber, leather	1.5	0.1	0.0
Incombustible	4.5	5.6	6.6
Metals	1.3	1.1	1.2
Bottles, glass	1.3	2.6	3.7
Ceramics and soil	0.2	0.7	0.6
Others	1.7	1.2	1.1
Total	100.0	100.0	100.0

Table B-10: Composition of Commercial, Institutional, Market and Road Sweeping Wastes

Unit: %

Composition	Commercial		Institutional	Market	Road sweeping
	restaurant	Other			
Combustible	95.1	97.5	89.3	96.8	88.3
Food waste	62.2	6.4	19.0	78.1	2.6
Papers	22.1	63.1	35.0	9.5	6.4
Textiles	0.0	5.2	1.1	0.3	0.4
Grass, wood, bamboo	0.3	11.8	12.3	1.4	75.3
Plastics	10.2	10.6	20.5	7.2	3.6
Rubber, leather	0.3	0.4	1.4	0.3	0.0
Incombustible	4.9	2.5	10.7	3.2	11.7
Metals	0.7	1.3	0.5	0.4	0.1
Bottles, glass	2.4	0.3	4.6	0.8	0.3
Ceramics and soil	0.0	0.0	1.6	0.7	9.8
Others	1.8	0.9	4.0	1.3	1.5
Total	100.0	100.0	100.0	100.0	100.0

c.3 Moisture Content

Table B-11 shows moisture content of each category.

Table B-11: Moisture Content

Category		Moisture content (%)
Residential	High income	51.5
	Middle income	47.0
	Low income	46.6
Commercial	Restaurant	58.8
	Other	12.8
Institutional		19.2
Market		64.9
Road sweeping		16.6

c.4 Carbon and Nitrogen Content

Table B-12 shows carbon and nitrogen contents of residential (middle income), restaurant and market waste.

Table B-12: Carbon and Nitrogen Content

Category	Content (%)		C/N ratio
	Carbon	Nitrogen	
Residential *	42.7	2.8	15.3
Restaurant	45.2	3.5	12.9
Market	44.6	3.3	13.5

Note: * middle income

B.3 Findings

Waste generation ratios of residential waste obtained are 600 g/person/day for high income, 540 g/person/day for middle income and 420 g/person/day for low income. These ratios have ranges, 500 to 700 g/person/day, 420 to 670 g/person/day and 320 to 520 g/person/day respectively in 95% confidence interval. Comparing with other studies in the Study Area and other Latin-American cities (See Table B-13 and Table B-14), it can see that the results of the survey show lower values than those data. It should be noted that this survey was carried out only in the dry season, meanwhile the studies in Nicaragua (Leon, Chinandega and Granada), Managua and Asuncion are conducted in both dry and rainy seasons. Annual average of waste generation ratios tends to be more than ones in dry seasons.

200 g/liter or less **Bulk density** of residential, other commercial and institutional wastes shows that use of compactor truck is reasonable as the compaction function can work effectively at such bulk density. However, the high bulk density of restaurant and market waste indicates that the compaction function can not be utilized effectively.

The results of **Physical composition** shows that higher portion of food waste and papers and lower portion of garden waste (grass, wood, bamboo and ceramics, soil) compared with other Latin American countries (See Table B-17). High portions of food waste and papers may reflect the higher economic conditions of the Study Area, lower portion of garden wastes probably shows the housing conditions in the Study Area, e.g., apartments, and houses without or small garden. However, the low portion of garden waste of high income might be exceptional as such high income people are generally living houses with large gardens.

The results of **Moisture content** show that the higher content of food waste, the higher moisture content. 45 to 65 % moisture content of residential, restaurant and market waste would be suitable for composting, as the optimum moisture content during operation of composting is 50 to 60 %.

The high **Nitrogen content** (2.81-3.52%) and the low **carbon and nitrogen ratio** (C/N ratio, 12.8-15.2) of residential, restaurant and market waste are attributed to the higher portion of food waste. The C/N ratios show that those waste are suitable for composting, as the optimum C/N ratio during composting operation is 20 and N tends to escape as NH_3.

Table B-13: Comparison of Waste Generation Ratio of Residential Wastes with Existing Reports

Unit: g/person/day

Category	**This study**	PAHO[1]	S.M[2]
High income	**600 (500 to 700)**	860	750
Middle income	**540 (420 to 670)**	850	
Low income	**420 (320 to 520)**	490	

Sources: 1 PAHO, 1998, "Analisis Sectorial de Residuos Solidos El Salvador".
2 The S.M Group International, 1997, " Diagonostico del Sector de los Residuos Solidos como apoyo al Programa Ambiental de El Salvador".

Table B-14: Comparison of Waste Generation Ratio of Residential Wastes with other Latin American Cities

Unit: g/person/day

Category	**This study**	Mexico City [1]	Tegucigalpa [2]	Nicaragua [3]	Managua [4]	Asuncion [5]
High income	**600**	616	375	675	664	961
Middle income	**540**					
Low income	**420**					

Sources:1 JICA, 1998, "The Study on Solid Waste Management of Mexico City in the United Mexican States".

2 JICA, 1997, "The Study on the Solid Waste Management of the Urban Area of Tegucigalpa's Central District in the Republic of Honduras".

3 JICA, 1997, "The Study on the Improvement of Urban Sanitation Environment of Principal Cities (Leon, Chinandega and Granada) in the Republic of Nicaragua".

4 JICA, 1994, "The Study on the Solid Waste Management System of the City of Managua in the Republic of Nicaragua".

5 JICA, 1994, "The Study on the Solid Waste Management for the Metropolitan Area of Asuncion in the Republic of Paraguay".

Table B-15: Comparison of Waste Generation Ratio of Commercial, Institutional, Market and Road Sweeping Wastes with other Latin American Cities

Category		Unit	**This study**	Mexico city	Tegucigalpa	Nicaragua	Managua	Asuncion
Commercial	Restaurant	g/seat/day	**466**	NA	NA	NA	NA	NA
	Other	g/employee/day	**482**	NA	NA	NA	NA	NA
Institutional		g/employee/day	**196**	413	217	98	61	78
Market		g/stall/day	**1,674**	1,025	3,670	2,827	3,875	5,961
Road sweeping		g/m/day	**198**	125	NA	37	50	255

Table B-16: Comparison of Bulk Density

Unit: g/liter

Category		**This study**	Tegucigalpa	Nicaragua	Managua	Asuncion
Residential	High income	**198**	200	190-270	200	220
	Middle income	**202**				
	Low income	**207**				
Commercial	Restaurant	**353**	NA	280-490	320	340
	Other	**60**	NA	50-150	40	70
Institutional		**85**	NA	40-80	250	90
Market		**335**	250	320-480	280	360
Road sweeping		**172**	NA	NA	160	NA

Table B-17: Comparison of Waste Composition (wet base)

Unit: %

Composition	This Study			Tegucigalpa	Nicaragua	Managua	Asuncion
	High	**Middle**	**Low**				
Combustible	**95.5**	**94.4**	**93.4**	82.4	79.5-88.4	75.1	71.1
Kitchen waste	**59.5**	**57.6**	**66.0**	47.2	26.1-50.0	34.8	36.6
Papers	**18.5**	**13.0**	**13.1**	11.5	1.9-5.3	5.4	6.4
Textiles	**1.2**	**1.1**	**2.5**	2.8	1.4-2.0	1.9	1.3
Grass, wood, bamboo	**2.7**	**16.8**	**4.0**	7.1	24.9-38.2	27.1	22.2
Plastics	**12.1**	**5.8**	**7.8**	11.6	2.8-6.1	3.9	3.9
Rubber, leather	**1.5**	**0.1**	**0.0**	2.2	0.3-6.0	2.0	0.7
Incombustible	**4.5**	**5.6**	**6.6**	17.6	11.6-20.5	24.9	28.9
Metals	**1.3**	**1.1**	**1.2**	1.9	1.1-1.8	1.7	1.3
Bottles, glass	**1.3**	**2.6**	**3.7**	3.5	1.0-1.3	2.9	3.1
Ceramics and soil	**0.2**	**0.7**	**0.6**	12.1	3.4-6.8	8.1	2.5
Others	**1.7**	**1.2**	**1.1**	0.1	4.2-14.0	12.2	22.0
Total	**100.0**	**100.0**	**100.0**	100.0	100.0	100.0	100.0