Chapter 3

Findings through the Field Surveys

3. Findings through the Field Surveys

Many useful findings were obtained through conducting various field surveys to understand the present conditions during the study. This chapter summarizes main useful findings. Detailed information on these field surveys are contained in Annex as shown below.

Title	Annex
Waste Generation Amount Survey	2
Survey on Waste Composition and Properties of Waste	3
Disposal Amount Survey	4
Survey on Recycling System	5
Survey on Scavengers	6
Survey on Private Collectors	7
Time and Motion Survey	8
Public Opinion Surveys	9
Large Dischargers' Opinion Surveys	10
Compost Demand Survey	11
Project Cycle Management Workshop on Final Disposal	12

3.1 Waste Generation Amount Survey

3.1.1 Methodology

In order to calculate the amount of waste generated, residential and non-residential sources were examined separately. Emphasis was placed on the determination of the amount of residential waste generated, as this generally comprises the largest portion of MSW. Physical collection and analysis were the main methods used to determine residential WAGRs, while secondary sources were used to determine the non-residential WAGRs.

Major methods used in this study to estimate the amount of municipal solid waste generated in the Central District are:

- The Waste Amount and Composition Survey: employed to estimate residential waste generation rates.
- The Survey of Disposal Amount: used to verify seasonal variations in generation.
- Questionnaires and interviews: used to determine generation amounts from non-residential sources and to estimate the amount illegally disposed.
- Results of relevant recent studies: used to verify residential and non-residential generation estimations.

3.1.2 Waste Amount Generation Rates (WAGR) for Residential Waste

Waste amount generation rates (measured in grams of MSW/capita/day) for households in the Central District were estimated by undertaking the Waste Amount

and Composition Survey (WACS). As the name suggests, the WACS estimates the amount of waste generated as well as the composition of MSW.

a. Initial Planning of WACS

The WACS was undertaken from the 9th to the 16th of February 1998, for households and markets of the Central District.

Because it is generally accepted that waste generation is proportional to level of income (i.e., higher incomes result in higher generation rates), it was desirable to undertake the WACS in areas representative of the income differences within the Central District. The urban region of the Central District is distinctly divided into three classes of residential areas: high, middle, and low income areas. So following a physical inspection of the Central District and discussions with counterpart staff, the following three *colonias* were selected as being representative, and surveyed.

Table 3-1: Sampling Areas and Points

Sampling Areas	Waste Category	No. of Points
Colonia Palmira	High Income	20
Barrio Lempira	Middle Income	20
Colonia Suazo Córdova	Low Income	20

The number of points (20 households) was selected to ensure that the accumulated size of the working sample would be large enough to give reliable and representative results. While on the other hand, the number of points that could be selected was limited somewhat by available resources.

b. Surveying

The first day of the survey, a Monday, was used as a trial run. Households, particularly in low income areas where service was irregular, had the chance to discharge any waste that may have accumulated. The trial also helped in sorting out other problems, such as a household who decided at the last minute not to participate.

Then on each of the following seven days between 7:00 a.m. and 3:00 p.m. the survey team visited each of the 60 households to collect bags of waste. The bags were immediately tied with different color string to identify the generation source, then weighed and recorded.

c. WACS Results

From the recorded weights and number of occupants per house, the residential WAGRs were calculated. The mean WAGRs for residential waste and a summary of statistical analysis are shown in Table 3-2.

The statistical analysis shows that the data tend to be peaked and slightly skewed, with a tail tending towards the positive. The positive Kurtosis indicates concentrated results (a sharp peak). While in regard to skewness, in general, some degree of

positive skewness is common with solid waste generation data[1]. It therefore is assumed that the data are reliable.

Table 3-2: Statistical Analysis of WACS Data

WASTE CATEGORY	Low	Middle	High
Mean	262 grams	274 grams	433 grams
Kurtosis[2]	37.95	3.15	5.19
Skewness[3]	5.12	1.44	1.92
90% Confidence Limits	±53grams	±38grams	±57grams

d. Verification of WAGRs

The WAGRs were then compared to rates obtained for other cities in Latin America, and also to those obtained by other studies carried out in the Central District:

- the recent IPES-IDNS (1996) study entitled *Produccion y Gestion de los Residuos Solidos Urbanos en La Ciudad de Tegucigalpa*, December 1996;
- a paper presented at the 12th Central American Congress on Sanitary and Environmental Engineering by JORGE A. RODRIGUEZ, entitled *Procesamiento Estadistico de Datos Para Determinar La Generacion de Basuras per Capita en el Distrito Central*, April 1979.

Table 3-3: Residential WAGRs from other Studies

Unit: g/cap/day

Waste Category	IPES-IDNS wet season, 1996	Rodriguez wet season, 1978	Managua[4] dry season, 1994	Asunción[5]
High Income	673	646	682	961
Middle Income	-	387	628	-
Low Income	387	268	657	-

Compared to these WAGRs shown in Table 3-3, the rates obtained in this study appear to be lower, the results of the IPES-IDNS study, the Rodriguez paper, and the Managua study are all approximately greater by 50%.

However, when comparing results it should be noted that the previous waste generation surveys done in the Central District were carried out towards the end of the rainy season; IPES-IDNS undertook their survey in September of 1996, and Rodriguez surveyed in August-September of 1978. While this study was carried out in February, which is in the middle of the dry season.

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[1] Tchobanoglous, George. Integrated Solid Waste Management. 1993.
[2] Degree of Peakness. Zero indicates normally distributed data. A positive result indicates peaked data and a negative result indicates that the curve is flat.
[3] Zero indicates normally distributed data. A positive result indicates data skewed so that the tail trails of to the positive direction.
[4] Kokusai Kogyo. The Study on the Solid Waste Management System of the City of Managua, Final Report. May 1995.
[5] Kokusai Kogyo, The Study on the Solid Waste Management for the Metropolitan Area of Asunción in the Republic of Paraguay, March 1994.

The difference in the WAGRs is therefore assumed to be a result of seasonal variation. This was further confirmed on inspection of Cleansing Department disposal records.

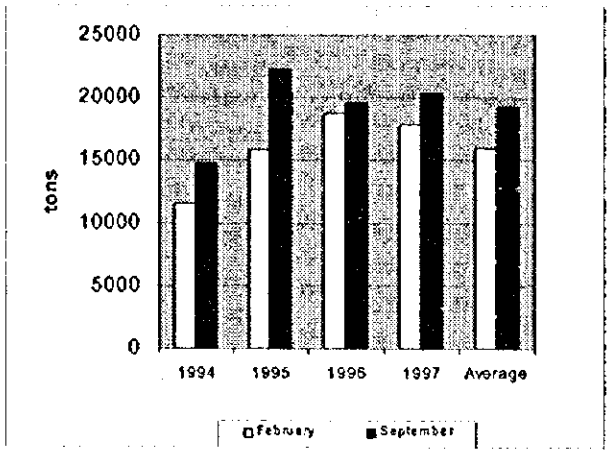

Figure 3-1: Comparison of February and September Monthly Disposal Amounts

Although there are many factors that may influence the Cleansing Department disposal records, and disposal amount is not necessarily representative of generation amount, Figure 3-1 clearly indicates that collection in September is greater than in February, on average 21% more in September. The apparent consistency of the data confirms the assumption that residential WAGRs vary according to the time of year.

The difference could be attributed to a number of factors, one being that February is just after Christmas and people have little money left over and are not consuming as much as usual. Also, most Hondurans are catholic (97%) and February sees the beginning of lent, a traditional time of fasting leading up to Easter.

Moreover, this year one of the worst droughts in recent history has hit Honduras. In the southern part of the country farmers lost crops, which accounted for nearly 15% of Honduras' yearly production[6]. Less produce has made it to the market and therefore is not being consumed at the usual rates. Lower yields also mean that incomes are lower and there is less money to purchase goods with (Agriculture accounts for 28% of the GDP, more than 60% of the labor force and two thirds of exports[7]). Hence, this year's generation rates could be lower than usual.

Because we are interested in obtaining average values and not seasonal variations, the WAGRs obtained in the WACS were multiplied by a factor of 1.25. The magnitude of this factor was approximated based on the discussion above and confirmed when the generation amount was put into the context of the "waste stream" (see section 4.2), which also takes into account collection, recycling, illegal dumping, and disposal amount.

[6] Honduras This Week, pg 1, Feb 28, 1998
[7] CIA World Fact Book

c. Calculation of Residential Generation Amount

To determine the total amount of residential MSW the seasonally adjusted WAGRs shown in Table 3-4 are multiplied by the proportion of population in each waste category to give the amount of residential waste generated in the Central District.

Population proportions are calculated in Chapter 2. However, these populations were based on income bracket (see below) and not the proportion of the population residing in high, middle, and low income areas.

INCOME BRACKET	MONTHLY INCOME
Upper income bracket	> 5,001 Lps
Middle income bracket	between 2,501 and 5,000 Lps
Lower income bracket	< 2,500 Lps

Therefore, this study assumes that the mean generation of MSW in each area surveyed is equal to the mean generation of the respective income bracket. The POS (Question 1-6) confirmed the validity of this assumption by asking residents what is their monthly expenditure. It was found that the mean expenditures of high, middle and low income areas corresponds with the respective income brackets shown above.

The total amount of residential waste is shown in Table 3-4.

Table 3-4: Total Daily Residential Waste Generation

Waste Category	WAGR gr/cap./day	% of total population	Proportion of population	Waste generation amount tons/day
High income/upper bracket	541	20	169,772	92
Middle income/middle bracket	343	30	254,658	87
Low income/lower bracket	328	50	424,430	139
Weighted average	375	TOTALS	848,859	318

3.1.3 Determination of Commercial, Restaurant, Institutional, Market and Street Sweeping WAGRs

The determination of WAGRs for commercial enterprises, restaurants, markets, and institutions were estimated from the results of the POS. Managers of commercial enterprises, institutions, restaurants, and markets were asked how much solid waste their establishment generates. Averages of representative non-residential sources are shown in Table 3-5.

Table 3-5: Average WAGRs according to POS data

Waste Category	Unit	WAGRs
Commercial	g/establishment/day	3,270
Restaurant	g/restaurant/day	24,900
Institution	g/employee/day	217
Market	g/stall/day	3,670

This method of determining the waste generation amount is rough, as many places do not keep precise records, and answers were given in terms of barrels, drums, bags, or truckloads per day. Thus to confirm the results obtained by the POS, the results were compared to data obtained from similar projects recently carried out in other Latin American cities (Table 3-6).

Table 3-6: Non-Residential WAGRs for other Latin American Cities

Waste Category	Unit	Asuncion[8]	Managua[9]	Leon[10]
Commercial	g/establishment/day	3,186	991	2,254
Restaurant	g/restaurant/day	31,958	15,166	16,457
Institution	g/employee/day	78	59	155
Market	g/stall/day	5,961	3,750	3,090

Even though Honduras has a GDP per capita similar to Nicaragua's, Honduras' Central District is more developed than the Nicaraguan cities; there are many more large supermarkets, shopping centers, fast food franchises, hotels, banks, etc. The shopping districts of the Central District are busier. People in the Central District are more likely to shop at supermarkets as well as in the main shopping centers and dine at restaurants than Nicaraguans, who are more likely to buy their goods from markets. It is therefore reasoned that the non-residential WAGRs in the Central District are higher than in the Nicaraguan cities.

On the other hand, Asuncion is more developed and GDP per capita is higher than the Central District. Therefore as a broad guideline, the actual non-residential WAGRs of the Central District are expected to lie somewhere between the WAGRs of Asuncion and the Nicaraguan cities.

a. Commercial Waste

Commercial waste includes waste discharged by retail and wholesale outlets (excluding market stalls), minimarkets, gas stations, printing shops, small workshops computer stores, supermarkets, hotels, beauty parlors, etc. The composition of the waste is varied but generally consists of packaging and container materials, used office supplies, and food wastes.

The unit used here to calculate generation amount is kilograms/establishment/day. According to the results of the POS question concerning the amount of waste discharge per day, the average discharge per shop is 3,270 g/establishment/day. This result appears reasonable when compared to the above data for other Latin American cities and therefore will be adopted as the WAGR for commercial waste.

The total number of commercial establishments in the Central is 17,504[11].

b. Restaurant Waste

There are 1,810 restaurants in the Central District[12]. This number includes all eating places, cantina bars, restaurants, cafeterias, etc.

The WAGR of representative restaurants (24,900 g/restaurant/day) obtained from the POS results falls between the WAGRs for Asuncion and Nicaragua; 24,900 g/restaurant/day is therefore adopted.

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[8] Ibid., Paraguay, 1994
[9] Ibid., Managua, 1995
[10] Kokusai Kogyo, The Study on the Improvement of Urban Sanitation Environment of Principal Cities in the Republic of Nicaragua, Final Report, 1997
[11] AMDC Computer Center, Quantity of Businesses by Economic Activity
[12] Ibid.

c. Institutional Waste

Institutional waste consists of waste that originates from offices such as government ministries and departments, banks, lawyers' offices, real estate agents, accountancy firms, schools, hospitals, etc. It therefore consists of predominantly paper.

As is generally the case there exists an enormous variation in the sizes of different institutions in the Central District so a more suitable unit for the calculation of generation amount is expressed as grams/employee/day of waste.

The figure of 217 grams/employee/day calculated from POS results is significantly higher than figures of other Latin American cities. Therefore a lower figure is adopted, 100 grams/employee/day, as this is a more reasonable figure when comparing to WAGRs of other Latin American cities.

The number of employees working in this sector is 131,003[13].

d. Market Waste

This includes waste generated from one of the four main markets in the Central District. Market wastes consists mainly of food and produce waste, grasses, and other organic packaging materials.

The largest market San Isidro-Colon is chosen as being the most representative. In fact this market contains approximately 30% of all stalls in the Central District.

The unit used to calculate the generation amount is the number of market stalls. The value of 3,670 grams/market/day obtained by the POS and the data from other Latin American cities correspond.

There are an estimated 5000 stalls in all markets in the Central District.

e. Street Sweeping

Street sweeping waste includes all waste generated by the cleaning of streets, parks, and public places. Waste mainly consists of litter, soil, dust, and vegetation.

The street sweeping WAGR was determined by examining the amount currently collected and disposed. Each day the Cleansing Section assigns areas that need special attention in regard to cleansing (special routes). These areas include major streets and boulevards, markets, and other public areas where there are large amounts of uncollected litter.

During the week of the WACS, on average 180 km of road per day were cleaned resulting in a total of 28.53 tons of waste collected. It is therefore assumed that the WGAR of the street sweeping operation is 158.5 kg per km.

[13] Director General of Statistic and Census, Employees in the Central District

3.1.4 Summary of Results

The generation amount from all sources has been tabulated in Table 3-7.

Table 3-7: Generation Amount of MSW

Waste Category	Unit	WAGR	Number	Waste generation amount tons/day
Residential Waste				
High income	g/capita/day	541	169,772	92.9
Middle income	g/capita/day	343	254,658	87.4
Low income	g/capita/day	328	424,430	139.1
Total Residential				**318.4**
Non-Residential Waste				
Commercial	g/establishment/day	3,270	17,504	57.2
Restaurant	g/restaurant/day	24,900	1,810	45.1
Institutional	g/employee/day	100	131,003	13.1
Market	g/stall/day	3,670	5,000	18.4
Street Sweeping	kg/km/day	163.9	180	29.5
Total Non-Residential				**162.3**
Total Waste Generated Per Day				**480.6**

A population of 848,859 translates into a residential WAGR of 375 g/person/day and a MSW WAGR of 564 grams per Central District citizen per day.

3.2 Survey on Waste Composition and Properties of Waste

3.2.1 Objectives

The Survey on Composition and Properties of Waste was undertaken to determine the composition and physical properties of residential and market waste generated in the Central District.

3.2.2 Methodology

As noted above samples of waste were collected from 60 households and 2 markets over seven consecutive days. These samples in their original uncompacted condition were then analyzed to determine the composition and physical properties of the waste.

As also noted, in this study, emphasis was placed on residential MSW. The following categories of waste were analyzed.

- residential waste from high income areas
- residential waste from middle income areas
- residential waste from low income areas
- market waste

Waste samples collected during the WACS (refer to section 3.1 Waste Generation Amount Survey) were then used for the analyses of composition and physical properties. The frequency of the MSW analysis is shown in Table 3-8.

Samples of market waste from the two main markets were obtained from dump trucks hauling the waste to the disposal site. Waste from the dump trucks was randomly selected.

Table 3-8: Frequency of MSW Analysis

Type of waste	Composition	Physical Properties
· residential waste (High Income) · residential waste (Middle Income) · residential waste (Low Income) · market waste	1 sample/day x 7 days for each type of waste	once for each type of waste

Collected samples from the high income area were mixed together resulting in a sample size of 40- 50 kg. Then the volume of the mixture was reduced as described below until the sample size was approximately 15 liters. This process was repeated for waste from middle and low income areas, and the markets.

3.2.3 Results

Table 3-9 shows the composition as it is generally presented, waste components are included with moisture content.

Table 3-9: Composition and Physical Properties

Category	Components	Residential Waste (%)				Market Waste (%)
		High income	Middle income	Low income	Weighted Average	
Combustibles	Food wastes	51.2	54.4	37.9	47.2	82.8
	Paper and CB	12.9	12.7	10.1	11.5	6.7
	Textiles	2.0	1.9	3.8	2.8	0.0
	Plastic	6.2	8.3	6.7	7.1	2.7
	Grass & Wood	16.5	10.0	10.6	11.6	2.9
	Leather & Rubber	0.4	0.00	4.2	2.2	0.1
	Sub-total	89.2	87.2	73.3	82.4	95.3
Incombustibles	Metal	2.8	1.1	1.9	1.9	0.2
	Glass	4.5	2.3	3.8	3.5	0.1
	Ceramic & stone	3.5	9.3	21.0	12.1	4.4
	Others	0.0	0.2	0.0	0.1	0.0
	Sub-total	10.8	12.8	26.7	17.6	4.7
Uncompacted Specific Weight (kg/l)		0.21	0.20	0.19	0.20	0.3
Moisture Content (%)		52.8	42.8	38.8	46.5	68.5

In Table 3-10 the moisture contents of components have been removed giving the actual dry mass of waste components. Residual ash content results are also given.

Table 3-10: Dry Composition and Residual Ash Content

Waste component	Dry mass of components (%)				RAC (%)
	High income	Middle income	Low income	Market	
combustibles	**37.4**	**44.7**	**35.7**	**27.8**	-
food waste	10.4	21.6	8.9	21.0	5.0
paper & cardboard	10.0	9.2	6.1	3.7	6.0
textiles	1.8	1.6	3.5	0.0	3.2
plastics	5.8	6.7	5.6	1.9	0.4
grass & wood	9.1	5.7	7.8	1.0	6.3
rubber & leather	0.3	0	3.7	0.1	15.0
incombustibles	**9.8**	**12.5**	**25.5**	**3.7**	-
metals	2.6	0.9	1.9	0.2	-
bottles and glass	4.5	2.3	3.7	0.1	-
ceramics and stone	2.6	9.1	20.0	3.4	-
other	0.0	0.2	0.0	0.0	-
moisture content	**52.8**	**42.6**	**38.8**	**68.5**	-

From the dry weights and the chemical composition the lower energy content using the two formulas was calculated and summarized in Table 3-11.

Table 3-11: Lower Energy Content

Method	High	Middle	Low	Average	Market
Karisato (calories/gram)	1568	1987	1568	1683	908
Dulong (calories/gram)	1522	1956	1668	1615	747

3.2.4 Findings

Residential Waste

The properties of the composition of residential waste are described as follows:

- Food wastes constitute the greatest portion, 47.2%, of residential waste. The proportion of food wastes in low income areas is the lowest at 37.9%.
- The percentage of paper and cardboard, 11.5%, is approximately equal to the percentage of grass and wood, 11.6%, as the second largest constituent of residential waste. The percentage of grass and wood is noticeably higher in the high income area.
- Ceramics and stone constitutes 21.0% of the waste from low income areas. During the seven days of the survey, ceramics and stone ranged between 14 and 36% of low income waste. Course sands and rocks being the main constituent of this component.
- From Table 3-10 it can be seen that the total amount of recyclable materials (paper and cardboard, plastic, metals, and glass) make up approximately 23% of waste of high income areas, 19% of middle, and 17% of low income areas. Only 6% of waste from markets is potentially recyclable.

Market Waste

- Market waste was found to be predominantly composed of foods waste (i.e. food scraps). The proportion of incombustibles is very low at 4.7%.

Uncompacted Specific Weight (USW)

The USW weighted average for residential waste is about 0.20 kg/l for the three areas, and 0.25 kg/l for market waste. Though the USW is expected to increase during the rainy season the results obtained are consistent with those from other cities in lower income countries.

Moisture Content

Moisture contents of residential waste vary between 39% and 53% having a weighed average of 46.7%. The moisture content of market waste was higher at 68.5%. Higher figures correspond to the higher percentages of food wastes.

Residual Ash Content

Percentages of ashes remaining after incineration ranged between 0.4% for plastics and 15% for leather and rubber. These figures are normal for MSW from lower income countries.

Lower Energy Content

The results of the two formulas correspond with each other. Market waste, with the highest moisture content (68.5%), has the lowest energy content. Residential waste from middle income areas, on the other hand, has the highest percentage of combustibles and the lowest moisture content and thus has the highest energy content.

3.3 Disposal Amount Survey

The existing disposal site does not have a weighbridge which gives us reliable data of waste disposal amount. The objective of the Disposal Amount Survey (DAS) is, therefore, to determine the amount of municipal waste currently being disposed at the final disposal site. This information is integral for the development of the waste stream.

3.3.1 Survey in February 1998

The main survey method used to determine the disposal amount was the Vehicle Weighing Survey.

Cleansing Department disposal records were used to provide information on the number and types of vehicles disposing waste at the final disposal site.

The method of the vehicle weighing survey is simple. Vehicles entering and exiting the landfill were randomly weighed on the portable truck scale in order to determine the average weight of waste being carried by the different types of vehicles disposing waste.

Table 3-12 shows the waste final disposal amount in 1997 obtained by the survey.

Table 3-12:Average Daily Disposal Amount: 1997

Type of Collection Vehicle	Percentage of Total Trips (%)	Estimated Number of Trips in 1997	Average Load (kg)	Waste Generated (kg/day)
Amount of Waste Disposed by AMDC Vehicles				
Hoist truck	6.5	1,872	1,250	8,154
Arm roll	5.7	1,638	2,818	16,084
Hino Compactor	18.3	5,265	6,403	117,471
Fiat Compactor	18.3	5,265	5,744	105,381
Nissan DT	19.4	5,577	3,850	74,819
Fiat DT	10.3	2,964	2,909	30,045
M Benz DT	16.6	4,758	3,253	53,933
Hino DT	4.8	1,365	5,303	25,223
Totals	100	28,706		431,110
Amount of Waste Disposed by Private Vehicles				
Small	47.4	7,634	322	8,565
Medium	23.1	3,714	653	8,450
Large	29.5	4,745	1,543	25,513
Totals	100	16,093		42,527
Average Daily Disposal Amount, 1997				**473,637**

The daily disposal amount is calculated taking into account the fact that waste in the Central District is disposed of 5.5 days per week (Monday to Friday and a half day on Saturday).

The same method was repeated using Cleansing Department data for the years 1994, 1995, 1996 and 1997. The total amounts of MSW disposed at the final disposal site are shown in Table 3-13.

Table 3-13: Estimated Yearly Waste Disposal Amount from 1994 to 1997

Year	Estimated Disposal Amount (tons/year)
1994	100,803
1995	131,196
1996	137,449
1997	135,929

The disposal amount calculated by this study was significantly lower than the amount estimated by the Cleansing Department. The difference is attributed to the fact that average truck weights used by the Cleansing Department to estimate waste amount were too high. Table 3-14 shows the average weights by type of vehicle as determined by this study and those currently being used by the Cleansing Department.

Table 3-14: Weights by Type of Vehicles

unit: ton/vehicle

Type of Vehicle	tons/load used by the Cleansing Section	tons/load measured by this study	Difference
Fiat compactor ($13m^3$)	6.26	5.7	-0.56
Fiat dump truck ($8m^3$)	6.26	2.9	-3.36
Hino compactor ($15m^3$)	6.26	6.4	+0.14
Nissan dump truck ($12m^3$)	6.26	3.9	-1.36
Hino dump truck ($8m^3$)	6.26	5.3	-0.96
M. Benz dump truck ($8m^3$)	6.26	3.2	-3.06
Hino arm-roll truck ($12m^3$)	6.26	2.8	-3.46
Hino hoist truck ($5.5m^3$)	6.26	1.3	-4.96
Private vehicles - small	3.5	0.3	-3.2
Private vehicles - medium	3.5	0.7	-2.8
Private vehicles - large	3.5	1.5	-2.0

3.3.2 Final Disposal Amount Data in August 1998

A private contractor started the operation for waste collection and haulage work in the beginning of June 1998. In addition, as one of pilot projects a system used by a computer to summarize the final disposal amount of waste started its operation in the middle of August. This section describes the data summarized by using the new system in August.

Table 3-15 shows the final disposal amount data of waste collected in August 1998. This data includes all amount of final disposal of waste within this period. The final disposal amount measured is 442.9 tons per day based on 5.5 days working days per week. It implies that on average 348.0 tons of waste per day are being disposed at the final disposal site.

Table 3-15: Waste Disposal Amount Data in August 1998

unit: tons/day

	10 mon	11 tue	12 wed	13 thu	14 fri	15 sat	16 sun	Total	Average ton/5.5day s/week	Average ton/7days/ week
AMDC	314.50	299.60	279.70	230.00	240.40	164.80	0.00	1,529.00	278.0	218.4
Contractor	140.75	182.02	139.54	129.77	143.02	72.51	0.00	807.61	146.8	115.4
Direct hauler	8.50	16.70	17.70	19.40	16.90	0.00	0.00	79.20	14.4	11.3
Special	2.20	3.40	3.30	4.30	6.70	0.00	0.00	19.90	3.6	2.8
National	0.00	0.00	0.00	0.30	0.00	0.00	0.00	0.30	0.1	0.0
Total	465.95	501.72	440.24	383.77	407.02	237.31	0.00	2,436.01	442.9	348.0

3.3.3 Conclusions

The final disposal amount measured in August 1998 is 88% of that estimated in February 1998. It has been confirmed by the Cleansing Department's record that the final disposal amount in summer is more than that in winter in general. Therefore the fact that the final disposal amount measured in August is less than that estimated in February is difficult to be justified.

The cause could be attributed to the followings.

1) The data of number of trips recorded by the Cleansing Department which was used for the estimation in February was wrong.

2) The collection and haulage capacity of the Cleansing Department has actually decreased very much since the previous year.

Since it is too difficult to estimate the final disposal amount of waste in the previous year, the final disposal amount measured in August 1998 is adopted for the master plan. It is

- 443 tons/day (based on 5.5 collection days/week)
- 348 tons/day (based on 7 collection days/week)

3.4 Survey on Recycling System

Recycling of waste materials is an important method of reducing the amount of waste disposed. Recycling also is important for the conservation of natural resources and landfill space.

3.4.1 Objectives

- To obtain an understanding of the current recycling systems in the Central District
- To obtain the quantity of materials being recycled at different points on the waste stream

3.4.2 Methodolgy

Information for the survey on the recycling system was obtained from the following sources:

- Survey of recycling firms and middlemen
- Scavenger Interview Survey
- Scavenging Waste Amount Survey
- Interviews to crews of collection vehicles, Time and Motion Survey
- Waste Amount and Composition Survey
- Public Opinion Survey
- Other relevant recent studies

Recycling occurs at many levels in the Central District, from the recycling of used perfume bottles for refilling and resale at the public markets to the collection and baling of aluminum cans for export to the United States for recycling. However, the Survey on Recycling focuses on those materials being recovered from municipal solid waste in the Central District on a large scale:

- paper
- plastics
- aluminum cans
- glass bottles

3.4.3 Survey Results

From preliminary investigations and discussions with middlemen and end users in the Central District it was determined that materials are recovered from the waste stream as shown in Figure 3-2.

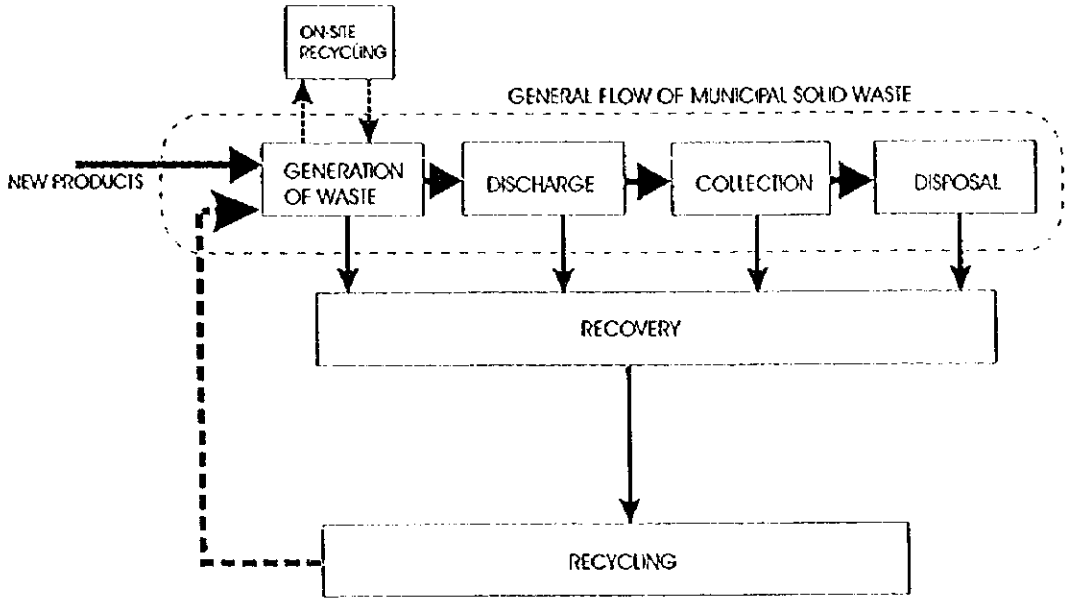


Figure 3-2: Recovery of Materials from the Waste Stream

a. Paper and Cardboard

a.1 Recovery Sources

According to the Survey on Composition and Properties of Waste, it is estimated that 79.3 tons of waste paper and cardboard are generated each day – 16.5% of all MSW is paper. The major sources being residential, commercial enterprises, and institutional waste

Paper is recovered at all points along the waste stream.

- According to the POS 30% of households are visited by people wanting to buy or collect paper.
- Collection crews separate paper from other recyclable materials while they are carrying out collection services and then sell to middlemen located near the final disposal site. Each day 2 to 3 bags of paper are collected per vehicle from waste in middle and high income areas.
- Scavengers at the final disposal site collect paper.

Cardboard is chiefly collected from large dischargers.

a.2 Destinations

There were only two end users found to be purchasing significant amounts of post consumer paper, KIMBERLY-CLARKE HONDURAS and TECHON. Both

companies recycle in San Pedro; Kimberly-Clarke has another plant in El Salvador. Kimberly-Clarke manufactures paper hygiene products and hence mainly purchases paper, while Techon manufactures "Techon™" a laminar roofing material and other materials manufactured predominantly from cardboard.

a.3 Quantity recovered

It is concluded that most of the paper is being recovered by collection vehicles or from the final disposal site and a negligible amount directly from generation and discharge.

Thirty (30) collection vehicles operating in middle and high income areas are collecting on average 3 bags of paper per day (Time and Motion Survey and driver interviews). And the amount obtained from the final disposal site was calculated by weighing the amount of paper leaving the site. They are summarized in Table 3-16.

Table 3-16: Quantity of Paper Recovered

unit: kg/day

Material	Generation	Collection	Disposal	End users
Paper	negligible	2,100	1,070	2,700
Cardboard	2,900	negligible	negligible	2,900

The amount of paper recovered is greater than the amount taken by the end user. It is assumed that approximately 15% of paper is discarded by middlemen when classifying because it is contaminated.

Because of its low cost and the preference for clean cardboard, a negligible amount of cardboard is recovered from the final disposal site or collection vehicles.

Compared to the total amount of waste paper and cardboard generated the portion recovered is very small.

a.4 Prices of paper

Paper collected by scavengers and collection crews is usually commingled (contains newspaper, printed paper, computer printout, manila folders, etc. excluding cardboard). The price paid mixed by middlemen varies between 0.10 and 0.40 lempiras depending on quality of paper and bargaining skills.

Once purchased, the middlemen classify the paper before transporting the paper to the end users for sale. Paper is sorted and sold according to four classes shown in Table 3-17.

Table 3-17: Classifications of Paper

Class	Description	Price paid by end user (Lps/lb.)
High-grade	blank paper, computer printout (non-impact)	0.8 - 1
1st	heavily printed paper	0.50
2nd	color paper, manila folders, newspapers, magazines	0.30
Cardboard	corrugated cardboard	0.15-0.20

When asked if the price of paper is stable, end users, middlemen, and persons recovering paper all said that it is. Moreover, comparing the prices obtained in this

study with the prices in the IPES-IDNS study undertaken in 1996, the prices are almost identical. Therefore taking into account inflation, the prices for paper have actually decreased in real terms.

Interestingly, end users stated that the supply of materials is low or variable. While middlemen complained that there is no market competition to increase prices.

A spokesperson from Kimberly-Clarke complained about the general lack of knowledge about separating materials for recycling.

b. Plastic

b.1 Recovery Sources

It was estimated that 33.6 tons of waste plastic is generated each day – 7% of all waste.

Most plastic is currently being recovered at two points along the waste stream:

- Directly from the generator
- From the final disposal site

Plastic recyclers Fibraplast and Techniplasticos have agreements with local factories that discard plastic, such as, soap and food plastic packaging that is no longer needed. While another company Duraplast has an agreement with scavengers at the final disposal site and obtains most of its plastic directly from there. Techniplasticos also imports plastic recovered from the San Pedro Sula final disposal site, *Centro de Desechables.*

According to the POS, only 2% of high income households said that someone buys or collects plastic directly from them.

b.2 Quantity Recovered

The average amount of plastic leaving the disposal site was calculated from the results of the survey on waste leaving the final disposal site. While the average amounts of plastic recovered from generation was estimated by interviewing end users. They are shown in Table 3-18.

Table 3-18: Quantity of Plastic Recovered

unit: kg/day

TYPE OF PLASTIC	Generation	Disposal site	End users
high/low-density polyethylene	600	1,140	1,740
polypropylene	30	nil	30
polyvinylchloride	150	nil	150
TOTALS	780	1,140	1,920

b.3 Destinations

The three above named companies are recycling plastic obtained from the Central District. Polyethylene products such as polyethylene pipe and fittings are main products manufactured from the recycled plastic. Also plant pot and water containers are produced. The PVC is recycled to make electrical accessories.

b.4 Price for recovered plastics

The prices for the major types of plastic recycled in the Central District are shown in Table 3-19. End users commented that cleanliness and classification of plastic were important factors in determining the prices, noting that plastic from the final disposal site is often dirty and poorly classified. Using the plastics from the disposal site is product less preferable than discarded plastic from factories, which is homogenous and clean.

Furthermore once cleaned and classified plastic must be ground up before it can be reprocessed. According to the IPES-IDNS study end users would be willing to pay around 3.0 Lempiras for cleaned, classified and ground plastic.

Table 3-19: Prices of Plastic Recycled in Central District

unit: Lps/lb.

TYPE OF PLASTIC	SOURCE		
	scavenger	middleman	factory
high-density polyethylene	0.4-0.8	1-3	1-1.5
low-density polyethylene	0.3-0.4	0.4-0.8	0.3-0.8
polypropylene	-	-	0.5
polyvinylchloride	-	-	1.0

However, there are several negative aspects against the expanded recycling of plastics:

- in nearly all cases recycled plastic can not be used for food packaging because of health regulations;
- most plastic discarded in the Central District is low-density polyethylene and of poor quality;
- plastic has a poor cost to weight ratio meaning that transporting plastic is often uneconomical; and
- processing machines are expensive.

In addition to the above factors and the abundance of plastic, the cheapness of virgin material, there is a lot of pressure keeping prices low. And hence the potential for improving plastic recycling is somewhat restricted.

c. Aluminum Cans

As is the case throughout Central America the preferred method of selling soft drinks in Honduras is in returnable bottles. Drinks from aluminum cans cost twice as much and make up only between 2 and 5% of annual sales of drinks in the Central District. However, due to the high demand for used aluminum cans and the expected future increase in sales, aluminum cans provide a good example of the potential of recycling in the Central District.

c.1 Recovery Sources

Aluminum cans are in strong demand in the Central District and are being recovered at all points of the waste stream. The main source of recovered cans is scavenging and collection vehicle crews.

- According to the POS 20% of households are visited by someone wanting to collect or buy used aluminum cans.
- The majority of scavengers interviewed in the urban areas were collecting aluminum cans.
- Collection workers assigned to vehicles operating in middle to high and middle income areas said that they collect between 1 and 2 sacks of cans per day.
- According to the Interview Survey of Scavengers at the final disposal site 71 scavengers collected aluminum cans.

c.2 Destinations

Three companies were found to be buying aluminum cans in significant amounts in the Central District: INVEMA, Ferreteria el Diamante, and INDRESA. All three send the cans to San Pedro Sula for baling and from there they are exported to North America for melting and production of aluminum sheets for recycling into cans.

c.3 Amount Recovered

From interviews with the three companies buying aluminum cans the total amount of cans recovered per day is estimated in Table 3-20.

Table 3-20: Quantity of Aluminum Can Recovered

kg/day

Material	Discharge	Collection	Disposal Site	End users
Aluminum cans	250	400	210	860

The total amount of cans collected by end users was calculated based on interviews with the three main collectors of cans.

Based on interviews with drivers and the results of the Time and Motion Survey it is estimated that each day 1.5 bags of cans are retrieved per collection truck operating in the high and middle class areas.

The average amount of aluminum cans leaving the disposal site was calculated from the results of the survey of waste leaving the final disposal site.

Scavengers collecting in urban areas were estimated to collect a significant amount of aluminum cans. This was estimated based on the other three results, as it was assumed that these were the only sources.

Considering that 65 cans weigh about one-kilogram, then approximately 56,000 cans are recovered each day. This is roughly equal to the total daily sales of aluminum cans in the Central District, i.e., a recovery rate of close to 100%. A very high recovery rate is not unreasonable considering that the contents of a bag of waste from middle to high income areas may be looked through three times before they are buried at the final disposal site.

c.4 Price for aluminum cans

Because the cans are sold to companies in the U.S.A. the price received is influenced by international competition, and therefore is generally higher and more variable than materials recycled locally (Table 3-21). Presently the demand for aluminum cans is very strong.

Table 3-21: Prices Paid for Aluminum Cans

Lps/lb.

	Price paid to scavengers	Price paid to middleman
Aluminum cans	Lps 2-3.50 /lb	Lps 4- 6 /lb

The international price (London Base Metals Market) for 99.7% pure aluminum is presently around $1,400/ton, or Lps8.34/lb. Taking into account transport and processing costs the prices received by the middlemen and the scavengers are very competitive.

d. Glass Bottles

As mentioned above soft drinks and beer are mainly consumed from glass bottles. Soft drink and beer bottling companies sell the bottle and the liquid to the retail outlet. For the retail outlet to retrieve the costs it must return the bottles to the bottling company. The policy of bottlers is to only receive bottles from those that return the purchased bottles and not to buy them back. The system is very successful and according to Cervecería Hondurenã, the major bottler in Honduras, 99% of bottles are returned.
Broken bottles on the other hand are generally just dumped at the landfill site as there is no demand for this material. The closest cullet processing plant is in Guatemala and it is not economical to transport the broken glass.

d.1 Recovery Sources

- 54% of residents replied that someone visits their house to buy or collect used bottles. This is the highest percentage of all materials. However, this mainly occurred in the middle and lower income areas, only 5% of households in high income areas replied that someone came to their house to collect or buy bottles;
- Urban scavengers interviewed said that they collect bottles;
- Scavengers at the final disposal site recovered whole bottles, but state that demand is weak.

d.2 Destinations of recovered bottles

No glass recycling plant exists in Honduras. One exists in Guatemala but according to collectors it is not feasible to transport broken glass there; the broken glass is disposed of at the final disposal site. Only whole bottles that can be sold back to the original owner or another user are recovered. Sauce, rum and other liquor bottles are returned to local manufacturers. Other bottles are sold in the markets for miscellaneous uses such as sauce and relish bottles, while some bottles are sold to pharmacists for storing medicines and chemicals.

d.3 Amount of bottles recovered

From the POS results it can deduced that a significant amount of bottles are recovered from the generation sites, though this study does not attempt to calculate the quantity as there are no major buyers.

Because not all types of bottles are recycled and the price varies according to type often bottles are simply ignored by scavengers at the final disposal site. On the two days of the Material Recovery Survey an average of 1039 kg of bottles was recovered. Or about 2,100 bottles, assuming the average bottle weighs 500 grams.

3.4.4 Other Recycling

As mentioned above the emphasis has been placed on paper, plastic, bottles, and Aluminum cans. 'Other' materials (such as, ferrous and non ferrous metals, textiles, wood, bones, sacks, food scraps, tires, etc.) because of their low potential for increases in recycling and because their impact on current solid waste management problems is small have been ignored. Scrap metal, for example, is purchased by local scrap metal merchants and recycled in much the same way scrap metal is recycled in developed countries. There is also a thriving 'pewter' industry that manufactures aluminum alloy ornaments from non-can aluminum.

The impact of these materials on the amount of material leaving the landfill site is, however, important because it affects the amount of waste that is being disposed of at the final disposal site and therefore may affect future landfill design. For this reason the amount of other material leaving the landfill site has been included in calculations.

3.4.5 Conclusions

A vibrant though small informal recycling system was observed to be operating in the Central District. The system is market driven, and is providing income for various levels of people: from the estimated 500 scavengers to the 100 or so middlemen and the numerous companies that rely on the recovered materials to manufacture various items, or for export dollars.

While aluminum cans are being recovered at a very high rate, problems exist in the cleanliness, classification, and volume of paper and plastic, especially material emanating from the final disposal site. If classification of materials is improved, in particular, voluntary classification in the home, in schools, and in businesses, then the prices offered and quantity of materials will correspondingly increase.

Further, as the wealth of Hondurans increase the number of people willing to recover materials will decrease with a corresponding decrease in the demand that presently exists for some recovered materials (e.g., whole bottles, textiles, certain plastics, wood). Therefore the current informal recycling will have to be gradually replaced with a more formal recycling system, and further efforts made to encourage competition among buyers of recovered materials.

3.5 Survey on Scavenger Activities

Scavengers operate at all points on the waste stream. Going door to door asking residents if they have any recyclable materials, sifting through discharged rubbish in the early hours of morning, collecting bones and burning them for sale as an additive for stock feed, and where they are post prolific, at the final disposal site recovering materials for recycling. Their impact is significant. Therefore, scavenger activities in the disposal site as well as in towns were investigated.

3.5.1 Objectives

- to understand the present role of scavengers of SWM in the Central District
- to understand the system of scavenging in the Central District and at which points of the waste stream scavenging occurs
- to understand the organization of scavengers and their present working conditions
- to estimate the amount recycled by scavengers at different points of the waste stream
- to facilitate prediction of the social impact of the master plan on the scavengers
- to learn what problems scavengers face and how to best improve conditions with possible improvements to the landfill

3.5.2 Methodology

The following were used to obtain information:

- Scavenger Attendance Survey (SAS) at the disposal site for 5 days.
- Scavenger Interview Survey (SIS) with 38 scavengers at the disposal site.
- Scavenging Waste Amount Survey (SWAS) for 2 days.
- Scavenger Interview Survey (SIS) with scavengers operating in urban areas of the Central District.
- Conversations with scavengers and general observations.
- Review or other reports.

3.5.3 Scavenger Attendance Survey at Disposal Site

AMDC Disposal Site Staff (actually a former scavenger) carried out the Scavenger Attendance Survey (SAS) for a period of 5 days from The 2nd of March to The 6th of March 1998. The attendance was recorded twice a day between 7:30 and 11:00 and 13:30 and 16:00. Scavengers were also asked their age.

a. Attendance Results

The number of scavengers present in each survey period was calculated from the attendance survey records and is shown in Table 3-22. It is plotted against date and time in Figure 3-3.

Table 3-22: Scavenger Attendance Survey Results

	Mon 2/3	Tue 3/3	Wed 4/3	Thu 5/3	Fri 6/3	Mean
7:30-11:00	130	177	153	120	112	138.4
1:30-4:00	158	184	150	144	121	151.4

From Figure 3-3: Scavenger Attendance, March 2nd to 6th, two points are immediately obvious. Firstly the number of scavengers is greatest earlier on in the week decreasing towards the end of the week. And secondly the number of scavengers is larger in the afternoon than in the morning

The reason why the number of scavengers is larger earlier on in the week is thought to be because of the greater amount of recyclable waste being disposed at this time. More residential waste is produced on weekends. Housewives do their weekly shopping, people drink beer, go to restaurants, eat more extravagant meals, etc. The result is more aluminum cans, bottles, and plastic, three of the most recycled materials.

The second point deduced from this survey is that the number of scavengers is larger in the afternoon. This is indicative of a gradual accumulation of scavengers until about mid afternoon when the number decreases.

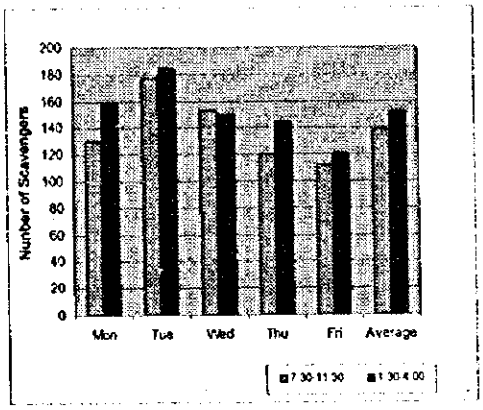


Figure 3-3: Scavenger Attendance, March 2nd to 6th

b. Other results

Table 3-23 shows the number of scavengers that listed as coming to the site during the five days of the survey. The literacy rate of 49 % at the final disposal site is well below the estimate for the whole population of 73%[14].

Table 3-23: Five day attendance record

	Number of scavengers identified	Literacy rate (%)	Average Age (years)
Females	88	45	30
Males	185	50	24.8
All Scavengers	273	49	26.4

[14] 1990 estimate from The World Fact Book, CIA, 1995

Figure 3-4 shows that 68% of the whole scavengers are male.

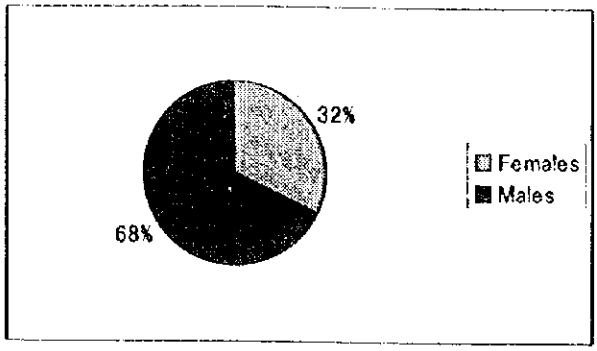


Figure 3-4: Proportion of Male and Female Scavengers

3.5.4 Scavenger Interview Survey at Landfill

Thirty-eight (38) scavengers of the disposal site were randomly selected and surveyed. Two women and one man from the AMDC Department of Cleansing carried out the surveys between the 11th an 19th of February.

a. Summary of Results

a.1 General questions

1) females and 21 males were surveyed. The average age was 33; the oldest surveyed being a sixty-eight (68) year old women (Figure 3-5).

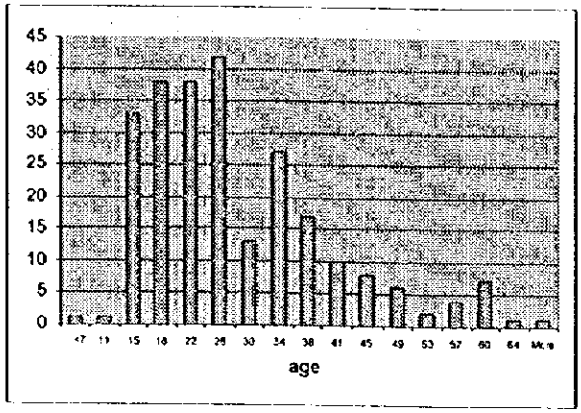


Figure 3-5: Age Distribution of Scavengers

2) answered that they liked scavenging very much, however, when asked would they prefer to do something else given the opportunity, 87% of those who responded to this question said they would like to do something else.

3) Asked if married: 58% percent said they were, while 87% said they were economically supporting someone. 79% were supporting children, indicating many unmarried parents.

4) The mean number of years that the respondents had been working as a scavenger was between 3 and 6 years. A 36-year-old man said that he had man said that he

had been scavenging since he was eleven years old, and a 33-year-old woman replied that she had been scavenging for 23 years.

5) Most people said they scavenged every day of the month. This is confirmed by the Attendance Survey. The roll taken for the Attendance Survey showed that for the scavengers who came to the final disposal site more than once, the were there most mornings and afternoons.

6) The scavengers surveyed said that they live at the final disposal site. The median distance that those not living at the site is between 6 and 8 kilometers.

7) When asked if they would continue to scavenge if the landfill moved 15 kilometers further away, 92% said that would. Indicating a strong desire to scavenge. Though when asked if they would consider living at the final disposal site only 38% said they would.

8) said that they either buy their lunch or bring it with them. It is assumed that the other eighteen 18% obtain their food from disposed waste.

a.2 Earnings

1) The amount of money earned per day from scavenging varied. 24% stated that s/he earned over 100 Lempiras, while 70% earned 50 Lempiras or less a day. Only 6% earning between 50 and 100 Lempiras. According to this data there is a substantial income gap between scavengers.

2) The average daily earnings were calculated at 51 Lempiras[15]. This value was confirmed by conversations with a scavenger leader who has about 22 scavengers working for him collecting plastic. According to a rough record taken of money paid to scavengers, the pay per day for his workers ranges from Lps. 35 to Lps. 155; the average between 60 and 70 Lempiras.

3) Also a survey was done of the materials taken from the site each day for recycling (see section Survey on Recycling System). Each day an estimated Lps. 5,611 of material exits the final disposal site. If it is assumed that on average there are 145 scavengers at the site then the average amount of money that a scavenger makes is Lps. 38.7 per day.

a.3 Materials recovered

1) When asked what materials they collected, they generally gave multiple answers. The major materials recovered are:

- paper
- high and low density polyethylene
- whole glass bottles
- aluminum cans
- textiles
- copper and bronze
- scrap iron

[15] The minimum wage in Honduras is around 35 Lempiras per day

1) The quantity of materials recovered varied according to price and demand.

Table 3-24: Prices, Demand and Price Stability

Material	Prices paid to scavengers Lps/lb.	Demand	Price Stability
plastics	0.4 – 1.0	steady (some types)	stable
paper	0.1 – 0.4	low	stable
Al cans	2.0 – 4.0	very strong	varies
whole bottles	5 – 25 cents/bottle	low - medium	stable
scrap metal	0.2 – 0.4	medium	stable
textiles	0.35 – 2.50	varies	stable
copper and bronze	1.5 – 8.0	very strong	varies

a.4 Problems and suggestions for improvements

1) Many scavengers replied that they had no problems. However those who replied said that problems are[16]:

- No water
- Sickness
- Environmental contamination
- Other workers were rude and did not respect women.
- There is discrimination.
- Dirty.

2) Many more scavengers were, however, keen to offer suggestions on how to improve their work. The main ones are listed below:

- Make the working area larger (8 scavengers suggested this).
- Improve the organization of workers.
- Improve work stability, pay and conditions.
- Prevent landfill fires.

b. Other Findings

1) The mood at the final disposal site was good and most scavengers work very hard. Scavengers were very approachable and were pleased to answer questions.

2) Even though the conditions at the final disposal site are very severe, it was observed that only a few scavengers wore any protective clothing such as gloves, masks, or hats.

3) A comprehensive thesis[17] undertaken in 1995 by a final year student of the national university, UNAH, provided supporting data.

Some interesting findings of this thesis:

- 76% of scavengers originate from rural areas of Honduras.
- 94% of scavengers did not complete elementary school, of these 78% dropped out before fourth grade.

[16] Problems and suggestions are listed with most frequent responses at top.

[17] Andrea Diaz Garcia, Conditions de Trabajo y de Vida de los Recolectores de Articulos de Crematorio, M.D.C., 1995.

- 44% of respondents replied that they consumed drugs (not including alcohol or cigarettes).
- 81% said that they had had previous working experience. Scavengers had experience in work such as carpentry, bricklaying, carrying goods in the market, and cleaning cars. 61% said that they left because they did not like their work while the other 39% left because of low pay.

3.5.5 Scavenger Interview Survey in Urban Areas

Scavengers in the urban area were surveyed to determine how they worked and what materials were recovered. Due to the dispersed nature of their work and the fact that some start working at 2:00 a.m. only 5 urban scavengers were interviewed.

The general consensus is that there are about 300 scavengers working in the middle and high income districts of Tegucigalpa.

Scavengers answered that they made around 50 Lempiras per day. Which is roughly equivalent to what landfill scavengers make. The most popular material of those interviewed was aluminum cans. This is because urban scavengers cover large areas and have to get the materials to a middleman for sale. Cans are approximately 10 times more valuable per pound than paper or bottles, and hence can be easily carried.

3.5.6 Concluding Remarks

In general scavengers are very committed to their work. On average the daily earnings of a scavenger is comparable and often above low paying jobs in the formal sector. Scavengers have a very free existence, which is reflected in most saying that they liked their work very much.

However, social benefits that come with formal employment are not available to scavengers. Moreover, the final disposal site is a dirty and unsafe place and the likelihood of a scavenger falling ill or being injured is high. The average age is 26 years. This indicates that work conditions are severe and the working life of a scavenger rarely extends into middle age, only 8.4% of scavengers were over 45 years.

The high number of unmarried scavengers with children, literacy rates well below the national average, and the high incidence of drug taking further indicate profound social problems.

On the positive side, however, it was found that there exists a strong desire to improve their conditions, through the better organization of scavengers and the improvement of scavenging methods.

3.6 Survey on Private Sector's Participation

A survey of the current situation concerning private sector's participation in the collection of municipal solid waste in Central District was carried out by interviewing Cleansing Department staff, by inspecting Cleansing Department records and by interviewing private collection companies. Supplementary information was obtained during the undertaking of other surveys.

3.6.1 Situation as of August 1998

There are two significant changes seen in the collection and haulage system and street sweeping system of the Central District since March 1998.

a.1 Contracting a part of Collection and Haulage Work out to a Private Company

The private contractor whose name is Compania Constroctura y Servicio Multiplaza started collection and haulage work in the part of the Central District as a contractor of the AMDC. Instead of the introduction of this contract, all vehicles which were used to be leased by the Cleansing Department were terminated.

The some information on the works done by the contractor are described below.

1) The amount collected by the contractor:

June 1998: approx. 1,800 tons

July 1998: approx. 2,800 tons

2) The contract rate:

Lps. 379 per ton of waste

3) Equipment used by the contractor as of 5th August 1998

15.3m^3 compactor	6 units
4.6m^3 container for compactors	80 nos.
Roll-on roll-off	2 units
15.3m^3 container for roll-on roll-off	24 nos.
21.4m^3 large truck	1 unit
Mechanical street sweeper	2 unit

a.2 Micro Enterprises for Street Sweeping Work

The AMDC started to contract some street sweeping works out to micro-enterprises in March 1998. As of August 1998, 43 micro enterprises, which have average seven members, were working as contractors. The contract rate is Lps.15,500 per month per enterprise.

3.6.2 Conclusions

a.1 Contracting a part of Collection and Haulage Work out to a Private Company

a) The Cleansing Department does not have a proper monitoring and supervision system for private contractors and therefore the performance quality and quantity of their work are not understood by the AMDC.

b) The current contract rate with "Compania Constroctura y Servicio Multiplaza" which is Lps.379 tons per ton is about 1.6 times more expensive than the proposed cost in our master plan and it is also 5 times more expensive than the present cost of AMDC's collection work.

c) Although the contract rate of Lps.379 per ton is too expensive, we think this rate is understandable due to the following reasons.

1) No competition for bidding

2) The contractor's risk is very high.

- The contractor cannot expect to continue the contract more than four years which is a term of the mayor. Therefore, the most equipment bought by the contractor are old and can be used only for a few years. According to our financial calculation, the contractor can depreciate the all equipment by this contract rate in two years.
- Payment by the AMDC is not sure.

d) They are carrying much waste which is very difficult to be carried by their vehicles and which can not be generated in their collection area. The following causes can be suspected.

1) They are carrying market waste which is heavier than residential waste. Uncompacted density of market waste here is 0.3 ton/m^3 while the uncompacted density of residential waste is 0.2 ton/m^3.

2) They are using 24 units of 20 cubic yard containers and 80 units of 6 cubic yard containers in the town. The container collection system has advantages and disadvantages as well. The disadvantages are as follows.

- It is very convenient for large amount waste dischargers to place their waste in them. For example, construction companies can place construction waste in containers.
- The container system is too convenient for resident to place their waste because they can discharge any wastes anytime. Therefore, the container system often encourage people to place more waste which are not discharged at the standard collection system. For example, the container is convenient for people to discharge garden waste, bulky waste, etc.

a.2 Micro Enterprises for Street Sweeping Work

- The contract rate of Lps.15,500/area/month is much more expensive than the former cost done directly by the Cleansing Department. As of March 1998 the Cleansing Department was employing majority of street sweepers by individual contract basis that is Lps. 1,000 /person/month. This rate Lps. 1,000 /person/month is deemed to be very cheap. The current contract rate which is Lps.15,500/area/month is equivalent to approximately Lps. 2,000 /person/month and this is deemed a reasonable rate. It implies that the new contract rate corrected too cheap former rate. However, this change of contract system has to lead the increase of expenditure for street sweeping work.
- The Cleansing Department street is well supervising the sweeping contractors' works and well planning it. However, the Social Development Department which is involved in the street sweeping work as well is giving training to micro-enterprises and take actions from the point of income generation. Then

the policy for the street sweeping work seems to be inconsistent among the AMDC.

3.7 Time and Motion Survey

3.7.1 Objectives of the Survey

Since the cost of collection and haulage work occupies the largest portion of the total SWM costs in developing countries, improvements in collection and haulage system efficiency is the most effective means to reduce the total SWM cost and to improve the whole SWM system.

Solid waste collection is extremely labor intensive. At the same time, the cost of collection vehicles is high in developing countries compared to labor cost. Therefore, the time and motion survey aims at the following three items.

- Maximum use of the vehicle capacity
- Maximum use of legal working hours
- Improvement of working conditions for collection workers

The survey included the following items.

- Bearing of time, distance and weight on collection and haulage.
- Type of dustbin and container used
- Work efficiency of waste collectors
- Level of user cooperation in waste collection activities
- Service level
- Maintenance and condition of equipment

3.7.2 Summary of Survey Records

Table 3-25 shows the summary of the Time and Motion Survey records.

Table 3-25: Summary of Time and Motion Records

		unit	No.1	No.2	No.3	No.4	No.5	No.6	No.7	No.8	No.9	No.10	No.11	No.12
Number of Trips	Tr	trips	3	2	2	2	2	2	2	2	5	6	4	4
Travel Distance	D	km	59.3	31.8	58.1	72.6	38.8	30.2	50.8	42.2	152.6	116	85	76.7
Vehicle Velocity	V	km/h	27.8	14.2	24.7	36.3	13.9	14.0	20.7	17.3	28.3	25.2	14.4	14.5
Travel Time	t0	m	128	134	141	120	168	129	147	146	323	276	354	318
Actual Working Hours	t1	m	481	458	589	446	468	428	514	376	380	355	451	386
Service Time	t2	m	41	7	37	0	0	6	6	3	0	5	7	4
Collection Time	t3	m	303	291	275	319	289	285	348	220	36	38	51	51
Discharge Time	t4	m	9	9	9	7	11	8	13	7	21	36	9	13
Lunch	t5	m	38	26	3	47	0	0	16	0	0	0	0	0
Idling Time	t6	m	0	17	127	0	0	0	0	0	0	0	0	0
Other purpose	t7	m	0	0	0	0	0	0	0	0	0	0	30	0
Efficiency	E	-	1.00	0.96	0.78	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

3.7.3 Findings

a. General

1) A daily briefing on collection and haulage work is not carried out either before or after a working day.

2) Administrators at the office are not given a daily summary of the collection work by the drivers.

3) The schedule of collection districts is compiled at the office.

4) The collection routes are not fixed and therefore left to the drivers' discretion. Sometimes the route taken is inappropriate.

5) Collection vehicles pick up collection workers on the way to the first collection area and drop them on the way back.

6) Collection workers wear a uniform but no gloves. They change from the uniforms into their clothes outside, following the final trip to the landfill.

7) Attendance of collection workers and drivers is not recorded by the office.

8) The trucks are refuelled at a specific private gas station. A driver is given an order sheet for diesel by the office on the previous day.

9) Collection workers mainly sort paper and aluminum and occasionally plastics and bottles that are sold onto middlemen.

10) Collection vehicles leave the depot between 5am and 6:30am and return between 2pm and 3:30pm on average.

11) However, the office opens around 6:30am.

12) The legal working hour is 6.5 hours per day excluding lunch break, while during the survey eight out of twelve cases exceeded the legal limit.

13) The approximate trend in the type of container used were observed to be the following.

Residential area	High Income	Middle Income	Low income
100-200 l plastic containers	10	10	5
Metal drums	0	3	10
Plastic bags	65	70	50
Plastic bags on a cage stand	20	10	0
Cartons	1-2	1-2	10
Returnable sacks	0	0	15
Baskets	0	1-2	10
On-site garbage storage	1-2	1	0

b. 13 m^3 Compactor Truck Collection

1) Between 2 to 3 trips are made per day.

2) The work is assessed to be quite efficient.

3) Collection workers assigned to compactor trucks are generally skilled and use techniques to collect waste quickly. One of methods used is where a

collection worker gathers waste bags along a street with very little traffic before a truck arrives, thus changing the curb collection to a point collection system to minimize the stopping and starting time of a truck. Another method is where a collection worker shifts waste bags from one side of the curb to the other so that the truck does not have to make a round trip to collect waste along the other lane.

4) Some compactor trucks ring a bell to inform people of their arrival. However this practice is not necessary as people are well aware of the collection days.

5) A 13 m^3 compactor truck is slightly too large in the places where roads are generally narrow and also busy, like the downtown districts. A 8 m^3 compactor truck is considered to be more suited to these areas.

6) The time that collection workers spend to sort wastes is estimated to be about 10 % of the total. It, therefore, does not seriously affect the overall productivity of the collection work.

7) Collection workers cannot spend much time sorting waste in areas where traffic is heavy like the downtown districts. However, they can still collect a large amount of paper and aluminum for recycling because these areas have many shops and offices, some of which discharge a large amount of paper separately.

8) Compactors are used in the high and middle income residential areas and commercial areas where the roads are all paved.

9) In the center of Comayagüela and near the central park of Tegucigalpa, waste collection becomes arduous after 7 am due to the heavy traffic and narrow streets.

10) The attitude of residents in the middle income residential areas toward the collection workers is generally considerate as they provide the workers with refreshments.

11) Residents' waste discharge manner is generally good.

c. 6 Ton Dump Truck Collection

1) Two (2) trips are made daily.

2) The work is assessed to be inefficient.

3) Most dump trucks operate under a bell collection system. This system reduces the productivity of garbage collection. If regular collection is reliable, this system should be abolished; the AMDC should request people to discharge waste on fixed collection days before a truck arrives.

4) Most collection areas where dump trucks operate have narrow inaccessible roads.

5) Productivity of the dump truck collection system is assessed to be low due to the bell collection method, poor accessibility, and excessive height of the vehicle for loading waste, etc.

6) Most of the unpaved places in the low income residential area except marginal areas are not so far from paved roads. Residents are willing to carry waste to their nearest road.

7) Residents from the dump truck collection area often request collection workers to return their garbage container such as plastic bags, gunny sacks, cartons, etc.

8) Less valuable materials are contained in the waste discharged in the areas where dump trucks operate.

9) A large volume of waste spills from the top of dump trucks during haulage, as there is no cover sheet.

10) Garbage collection work for those assigned to dump trucks is extremely unhygienic and very labor intensive.

d. Arm-roll Truck with 12 m^3 Container Collection

1) On average 6 trips are made per day.

2) The work is assessed to be quite efficient.

3) A large amount of waste overflow from the top of the trucks during transportation due to the lack of a cover sheet.

4) Garbage is scattered around the containers. The following two reasons are suspected.

- The height of container (1.8 m) is too high for people to place their garbage.
- Commercial dischargers dispose their waste improperly.

e. Hoist truck with 5 m^3 Container

1) Approximately 4.5 trips are made daily. The present work is inefficient.

2) The number of trips made could be increased, if there are more skips. In Tegucigalpa, a hoist truck is estimated to handle 15 skips.

3) The hoist truck is sometimes used instead of a dump truck, such as transporting workers and collecting waste.

4) The area surrounding skips is relatively clean unlike the area around the 12 . m^3 containers.

5) A large volume of waste is scattered from the skips during transportation as cover sheets are not being used.

3.8 Public Opinion Surveys

Public Opinion Surveys for the urban area of the Central District was conducted between February 7th and February 25th, 1998 by a team of 9 surveyors.

3.8.1 Survey methodology

The Engineer gave instructions on survey methodology to the surveyors, who asked questions directly to the interviewees. Three hundred people from different families in the study area were interviewed, as indicated in Table 3-26. The population ratios by income levels were not taken into account to determine the number of samples due to the limited number of participants.

Table 3-26: List of Participants

Sub-category	Discharger	Nº of participants
High income	Col. Palmira	25
	Col. Florencia	25
	Col. Miramonte	25
	Col. America	25
Middle income	Barrio Lempira	25
	Barrio Villa Adela	25
	Col. Kennedy	25
	El Hato de Enmedio	25
Low income	Col. Suazo Córdova	25
	Col. San Miguel	25
	Col. Alemania	25
	Col. 3 de Mayo	25

3.8.2 Analysis of the Public Opinion Survey

a. General Questions

1) In the high and middle-income areas, the average family size is five persons.

2) In the low-income area, the number of people per household varies between one and twenty-one. However, the average family size is five persons.

3) In the high-income area, 89% of the respondents replied that they live in a detached house. In the middle and low-income areas, 75% and 97% replied that they live in a detached house, respectively .

4) In the high-income area 81% replied that they owner-residents. In the middle and low-income areas, 63% and 90% replied that they live in the house they own.

5) In the high-income area, 58% of households have less than 100m^2 of garden space.

6) In the middle and low-income areas, 52% and 41% do not have a garden.

7) In all of the areas surveyed, the father is the bread-winner of the family.

8) In the high-income area, 24 households replied there are one or two children with a source of income. In the middle and low-income areas, 19 and 35 households, respectively, replied the children have an income.

9) In the high-income area, 39% replied that their monthly family expenditure is between Lps 5,000.00 and Lps 9,999.00; only one household has a monthly expenditure of less than Lps 1,000.00. In the middle-income area, 29% of the households have a monthly expenditure ranging from Lps 2,000.00 and Lps 2,999.00 and 29% between Lps 3,000.00 and Lps 3,999.00. In the low-income

area, 54% of the households have a monthly expenditure within the Lps 1,000.00 to Lps 1,999.00 bracket.

10) In the high-income area, 74% replied that they have lived in the Central District for more than 20 years; only 4% replied that they have lived in the Central District for less than 5 years. In the middle and low income areas, 67% and 77% replied they have live in the city for more than 20 years; 12% and 2% have lived in the Central District for less than 5 years.

b. Present Situation of Public Services

1) In the high and middle-income areas, all respondents have a water supply and in the low-income area the figure was 99%.

2) In the high-income area, 99% of the households have flush toilets connected to sewage pipes, in the middle-income area this rate is 95%, and in the low-income area the figure is down to 56%.

3) All of the households in the high-income area have electricity; 96% in the middle-income and 99% in the low-income area have an electrical supply. ENEE is the sole provider of this service.

4) In the high-income area, 94% of the roads have asphalt/ concrete/ brick paving, but all residential buildings have an access road and only 1% is unpaved. In the middle-income area 84% of the surveyed households have an access road; 89% of the roads are paved, 1% has gravel and 10% are unpaved. In the low-income area 80% replied that they have an access road; 6% of the roads are paved, 15% have gravel and 79% are unpaved.

5) Of the various public services (water supply, stormwater drainage, sewer pipe network, wastewater collection, garbage collection, electricity supply, access road) the highest priority was given to garbage collection.

c. Waste Discharge from Premises

1) In the high-income area, 92% of the respondents discharge their waste to a specific location.

2) In the middle and low-income areas, 81% and 64% replied that they discharge their waste to a specific location.

3) The most common container used to dispose waste in all three categories is the plastic bag; the main reason being the ease in handling.

4) Fifty six percent of the respondents of the high-income area replied that they generate garden waste.

5) The majority of the surveyed households replied that they take their waste to a collection point.

d. Refuse Collection Services

1) Nearly all the respondents have a garbage collection service in their area and only 29% in the low-income area do not receive this service.

2) The main collector of garbage in the CD is the AMDC, only 3% hand their waste to private collectors.

3) In the high and middle-income areas, nearly 30% of the respondents are dissatisfied with the collection service; the figure is only 21% for the low-income area.

4) Almost all the respondents say they carry their refuse to the front of the house.

5) In the high and middle-income areas, the frequency of the collection service is twice a week. In the low-income area 57% receive the service once a week.

6) Most of the collection service is conducted at a fixed time; most of the respondents answered they want a collection service.

e. Recycling and Waste Reduction

1) Overall, 91% of the respondents said that they would cooperate if the AMDC changes the system.

2) The main reasons for not cooperating with the new system were that the new system would require more effort that may increase collection and discharging costs.

3) Ninety nine percent of all the respondents thought that recycling is necessary for Tegucigalpa. However, 49% of the respondents say that no one collects their recyclable waste.

4) The most commonly collected recyclable materials are bottles, paper and aluminum cans.

5) Ninety seven percent of the respondents do not sell recyclable materials to shops.

6) Among those who sell recyclable materials the most commonly sold items are bottles, paper and aluminum cans.

7) In all the areas, 81% expressed their willingness to contribute to community fund raising activities.

8) Eighty nine percent of the respondents do not use kitchen or garden waste for compost.

f. Collection Fee and Financial Matters

1) In all the areas, the majority responded that they believe the AMDC is responsible for solid waste management.

2) Seventy four percent of the respondents are satisfied with the present solid waste management system being carried out by the AMDC.

3) Almost all the respondents replied that they do not know how much they pay for the collection service; among those who know the amount paid for collection, the average is Lps 200.00 per year.

4) Eighty one percent of the respondents from all areas consider the collection fee to be appropriate, 12% think it is expensive, 6% think it is cheap and only 1% think it is not fair.

5) The maximum amount of waste collection fee people are willing to pay are as follows.

- High income residents: 40 Lps/month
- Middle income residents: 30 Lps/month
- Low income residents: 20 Lps/month

6) The most preferred method of payment is a lump sum for the year followed by monthly installments.

7) Fifty six percent of the respondents do not accept the present billing system, nearly 100% would not accept joint billing along with either income tax, water supply or electricity bill. Fifty six percent of the respondents would prefer an independent billing system.

g. Public Cooperation

1) In the high-income area, 52% of the respondents have not been instructed on proper waste discharge. In the middle and low-income areas, 42% and 72% respectively have not been taught methods of proper waste discharge.

2) Seventy five percent of the respondents in the high-income area answered that someone in their household cleans the road shoulder or adjacent public area in front of their premises; this percentage rises to 88% and 79% in the middle and low-income areas.

3) Ninety-eight percent of the respondents in all areas believe public cooperation is essential to maintain a cleaner city and environment, and are willing to cooperate.

4) Almost all of the respondents think that public education and campaigning is necessary to maintain a cleaner city and environment, and that the AMDC is responsible for such actions.

h. Grave Issues Regarding Solid Waste Management

The main concern among respondents related to solid waste management is that illegally dumped garbage causes offensive odor followed by the high incidence of pests (mice and rats).

3.9 Project Cycle Management (PCM) Workshop on Final Disposal

In the workshop, the first three analyses of the PCM method, which are participation analysis, problem analysis and objectives analysis, were executed. This is because the objectives of the workshop were limited to ascertaining the current state of final disposal and to understand the needs of the people concerned; the outcome of the workshop was reflected in one of the pilot projects, that is, the improvement of the final disposal site.

Individuals, groups, and organizations that may be affected by the improvement of the present landfill site were identified by the JICA Study Team and thirteen people were invited to the workshop as participants as shown in Table 3-27. When selecting the participants, an even balance between the number of participants associated with the municipal authority and the residents, including scavengers, was taken into account to avoid a one-sided discussion.

Table 3-27: List of Participants

Category	Representatives (Number of Participants)
"Decision Makers" "Implementing Agency"	• Urban Development Department (1) • Social Development Department (1) • Cleansing Section (1) • Environment Section (1) • Inspector working at the final disposal site (1)
"Cooperation Agency"	• JICA Study Team (2)
"Beneficiary"	• Community Leader representing neighbors of the disposal site (1) • Resident living far from the disposal site (1) • Scavengers (4)
"Affected Group"	• Scavengers
"Community Leader"	• Community Leader, representing neighbors of the disposal site
"Potential opponent"	• Scavengers

Through a discussion, problems related to the present final disposal and the needs of the people were identified. It was evident that everyone perceived the importance of taking some decisive measures to improve the present situation of the final disposal site, as quickly as possible. The biggest concern expressed was the grave health risk associated with the operation of the current disposal practices at the site. In particular, the community leader representing neighbors of the disposal site reiterated the concerns voiced by the residents about the air and water pollution resulting from the current disposal site.

Participants agreed that better landfill operations would contribute to the improvement of the present landfill site state, and consequently the sanitary environment. Improvement of cover soil application procedures, making spare parts for repair of broken down vehicles readily available, and effective provision of vocational training to municipal staff at the disposal site on proper landfill site operations, are suggested as being solutions to the present problems.

Feedback from the participants was very positive. Participants appreciated the opportunity to frankly exchange views on the improvement of the final disposal site, which is one of the most urgent issues that need to be dealt with in the Central District. At the end of the workshop, participants agreed that their overall awareness of critical issues related to waste was raised through discussions with the people concerned.

It was also very encouraging to see that a large number of people expressed their interest in participating in the workshop. Although the number of those wishing to attend the workshop exceeded twenty people, the number had to be restricted in order to carry out the discussion more smoothly.

Chapter 4

Current Situation of the Municipal Solid Waste Management

4 Current Situation of the Municipal Solid Waste Management

The current situation described in this chapter is the situation as of August 1998.

4.1 History of SWM

In Honduras, the municipalities are obliged to engage in the management of solid waste, and as such, in the Central District it is performed by the Cleansing Department under the jurisdiction of the municipal government.

The SWM history of the city begins with the purchase of its first collection vehicle in 1936.

In the past there has been technical assistance from different sources as follows.

a) In 1973, the Asociación Venezolana de Cooperación Institucional (AVECI) conducted a diagnosis of the situation and in its recommendations, suggested the purchase of 15 compactor vehicles that were consequently acquired.

b) In 1975, the Empresa Abonos Orgánicos was hired to take care of the waste collection in the city and the municipal vehicles were consequently transferred over to them. However, this company was never able to reach a financial balance and was therefore unable to fulfill its obligations as stipulated in the contract, which contributed to the continuous strikes by employees over delays in payment of wages; this lead to the failure of the project.

c) In 1977, the municipal government acquired a plot of land along the road to Olancho, 6.5 km from the city center, for the purpose of converting it to a new final waste disposal site; back then, solid waste was being deposited 11 km along the old road to Danlí.

d) In 1978, the Cleansing Department was inaugurated under the Urban Renovation and Environmental Control Management Office, and a decree was established in which waste collection fees were set. In the same year, 18 compactor vehicles with machinery to service containers were purchased.

e) In 1980, with technical assistance from the Organización Panamericana de la Salud, a program for the Integral Development of the Solid Waste System was prepared. It was at this point that the actual organization of the Cleansing Department was established.

f) In 1987, the municipality purchased additional collection equipment from Argentina, with financing from the Banco Municipal Autónomo de Honduras, consisting of 18 compactors, 10 dump trucks and 2 water tankers. Some of the equipment still operate today.

g) In 1991, a donation of equipment was solicited from the Japanese Government, which was examined by the Japan International Cooperation Agency (JICA), the official government agency, in the Study on Basic Design for the Improvement of the Solid Waste Management System in the Central District, undertaken by Kokusai Kogyo Co, Ltd. Subsequently, in 1993 the following were granted by the

Japanese Government: 3 bulldozers (CAT D7H), 2 Komatsu wheel loaders, 3 dump trucks for soil, 12 compactors, 10 dump trucks for waste, 1 hoist truck, 1 arm-roll truck, 19 containers, 1 mobile workshop, equipment for the repair shop and spare parts.

In general, the Cleansing Department has historically been under the Department of Public Works, with the exception of a brief period between 1990 and 1994, when it operated as an office under the Upper Management of the municipality.

4.2 Determination of the Current Waste Stream

4.2.1 Introduction

Following the generation of municipal solid waste, waste takes many courses. MSW is put out for collection by households and collected by AMDC's trucks, dumped in rivers or on the side of the street, burnt or buried in the backyard, composted, washed down drains, recovered by scavengers, resold in markets, sold for export, picked up by street sweepers or community groups, separated by school children, buried at the city landfill, made in to plastic pipe, fed to cattle, etc.

Up until now, studies done in relation to the flow of municipal solid wastes in the Central District have concentrated on just one or two parts. In reality, however, the flow of municipal solid waste in the Central District is complex and a more holistic approach is required. Therefore this study attempts to look at all major parts in a more integrated manner.

The most important tool for perceiving this is the **waste stream**. The waste stream describes and quantifies the waste generated by different sources and maps out the routes taken by the waste and presents this in figurative form (Figure 4-1).

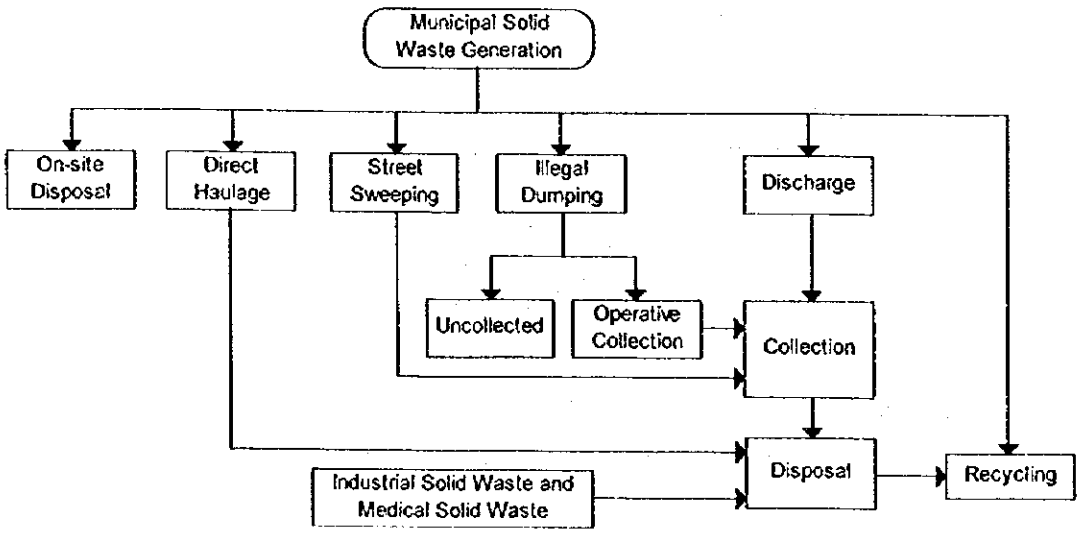


Figure 4-1: Schematic of Waste Stream

a. Waste Stream Terminology

MSW Generation

The amount of MSW generated by all residential and non-residential sources. (Note: does not include ISW generation amount)

On-site Disposal

Waste disposal amount within the property of generator. In this study on-site disposal refers to the amount of residential waste being disposed of by either burning or burying on the premises (yard) of the generator. This is particularly common in marginal areas not served by regular AMDC collection services.

Illegal Dumping

Waste amount that is dumped outside the property of the generator into areas where such behavior is prohibited. This illegal dumping practice often occurs in the marginal areas of the Central District where regular collection services do not exist, e.g. dumping at the roadside, in open spaces, in drains, over the side of cliffs, valleys, etc.

Direct Haulage

MSW amount transported directly from the source to the final disposal site by the generator. In the Central District this includes waste generated and hauled by supermarkets, restaurants, banks, department stores, the army, various institutions, and the national university. The industrial waste amount, though directly hauled, is included under ISW, see below.

Street Sweeping

Street sweeping *(recorridos)* is the amount of MSW collected by Cleansing Department staff from specially assigned locations around the Central District. Including MSW collected near markets, the central business area, along busy roads and other areas where waste quickly accumulates.

Operatives

The MSW amount collected by specially organized cleansing operations usually undertaken in poorer areas of the Central District with irregular collection services. Operatives are generally carried out on weekends and involve local residents organized by Cleansing Department staff.

Discharge

Discharge refers to the action of taking the waste to an approved collection point; placing it in an AMDC or private waste collection truck or dumping it in a container or skip located at various places around the City.

Recycling

The term recycling refers to the separation, collection and processing of materials or objects (e.g., paper, bottles, plastic, cans) so that they may be used again. In the context of the waste stream, 'reuse' is included under recycling.

Collection

Refers to the activities of collecting and hauling discharged solid waste. In the Central District the AMDC or individual companies are undertaking the collection of solid waste.

ISW (industrial solid waste)

The disposal amount of solid waste discarded from large industrial sources or derived from manufacturing processes. In the Central District these include the solid waste discarded by the maquiladoras, Cerveceria Hondureña, Quimicas Dinan, etc. It also includes construction waste. This does not, however, include solid waste discarded by hardware stores, auto repair shops, and small workshops. (Note: The ISW generation amount is not included in the waste stream as this is beyond the scope of the study.)

Disposal

The amount resulting from activities associated with the long-term handling of solid wastes that are collected and are of no further use. In the Central District disposal of waste is accomplished by means of burial at the city landfill.

4.2.2 Derivation of Waste Stream Components

The main objective of many of the surveys carried out in the first study period in Honduras was to provide information for the derivation of the waste stream.

a. Generation

Results of the Waste Generation Amount Survey (section 3.1) are shown in Table 4-1.

Table 4-1: Waste Generated in the Central District

Waste Category	Unit	WAGR	Number	Waste generation amount tons/day
Residential Waste				
High income	g/capita/day	541	169,772	91.9
Middle income	g/capita/day	343	254,658	87.4
Low income	g/capita/day	328	424,430	139.1
Total Residential				318.4
Non-Residential Waste				
Commercial	g/establishment/day	3,270	17,504	57.2
Restaurant	g/restaurant/day	24,900	1,810	45.1
Institutional	g/employee/day	100	131,003	13.1
Markets	g/stall/day	3,670	5,000	18.4
Street Sweeping	g/km/day	158,333	180	28.5
Total Non-Residential				162.3
Total Waste Generated Per Day				480.7

b. Disposal

The amount of waste being disposed at the final disposal site was obtained from the results of the Disposal Amount Survey.

Each day of 1998 (Monday to Friday, and a half day on Saturday), according to the Disposal Amount Survey, 424.2 tons of waste is disposed of at the final disposal site. If it is assumed that disposal occurs 7 days a week then 338.0 tons/day is disposed of at the final disposal site. The amount recovered by scavengers at the final disposal site (4.7 tons/day), is subtracted from this figure giving a disposal amount of 333.3 tons/day. In addition, approximately 10 tons of industrial and medical wastes are disposed of at the final disposal site.

c. Recycling

According to the Survey on Recycling System the amounts of materials retrieved from the four points along the waste stream are:

Generation	3.7 tons/day
Discharge	3.0 tons/day
Collection	2.5 tons/day
Disposal	4.7 tons/day

Only the amounts of paper, plastics, and aluminum cans have been included in the amounts recovered from generation and discharge points (refer to Section 3.4, Survey on Recycling System). While it is assumed that the amount of other materials recovered from generation is negligible, the amount recovered by urban scavengers (from discharge points) is significant.

It has been estimated that there are approximately 300 scavengers operating in urban areas. If it is assumed that each scavenger collects 10 kilograms of waste per day (taking into account that urban scavengers carry all material recovered and are not likely to work everyday), it is calculated that 3.0 tons of material is recovered each day from discharge.

d. Operatives

Cleansing Department records state that in 1997, vehicles hauling waste borne by operatives made 264 trips (dump trucks) to the final disposal site. It was determined that the average weight of the load of dump trucks is 3.6 tons, so it is therefore estimated that 2.6 tons of waste per day results from operatives.

It is assumed that all MSW collected by operatives is residential waste from colonias where collection services are irregular. Hence it is assumed that the waste collected through operatives is illegally dumped residential waste.

e. Street Sweeping

Street sweeping, on the other hand, is undertaken where there are existing regular collection services and hence none of the 104.4 tons/day of illegally dumped residential waste is collected by street sweeping. It is therefore assumed that the waste collected by street sweeping activities consists of waste illegally discharged as a result of: indiscriminant littering by motorists and pedestrians, and waste illegally discharged by non-residential sources.

The total amount of street sweeping waste that is collected is 28.5 tons/day.

f. Direct Haulage and ISW

It was estimated from the truck weighing survey and Cleansing Department disposal records that the total amount of waste being disposed at the final disposal site by private vehicles is 33.4 tons per day. Of this amount 23.4 tons is MSW and 10.0 tons is ISW.

g. On-site Disposal and Illegal Dumping

Disposal habits of Central District residents were determined using questionnaires. Residents were asked how they disposed of their waste, and from the results of these questionnaires it was possible to estimate the amounts of residential waste being disposed on-site and the amount of residential MSW illegally dumped each day (Table 4-2).

Table 4-2: Disposal Amounts of Central District Residents

Category	Total waste generated daily (ton/day)	AMDC collected (tons/day)	Illegally Dumped (tons/day)	Disposed on-site (tons/day)
Low	139.1	70	69.1	19.5
Middle	87.4	61	26.4	-
High	91.9	83	8.9	-
TOTAL	318.4	213	104.4	19.5

The total amount of MSW illegally dumped and left uncollected is calculated by subtracting the amounts disposed (on-site and at final disposal site) and recycled from the total MSW generation amount. This calculation gives to a total of 116.6 tons/day of waste uncollected.

From the above illegally dumped quantity (104.4 tons/day), estimated from questionnaire results, it was estimated that 2.6 tons/day is collected operatives. The remaining 101.8 tons remains uncollected. Therefore it is assumed that the total uncollected amount consists of 101.8 tons of residential waste and 14.8 tons/day of non-residential waste.

4.2.3 Formation of the Waste Stream

The waste stream is summarized in Table 4-3.

Table 4-3: Summary of Waste Stream Amounts - 1998

unit: tons/day

Waste Stream Component		Daily Amount	
Component	Sub-component	Amount	Total
Generation	residential	318.4	
	commercial	57.2	
	restaurant	45.1	
	institutional	13.1	
	market	18.4	
	street sweeping	28.5	480.7
Discharge			289.0
Collection			286.0
On-site disposal			19.5
Illegal dumping			116.6
Final disposal			343.3
Direct haulage			23.4
Street sweeping			28.5
Operatives			2.6
ISW			10.0
Recycling	from generation	3.7	
	from discharge	3.0	
	from collection	2.5	
	from final disposal	4.7	13.9

Inputting the above values gives an estimate of the 1998 waste stream for the Central District as shown in Figure 4-2.

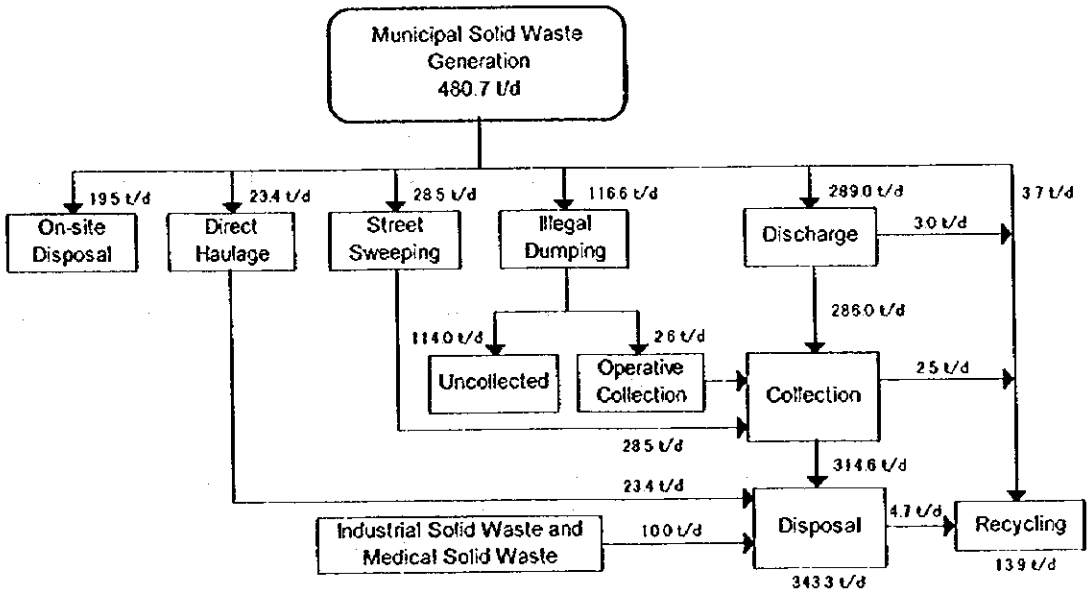


Figure 4-2:1998 Central District Waste Stream

4.3 The Current Situation of the Technical System

4.3.1 Hygiene Condition of Central District

One of the top priority issues that the new AMDC is focusing on is the enhancement of cleansing work and beautifying the city. In late January 1998, immediately after the inauguration of the new mayor, the AMDC launched a campaign under the slogan: "La Nueva Capital" meaning "The New City" and consolidated the cleansing work. For example, many trash boxes were installed along the main streets in the city center to maintain the city's cleanliness, collection work operations for marginal areas[1] were reinforced, and the river bed of Choluteca River in the city center was cleaned. These activities helped to enhance the hygiene of the city.

The appearance of the Study Area as of February 1998 is generally clean except some parts of low income residential areas that currently do not receive regular waste collection services.

The present waste collection service rate for the Central District is approximately 64%. All high and most middle income residential areas receive regular waste collection services: most areas with no regular waste collection services are located in the low income residential areas.

Illegal dumping is only observed in the low income residential areas that either has irregular or insufficient waste collection services, however, this is not so rampant. A large amount of scattered waste is observed along the road within a 1 km radius from the disposal site entrance.

The hygiene of the Central District is assessed to be generally fair except in some low income residential areas.

4.3.2 Discharge and Storage System

In the areas that have no regular waste collection services, 45% of people discharge waste somewhere outside of their premises, 36% burn or dispose of waste in a pit in their backyard, and 11% give it to private collectors according to the responses of the public opinion survey.

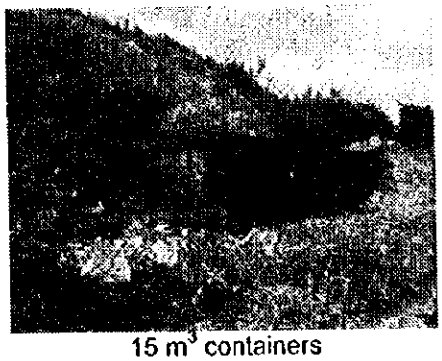
The AMDC is responsible for regular waste collection, most of which are conducted by either the AMDC directly or by its contractor. The waste is not collected separately and customers are not obliged to discharge their waste separately; only mixed discharge is carried out.

In areas where waste is collected by compactors or dump trucks, the types of containers typically used are plastic bags, flour sacks, plastic containers and cartons. More than 90% of people use plastic bags for discharge according to the responses in the public opinion survey. Twenty liter plastic bags are commonly used, which is distributed to residents by shops to carry their groceries.

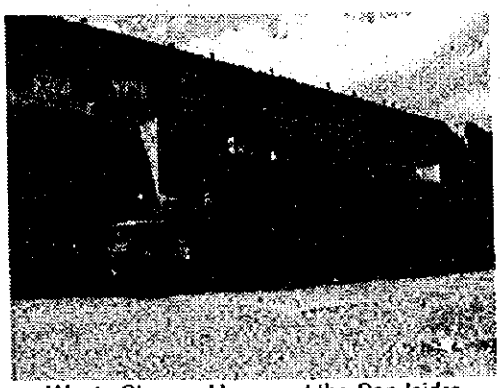
[1] Waste collection activity for areas having no regular waste collection services, with public cooperation.

In the high and middle income residential areas, some people use large 80 liter plastic bags to discharge waste. Some also use plastic containers that are about 100 to 200 liters. The 100 liter plastic containers used as waste receptacles are originally for water, but is also very suitable as a container to store waste.

In the low income residential areas, quite a few metal drums are used. It decreases the collection efficiency due to its heavy weight. Also flour sacks are used by a few people for waste discharge. The collection workers return these sacks after the waste inside is emptied into the trucks.


15 m^3 containers

In some of areas where a private contractor, Compania Constroctura y Servicio Multiplaza, is collecting waste, they are using approximately 4 m^3 containers and 15 m^3 containers for collection points.


Waste Storage Hopper at the San Isidro Market

As for market waste, three markets have waste storage hoppers called "rampas". The picture to the right shows a waste storage hopper at one of the three markets in San Isidro. Waste collected in the market is stored in a hopper once and then dropped by opening gates onto a dump truck. This storage and discharge system is very appropriate for market waste and works efficiently.

4.3.3 Collection and Haulage System

a. Collection Method

The AMDC officially only carries out mixed waste collection in the study area, however, collection workers unofficially sort wastes for selling reusable materials to middle men during collection work. The items sorted by collection workers are mainly paper and aluminum and also some plastics and bottles. The middle men purchase recyclable materials from the workers near or at the disposal site.

The practice of sorting waste by collection workers decreases the collection work efficiency, however it is also true that it contributes to the recycling of waste in the Central District where no official recycling system is in place. However, the reduction in collection work efficiency due to waste sorting by collection workers, is observed to be marginal in general. Sorting work is being carried out quite efficiently by the workers, and therefore productivity loss is estimated to be slightly less than 10 %.

Collection workers for the Compania Constroctura y Servicio Multiplaza were not seen to be sorting recyclable materials.

b. Regular Waste Collection Service Rate

The total population in the Study Area receiving a regular waste collection service is estimated to be 64% of the total, which is equivalent to approximately 543,000 people. The waste collection service rate in the high and middle income residential areas is more than 70%, and waste collection frequency is two to three times a week. In the areas that receive a regular waste collection service in the low income residential districts, the frequency is generally only once a week. A large number of people in the low income residential areas do not have their waste collected on a regular basis. The estimated population with no regular collection service is approximately 306,000, corresponding to 36% of the total population. This is mainly because of two reasons: the limited financial capacity of the AMDC and very poor accessibility of roads.

c. Executing Body

The AMDC is solely responsible for the collection of residential waste; it is carrying out the work directly in some areas but also its contractor, Compania Constroctura y Servicio Multiplaza, does some collection work. It was confirmed through the public opinion survey that private micro-enterprises operate in some low income residential areas, however, the quantity of waste collected by them is considered to be negligible.

Some waste generated through business activities are collected and hauled to the disposal site using their own or hired vehicles. The Study Team could not find any private companies dealing with collection and haulage services for this type of waste.

d. Equipment Used for Collection and Haulage Work Owned by the Cleansing Department

Table 4-4 shows an inventory list.

Table 4-4: Inventory List of Collection and Haulage Equipment owned by the Cleansing Department

Equipment	Capa-city	GVW (kg)	Manufacturer		Year	Number of Operational Vehicles
			Chassis	Body		
Compactor	appx.13 m^3	N.A,	Fiat	N.A,	1988	9
Compactor	15 m^3	15,100	Hino	ShinMaywa	1993	11
Dump Truck	appx. 6 m^3	N.A,	Fiat	N.A,	1988	5
Dump Truck	12 m^3	13,500	Nissan	ShinMaywa	1993	10
Arm-Roll Truck	-	13,000	Hino	ShinMaywa	1993	1
12 m^3 containers for an armroll truck	12 m^3	-	-	-	1993	13
Hoist Truck		13,000	Hino	ShinMaywa	1993	1
5.5 m3 containers for a hoist truck	5.5 m^3	-	-	-	1993	11
Total	-	-	-	-	-	37

d.1 13 - 15 m^3 Compactor Truck System

This type of truck is used in the high and middle income residential areas as well as commercial areas where road conditions are fair. It generally makes two trips, and occasionally three when it works in the collection area near the disposal site.


15 m^3 Compactor Truck

A collection crew consists of a driver and four or five collection workers. Collection workers are generally skilled and use various techniques to collect waste quickly. One of methods used is where a collection worker gathers waste bags along a street with very little traffic before a truck arrives, thus changing from a curb collection to a point collection system to minimize the stopping and starting times of the truck. Another method is where a collection worker shifts waste bags from one side of the curb to the other so that the truck does not have to make a round trip to collect waste along the other lane.

Some compactor trucks ring a bell to inform people of their arrival, however, this practice is not necessary because most people place their waste along the curbs before the compactor reaches the collection point.

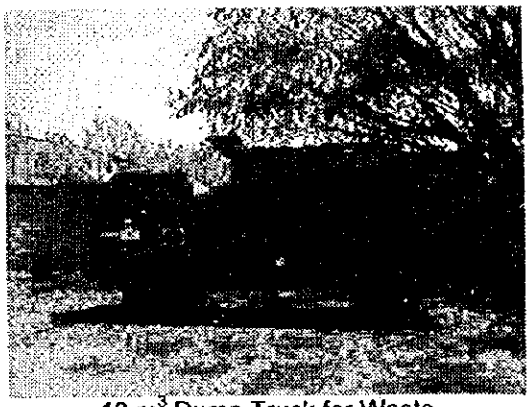
The truck weighing survey at the disposal site found 60% of the compactor trucks to be overloaded and the average loading rate is 101% of the designed capacity. This figure is assessed to be too high and should be controlled to around 90%.

The type and capacity of compactor trucks currently used is assessed to be generally appropriate for the present collection area in terms of haulage time, waste quality, etc. However, it is found that compactor trucks currently used are too large to operate in areas where roads are generally narrow and also busy, such as the old city center.

In general, the compactor truck collection system is assessed to be efficient.

d.2 6 -12 m^3 Dump Truck System

Dump trucks used by the AMDC are mainly divided into two types: a modified truck for waste collection and a standard dump truck. A modified truck has a large vessel that has a capacity of 12 m^3 for hauling waste. They are used for collection of residential waste in the middle and low income areas where roads are unpaved.


12 m^3 Dump Truck for Waste

The work efficiency for both types of dump trucks is poor and the collection work is very labor intensive; the height of the trucks is too high to load waste swiftly and the roads are in a poor condition. In addition, a large amount of waste is scattered from the vessel while hauling waste to

the disposal site. During haulage, wastes fall from the open vessel of a dump truck. Only a few dump trucks use cover sheets to prevent waste from being dispersed.

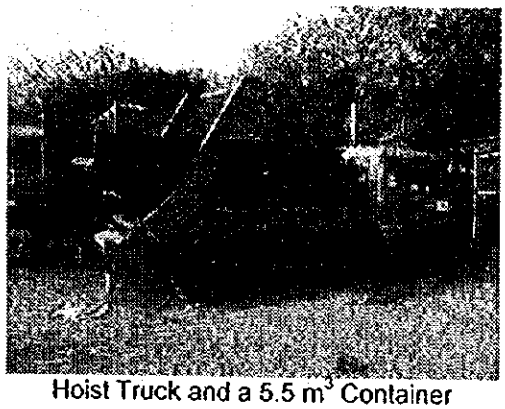
The dump trucks generally operate under a bell collection system. This system affects the productivity of garbage collection because the collectors have to wait for people to bring the waste to them. If regular collection is reliable at present, the AMDC should stop this practice and request people to place waste on fixed collection days before a truck is due to arrive.

The dump truck collection system involves 2 trips to be made daily, this is almost equal to the number of trips made by a compactor truck. However, a 6-ton modified dump truck only carries 3.85 tons of waste and a standard 6-tons dump truck carries less than 3 tons per trip while a compactor truck typically carries about 6 tons of refuse per trip.

The productivity of the dump truck collection system is assessed to be low due to the bell collection method, low accessibility to some areas, and excessive height of the vessels for loading waste, etc.

d.3 Hoist Truck and 5.5 m^3 Skip System

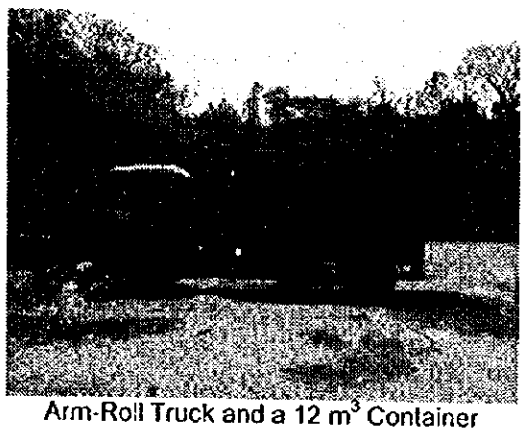
A hoist truck has two steel arms which rotate to load and unload containers as shown in the photograph. There are eight 5.5 m^3 skips in use.


Hoist Truck and a 5.5 m^3 Container

The areas surrounding the skips are generally well maintained and clean; this system is assessed to be appropriate for inaccessible areas. However, the hoist truck does not meet the demands in the volume of waste generated. This system could be expanded for inaccessible areas providing that people's cooperation in discharge manner is assured.

d.4 Arm-roll Truck with 12 m^3 Communal Containers System

An arm-roll truck has a steel arm to load and unload a container, as shown in the photograph below. Since the arm holds the container directly, it assures outstanding stability in loading and unloading operations.


Arm-Roll Truck and a 12 m^3 Container

One arm-roll truck with eleven (11) 12 m^3 communal containers have been operating since 1993.

Waste collected through street sweeping activities are gathered and placed in communal containers; residential and commercial wastes are also disposed in

these containers. It was observed that a considerable amount of waste is always scattered around the containers. The reason being one or both of the following two explanations.

- The height of container (1.8 m) is too high for people to place their waste.
- Commercial waste is discharged into the containers improperly.

As for the truck productivity, it is assessed to be good because it makes 4.8 trips per day on average, covering a distance in excess of 100 km and sometimes more than 150 km per day. However, a large amount of waste spill from the top of dump trucks during transportation due to the lack of a cover sheet.

e. Equipment Owned by Compañía Constructora y Servicio Multiplaza (CCSM) Used for Collection and Haulage Work

Table 4-5 shows an inventory list of equipment.

Table 4-5: Inventory List of Equipment owned by CCSM

Equipment	Capacity	Numbers	Manufacture Year
Compactor	15.3m^3	6	1989 - 1992
Container	4.6m^3	80	1998
Roll-on roll-off	-	2	1989, 1990
Container	15.3m^3	24	1998
Large truck	21.4m^3	1	1988
Mechanical street sweeper	-	2	1991, 1992

e.1 15.3m^3 Compactor Truck with 4.6 m^3 Container System

15.3m^3 Compactor Truck

The CCSM uses four 15.3 m^3 compactor trucks and eighty 4.6 m^3 containers for collecting residential waste in Colonia Kennedy and its environs. The compactors have lifting devices to load waste from containers. This system is efficient and very sanitary for workers because they do not come in contact with waste. The compactors make one to two trips per day in general. But because this system enables compactors to make two trips per day, they are under utilized. This system is applicable only in the areas where the land is flat and where there is enough open space to place containers.

e.2 Roll-on roll-off with 15.3 m^3 Container System

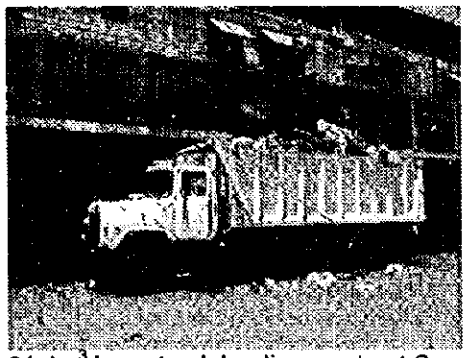
A roll-on roll-off is used generally in the new housing development areas where enough open space for a large container is secured. A container can receive waste discharged by many households within a wide area.

This system is also used along trunk roads to receive residential waste and also as collection points for street sweeping waste.

This system is efficient and sanitary for workers as there is no need for them to come in contact with waste.

Roll-on roll-off loading a 15.3m^3 container

e.3 21.4 m^3 Large Truck System



21.4m^3 large truck loading waste at San Isidro

A large (21.4 m^3) truck system is used for market waste discharged from San Isidro. The AMDC previously used this system at San Isidro, but used 12 m^3 dump trucks until May 1998. This truck is suitable for carrying a large amount of market waste, however, it is considered to be inappropriate for San Isidro in environmental terms because the access road to San Isidro is narrow and always very congested during the day.

f. Comparison of the Productivity of Equipment owned by the AMDC

Figure 4-3 shows the actual amounts of waste hauled per trip by type of vehicle, obtained by the Team through the weighing survey at the disposal site. It proves that the productivity of the compactor truck is much higher than the rest per trip, implying the waste generated in the Central District, which naturally has a low density, can be readily compacted.

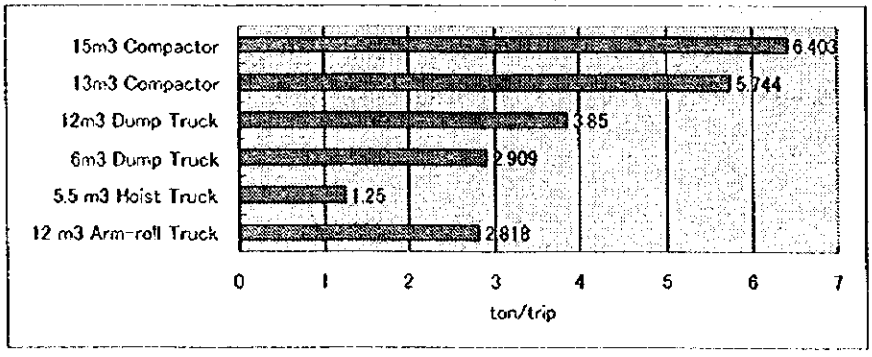


Figure 4-3: Actual Amounts of Waste Hauled per Trip by Vehicle Type

In terms of the number of trips per day, the arm-roll truck and hoist truck made more than double the amount of trips of any other type of vehicles (Figure 4-4).

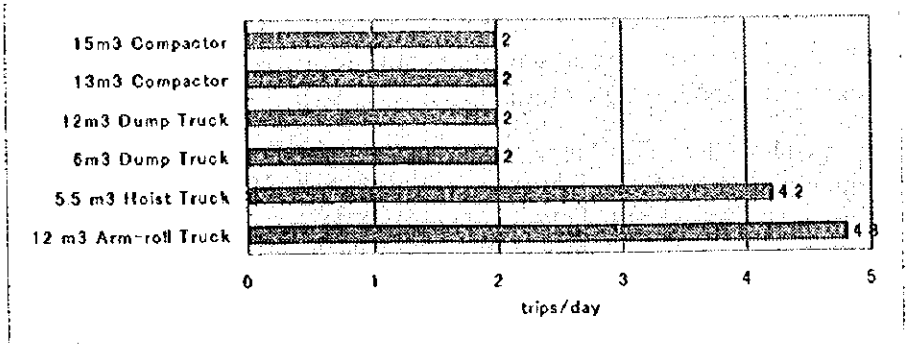


Figure 4-4: Number of Trips by Vehicle Type per Day

In terms of the daily productivity, the arm-roll truck ranked at the top followed by the 15 m^3 compactor truck (Figure 4-5).

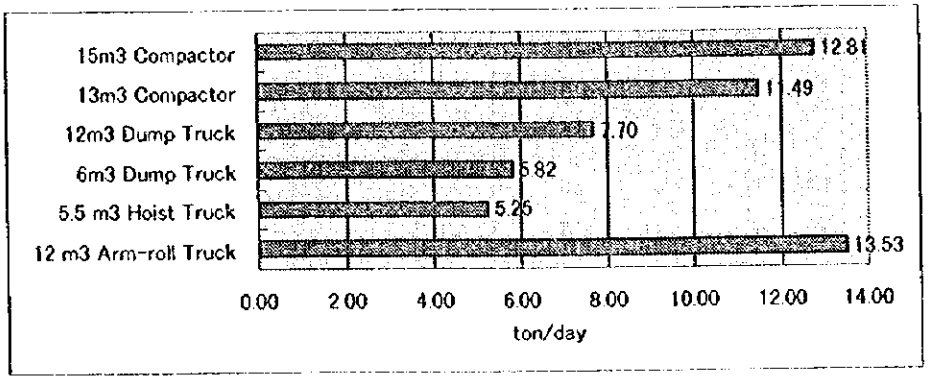


Figure 4-5: Productivity of Vehicles per Day

4.3.4 Processing, Treatment and Recycling Systems

At present, the AMDC does not have any processing, treatment or recycling systems. Besides those owned by the AMDC, there is currently no other kind of waste treatment/processing facilities in the study area.

Many residents in the area who either receive irregular or insufficient waste collection burn their waste on site but only a few make compost from their waste. As for a modern incineration facility, a plant to incinerate infectious waste generated by medical institutions is under construction near the disposal site, financed by the Swiss Government.

Although there is no formal, organized recovery of materials by the AMDC or private individuals from the generated waste, informal recycling activities are seen to be widespread. The type of activities that currently contribute to recycling are sorting by the AMDC collection workers, resource recovery by scavengers at the disposal site and collection of recyclable materials by a group of individuals.

4.3.5 Street Sweeping System

Street sweeping works are exclusively a manual operation by street sweeping workers who use brooms and carts. Street waste is accumulated and collected with brooms by street sweeping workers; this waste is subsequently hauled by carts to the nearest 12 m^3 container and deposited for disposal.

The AMDC Cleansing Department has 17 street sweeping groups, consisting one foreman and between 10 to 12 street sweeping workers. Usually, they work between 6 a.m. and 2 p.m. In addition, around 230 street sweepers have been employed temporarily until March 1998.

Many drums, cut in half, and other metal containers were placed along the streets in February 1998. This system will help to keep the streets clean and to reduce the amount of street sweeping works.

Table 4-6:Current Situation of Street Sweeping in Tegucigalpa

Crew No.	Contractor	No. of Employees	Km Swept	Schedule	Frequency	Zone swept
1	Alejandrina Flores	8	4.0	3:00 a.m. 10:30 a.m.	Daily	Tegucigalpa Downtown
2	Rigoberto González	8	2.6	3:00 a.m. 10:30 a.m.	Daily	Concordia
3	Alba Luz López	8	2.8	3:00 a.m. 10:30 a.m.	Daily	Barrio Abajo
4	Erica Yamileth Flores Corea	8	2.8	3:00 a.m. 10:30 a.m.	Daily	Barrio San Rafael
5	Ana Lidia Vivas	8	2.9	3:00 a.m. 10:30 a.m.	Daily	Guanacaste
6	Mercedes Alvarez	8	2.5	3:00 a.m. 10:30 a.m.	Daily	Cuesta del Barrio Buenos Aires
7	Mirza B. Zelaya	8	2.6	5:00 a.m. 1:00 p.m.	Daily	Concordia
8	Nilsa Barahona	8	2.9	4:00 a.m. 10:30 a.m.	Daily	La Moncada
9	Lidia Vasquez	8	2.9	3:00 a.m. 10:30 a.m.	Daily	La Merced and El Jazmín
10	María del Carmen Zúniga	8	2.9	10:30 p.m. 3:30 a.m.	Daily	El Jazmín
11	Marina Banegas	8	4.5	Afternoon	Daily	La Ronda
12	Genara Montoya	8	2.4	10:00 a.m. 4:30 p.m.	Daily	La Hoya
13	Marina Arriola	8	4.0	10:30 a.m. 5:30 p.m.	Daily	Downtown
14	Gloria Marina López	8	4.5	3:00 a.m. 10:30 a.m. Daily	Daily	La Ronda
15	Roque Villalta	8	4.0	4:00 p.m. 11:00 p.m.	Daily	Downtown
35	German Alvarado	8	4.3	5:00 a.m. 1:00 p.m.	Daily	La Isla - Morazan Stadium
40	Rixa Martínez	8	2.5	6:00 - 8:00 a.m. 5:00 - 8:00 p.m.	Daily	*Barrio* Buenos Aires
Total	17	136				

Table 4-7: Situation of Street Sweeping in Comayaguela

Crew No.	Contractor	No. of Employees	Km Swept	Schedule	Frequency	Zone swept
19	Martha Irene Cruz	8	5.2	5:00 a.m. 1:00 p.m.	Daily	1-4 Ave. 1-9 street
21	Vilma Rosa Osorto	8	4.2	5:00 a.m. 1:00 p.m.	Daily	1-4 Ave. 1-9 street
23	Marina Flores	8	4.7	5:00 a.m. 1:00 p.m.	Daily	6-8 Ave. 1-9 Street
18	Tomasa Dominguez	8	5.6	5:00 a.m. 1:00 p.m.	Daily	1-5 Ave. 9-16 Street
31	Angela Micaela Raudáles	8	5.4	5:00 a.m. 1:00 p.m.	Daily	6-11 Ave. 9-14 Street
20	Lilian Matute	8	4.9	5:00 a.m. 1:00 p.m.	Daily	6-10 Ave. 14-18 Street
16	César Ceballos	8	2.0	5:00 a.m. 1:00 p.m.	Daily	5-9 Ave. 14-26 Street
22	German Salgado	8	4.2	11:00 a.m. 6:30 - 7.00 p.m.	Daily	4-6 Ave. 1-9 Street
24	Héctor Napoleón Rodas	8	4.7	11:00 a.m. 5:00 p.m.	Daily	6-8 Ave. 1-9 Street
17	Bertha Marina Zelaya	8	5.2	11:00 a.m. 5:00 p.m.	Daily	1-4 Ave. 1-9 Street
Total	10	80	46.1			

Table 4-8: Situation of Main Streets and Boulevards (Tegucigalpa)

Crew No.	Contractor	No. of Employees	Km Swept	Schedule	Frequency	Zone swept
38	Darwing Lozano	8	9.9	5:00 a.m. 1:00 p.m.	Once a week	Armed Forces Boulevard
34	Andrés Hernández	8	5.0	5:00 a.m. 1:00 p.m.	Twice a week	Suyapa Boulevard
39	Delmy Amparo Cáceres	8	3.5	5:00 a.m. 12:00 m	Daily	La Paz Ave.
32	Gloria Aguilar	8	3.5	5:30 a.m. 12:00 m	Daily	Morazán Boulevard
37	Reina Rámirez	8	4.0	5:00 a.m. 1:00 p.m.	Twice a week	Guadalupe, Juan Pablo II Boulevard, Infop
33	Nancy Rivas	8	2.1	5:00 a.m. 10:00 a.m.	Twice a week	Stadium-Prado, Kuwait Blvd., IHSS Peripheric.
36	Piere Silva	8	3.0	5:00 a.m. 12:00 m	Twice a week	Exit to Danlí
Total	7	56	31			

Table 4-9: Situation of Main Streets and Boulevards (Comayaguela)

Crew No.	Contractor	No. of Employees	Km Swept	Schedule	Frequency	Zone swept
30	Onofredo Cerrato	8	4.0	5:00 a.m. 1:00 p.m.	Twice a week	Guacerique-Airport Bridge
26	Sergio Andrade	8	1.8	5:00 a.m. 1:00 p.m.	Daily	Sta. Fe Blvd. Left lane, Carrizal Bridge
41	Martina Cerrato	8	1.0	5:00 a.m. 1:00 p.m.	Daily	Zonal Belén Market
28	Rafaela Medina	8	2.0	5:00 a.m. 1:00 p.m.	Twice a week	Toncontín Cortijo
29	Gregorio Raudáles	8	3.1	5:00 a.m. 1:00 p.m.	Twice a week	Cerro Grande
25	Irma Isabel Luna	8	1.8	5:00 a.m. 1:00 p.m.	Daily	Sta. Fe Blvd. Right lane, Carrizal Bridge
27	Emelda Castro	8	5.1	5:00 a.m. 1:00 p.m.	Twice a week	Dippsa Carizal - Camosa Bridge, Armed Forces Boulevard
42	Eugenio Berríos	8	1.6	5:00 a.m. 1:00 p.m.	Twice a week	Northern Exit
43	Aminda Cárdenas	8	1.6	5:00 a.m. 1:00 p.m.	Three times a week	Semaphore deviation to Country Club, Santa Anita Cemetery
Total	9	72	22.0			

a. Frequencies

In Tegucigalpa and downtown Comayagüela the streets are swept daily, twice a day. Streets that do not have much pedestrian traffic (collectors and boulevards) are swept with a frequency of 2 to 3 times per week.

b. Performance and Street Sweeping Costs

Forty three crews, working under contract, sweep on average 50 km a day; as a result, an average performance of 0.5 km. per sweeper is obtained. This performance is understandable for streets that are swept twice a day and those located near the markets.

The total street sweeping costs, taking into account that each of the 43 crews receives Lps. 15,500/month, is approximately Lps. 8 million per year.

4.3.6 Final Disposal System

a. General Site Condition

The existing final disposal site for the Central District is located in Tustorique, approximately seven kilometers from the city center along the highway that leads to Olancho. It is situated between Los Jutes and Los Limones creeks, both of which are tributaries of the Choluteca River.

The disposal site receives, not only municipal solid wastes such as residential, commercial and institutional wastes, and garbage from public areas, but also construction debris, industrial, agricultural, agro-industrial, hospital wastes, among others. According to the information given by the Cleansing Department, 44,799 trips were made to the final disposal site in 1997 alone. The Study Team found that approximately 135,827 tons of wastes were disposed in 1997 and approximately 470 tons of wastes are disposed of daily, except on Sundays, at the disposal site.

b. Existing Facilities at the Final Disposal Site

There is no gate nor instruction board at the entrance of the disposal site. The site is also not fenced to prohibit the entry of private individuals including vehicles. Therefore, various waste types are constantly being brought to the site. In addition, anybody, including children, can gain access to the site. The length of the access road from the entrance to the filling area is approximately 500 meters, 300 meters of which slope at approximately 10 % and is unpaved.

The site is only equipped with a small wooden hut, approximately 15m^2 for the storage of a few tools and stationery owned by the AMDC. Equipment repair is conducted in the open. The site is not provided with a water supply system, water tank and sewerage. Neither does it have toilets, facilities for personal hygiene or a communication system in case of emergency, should an accident occur at the landfill. There are no stormwater drains in the site to protect access roads as well as the workers.

c. Landfill Operation

Three 215 Hp bulldozers, a wheel loader and three 10-ton dump trucks are operated at the site. The bulldozers are used for waste compaction and soil covering: two have

blades for spreading waste, while one has a blade for spreading and leveling the cover soil. The wheel loader is used to excavate and load the cover soil, and the dump trucks are used to transport soil from the borrow pit within the site to the filling area. However, due to lack of diesel, at times these equipment are not being used. The bulldozers are only operated for about four to five hours daily, and the excavation and transport of soil can only be carried out few days a week.

The AMDC employs four heavy equipment operators, three dump truck drivers and seven other staff including supervisors, foremen and workers. In addition, three mechanics commute to the site from the central workshop daily. One of the AMDC staff is in charge of counting the number of incoming vehicles at the site.

The site is not equipped with a bottom liner and leachate collection facilities for the landfill. To control leachate, a thick layer of soil is required. However, a large section of Los Limones creek does not have a soil cover, allowing leachate – as observed in several places - to flow freely to the bottom of the creek.

The landfill site does not house any facilities to trap and somehow control the biogas generated through the anaerobic decomposition of organic fractions in the waste. Neither does it have facilities or a plan to implement such facilities to control odor emission, vermin proliferation and the generation of fires inside the landfill. There are also no barriers to prevent the scattering of light waste, such as paper and plastic, and waste sprinkling is not carried out to avoid dust from rising.

The landfill method employed is the formation of terraces in the hillside and the small creek. There are three terraces constructed at intervals of approximately 25m and 10m; the smallest is 35m above the level of the highway.

d. Existing Environmental Impacts

The problems observed in the landfill range from those relevant to infrastructure and operations to those related to sanitation and the environment. The latter goes beyond the limits of the landfill site, affecting surrounding areas in varying degrees. The most serious problems are identified and analyzed hereafter.

d.1 Propagation of Parasites and Micro-organisms

The highly organic quality of municipal solid wastes makes these wastes a suitable medium for the rapid proliferation of parasites and micro-organisms. The current operation of the landfill leaves waste uncovered over long periods, allowing all types of animals to feed on the waste and scavengers, including children, to have direct contact with the waste. This type of operation converts the disposal site into a fertile breeding ground of parasites and micro-organisms.

People and animals become mediums for parasites and micro-organisms. Pathogens are transmitted to populated centers or homes, causing some of the serious diseases that prevail in the area.

d.2 Water Resource Modification

For the El Crematorio landfill , the amount of leachate produced is difficult to quantify as it either infiltrates the ground or is drained over the hillside and runs toward Los Limones creek. Several observations made in February confirmed a leachate flow of no more than 100 ml/sec, hence leachate does not reach Choluteca

River. However, it is very likely that during the rainy season, leachate production is higher, but conversely the effluent becomes diluted.

d.3 Air Modification

There is no biogas removal system that can serve to measure biogas production as well as combustion; the latter is the conversion of methane (CH_4) into CO_2 and H_2O - compounds that cause less harm to the atmosphere. Methane and other landfill gases are flammable and potentially toxic; it could present a risk to public health as well as being an occupational hazard for landfill workers and scavengers. Flaring is a recommended means to remove the harmful properties of biogas. In the case of the El Crematorio landfill site, methane production may not be that high, as the aerobic decomposition of other waste constituents due to the daily combustion of organic matter produces no methane.

Uncovered waste, the burning of waste, biogas and leachate all contribute to the emission of odor. Odor diffuses and affects nearby areas, including sites along the highway to Olancho, in varying degrees depending on the velocity and direction of the wind.

Dust results from suspended particles generated by the transportation of cover material, vehicular traffic into the landfill site, and wind. This problem, however, has the least effect on air conditions and only occasionally affects areas beyond the landfill limits.

d.4 Land and Landscape Deterioration

In addition to the deterioration of the landscape, light wastes, e.g. paper, plastic, that are scattered due to wind also influence soil conditions and adversely affect humans and animals that make use of the surrounding vegetation.

The extraction of soil for use as waste cover material also affects soil characteristics. Hence, it is necessary to take measures that will allow the soil to recover after the landfill is closed.

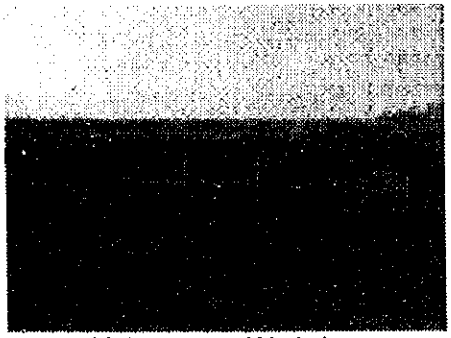
As a large part of the waste in the disposal site is currently left uncovered or un-compacted over long periods, the wind often scatters it outside the final disposal site boundaries. This destroys the beauty of landscapes inside and outside the final disposal site. Furthermore, this condition complicates the use of soil for landfilling, as frequent soil cleaning prior to use becomes a necessity.

e. Lifespan

At this moment, the land earmarked for landfill use is approximately 30ha, of which 12ha has been used since 1977. By developing a suitable program regarding the source and method of obtaining cover soil, it is possible to produce new landfill space once the current area has completed its useful life. If these areas can be used for landfill purposes as well as the other 8 to 10ha that have not been used, it leaves about 8 to 10ha for the construction of a security building or protection areas (buffer zone). Even if the landfill is not expanded to adjacent areas, it is possible to operate the present site for several years.

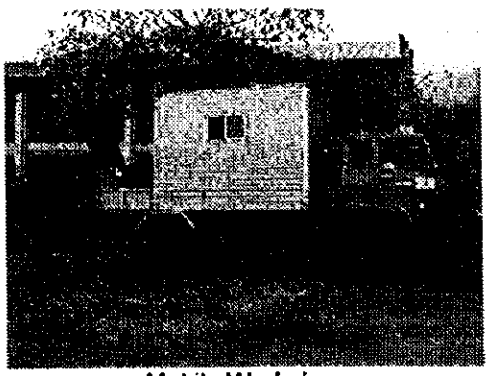
4.3.7 Maintenance System

The Cleansing Department has a workshop and a motor pool within the premises of the Public Service Devision at Colonia 21 de Octubre and a mobile workshop.


Maintenance Workshop

All collection vehicles are parked at the motor pool at Colonia 21 de Octubre and leave early in the morning to return in the afternoon.

The workshop deals with almost all maintenance and repair works for collection vehicles as well as heavy movable equipment such as a wheel loader. The maintenance capacity was enhanced in 1993 by introducing many maintenance machinery under Japan's grant aid.


Mobile Workshop

A mobile workshop is used for maintaining bulldozers that operate at the disposal site. It is parked at the motor pool and leaves for the disposal site in the morning and returns in the afternoon daily. It also delivers diesel to the bulldozers in the disposal site.

The mechanics' technical level is assessed to be acceptable because compactor trucks, the most difficult equipment to maintain among collection equipment, are in a good condition.

However, repair works often take time, this is mainly attributed to excessive bureaucracy. The purchase of spare parts requires many processes that is extremely time consuming. In addition, the use of poor quality hydraulic oil, due to financial constraints, have caused mechanical problems.

4.3.8 Main Resources Currently Used for SWM

The Cleansing Department has approximately 260 employees, 37 collection vehicles, one final disposal site and one maintenance workshop. Table 4-10 show the breakdown of equipment and facilities engaged in solid waste management work.

Table 4-10: Inventory of Main Equipment Owned by the Cleansing Department

Work Category	Description	Year Purchased	Unit	Quantity
Collection and Haulage	15 m^3 Compactor	1993	units	11
	13 m^3 Compactor	1988	units	9
	12 m^3 Dump truck	1993	units	10
	6 m^3 Dump truck	1988	units	5
	Arm-roll truck	1993	units	1
	Hoist truck	1993	units	1
	12 m^3 Container for Arm-roll truck	1993	nos.	13
	5.5 m^3 Container for hoist truck	1993	nos.	11
Street Sweeping	Only manual work	-	-	-
Final Disposal	Final disposal site in Guanábana	since 1977	ha	31.7
	Bulldozer CAT D7	1993	units	3
	Wheel loader	1993	units	2
	Dump truck	1993	units	3
Maintenance	Workshop in Colonia 21 de Octbre	-	place	1
	Mobile workshop	1993	units	1
Supervision, Inspection, etc.	Pick-up	1993	units	1
Administration	Office building in Colonia 21 de Octubre	1994	unit	1

Table 4-11 shows the estimated the collection and haulage capacity. The Cleansing Department of AMDC and a private company, CCSM, have the capacity to collect 300 tons/day and 110 tons/day respectively.

Table 4-11: Collection and Haulage Capacity

Category	Type of Equipment	Capa-city	Nos of equip. owned	Weight per load	No of trips per day	Total trip per day	Productivity per day	Collection capacity	Adjusted collection capacity
			nos	t/trip	trip/d	trip/d	t/day	t/d	t/d
AMDC	Compactor	15m^3	11.0	6.4	2.0	22	12.8	140.8	112.6
	Compactor	13m^3	9.0	5.7	2.0	18	11.4	102.6	82.1
	Dump truck	12m^3	10.0	3.9	2.0	20	7.8	78.0	62.4
	Dump truck	6m^3	5.0	3.2	2.0	10	6.4	32.0	25.6
	Arm-roll truck	12m^3	1.0	2.8	5.0	5	14.0	14.0	11.2
	Hoist truck	5.5m^3	1.0	1.3	5.0	5	6.5	6.5	5.2
	Total					80		373.9	299.1
		cf.	Efficiency	80%					
CCSM	Compactor	15m^3	6.0	6.4	2.0	12	12.8	76.8	69.1
	Large truck	21m^3	1.0	6.3	2.0	2	12.6	12.6	11.3
	Roll-on Roll-off	15m^3	2.0	3.5	5.0	10	17.5	35.0	31.5
	Total					24		124.4	112.0
		cf.	Efficiency	90%					112.0
	Grand total								411.1