

WASTE COMPOSITION/GENERATION STUDY FOR THE CITY OF DAVAO, MINDANAO, PHILIPPINES

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SUMMARY: The City of Davao is located on the Island of Mindanao, which is the second largest Island of the Philippines. The City has an official population of 1,080,000 people. Waste disposal for the City occurs in an open dump located approximately nine kilometers northwest of the center of downtown. The refuse is pushed over a steep slope and no cover material is applied. The dumpsite was on private property and sited immediately adjacent to a main highway into the City. In order to close the current site and design and build a modern sanitary landfill in Davao, the amount and types of waste disposed of by the City needed to be determined. In order to make this determination, a field investigation was conducted. The investigation consisted of waste sorts, volume calculations, weight studies, and evaluating recycling practices of incoming wastes. The type and quantity of waste coming into the site could then be used to size and design a new landfill facility.

1. INTRODUCTION

Solid waste disposal practices in the Philippines consist primarily of open dumping. In the City of Davao, open dumping occurred in a steep ravine along a major access route into the City. The site was located on private property and the owner desired that waste disposal be halted at the location. In order to adequately size and design a new solid waste disposal facility, information regarding the types and quantities of waste disposed of each day was required. To accomplish this, a waste composition and generation study was undertaken consisting of waste sorts, volume calculations, weight studies, and evaluating recycling practices of incoming waste from the Davao collection vehicles and private collection vehicles which use the dumpsite.

The investigation was conducted in three phases. Phase I consisted of research and review of existing data, Phase II consisted of data collection, and Phase III consisted of compilation of the data. The following report is a presentation of the findings made during this study.

2. SETTING

Davao is located on the Island of Mindanao, which is the second largest island of the Philippines. Davao is a City/Province served by a democratically elected Mayor, Vice Mayor and City Council. Geographically, Davao is the largest City in the Philippines with a total land area of 2,440 square kilometers. Of this, 91 percent of the land area is classified as either agricultural or forested. The official population of the city is 1,080,000. Davao experienced a 3.67 percent average annual growth between 1990 and 1996 (Davao City Profile 1996). It was estimated that current growth could be as high as 5 percent (Jusain 1997). Extrapolation of these two growth rates indicates that the population will increase to between 2,000,000 and 2,600,000 by the year 2015 as shown in Table 1.

3. LANDFILL

The City of Davao has one operational landfill, which serves approximately 70 percent of the population. The landfill is located approximately nine kilometers northwest of the center of the downtown area along the Phil-Japan Friendship Highway. The landfill is a ravine fill where waste is pushed over a slope estimated at 60 percent. No cover material is applied at the landfill where an uncontrolled smoldering fire is occurring.

The landfill is a modified open dump where waste is unloaded immediately adjacent to the highway by an assortment of City-owned and private trucks. After the trucks dump their loads, the wastes are picked through by scavengers who remove recyclable materials. After the wastes are scavenged, a D-7 Caterpillar tracked dozer pushes the waste over the edge of the slope.

4. COLLECTION

The City of Davao provides solid waste collection service to approximately 70 percent of the residences and commercial businesses located in the Davao region. Service is limited to the City proper, and the populated areas along the roads connecting Davao to the Villages of Toril, Bunawan, and Calinan, as well as within the Village of Baguio (Jusain 1997). The collection vehicles are operated by the City's Environmental and Natural Resources Office, Solid Waste Management Section (SWMS). Davao's collection fleet consists of 46 trucks, 32 of which were operational as of July 22, 1997. There are both open collection vehicles and compaction vehicles. In addition, the City has three operational compactor trucks.

The City's collection operation consists of three shifts per day, with each shift comprising two or more cycles depending on the distance to the landfill from the route and time of collection. Collection stops are established by the SWMS. Collection from the City proper is limited to the period between midnight and 5:00 a.m., the low traffic period. In both the residential and commercial districts, multiple users share the same collection point with individuals being able to subscribe to additional collection for an increased fee paid to the SWMS. A typical collection crew consists of a driver, three collectors, and two loaders. It is a common practice for collection crews to sort through garbage as it is being dumped into vehicles and remove a portion of the recyclable component of the waste stream. The amount of recyclables removed by collection crews was assessed during the waste classification study and is discussed in that section.

Table 1 - City of Davao Estimated Population Growth

| YEAR | POPULATION AT 3.67% GROWTH | POPULATION AT 5% GROWTH |
|------|----------------------------|-------------------------|
| 1997 | 1,080,000 | 1,080,000 |
| 2000 | 1,203,000 | 1,250,235 |
| 2005 | 1,441,000 | 1,595,651 |
| 2010 | 1,725,000 | 2,036,501 |
| 2015 | 2,066,000 | 2,599,148 |

Official City records identify that during the month of June 1997, thirty-two City owned and operated collection vehicles collected 26,445 cubic meters of mixed residential/commercial waste. In addition to the City collection, private vehicle deliveries of waste occur at the landfill. Through observations and records review, it was determined that most private vehicles deliver waste from commercial, industrial, agricultural, or land development sources. The majority of private vehicle deliveries consisted of homogeneous wastes such as lumber, yard waste construction/demolition wastes, and land clearing waste.

5. ASSESSMENT STUDIES

In order to determine the composition and weight of the waste being delivered to the landfill, waste characterization sorts of Davao's collection vehicles were conducted over a four-day period. Private vehicles were also examined during this period. On the fifth day of the study period, gross and tare weights were obtained from the City collection vehicles in order to calculate the weight of waste being received at the landfill.

6. WASTE CHARACTERIZATION

The waste characterization sort study was conducted in a manner consistent with United States accepted practices for classification of solid wastes at a landfill taking into consideration local constraints regarding logistics and health and safety. The City of Davao provided the manpower necessary to conduct the sorts and assumed responsibility for health and safety issues of the work crew.

Physical separation and sampling of wastes were accomplished as follows:

1. Random selected collection trucks were diverted from the landfill and directed to dump their load on the ground in an area that had been cleared of waste;
2. The number of the truck was recorded as was the area within the City where collection occurred;
3. The waste load was divided into quarters by visual estimation;
4. Wastes were separated by hand into waste categories and placed into plastic sacks; and

5. Each sack was weighed and recorded.

The results of the waste characterization study indicate that the waste stream is comprised of a large organic component. Compared to the United States average composition of solid waste (Tchobanogous 1993), the City of Davao generates a waste stream 2.3 times higher in food waste than the average waste stream in the United States. Figure 1 presents the percentage of waste types found during the characterization at the City of Davao Landfill.

6.1 Private vehicle dumping

Private vehicle deliveries at the Davao Landfill consist of vehicles from industrial sources such as lumber mills and metal fabrication plants; commercial sources such as markets and restaurants; agricultural processing facilities transporting wastes such as durian and coconut waste, and land clearing and subdivision construction waste. Private vehicles were inspected to determine the content of the load, the capacity of the truck, and the volume of waste being unloaded. The following methods were employed when inspecting the private vehicles:

1. The dimension of each truck bed was measured with a cloth tape;
2. The contents were visually examined, with estimates being made of load characterization;
3. A percentage, by waste category, was determined based upon visual inspection versus the capacity of the truck; and
4. Trucks were visually inspected during random periods of operation at the facility.

The results of this volume/composition assessment were tabulated and the volumes were converted into both metric and English units based upon industry standard weights for each waste type. Table 2 estimates that over 198 tonnes of waste are delivered to the site on a daily basis.

During the study, a total of 48 vehicles were examined during a period representing 13 hours. The vehicle deliveries per hour ranged from 5.0 to 2.9 and averaged 4 vehicles per hour. A total of 303.5 cubic meters of waste was measured during these waste dumps at the landfill. The most common waste type observed was site clearing debris, which comprised almost 43 percent of the total waste observed coming from private sources. Wood and food wastes comprised the second and third largest observed component, at 25 percent and 22 percent, respectively.

Records are kept at the landfill for incoming private vehicles dumping at the landfill. A comparison of these records to visual observations made of the site suggests a number of private trucks dumping at the site is being missed in the daily count. Deliveries of wastes from private vehicles occur from 9 a.m. to 9 p.m. daily. On July 16, 1997, the dump record shows that seven deliveries were made with a total volume of 60 cubic meters. During the observation period of 3 p.m. to 6 p.m. on July 16, 1997, fifteen private vehicles were observed dumping an estimated 132 cubic meters of waste at the landfill. An assessment of private vehicles entering the site is being conducted to verify this potential under reporting of vehicles and waste being disposed at the site.

6.2 Weight assessment

In order to calculate the weight of the waste received at the landfill from City vehicles, random shipments of wastes were stopped prior to dumping their load and diverted to the nearest weight scale (9 kilometers distance) to determine a gross weight. A record was made of each vehicle, including its number, where the waste came from, and the volume of the truck. After recording its gross weight, the truck returned to the landfill to dump its load. After dumping its load, the truck was diverted back to the weigh scale for tare weight determination. A total of eight collection vehicles were weighed. The average weight of waste per truck was 2,053 kilograms with each truck

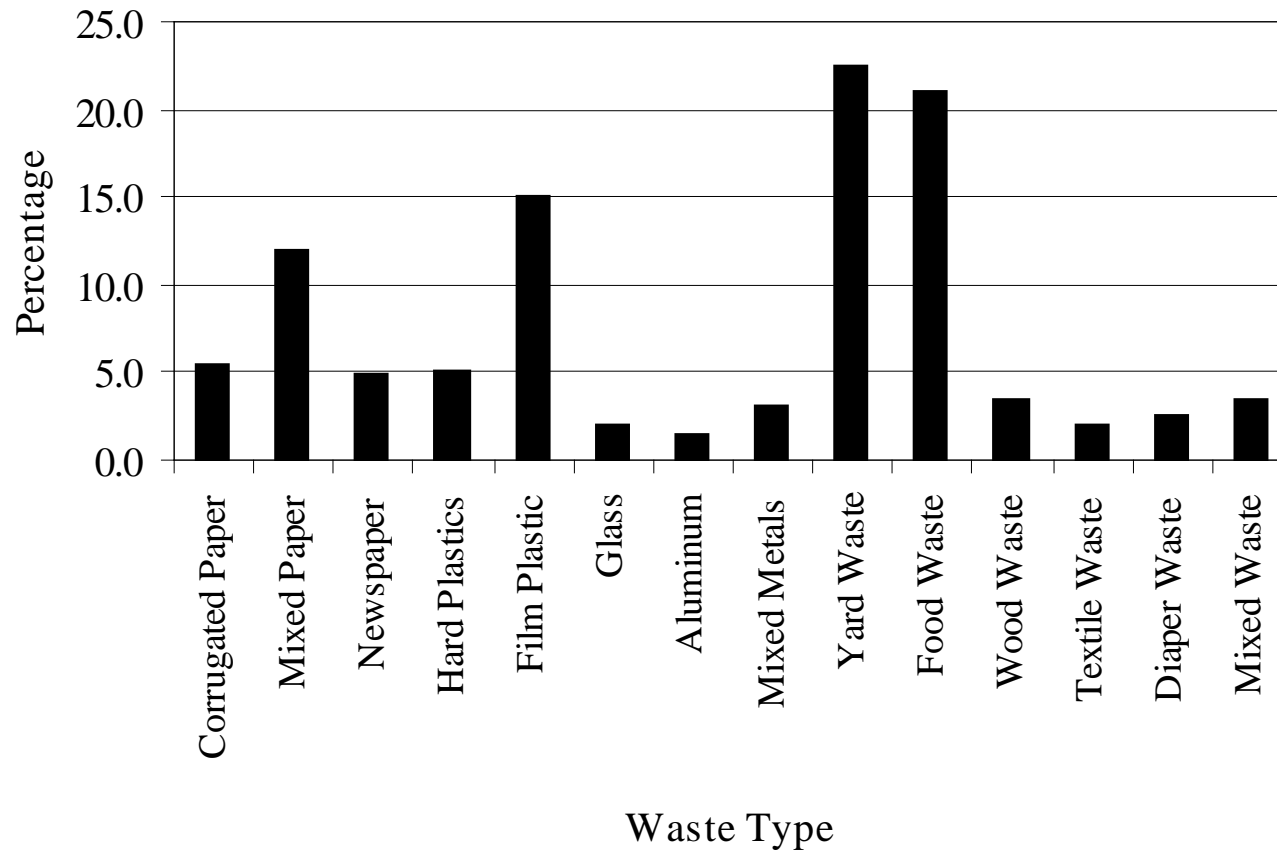


Figure 1. City of Davao City Collection Vehicle Waste Classification

Table 2 – Composition and Weight Assessment for Private Vehicle Deliveries at the Davao Landfill

| Date | Hours of Observation | Number of Vehicles | Average Vehicles Per Hour | Observed Volume in Cubic Meters ¹ | | | | | | | TOTAL |
|--|----------------------|--------------------|---------------------------|--|------------|------------|--------------|----------------------|-------------|-------------|-----------|
| | | | | Yard Waste | Food Waste | Wood Waste | Construction | Site Clearing Debris | Mixed Waste | Mixed Paper | |
| 16-Jul-97 | 3 | 15 | 5.0 | 7.5 | 0.5 | 4.5 | 1.0 | 118.5 | 0.5 | 0 | 132.5 |
| 17-Jul-97 | 4 | 13 | 3.25 | 0 | 61.4 | 11.0 | 5.0 | 1.2 | 3.4 | 0 | 82.0 |
| 18-Jul-97 | 2 | 10 | 5.0 | 0 | 1.8 | 49.4 | 0.8 | 0.0 | 1.6 | 1.2 | 54.8 |
| 21-Jul-97 | 4 | 10 | 2.5 | 5.0 | 2.7 | 10.4 | 3.0 | 10.0 | 0 | 3.1 | 34.2 |
| TOTAL | 13 | 48 | 4.0 | 12.5 | 66.4 | 75.3 | 9.8 | 129.7 | 5.5 | 4.3 | 303.5 |
| PERCENTAGE | | | | 4.1 | 21.9 | 24.8 | 3.2 | 42.7 | 1.8 | 1.4 | 100 |
| ESTIMATED VOLUME PER DAY (CUBIC METERS) | | | | 12.5 | 66.4 | 75.3 | 9.8 | 129.7 | 5.5 | 4.3 | 303.5 |
| AVERAGE KILOGRAMS/CUBIC METER ² | | | | 101.0 | 291.0 | 160.0 | 1,420.0 | 1163.0 | 131.0 | 50.0 | 474.0 |
| AVERAGE KILOGRAMS PER DAY ³ | | | | 1,262.0 | 19,322.0 | 12,048.0 | 13,916.0 | 150,841.0 | 721.0 | 215.0 | 198,325.0 |
| AVERAGE TONNES PER DAY ⁴ | | | | 1.3 | 19.3 | 12.0 | 13.9 | 150.8 | 0.7 | 0.2 | 198.3 |
| TOTAL TONNES PER DAY | | | | | | | | | | | 198.3 |

¹ Other wastes reported but not observed during study include metal shavings, animal wastes, and broken glass.

² Tchobanoglous, G. et al., *Integrated Solid Waste Management*, 1993, Table 4.3.

³ Multiply estimated volume/day by kilograms/cubic meter.

⁴ Kilograms/1,000

having a capacity of 6 cubic meters. Tables 3 and 4 present the findings of the weight assessment of City trucks.

6.3 Analysis of weight and volume data

Based on the records of the SWMS, 26,500 cubic meters of solid waste were disposed of at the landfill in June 1997. This number closely matches the average holding size of each vehicle by 30 days of operation/month by the number of trucks/day (26,500 cu.m./day = 6 cubic meters average size per vehicle x 30 days of operation per month x 147 trucks/day). As determined in Table 4, based on an average of 8 vehicles, the weight of an average cubic meter of solid waste measured during the study period was 342 kilograms. At 147 trucks/day carrying 6 cubic meters/truck, an average of 882 cu.m./day are delivered to the landfill. This equates to 302 tonnes/day based on 342 kg/cu.m. Based on a plus/minus range, this feasibility assessment estimates 500 tonnes per day are disposed at the landfill within a range of +/- 10%.

7. CONCLUSION

Based on an assessment of the refuse disposed of via City and privately owned collection vehicles, it was determined that the waste accepted at the City of Davao Landfill was approximately 500 tonnes per day. This waste generation, combined with the population increase over the next several years, can be used to determine the land area required to dispose of refuse in a new sanitary landfill. Careful determination of incoming refuse quantities allows engineers to properly site, design, construct, and fill new sanitary landfill facilities.

8. REFERENCES

- Davao City Profile, Facts and Figures 1996*, Office of the City Planning and Development Coordinator.
- Jusain, Fernando, Environmental Management Specialist I, Davao, Solid Waste Management Section, 1997 personal communication.
- Tchobanogous, G., *Integrated Solid Waste Management*, 1993, Table 3-4.

Table 3 - Summary of Waste Volume on Weight Basis Received at Davao Landfill

| Source | Cubic Meters Per Day | Estimated Kilograms/ Cubic Meter | Total Daily Kilograms Disposed | Tonnes Per Day Disposed |
|--------------------------------|----------------------|----------------------------------|--------------------------------|-------------------------|
| City Trucks | 882 | 342 | 301,644 | 301.64 |
| Privately Owned Service Trucks | 304 | 474 | 198,325 | 198.32 |
| TOTALS | 1,186 | Average = 408 | 499,969 | 500.00 |

Table 4 – Weight Study City of Davao Collection Vehicles. Date of Study: 22-July-1997

| Truck Number | Collection | Truck Capacity (Cubic Meters) | Weight in Kilograms | | | Average Kilograms Per Cubic Meter |
|--------------|-------------|----------------------------------|---------------------|---------|--------|---|
| | | | Gross | Tare | Net | |
| 34 | Residential | 6.0 | 8,250 | 6,615 | 1,635 | 272.5 |
| 46 | Residential | 6.0 | 8,200 | 6,600 | 1,600 | 266.7 |
| 41 | Residential | 6.0 | 8,310 | 6,625 | 1,685 | 280.8 |
| 39 | Residential | 6.0 | 8,290 | 6,625 | 1,665 | 277.5 |
| 32 | Residential | 6.0 | 8,850 | 6,420 | 2,430 | 405.0 |
| 41 | Residential | 6.0 | 8,630 | 6,430 | 2,200 | 366.7 |
| 44 | Commercial | 6.0 | 9,310 | 6,470 | 2,840 | 473.3 |
| 40 | Commercial | 6.0 | 8,820 | 6,450 | 2,370 | 395 |
| TOTAL | | 6.0 | 8,582.5 | 6,529.4 | 2053.1 | 342.2 |

Average Weight/Truck = 2,053 kg

Average Weight/Residential Truck = 1,869 kg

Average Weight/Commercial Truck = 2,605 kg