AUDIT OF SOLID WASTES FROM HOTELS AND COMPOSTING TRIAL IN HALONG CITY, VIETNAM

by

Hoang, Phuong Chi

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Graduate Department of Civil Engineering
University of Toronto

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This thesis investigates the feasibility of composting organic wastes from hotels in HaLong City, Vietnam. Three interrelated studies were carried out. First, a waste audit at three hotels was conducted to determine the amount of compostables available for composting. The one-week waste audit process revealed that among disposed waste, approximately 60% was compostables and recyclables made up around 5%. Also, about 250 kg of compostables was determined ready for composting per day during the fruit-growing and tourism season.

For the second part of the research, a composting trial was implemented. After sixty days of composting and maturing, about 60 kg of fine compost was produced from the input of 702 kg of compostables.

Thirdly, some physical and chemical characteristics of the compost were tested and compared to standards of compost quality of some countries in Europe, Australia, and North America. All tested properties, except for level of pathogenic micro-organisms and foreign matter, meet the standards. The thesis ends with recommendations on waste separation at source, seasonal effects, and compost application for improving the implementation of composting in HaLong City.
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INTRODUCTION

1.1 Introduction to Vietnam

Located in Southeast Asia, Vietnam shares its borders with China, Laos, and Cambodia. The total area of Vietnam’s territory is about 332,000 km$^2$. As can be seen in Figure 1.1, its territory extends longitudinally over 1,650 km from the north to the south, with the widest point measuring roughly 600 km while the narrowest is only 50km (NEA and UNEP, 2001). Also, it has a long coastline of 3260 km with thousands of islands. One well-known bay, designated as the World Hesitate by UNESCO since December in 1994, is HaLong Bay.

With a long coastline on the Gulf of Tonkin and the South China Sea, Vietnam has a tropical climate characterized by monsoons. From May to September, the country is dominated by southerly to southeasterly winds while the north monsoon is dominant during the rest of the year. Also, Vietnam has a single rainy season when the south monsoon prevails. Rainfall is abundant, with annual rainfall exceeding 1000mm almost everywhere. Temperatures are high all year round for southern and central Vietnam; but northern Vietnam has a definitely cooler season as the north monsoon occasionally advects cold air from China.

In terms of territory area, Vietnam is a small country in the world; however, with the 1999 average population density of 231 persons/km$^2$, Vietnam is one of the most populated countries. The total estimated population of Vietnam, up to April 1$^{st}$, 1999, was around seventy million. The average annual growth was 2.1% from 1979 to 1989, then decreased to 1.7% during the next ten year period from 1989 to 1999 (NEA and UNEP, 1999).

With the convenient geographic location and large population, Vietnam has been seen as the potential market for foreign investors. In particular, after the sixth National congress of Vietnam's Communist Party, held in December 1986, an overall economic renovation policy was introduced. This policy has been known as "Doi Moi", which aims at improving the standard of living of the people through relaxing macro-economic policy and reducing the government intervention in the market. In addition, incentive measures had been introduced to attract foreign direct investment (FDI) that was more than welcomed by the business sector. Since then, Vietnam has developed significantly.
Nevertheless, the encouraging development in the economy over the past two decades has appeared to be at the expense of the environment. Land degradation, deforestation, loss of biodiversity, water pollution, air pollution, and solid waste management are not only the familiar concepts, but also the key concerns of the national reports on the state of the environment in Vietnam. Among these critical problems, solid waste management historically drew little attention from environmental managers and decision makers in Vietnam. For many reasons, this situation has changed considerably in recent years, and the current condition of solid waste management has been mentioned in some national reports. NEA and UNEP (1999) states that waste collection efficiencies are very low due to the incomplete establishment of the collection services in most cities. Also, treatment facilities were not properly designed to meet the sanitary requirements.

Unfortunately, these issues still remain and solid waste management represents significant economic and environmental burdens for developing countries in general, and for Vietnam in particular. The environmental issues are normally related to improper services of solid waste management and treatment systems. For many years, the most common method to deal with solid waste has been dumping or landfilling; however, it is causing new problems, such as
groundwater contamination from landfill leachate and greenhouse gas emissions from methane generation in landfills. The main culprit is organic waste since it is degraded under the anaerobic condition to produce leachate and methane. Also, organics are the largest category of municipal solid waste (MSW). As shown in Figure 1.2, the solid waste in five big cities within Vietnam is largely composed of organic material which makes up roughly 40%.

Source: (NEA and UNEP, 2001)

Figure 1.2 Composition of Municipal Solid Waste across Vietnam

To reduce wastes in major cities of developing countries, the diversion of organics from the MSW stream (for composting or animal feed) is now gaining popularity. Furthermore, according to Vietnam’s national strategy on solid waste management (NEA and UNEP, 2001), the major methods for treatment of solid waste will be sanitary landfilling and recycling. Therefore, diversion of organic waste in general and composting in particular is important for Vietnam in years to come.

1.2 Review of Compost and Composting

Around the world, there are many working definitions of compost; however, most agree that compost is an entirely natural product:

*Compost is simply the final result of nature’s own recycling system which breaks down organic wastes and return the nutrients back to the soil* (Haight and Taylor, 2000).
The evident example is the natural decomposition process that turns leaves and tree trimmings on the forest floor to humus. By definition, composting is the biological decomposition of waste consisting of organic substrates of plant and animal origin under controlled conditions to a state sufficiently stable for convenient storage and utilization (Diaz, Eggerth et al., 1993). The composting process can occur with or without the presence of oxygen, depending on the species of microorganisms involved. However, the composting process that is discussed and applied in the scope of this study is aerobic decomposition, in which micro-organisms convert the organic material, with the presence of oxygen, into carbon dioxide (CO$_2$), water (H$_2$O) and humus substances.

\[
\text{Organic matters} + \text{O}_2 \xrightarrow{\text{micro-organisms, nutrients}} \text{CO}_2 + \text{H}_2\text{O} + \text{compost} + \text{heat.}
\]

There are some principle factors that strongly impact the decomposition process:

- **Moisture Content:** Water is necessary for the metabolic processes of the micro-organisms in the compost pile. It also serves as a holding and transport medium for nutrients and micro-organisms. A starting moisture level of 50 – 60% is recommended because the heat of the compost reaction will evaporate a lot of water. The optimal moisture range for composting is 40-65%. If the moisture content of the mass is below 25%, micro-organisms are inactivated, while if it is so high as to displace most of air from the interstices, anaerobic conditions develop within the mass (Epstein, 1997; Haug, 1993).

- **Ratio C/N:** With respect to the nutrient needs of the microbes active in composting, the C:N ratio of the waste to be composted is the most important factor that requires more attention. Both elements are used by the microbes in their metabolism to obtain energy and in the synthesis of new cellular material. The target C:N ratio is within the range from 20:1 to 40:1. If the ratio is too high, it will slow down the composting process, while odour problems will arise if too much nitrogen is present in feedstock (Hoornweg, 1999; Satriana, 1974).

- **Alkalinity:** pH is especially important with raw materials that are high in nitrogen content and which usually have an alkaline pH. Starting pH close to neutral (pH = 7) is desirable (Epstein, 1997).

- **Aeration:** Aerobic composting requires aeration to provide sufficient oxygen to support the microorganisms’ activities; without sufficient oxygen, the process can turn anaerobic, creating undesirable odours and incomplete decomposition (Dulac, 2001).

- **Temperature:** Thermophilic temperature is desirable for the destruction of pathogens, insect larvae and weed seeds. However, if it rises to more than 70°C, some useful microorganisms

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are also killed. Conversely, if the temperature is less than $30^\circ C$ the break-down rate of organics will be slow. Therefore, the optimum temperature range for rapid and complete composting is $55-65^\circ C$ (Dulac, 2001; Epstein, 1997).

- **Particle Size:** The significance of particle size is in the air exposure surface area of the waste particles to microbial attack; the greater the ratios of the surface area to mass (or volume), the more rapid the rate of microbial attack. Theoretically, the smaller the particle, the more readily and rapidly it can be broken down. The optimum size ranges from 2 cm to 5 cm (Dulac, 2001; Haug, 1993).

### 1.3 Waste Econ Program

The research project report here was carried out as part of a Waste-Econ Program between the University of Toronto, Canada and a number of government institutions, universities, and non-governmental organizations (NGOs) in Vietnam, Laos, and Cambodia. The aim of this five-year program, which is funded by the Canadian International Development Agency (CIDA), is to explore methods for recycling, exchanging and reducing wastes in a way that will be beneficial to the economies of the partner countries, the people working in the waste sector and to the environment as a whole. In Vietnam, the Waste-Econ partners are the National Institute for Science & Technology Policy and Strategy Studies (NISTPASS), four leading universities, eight government agencies and a number of NGOs. This research was part of a larger pilot-project on organic waste management for the BaiChay tourism destination, HaLong Bay, Vietnam. The objectives of the pilot project are to assess the existing sources of solid waste and the current status of the solid waste management, and to recommend ways to better manage wastes, especially the organic wastes.

### 1.4 Research Area

HaLong City is the most populated area within QuangNinh province. According to a recent study (Nhue, 2003), the total solid waste generation from households was about 0.7 kg per capita per day; therefore, it was estimated that 230,000 inhabitants within HaLong City generate approximately 58,000 tons of solid waste annually. This figure is expected to increase due to the population growth as well as the increasing development of socio-economic and tourism activities. There are only two organizations, BaiChay and HaLong Urban Environmental Company (Urenco), having responsibility for collecting and transporting solid waste within HaLong City. JICA (1999) states that if the target collection coverage was about 85% for
HaLong City by 2010, an extra 450,000 m\(^2\) landfilling area should be provided since two current landfills, Deo Sen and Ha Khau, have adequate disposal capacity until 2008. With the increase in population and expansion of the city, it may become difficult to find future waste disposal sites within easy access for solid waste disposal. Reducing the quantity of municipal solid waste (MSW) to be disposed would reduce the need for additional landfill space and the costs for managing the wastes. As shown in Figure 1.2, organic waste made up 41% of solid waste in HaLong, and removal of organic waste could lead to a significant reduction of solid waste.

1.5 Purposes and Methods of the Study

Discussions between the study team and local institutions, such as BaiChay Urban Environmental Company and Department of Resources and Environment, revealed their interest in establishing a small-scaled compost plant at HaKhau landfill in order to reduce wastes entering the landfill, and gain some profits from the sale of the compost product. However, more information about local solid waste characteristics, compost production, and compost quality is needed before proceeding with these plans. For this reason, the objectives of this study were to:

- Carry out a waste audit at some hotels in HaLong to assess solid waste quantities and composition. The audit is needed to evaluate whether the amount of organic waste from hotels is sufficient for the compost trial;
- Establish a temporary, low-cost composting pilot facility to test and serve as a model for future facilities, and as a training center for those who would work at such plants; and
- Assess the quality of the compost product from the pilot facility, and compare it to the current standards and regulations on compost quality in Vietnam and other countries.

The study was implemented through field work and information collection during the summer of 2004. The field work for the waste audit and compost trial was carried out by the author of this report in BaiChay, which is a part of HaLong City, while information collection came from data in both published and unpublished reports and working papers by government agencies, and research institutes. The detailed methodology for each specific part of the research is discussed in each chapter.

Some important limitations of the study were:

- Since the study was conducted in the wet season (from June to August, 2004), the results do not reflect the seasonal variability of wastes, and the high humidity in the ambient air may affect the weight of the waste.
- Since the waste audit was conducted in only three hotels (two-star, three-star, and four-star), the results may not represent all hotels within BaiChay.

- The organic waste for the compost trial was almost fully separated at source in three hotels over a period of about one week, and the analysis of compost quality was based on only one composting pile. Thus, the resulting compost quality may not adequately represent the quality of compost that would be produced.

1.6 Structure of the Study

The remainder of this report is divided into four chapters.

- Chapter 2 presents the waste audit process conducted in three hotels, the analysis of the collected data, and the resulting estimates of the composition and generation rate for each hotel.

- Chapter 3 describes the composting trial, including source separation, transportation, blending, piling, composting, maturing and screening, and the analysis and evaluation of mass flows and other chemical and physical parameters.

- Chapter 4 discusses compost quality control in Vietnam and other countries. The quality of the compost from the trial is also analyzed to identify whether or not the compost may be accepted in the market.

- Chapter 5 summarizes the results of the study and provides some recommendations on waste separation at source, seasonal effects, and compost application in order to improve the feasibility of composting in HaLong City.
CHAPTER 2
HOTEL WASTE AUDIT

2.1 Methodology: Capabilities and Limitations

There are many methodologies for quantifying and characterizing solid waste, including Direct Waste Analysis, Material Flow Analysis, Survey Analysis and Empirical Analysis. Each methodology has certain capabilities and limitations (SENES, 1992). This study applied one of the most commonly encountered methods, Direct Waste Analysis. As the name implies, the method involves direct examination of the waste stream characteristics, such as weight, composition, and existing waste management practices (e.g., reuse, recycling, disposal).

In this study, Direct Waste Analysis is used to measure total amount of waste disposed of and generation rates for three hotels. In practice, the method is very flexible and may be tailored to suit the goals of a specific study. The reporting capabilities are extensive if appropriate information is collected, and data may be reported in various units, including those based on economic activity. Generation rate for each hotel, for example, was reported as per guest per unit of time (e.g. kg/guest/day). Estimation of the composition of the waste was also an important part of this study. Component categories, which were based on waste materials, such as glass, metal, plastics and paper, were estimated for different waste sources (kitchen, garden, and guest/office rooms). Since the study focuses on composting, more detailed information is needed about compostables which was sub-categorized into leftover food, fruit waste, vegetable waste, and yard waste. Finally, statistical methods were applied to the sampling and data analysis procedures.

There are also some major limitations of the method that may affect the results of this study in some ways. First, waste generation rate and composition depend on external factors, such as climate, seasons, and location. The results are only considered valid for each selected hotel and for the tourist season (from June to July). The intensive labour required to physically sort the waste is another drawback to the method applied in the project.

The procedure implemented during the audit process included:

- Hotels were selected on the basis of their size, in terms of the number of rooms, and their rating.
- Hotel management personnel were interviewed informally to identify the numbers of rooms and occupancy levels during the waste audit period. Waste collection processes for
each hotel were observed, and all waste storage areas on the property were recognized. Details of waste collection and removal methods and frequency of removal were recorded (discussed below).

- Each waste collection area was observed before auditing. The hotels were visited at different times during a 24 hour period to make sure all waste generated was accounted for and to identify each waste source and composition. There are three typical sources of waste from hotels: kitchen, guest/staff rooms, and garden. Each of these sources has its own waste composition. For example, waste from the garden contains a lot of leaves and tree trimmings, while there are more vegetable and fruit wastes in kitchen waste.

- Both generation and composition vary with time of day, and day of week. In order to include these variations, a one-week audit was conducted for each hotel. During that time, waste was collected in a storage area where it was physically sorted into the different categories that are listed both in Table 2.3 and in the material column of the audit form presented in Appendix A; then, the sorted waste was weighed to estimate the generation rate, disposal rate and waste composition.

**2.2 Solid Waste Collection System for Hotels in HaLong**

There are about one hundred hotels in HaLong City, ranging from mini to four-star hotels, and this number is projected to increase considerably in the years to come. Deciding how many hotels and which hotels should be selected for the waste audit process and the compost trial was not an easy task. Therefore, some criteria were chosen, including location, property, size, and rating. This study assumed that hotels with more than 200 rooms are large, those with between 100 to 200 rooms are medium, while small ones have less than 100 rooms. Interestingly, there is a link between the size and the rating of hotel since larger hotels normally have higher rating. No five-star hotel is available in HaLong and also no hotel is registered as one-star. Due to limited time and labour, only three hotels could be selected. Hence, one four-star hotel, one three-star hotel, and one two-star hotel were selected and agreed to participate. Table 2.1 outlines some basic information on the three hotels.

SaiGon-Halong hotel, a four-star hotel, consists of a fourteen-floor building and 5 villas. This is one of the biggest and most modern hotels in BaiChay, HaLong City with the room rate ranging from US$ 50 to US$ 998 per night. With a beautiful garden and other luxury facilities, it attracts more than 90,000 guests annually, mostly from Taiwan, China, Japan, Korean, and Europe.
CongDoan hotel, a three-star, is the favorite destination of both high-income and medium-income guests, since the room rate is from around US $15 to US $40. Located at the heart of BaiChay, CongDoan hotel had around 50,000 overnight guests in 2003, including more than 20,000 overseas tourists. TienLong hotel, a two-star hotel, is a popular destination of Vietnamese tourists because of its low room rate.

<table>
<thead>
<tr>
<th>Name</th>
<th>Rating</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>SaiGon-HaLong Hotel</td>
<td>* * * *</td>
<td>228 + 5 villas</td>
</tr>
<tr>
<td>CongDoan Hotel</td>
<td>* * *</td>
<td>121</td>
</tr>
<tr>
<td>TienLong Hotel</td>
<td>* *</td>
<td>84</td>
</tr>
</tbody>
</table>

In order to design a proper waste audit process that caused little or no effect on the routine business of three participating hotels, the source and collection routes of solid waste were examined thoroughly.

*SaiGon-HaLong Hotel:*

There are three major sources of solid waste: kitchen/restaurant, garden, and staff/guest rooms. In each guest room, two dust bins are provided, one in the bathroom and one in the bedroom. Housekeeping staff would clean the room in the morning and after guests check out. Waste from guestrooms would be gathered in plastic bags and then thrown to a chute that is located at the end of the hall. Recyclables, theoretically, are not collected because the hotel managers did not allow their staff to touch waste and then make the beds. However, many room cleaners try to collect recyclables before throwing waste through the chute. During the one-week audit, the amount of these recyclable materials that they took out of the waste stream was estimated by asking housekeeping staff to bring these materials to the storage sites so that they could be weighed before they were sold. This approach did not work well because there was a lack of understanding of the purpose of the study and many of the room cleaners were afraid that this issue would be reported to the hotel’s managers.

Waste through the chute, then, goes down to a 5 m² storage room located on the ground floor (see Picture 2.1), where waste is kept from the elements and vermin, and stays there until the afternoon. Two cleaners have the responsibility to clean the room and take the waste away. However,
before doing their duties, one of them opens the plastic bags to collect recyclables. The remainder is brought to three push-carts, located at the back entrance of the hotel, where the BaiChay Urban Environmental Company’s compaction trucks come and transport the waste to HaKhau landfill.

In the kitchen, there are many waste containers placed at different locations. Vegetable, fruit, and food were processed at different places, and each place had one or two waste containers. Most leftover food, such as rice, mashed potatoes, cakes, and some types of vegetable wastes, is collected by one pig-farmer for animal feeding every morning. Recyclables, such as plastics and paper, are collected by kitchen staff for selling while reusable materials as beer bottles are collected to return to manufacturers. The remainder is gathered in large containers and brought to the push-carts twice per day.

Yard waste is dependent on the seasons (e.g. rainy season). Trees are trimmed monthly, even more often during the growing season. With the 15,000 m² garden, the amount of waste generated by this activity is estimated to one tonne per month; however, this amount was not considered in the waste audit report, because tree trimming is conducted periodically and there was no tree trimming activity during the one-week waste audit period. Yard waste considered for the waste audit and composting trail was mostly grass clippings, fallen leaves, and small tree trimmings that were collected from the surface of the road and paths within the hotel.

**CongDoan and TienLong Hotels:**

There is no waste collection system by chute in these two hotels; instead, waste from office and guest-rooms is brought directly to storage areas by cleaners. The storage area at CongDoan hotel is enclosed (Picture 2.2), while that at TienLong hotel is open and at a location where the waste is affected by weather conditions and grazed by animals.

Like staff at Sai Gon-Halong hotel, housekeepers at these two hotels try to collect recyclables as much as possible, again in an informal way. Waste from the kitchen is well mixed as there are only one or two waste containers standing at the back door. Urenco’s trucks come to CongDoan hotel once per day and to TienLong hotel once every two days.
2.3 Waste Quantification Study

Theoretically, the total quantity of waste generated from hotels, before recyclables are collected by hotel staff, is estimated by an average daily generation rate. Whereas, an average daily disposal rate is defined as the total amount of waste disposed of in the landfill, after most recyclables are removed. However, in fact, recyclable items were removed by hotel staff without reporting; and it was difficult to record their correct weight due to low cooperation from staff. As the result, the generation rate was underestimated. Nevertheless, the disposal rate could be estimated accurately, since determining the precise weight of solid waste gathered at storage areas was possible.

The estimate of the quantity of waste generated or disposed of is determined by the amount of waste from each source. The average generation rate, the amount of waste generated per day, is determined by Equation 2.1.

\[
W_{G,i} = \frac{\sum W_{i,Gd}}{n_i}
\]  
Equation 2.1

Where

\( W_{G,i} \): average waste generated by hotel \( i \) over the audit period (kg/day)
\( W_{i,Gd} \): waste generated by hotel \( i \) on day \( d \) of the audit period (kg)
\( n_i \): the number of audit days that hotel \( i \) participated in the audit (day)

The average waste disposal rate by a hotel is defined as follows:

\[
W_{D,i} = \frac{\sum W_{i,Dd}}{n_i}
\]  
Equation 2.2

Where

\( W_{D,i} \): average waste disposed by hotel \( i \) over the audit period (kg/day)
\( W_{i,Dd} \): waste disposed by hotel i on day d of the audit period (kg)
\( n_i \): the number of audit days that hotel i participated in the audit (day)

Since the amount of waste per day fluctuates and is dependent on the number of overnight guests (more guests, more waste), more useful measures of waste generation (or disposal) are the daily amount of waste generated (or disposed) per guest per day and the average amount waste generated (or disposed) per guest per day over the audit period. They are defined by using Equation 2.3a and 2.3b.

\[
\begin{align*}
(1) \quad W_{d,GG,i} &= \frac{W_{i,Gd}}{n_{g,d}} \quad \text{and} \quad (2) \quad W_{A,GG,i} &= \frac{\sum W_{i,Gd}}{\sum n_{g,d}} \quad \text{Equation 2.3a} \\
(1) \quad W_{d,DG,i} &= \frac{W_{i,Dd}}{n_{g,d}} \quad \text{and} \quad (2) \quad W_{A,DG,i} &= \frac{\sum W_{i,Dd}}{\sum n_{g,d}} \quad \text{Equation 2.3b}
\end{align*}
\]

Where

\( W_{d,GG,i} \): daily waste generated per guest per day by hotel i on day d (kg/guest/day)
\( W_{A,GG,i} \): average waste generated per guest per day by hotel i over the audit period (kg/guest/day)
\( W_{d,DG,i} \): daily waste disposed by a guest per day by hotel i on day d (kg/guest/day)
\( W_{A,DG,i} \): average waste disposed by a guest per day by hotel i over the audit period (kg/guest/day)
\( W_{i,Gd} \): waste generated by hotel i on day d of the audit period (kg)
\( W_{i,Dd} \): waste disposed by hotel i on day d of the audit period (kg)
\( n_{g,d} \): the number of guests staying in hotel i on day d of the audit period (guest)

To illustrate the use of Equations 2.1, 2.2, 2.3a, and 2.3b, data gathered from TienLong hotel over the one-week audit period is shown in Table 2.2. The amount of waste, both generated and disposed, fluctuated during the one-week audit period. For example, the quantity of waste generated on day 1 was 133.4 kg. This figure increased considerably to 172.7 on day 2, then decreased to 119.5 on day 3. The average waste generated by TienLong hotel during the audit period is shown in the column \( W_{G,i} \) (137.2 kg/day) while an average of only 89.2 kg was disposed of every day. Also, if the number of guests is accounted for (shown in row 3), the amount of waste generated and disposed by a guest on each day is calculated, as shown in the last two rows. For the entire 7-day audit period, an average of 0.81 kg and 0.53 kg of solid waste was generated and disposed per guest per day respectively. These and other results are presented and discussed in section 2.6.
Table 2.2 Use of Equation 2.1, 2.2, 2.3 on Data Gathered from TienLong Hotel

<table>
<thead>
<tr>
<th></th>
<th>Day 1</th>
<th>Day 2</th>
<th>Day 3</th>
<th>Day 4</th>
<th>Day 5</th>
<th>Day 6</th>
<th>Day 7</th>
<th>$W_{G,i}$</th>
<th>$W_{D,i}$</th>
<th>$W_{A,GG,i}$</th>
<th>$W_{A,DG,i}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$W_{G,i}$</td>
<td>133.4</td>
<td>172.7</td>
<td>119.5</td>
<td>151.7</td>
<td>126.1</td>
<td>144.8</td>
<td>137.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$W_{D,i}$</td>
<td>81.4</td>
<td>123.1</td>
<td>76.4</td>
<td>102.6</td>
<td>68.3</td>
<td>77.1</td>
<td>95.8</td>
<td>89.2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$n_{d,i}$</td>
<td>174</td>
<td>166</td>
<td>153</td>
<td>226</td>
<td>201</td>
<td>118</td>
<td>147</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$W_{d,GG,i}$</td>
<td>0.77</td>
<td>1.04</td>
<td>0.78</td>
<td>0.67</td>
<td>0.56</td>
<td>1.07</td>
<td>0.99</td>
<td>0.81</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$W_{d,DG,i}$</td>
<td>0.47</td>
<td>0.74</td>
<td>0.50</td>
<td>0.45</td>
<td>0.34</td>
<td>0.65</td>
<td>0.65</td>
<td></td>
<td></td>
<td></td>
<td>0.53</td>
</tr>
</tbody>
</table>

2.4 Waste Composition Study

As discussed in the previous section, there are three main sources of waste from hotels (office/guest rooms, gardens, and kitchen/restaurant), and each source contains different types of waste. For example, there are a lot of compostables, which can be biologically decomposed, present in kitchen-waste while more recyclables are present in waste from office/guest rooms. To give sufficient information to evaluate different disposal options such as recycling, landfilling, and especially composting in this study, the categories for separation are based on the waste sources. Furthermore, to establish the list of categories (shown in Table 2.3), some hotel staff who worked with solid waste were interviewed and also some published reports (Chopra, 2004; CCME, 1996; Kauffman, 1990; SENES, 1992) on waste audit were reviewed.

Waste from each source was separated into two or three main categories: compostables, recyclables, and miscellaneous. Since the major purpose of the study focuses on composting applicability for hotels, the quantity and composition of compostables was examined thoroughly. In the scope of this study, compostables were divided into seven sub-categories: leftover food, fruit waste, flower waste, vegetable waste, yard waste (including leaves and glass clippings), egg shells, and seafood waste. That is because each category has its own properties that strongly influence composting processes, such as moisture content, pH, and Carbon - Nitrogen ratio.

Recyclables contain four main categories: recyclable paper, glass, metals and recyclable plastics. As shown in Table 2.3, paper and plastics were separated into non-recyclable and recyclable. Non-recyclable paper or plastics are the items that can not be sold and recycled, while recyclable items were valuable for selling. For example, the fibers of tissue paper are too soft and short to be recycled. Therefore, in this study, non-recyclable plastics and paper, along with other wastes...
like rubber, cloth, and dirt that do not belong to any of the mentioned categories, were placed into a “miscellaneous” category.

The percentage of each main category of the daily waste generated by each hotel and the average proportion of waste generated over the audit period is defined as:

\[
(1) \quad P_{G,c,i,d} = \frac{W_{G,c,i,d}}{W_{G,i,d}} \times 100 \quad \text{and} \quad (2) \quad P_{A,G,c,i,d} = \frac{\sum W_{G,c,i,d}}{\sum W_{G,i,d}} \times 100 \quad \text{Equation 2.4}
\]

Where:

- \( P_{G,c,i,d} \): % composition of waste in category c generated by hotel i on day d (%)
- \( P_{A,G,c,i,d} \): average % composition of waste in category c generated by hotel i over the audit week (%)
- \( W_{G,c,i,d} \): waste in category c generated by hotel i on day d (kg/day)
- \( W_{G,i,d} \): the total amount of waste generated by hotel i on day d (kg/day).

The percentage of each main category of the daily waste disposed of by each hotel and the average percentage over the audit period are determined by:

\[
(1) \quad P_{D,c,i,d} = \frac{W_{D,c,i,d}}{W_{D,i,d}} \times 100 \quad \text{and} \quad (2) \quad P_{A,D,c,i,d} = \frac{\sum W_{D,c,i,d}}{\sum W_{D,i,d}} \times 100 \quad \text{Equation 2.5}
\]

Where

- \( P_{D,c,i,d} \): % composition of waste in category c disposed of by hotel i on day d (%)
- \( P_{A,D,c,i,d} \): average % composition of waste in category c disposed by hotel i over the audit week (%)
- \( W_{D,c,i,d} \): waste in category c disposed by hotel i on day d (kg/day)
- \( W_{D,i,d} \): the total amount of waste disposed by hotel i on day d (kg/day).

Also, for compostables, the percentage of each sub-category is given by:

\[
(1) \quad P_{O,c,i,d} = \frac{W_{O,c,i,d}}{W_{O,i,d}} \times 100 \quad \text{and} \quad (2) \quad P_{A,O,c,i,d} = \frac{\sum W_{O,c,i,d}}{\sum W_{O,i,d}} \times 100 \quad \text{Equation 2.6}
\]

Where

- \( P_{O,c,i,d} \): % composition of compostables in sub-category c for hotel i on day d (%)
- \( P_{A,O,c,i,d} \): average % composition of compostables in sub-category c for hotel i over the audit week (%)
- \( W_{O,c,i,d} \): compostables in sub-category c generated or disposed by hotel i on day d (kg/day)
- \( W_{O,i,d} \): the total amount of compostable generated or disposed by hotel i on day d (kg/day).
## Table 2.3 List of Material Categories

<table>
<thead>
<tr>
<th>Material Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Waste from Guest Room</strong></td>
<td></td>
</tr>
<tr>
<td>Compostables</td>
<td></td>
</tr>
<tr>
<td>Fruit waste</td>
<td>Rambutan, watermelon, dragon fruit, litchi, pineapple, mangosteen shells</td>
</tr>
<tr>
<td>Leftover food</td>
<td>Bread, sticky rice</td>
</tr>
<tr>
<td>Flower waste</td>
<td>Daisy, roses</td>
</tr>
<tr>
<td>Recyclables</td>
<td></td>
</tr>
<tr>
<td>Metal</td>
<td>Aluminum cans</td>
</tr>
<tr>
<td>Glass</td>
<td>Beer bottle, glasses</td>
</tr>
<tr>
<td>Recyclable plastics</td>
<td>Bottles, clear bags</td>
</tr>
<tr>
<td>Recyclable paper</td>
<td>Tissues, cardboard, print paper, newspaper</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td></td>
</tr>
<tr>
<td>Non-recyclable paper</td>
<td>Damp napkins, tissues</td>
</tr>
<tr>
<td>Non-recyclable plastics</td>
<td>Plastics bags, hard plastics…</td>
</tr>
<tr>
<td>Others</td>
<td>Wood chips, sand, dust, rubber, cloth, …</td>
</tr>
<tr>
<td><strong>Waste from Kitchen and Restaurant</strong></td>
<td></td>
</tr>
<tr>
<td>Compostables</td>
<td></td>
</tr>
<tr>
<td>Leftover food</td>
<td>Rice, cooked meat, cakes, …</td>
</tr>
<tr>
<td>Fruit waste</td>
<td>Rambutan, watermelon, dragon fruit, litchi, pineapple, mangosteen shells</td>
</tr>
<tr>
<td>Vegetable waste</td>
<td>Water-morning glory, pot-herbs, onion, spinach, carrot,</td>
</tr>
<tr>
<td>Egg shells</td>
<td>-</td>
</tr>
<tr>
<td>Sea-food waste</td>
<td>Lobster, crab, shells, fish</td>
</tr>
<tr>
<td>Recyclables</td>
<td></td>
</tr>
<tr>
<td>Recyclable paper</td>
<td>Tissues, cardboard, print paper, newspaper</td>
</tr>
<tr>
<td>Metal</td>
<td>Aluminum cans</td>
</tr>
<tr>
<td>Glass</td>
<td>Beer bottle, kitchen stuff</td>
</tr>
<tr>
<td>Recyclable plastics</td>
<td>Bottles, clear bags</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td></td>
</tr>
<tr>
<td>Non-recyclable paper</td>
<td>Damp napkins, tissues</td>
</tr>
<tr>
<td>Non-recyclable plastics</td>
<td>Plastics bags, hard plastics…</td>
</tr>
<tr>
<td>Others</td>
<td>Bone, dirt, sand, cloth, rubber, …</td>
</tr>
<tr>
<td><strong>Waste from Garden</strong></td>
<td></td>
</tr>
<tr>
<td>Compostables</td>
<td></td>
</tr>
<tr>
<td>Leaves</td>
<td>Pine needles, brush, leaves, tree trimmings</td>
</tr>
<tr>
<td>Grass clippings</td>
<td>-</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td></td>
</tr>
<tr>
<td>Others</td>
<td>Dirt, sand, rubber, cloth, foam, …</td>
</tr>
</tbody>
</table>
To illustrate the use of Equation 2.4, 2.5, and 2.6, the data gathered for SaiGon-Halong hotel on day 1 are applied and the results are shown in Table 2.4. First, the total weight of each category would be the sum of weight from all sources, since one category, such as recyclables and compostables, can be present in two or three sources. The results of the total weight of each category generated and disposed of are shown in the row titled $W_{G,c,i,d}$ and $W_{D,c,i,d}$ respectively. Equation 2.4, and 2.5 can then be used to determine the percentage of each category in the total waste for day 1 and these calculations can be found in the row titled $P_{G,c,i,d}$, $P_{D,c,i,d}$. To calculate the composition of compostables, the same procedure is applied, and its results are shown in the last two rows. Also, the average values are found in Appendix A (from table A6 to Table A14).

### Table 2.4 Use of Equation 2.4, 2.5, 2.6 for Data of SaiGon-Halong Hotel on Day 1

<table>
<thead>
<tr>
<th>Generation-based Composition</th>
<th>Compostables</th>
<th>Recyclables</th>
<th>Miscellaneous</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>$W_{G,c,i,d}$ (kg)</td>
<td>291.3</td>
<td>42.3</td>
<td>22.0</td>
<td>355.6</td>
</tr>
<tr>
<td>$P_{G,c,i,d}$ (%)</td>
<td>81.9</td>
<td>11.9</td>
<td>6.2</td>
<td>100.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Disposal-based Composition</th>
<th>Compostables</th>
<th>Recyclables</th>
<th>Miscellaneous</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>$W_{D,c,i,d}$ (kg)</td>
<td>174.0</td>
<td>2.3</td>
<td>22.0</td>
<td>198.3</td>
</tr>
<tr>
<td>$P_{D,c,i,d}$ (%)</td>
<td>87.8</td>
<td>1.1</td>
<td>11.1</td>
<td>100.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Composition of Compostables</th>
<th>Fruit waste</th>
<th>Leftover food</th>
<th>Vegetable waste</th>
<th>Yard waste</th>
<th>Others (eggs, seafood, flower)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>$W_{O,c,i,d}$ (kg)</td>
<td>Generation</td>
<td>100.7</td>
<td>104.8</td>
<td>58.5</td>
<td>21.4</td>
<td>5.9</td>
</tr>
<tr>
<td></td>
<td>Disposal</td>
<td>100.7</td>
<td>0.0</td>
<td>46.0</td>
<td>21.4</td>
<td>5.9</td>
</tr>
<tr>
<td>$P_{O,c,i,d}$ (%)</td>
<td>Generation</td>
<td>34.6</td>
<td>36.9</td>
<td>20.1</td>
<td>7.3</td>
<td>2.0</td>
</tr>
<tr>
<td></td>
<td>Disposal</td>
<td>57.9</td>
<td>0.0</td>
<td>26.4</td>
<td>12.3</td>
<td>3.4</td>
</tr>
</tbody>
</table>

#### 2.5 One-Week Waste Audit Process

The waste audit was conducted in two weeks in June, 2004, from 6th to 12th June for SaiGon-HaLong hotel and from 15th to 21st June for the CongDoan and TienLong hotels. Some scavengers and hotel staff participated in conducting the waste audit. Prior to auditing, they were provided with necessary training and information in order to manage their tasks for each day of the audit. Also, some necessary equipment and supplies, such as scales, gloves, plastic bags and record sheets, were provided.
An important point to note is that the hotels needed to operate as usual during the waste audit period; thus the audit process was flexible and depended on the waste disposal route and time schedule. For waste from office and guest rooms, housekeeping staff were asked to place all the waste that they collected from the rooms to the storage areas at their convenience. At the end of the day, black plastic bags with white labels identifying the different categories of waste were provided and two scavengers started sorting waste into the categories shown in Table 2.3. After sorting, each bag of waste was weighed and recorded (see Picture 2.3).

Since kitchen waste is generally wet and sticky, it is very difficult to sort when the wastes are well-mixed. To avoid this problem, the kitchen wastes were kept separately by providing labeled baskets or plastic bags for each category, and placing them at convenient location where staff could easily put waste in the appropriate baskets or plastic bags. Sorted kitchen and restaurant waste was normally weighed twice per day, after breakfast and dinner time, since kitchen waste must be disposed of right after processing due to quick biodegradation of compostables. Yard waste was sorted into its three categories (leaves, glass clippings and miscellaneous), and each of these was placed in a black plastic bag. After being gathered in the waste storage sites, the bags were weighed at the end of the day.

**Picture 2.3 Waste from Guest-rooms (left) and Kitchen (right) are Sorted at SG-HL Hotel**

### 2.6 Results, Analysis, and Discussions

#### 2.6.1 Quantity Estimation

The waste quantity data gathered from the three hotels during the one week audit period are shown in Table A1, A2, and A3. To interpret the relationship between the amount generated or
disposed with time and the number of overnight guests, various statistical analysis procedures were employed, including measures of central tendency, measures of dispersion, and confidence intervals. Measures of central tendency are concerned with the average (or mean) value of the set of the data; for example, the average amount of waste generated per day. However, since the mean value does not show how the individual data vary around the mean, measures of spread of the data are employed, including standard deviation and range. Finally, the confidence interval for a mean gives the range of values around the mean where we expect the “true” mean is located. To summarize and graphically illustrate the various measures of the central tendency and dispersion of the data, Box-Whisker plots were also used. Figure 2.1 shows the Box-whisker plots for the waste amount generated in the three hotels. All mathematical calculations of the data and explanations on how to interpret all statistical measures and the Box-whiskers plots can be found in Appendix A4.

Table 2.5 summarizes the daily waste quantities, both generated and disposed, for each hotel during the one-week audit period. The table also shows the results of the statistical analysis procedures. The amount of waste generated fluctuated over the one week period. For example, about 356 kg of solid waste was generated in SaiGon-HaLong hotel on day 1 (Sunday). This amount considerably increased to 479 kg on day 2 (Monday); then decreased gradually to 292 kg on day 4 (Wednesday). It steadily rose to 437 kg on the last day of the audit. The same pattern was also found in TienLong hotel. The trend of the generation rate in CongDoan hotel was different since the amount of waste generated increased from 184 kg to 209 kg during the first four days; however, it decreased considerably (by over 20%) over the last four days. Another important feature from Table 2.5 to note is that the range of waste generated each day for all three hotels is quite large: from 292 kg to 479 kg for SaiGon-HaLong hotel, from 163 kg to 209 kg for CongDoan hotel, and from 112 kg to 173 kg for TienLong hotel. The table also shows that the SaiGon-HaLong hotel was the biggest waste generator, with the average generation rate of 359 kg per day. This was two times larger than that of the CongDoan hotel (182 kg/day) and nearly three times if compared with that of the TienLong hotel (137 kg/day). This can be seen clearly in the Box – Whiskers plot shown in Figure 2.1. Correspondingly, the standard deviation for the SaiGon-HaLong hotel was much higher than those for two other hotels. This means that the daily amount of waste generated by SaiGon-HaLong hotel was more fluctuant and dispersed from the average amount. These fluctuations were mainly because the amount of waste per day is dependent on the number of overnight guests, which will be discussed later in this section.
Table 2.5 Quantities of Waste, both Generated and Disposed, for Each Hotel during One Week Audit

<table>
<thead>
<tr>
<th>Name of Hotel</th>
<th>Day 1</th>
<th>Day 2</th>
<th>Day 3</th>
<th>Day 4</th>
<th>Day 5</th>
<th>Day 6</th>
<th>Day 7</th>
<th>Mean</th>
<th>STDEV</th>
<th>Range</th>
<th>95% CI of mean</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SaiGon-Halong</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Generation Rate</td>
<td>355.6</td>
<td>479.4</td>
<td>304.1</td>
<td>292.1</td>
<td>299.8</td>
<td>345.1</td>
<td>437.3</td>
<td>359.1</td>
<td>72.8</td>
<td>291.7 to 426.4</td>
<td></td>
</tr>
<tr>
<td>Disposal rate</td>
<td>198.3</td>
<td>328.8</td>
<td>194.2</td>
<td>136.6</td>
<td>144.7</td>
<td>194.0</td>
<td>226.4</td>
<td>203.3</td>
<td>63.7</td>
<td>136.6 to 328.8</td>
<td></td>
</tr>
<tr>
<td><strong>CongDoan</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Generation Rate</td>
<td>184.1</td>
<td>173.4</td>
<td>170.2</td>
<td>208.8</td>
<td>169.2</td>
<td>208.3</td>
<td>163.1</td>
<td>182.4</td>
<td>18.9</td>
<td>163.1 to 208.8</td>
<td></td>
</tr>
<tr>
<td>Disposal rate</td>
<td>114.6</td>
<td>105.6</td>
<td>101.8</td>
<td>141.6</td>
<td>100.5</td>
<td>144.3</td>
<td>91.6</td>
<td>114.3</td>
<td>20.7</td>
<td>91.6 to 144.3</td>
<td></td>
</tr>
<tr>
<td><strong>TienLong</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Generation Rate</td>
<td>133.4</td>
<td>172.7</td>
<td>119.5</td>
<td>151.7</td>
<td>112.3</td>
<td>126.1</td>
<td>144.8</td>
<td>137.2</td>
<td>20.8</td>
<td>112.3 to 172.7</td>
<td></td>
</tr>
<tr>
<td>Disposal rate</td>
<td>81.4</td>
<td>123.1</td>
<td>76.4</td>
<td>102.6</td>
<td>68.3</td>
<td>77.1</td>
<td>95.8</td>
<td>89.2</td>
<td>19.1</td>
<td>68.3 to 123.1</td>
<td></td>
</tr>
</tbody>
</table>

20
In Table 2.5, the disposal rate is also included. This rate is of particular interest since it reflects the actual amount of waste from hotels that is discharged to the environment. As can be seen in the table and from the Box-whiskers plot (Figure 2.2), the SaiGon-HaLong hotel disposed the largest amount of waste with the average disposal rate of 203 kg per day, followed by the CongDoan hotel with 114 kg per day, and the TienLong hotel with 89 kg per day. As a result, the ratios of disposal rate to generation rate\(^1\) for three hotels are 57%, 63%, and 65% respectively. Almost all recyclables, such as plastics and paper from staff and guest rooms in SaiGon-Halong hotel were collected for selling by two cleaners who are not paid for cleaning the storage area and transporting waste, but allowed to collect recyclables from waste stream in the hotel. As discussed previously, recyclables from two other hotels were also sorted by house keeping staff, but in the informal way; therefore, they often did not have time to do a thorough job.

As discussed earlier, hotel waste generation can be affected by the number of guests staying in the hotel. To account for this, Table 2.6 shows the amount of waste generated and disposed per guest per day at the three hotels, called “guest-based generation rate and disposal rate”. The number of overnight guests can be found in Table A.5a and Table A.5b.

SaiGon-Halong hotel, again, had the highest average guest-based generation rate; on average, each guest produced 0.90 kg per day. TienLong hotel was followed with the rate of 0.81 kg/guest/day and 0.69 kg/guest/day for CongDoan hotel. However, in terms of the average guest-
based disposal rate, SaiGon-HaLong and TienLong had similar amounts of approximately 0.5 kg/guest/day, while 0.43 kg was the average amount of waste disposed by a guest in CongDoan hotel. With only few exceptions, over the one-week audit period, the average generation rate was quite constant. For the SaiGon-Halong hotel, the amount of waste generated and disposed on the second day was over 1.5 times higher than that on other days.

### Table 2.6 Waste Generated and Disposed per Guest per Day

<table>
<thead>
<tr>
<th>Name of Hotel</th>
<th>Day 1</th>
<th>Day 2</th>
<th>Day 3</th>
<th>Day 4</th>
<th>Day 5</th>
<th>Day 6</th>
<th>Day 7</th>
<th>Average*</th>
</tr>
</thead>
<tbody>
<tr>
<td>SaiGon Halong</td>
<td>Generated</td>
<td>0.83</td>
<td>1.42</td>
<td>0.89</td>
<td>0.85</td>
<td>0.79</td>
<td>0.71</td>
<td>0.90</td>
</tr>
<tr>
<td></td>
<td>Disposed</td>
<td>0.46</td>
<td>0.98</td>
<td>0.57</td>
<td>0.40</td>
<td>0.38</td>
<td>0.40</td>
<td>0.47</td>
</tr>
<tr>
<td>Cong Doan</td>
<td>Generated</td>
<td>0.63</td>
<td>0.70</td>
<td>0.55</td>
<td>0.76</td>
<td>0.63</td>
<td>0.83</td>
<td>0.75</td>
</tr>
<tr>
<td></td>
<td>Disposed</td>
<td>0.39</td>
<td>0.43</td>
<td>0.33</td>
<td>0.52</td>
<td>0.38</td>
<td>0.58</td>
<td>0.42</td>
</tr>
<tr>
<td>Tien Long</td>
<td>Generated</td>
<td>0.77</td>
<td>1.04</td>
<td>0.78</td>
<td>0.67</td>
<td>0.56</td>
<td>1.07</td>
<td>0.99</td>
</tr>
<tr>
<td></td>
<td>Disposed</td>
<td>0.47</td>
<td>0.74</td>
<td>0.50</td>
<td>0.45</td>
<td>0.34</td>
<td>0.65</td>
<td>0.65</td>
</tr>
</tbody>
</table>

Note: * the average guest-based amount is determined by Equation 2.3a (2) and 2.3b (2).

Some possible explanations for these results are as follows. First, the amount of waste generated or disposed could have been dependent on guests’ nationality and purpose for staying in the hotel. According to some house-keeping staff, tourists from China, Taiwan, Vietnam and other Asian countries often bring food and groceries with them; therefore a greater amount of packaging and food waste can be found after those guests checked out. However, guests from Europe or North American bring far less luggage while traveling. Also, guests traveling for business often carry less than tourists; thus often producing less waste. Another reason may be due to hotel rating. The four-star hotel, SaiGon Halong, does not allow its staff to collect recyclable; in particular, leftovers from the kitchen, even when they are still fresh, must be discharged due to so-called “health safety”. However, staff in the TienLong and CongDoan hotels was encouraged to preserve leftovers for their own use. Lastly, all three hotels organize workshops or conferences if required. Participants of those events simply come to attend and have meals, but they also generate waste. As a result, some waste collected was not produced from overnight guests.
2.6.2 Composition Estimation

The percent composition of both wastes generated and disposed of are calculated and shown in Table 2.7 and Table 2.8 (detailed information, such as composition-based weight, is described in Appendix A, from Table A6 to Table A11). As mentioned in Section 2.4, there are three main categories, including compostables, recyclables, and miscellaneous, and each category can be used for different purposes. Compostables and recyclables are value feedstock for composting and recycling processes respectively, while miscellaneous is often disposed of into landfills since it has no or little value.

Table 2.7 summarizes the generation-based composition of the daily waste generated by each hotel. Based on a visual comparison, there appear to be no obvious or important differences in the average percent composition among three hotels. Compostables was the largest portion of the waste stream, accounting for more than 70%. This is followed by miscellaneous, with the percentage ranging from 15% to 22%. In the SaiGon Halong hotel, for example, about 75% of waste generated per day was compostables, while recyclables made up 10%. Waste from two other hotels contained lower proportion of recyclables but the same portion of compostables.

Table 2.7 Generation-based Composition of Solid Waste in Hotels, HaLong

<table>
<thead>
<tr>
<th>Location</th>
<th>Material Category</th>
<th>Day 1</th>
<th>Day 2</th>
<th>Day 3</th>
<th>Day 4</th>
<th>Day 5</th>
<th>Day 6</th>
<th>Day 7</th>
<th>Average*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
</tr>
<tr>
<td>SaiGon-Halong</td>
<td>Compostables</td>
<td>81.9</td>
<td>72.6</td>
<td>73.7</td>
<td>80.9</td>
<td>64.9</td>
<td>73.7</td>
<td>75.1</td>
<td>74.7</td>
</tr>
<tr>
<td></td>
<td>Recyclables</td>
<td>11.9</td>
<td>10.5</td>
<td>12.6</td>
<td>6.0</td>
<td>15.9</td>
<td>9.3</td>
<td>9.4</td>
<td>10.7</td>
</tr>
<tr>
<td></td>
<td>Miscellaneous</td>
<td>6.2</td>
<td>16.9</td>
<td>13.7</td>
<td>13.1</td>
<td>19.2</td>
<td>17.0</td>
<td>15.5</td>
<td>14.6</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>CongDoan</td>
<td>Compostables</td>
<td>81.7</td>
<td>75.4</td>
<td>73.2</td>
<td>77.7</td>
<td>76.3</td>
<td>67.7</td>
<td>67.0</td>
<td>74.2</td>
</tr>
<tr>
<td></td>
<td>Recyclables</td>
<td>3.7</td>
<td>3.7</td>
<td>4.8</td>
<td>4.8</td>
<td>3.5</td>
<td>7.8</td>
<td>13.5</td>
<td>10.5</td>
</tr>
<tr>
<td></td>
<td>Miscellaneous</td>
<td>14.6</td>
<td>20.9</td>
<td>22.0</td>
<td>18.8</td>
<td>15.9</td>
<td>18.8</td>
<td>22.5</td>
<td>19.0</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>TienLong</td>
<td>Compostables</td>
<td>63.7</td>
<td>84.0</td>
<td>73.2</td>
<td>75.1</td>
<td>66.1</td>
<td>71.5</td>
<td>73.5</td>
<td>73.1</td>
</tr>
<tr>
<td></td>
<td>Recyclables</td>
<td>4.0</td>
<td>2.4</td>
<td>6.3</td>
<td>2.0</td>
<td>16.1</td>
<td>2.3</td>
<td>3.0</td>
<td>4.7</td>
</tr>
<tr>
<td></td>
<td>Miscellaneous</td>
<td>32.3</td>
<td>13.6</td>
<td>20.5</td>
<td>22.9</td>
<td>17.8</td>
<td>26.2</td>
<td>23.5</td>
<td>22.2</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

Note: * the average generation-based composition is determined by Equation 2.4 (2)

However, there are some fluctuations in daily composition over the one-week audit period. For instance, on day 1, 12% of waste generated in SaiGon-Halong hotel was recyclables while only...
6% was found on day 4. The same variation was also true for other categories. Based on discussion with hotel staff and waste scavengers, and audit results, the daily composition of the waste generated by any hotel in any one audit day might be influenced by:

- The number of guests staying and having meal in hotels. For example, more compostables are produced if more guests order meals in the hotel.
- Cooperation of hotel staff in reporting the amount of recyclables they collect. For example, on the second day in SaiGon – HaLong Hotel, there was no glass or metal collected. However all three hotels have restaurants that would generate glass and metal wastes from beverage containers. From informal interviews with some hotel staff, it was revealed that housekeeping staff and bar/restaurant servers usually take metal items since they are easy to be flattened and placed into small bags. Also, glass items, such as beer bottles, are taken to be sold back to manufacturers.

The disposal-based composition of the waste disposed of by each hotel is described in Table 2.8 Compostables were still the largest portion of the waste stream, accounting for 60% or 70%. Miscellaneous, with the average percentage ranging from 26% to 34%, gained the second-place. It can be seen that, in SaiGon-HaLong hotel, most recyclables were removed from the waste stream before it was disposed of; no recyclables were found on the last four days. On the contrary, the average percentage of recyclables in waste disposed of by both CongDoan and TienLong hotels increased to 9% and 7% respectively, mainly because the large proportion of compostables was collected for animal feeding. Similar to the daily generation-based composition, there are fluctuations in daily disposal-based composition over the one-week audit period, as shown in Table 2.8. The reasons for these fluctuations could be the same as those mentioned for generation-based composition.

### 2.6.3 Compostables Quantification and Composition

One of the most important pieces of information for a composting facility is the quantity and composition of compostables (Table 2.9); therefore, a closer examination of compostables was conducted. As discussed in Section 2.4, compostables were divided into seven sub-categories: leftover food, fruit waste, flower waste, vegetable waste, yard waste (including leaves and glass clippings), egg shells, and seafood waste. However, based on hotel observation and audit results, the amount of flower, egg shells, and seafood waste was negligible. Hence, these three sub-categories were placed into one category, named “others”.

24
Table 2.8 Disposal-based Composition of Solid Waste in Hotels, HaLong

<table>
<thead>
<tr>
<th>Location</th>
<th>Material Category</th>
<th>Day 1</th>
<th>Day 2</th>
<th>Day 3</th>
<th>Day 4</th>
<th>Day 5</th>
<th>Day 6</th>
<th>Day 7</th>
<th>Average*</th>
</tr>
</thead>
<tbody>
<tr>
<td>SaiGon-HaLong</td>
<td>Compostables</td>
<td>87.8</td>
<td>72.9</td>
<td>77.1</td>
<td>72.0</td>
<td>60.2</td>
<td>69.7</td>
<td>73.2</td>
<td>73.3</td>
</tr>
<tr>
<td></td>
<td>Recyclables</td>
<td>1.1</td>
<td>2.5</td>
<td>1.5</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.9</td>
</tr>
<tr>
<td></td>
<td>Miscellaneous</td>
<td>11.1</td>
<td>24.6</td>
<td>21.4</td>
<td>28.0</td>
<td>39.8</td>
<td>30.5</td>
<td>26.8</td>
<td>25.8</td>
</tr>
<tr>
<td></td>
<td>Total</td>
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<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>CongDoan</td>
<td>Compostables</td>
<td>72.0</td>
<td>61.9</td>
<td>55.6</td>
<td>67.2</td>
<td>61.1</td>
<td>54.1</td>
<td>47.7</td>
<td>60.4</td>
</tr>
<tr>
<td></td>
<td>Recyclables</td>
<td>4.6</td>
<td>3.7</td>
<td>7.6</td>
<td>5.1</td>
<td>12.1</td>
<td>18.7</td>
<td>12.1</td>
<td>9.3</td>
</tr>
<tr>
<td></td>
<td>Miscellaneous</td>
<td>23.4</td>
<td>34.4</td>
<td>36.8</td>
<td>27.7</td>
<td>26.8</td>
<td>27.2</td>
<td>40.2</td>
<td>30.3</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>TienLong</td>
<td>Compostables</td>
<td>40.5</td>
<td>78.0</td>
<td>60.9</td>
<td>63.3</td>
<td>45.7</td>
<td>53.4</td>
<td>59.9</td>
<td>59.3</td>
</tr>
<tr>
<td></td>
<td>Recyclables</td>
<td>6.5</td>
<td>2.9</td>
<td>7.1</td>
<td>2.7</td>
<td>25.0</td>
<td>3.8</td>
<td>4.6</td>
<td>6.6</td>
</tr>
<tr>
<td></td>
<td>Miscellaneous</td>
<td>53.0</td>
<td>19.1</td>
<td>32.0</td>
<td>34.0</td>
<td>29.3</td>
<td>42.8</td>
<td>35.5</td>
<td>34.1</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

Note: * the average deposition-based composition is determined by Equation 2.5 (2)

The total amount of compostables generated and disposed by the three hotels is summarized in Figure 2.3. SaiGon-HaLong hotel, with the average compostables quantity of 268 kg, was the biggest producers, whereas 135 kg and 100 kg of compostables were generated by CongDoan and TienLong hotel respectively. However, after most leftover food and some vegetables were collected for animal feeding, only about 50% of compostables were disposed of into the environment, and this amount would be seen as a potential source for the composting trial.

![Figure 2.3 The Average Amount of Compostables Generated and Disposed by Hotels.](image)
### Table 2.9 Composition of Compostables

<table>
<thead>
<tr>
<th>Location</th>
<th>Categories of compostable waste</th>
<th>Day 1</th>
<th>Day 2</th>
<th>Day 3</th>
<th>Day 4</th>
<th>Day 5</th>
<th>Day 6</th>
<th>Day 7</th>
<th>Average*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SaiGon-HaLong</td>
<td>Fruit waste Generated</td>
<td>34.6</td>
<td>42.2</td>
<td>29.8</td>
<td>20.0</td>
<td>26.7</td>
<td>31.7</td>
<td>29.8</td>
<td>31.6</td>
</tr>
<tr>
<td></td>
<td>Disposed</td>
<td>57.9</td>
<td>61.4</td>
<td>44.7</td>
<td>48.0</td>
<td>59.7</td>
<td>59.5</td>
<td>61.8</td>
<td>56.8</td>
</tr>
<tr>
<td></td>
<td>Leftover food Generated</td>
<td>36.0</td>
<td>38.4</td>
<td>31.4</td>
<td>58.4</td>
<td>55.2</td>
<td>46.8</td>
<td>52.1</td>
<td>45.0</td>
</tr>
<tr>
<td></td>
<td>Disposed</td>
<td>0.0</td>
<td>30.0</td>
<td>1.9</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.6</td>
<td>7.3</td>
</tr>
<tr>
<td></td>
<td>Vegetable waste Generated</td>
<td>20.1</td>
<td>14.9</td>
<td>26.1</td>
<td>9.5</td>
<td>11.6</td>
<td>12.8</td>
<td>13.9</td>
<td>15.5</td>
</tr>
<tr>
<td></td>
<td>Disposed</td>
<td>26.4</td>
<td>2.1</td>
<td>34.4</td>
<td>22.9</td>
<td>25.8</td>
<td>24.0</td>
<td>28.9</td>
<td>21.6</td>
</tr>
<tr>
<td></td>
<td>Yard waste (leaves and glass clippings) Generated</td>
<td>7.3</td>
<td>2.0</td>
<td>6.6</td>
<td>11.4</td>
<td>2.4</td>
<td>7.7</td>
<td>2.6</td>
<td>5.5</td>
</tr>
<tr>
<td></td>
<td>Disposed</td>
<td>12.3</td>
<td>2.9</td>
<td>9.8</td>
<td>27.5</td>
<td>5.3</td>
<td>14.6</td>
<td>5.4</td>
<td>9.9</td>
</tr>
<tr>
<td></td>
<td>Others (egg shells, seafood, flower) Generated</td>
<td>2.0</td>
<td>2.5</td>
<td>6.1</td>
<td>0.7</td>
<td>4.1</td>
<td>1.0</td>
<td>1.6</td>
<td>2.4</td>
</tr>
<tr>
<td></td>
<td>Disposed</td>
<td>3.4</td>
<td>3.6</td>
<td>9.2</td>
<td>1.6</td>
<td>9.2</td>
<td>1.8</td>
<td>3.3</td>
<td>4.4</td>
</tr>
<tr>
<td>CongDoan</td>
<td>Fruit waste Generated</td>
<td>27.9</td>
<td>35.3</td>
<td>28.6</td>
<td>31.8</td>
<td>24.3</td>
<td>31.2</td>
<td>23.1</td>
<td>29.1</td>
</tr>
<tr>
<td></td>
<td>Disposed</td>
<td>50.9</td>
<td>70.5</td>
<td>62.9</td>
<td>54.2</td>
<td>51.1</td>
<td>56.3</td>
<td>57.7</td>
<td>57.1</td>
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<tr>
<td></td>
<td>Leftover food Generated</td>
<td>33.9</td>
<td>41.3</td>
<td>42.4</td>
<td>31.3</td>
<td>39.9</td>
<td>36.6</td>
<td>48.5</td>
<td>38.5</td>
</tr>
<tr>
<td></td>
<td>Disposed</td>
<td>1.2</td>
<td>3.8</td>
<td>1.4</td>
<td>0.7</td>
<td>1.6</td>
<td>0.8</td>
<td>2.3</td>
<td>1.6</td>
</tr>
<tr>
<td></td>
<td>Vegetable waste Generated</td>
<td>25.2</td>
<td>17.4</td>
<td>17.9</td>
<td>28.7</td>
<td>28.8</td>
<td>20.3</td>
<td>21.5</td>
<td>23.1</td>
</tr>
<tr>
<td></td>
<td>Disposed</td>
<td>24.2</td>
<td>13.8</td>
<td>11.1</td>
<td>31.1</td>
<td>32.6</td>
<td>21.4</td>
<td>22.9</td>
<td>23.0</td>
</tr>
<tr>
<td></td>
<td>Yard waste (leaves and glass clippings) Generated</td>
<td>3.1</td>
<td>3.1</td>
<td>4.5</td>
<td>3.1</td>
<td>3.5</td>
<td>4.0</td>
<td>2.9</td>
<td>3.5</td>
</tr>
<tr>
<td></td>
<td>Disposed</td>
<td>5.7</td>
<td>6.1</td>
<td>9.9</td>
<td>5.3</td>
<td>7.3</td>
<td>7.2</td>
<td>7.3</td>
<td>6.8</td>
</tr>
<tr>
<td></td>
<td>Others (egg shells, seafood, flower) Generated</td>
<td>9.8</td>
<td>2.9</td>
<td>6.7</td>
<td>5.1</td>
<td>3.5</td>
<td>7.9</td>
<td>3.9</td>
<td>5.8</td>
</tr>
<tr>
<td></td>
<td>Disposed</td>
<td>17.9</td>
<td>5.8</td>
<td>14.7</td>
<td>8.7</td>
<td>7.3</td>
<td>14.3</td>
<td>9.8</td>
<td>11.5</td>
</tr>
<tr>
<td>TienLong</td>
<td>Fruit waste Generated</td>
<td>12.7</td>
<td>2.0</td>
<td>14.2</td>
<td>24.8</td>
<td>10.0</td>
<td>4.9</td>
<td>25.1</td>
<td>13.2</td>
</tr>
<tr>
<td></td>
<td>Disposed</td>
<td>32.7</td>
<td>3.0</td>
<td>26.7</td>
<td>43.6</td>
<td>23.7</td>
<td>10.7</td>
<td>46.5</td>
<td>25.1</td>
</tr>
<tr>
<td></td>
<td>Leftover food Generated</td>
<td>61.2</td>
<td>33.8</td>
<td>40.3</td>
<td>37.0</td>
<td>61.3</td>
<td>48.1</td>
<td>50.0</td>
<td>45.7</td>
</tr>
<tr>
<td></td>
<td>Disposed</td>
<td>0.0</td>
<td>0.0</td>
<td>0.6</td>
<td>0.3</td>
<td>8.0</td>
<td>3.4</td>
<td>7.3</td>
<td>2.3</td>
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<tr>
<td></td>
<td>Vegetable waste Generated</td>
<td>2.4</td>
<td>6.6</td>
<td>18.7</td>
<td>14.1</td>
<td>12.4</td>
<td>22.2</td>
<td>10.3</td>
<td>12.0</td>
</tr>
<tr>
<td></td>
<td>Disposed</td>
<td>6.1</td>
<td>9.9</td>
<td>22.4</td>
<td>13.9</td>
<td>29.5</td>
<td>31.6</td>
<td>19.2</td>
<td>17.4</td>
</tr>
<tr>
<td></td>
<td>Yard waste (leaves and glass clippings) Generated</td>
<td>21.2</td>
<td>57.0</td>
<td>23.7</td>
<td>24.0</td>
<td>14.8</td>
<td>19.1</td>
<td>9.4</td>
<td>26.6</td>
</tr>
<tr>
<td></td>
<td>Disposed</td>
<td>54.5</td>
<td>86.1</td>
<td>44.5</td>
<td>42.2</td>
<td>35.3</td>
<td>41.7</td>
<td>17.4</td>
<td>50.5</td>
</tr>
<tr>
<td></td>
<td>Others (egg shells, seafood, flower) Generated</td>
<td>2.6</td>
<td>0.6</td>
<td>3.1</td>
<td>0.0</td>
<td>1.5</td>
<td>5.8</td>
<td>5.2</td>
<td>2.5</td>
</tr>
<tr>
<td></td>
<td>Disposed</td>
<td>6.7</td>
<td>0.9</td>
<td>5.8</td>
<td>0.0</td>
<td>3.5</td>
<td>12.6</td>
<td>9.6</td>
<td>4.7</td>
</tr>
</tbody>
</table>

Note: * the average percent composition of compostables is determined by Equation 2.6 (2)

In addition, as seen in Table 2.9, among compostables generated by the hotels, leftover food accounted for the largest percentage at around 40% to 45%, followed by fruit waste, vegetable waste, and yard waste. However, since most of leftover food was collected by pig raisers, the amount of leftover food present in disposed compostables is extremely low, only 2% to 7%. Therefore, the main categories of compostables in the disposed waste are fruit waste, vegetable waste, and yard waste. This conclusion may help hotel composters set up a desired feedstock recipe for composting processes.
2.7 Conclusions

The solid wastes from three hotels in BaiChay were collected, separated and weighed over the one-week period. The quantities and composition of both generated and disposed wastes were estimated. Key findings that relate to the composting of the organic component are:

- The average amount of waste generated in each hotel ranged from about 140 to 360 kg/day.

- After removal of some recyclables and leftover food, the average amount of waste disposed ranged from about 90 to 200 kg/day. Thus, approximately 35% to 45% of the waste was recycled or reused.

- The amount of waste generated per guest ranged from about 0.7 to 0.9 kg/guest/day. Also, if these amounts were based on the disposal rate, they dropped to around 0.4 to 0.5 kg/guest/day.

- Of the amount generated, approximately 75% was compostables and 5% to 10% were recyclables. However, after some recyclables and leftover food were collected for selling and feeding pigs, the percentage of compostables in the disposed waste reduced to about 60% to 70%. The main categories of the disposed compostables were fruit waste, vegetable waste, and yard waste.

- The three hotels disposed a total of approximately 250 kg of compostables per day, which could be available for the composting trial if separated from the noncompostables. The composting trial is described in the next chapter.
CHAPTER 3
COMPOSTING TRIAL

There is no existing composting facility in HaLong, Vietnam. The main approach to solid waste management is disposal into two landfills: DeoSen and HaKhau. However, through some discussions with the author, BaiChay Urban Environmental Company (Urenco) and other local institutions were considering establishing a small-scale compost facility at the HaKhau landfill with the expectation that few compostables would enter the landfill. Nevertheless, lack of knowledge on compost production and facilities prevent them from doing this. In addition, after the objectives of the study had been discussed with some hotel managers, it became clear that none of them were familiar with the composting process and its benefits, and they also recognized that some problems, such as odours, rodent attraction, and leachate, may affect their business if composting piles were established inside or near their hotels. Therefore, in order to test composting and show a composting facility to potential participants, a composting trial was conducted as part of this study. It would also serve as a training center for those who would develop and work in a permanent compost plant. The success of the composting trial could also help gain the awareness of the public and other hotels.

3.1 Description of Composting Trial

The composting trial was located within the administration area at HaKhau landfill, HaLong City. The overview of HaKhau landfill can be seen in Picture 3.1. The selected site was temporary and closed after the study was completed on August 29th, 2004. This location was chosen for the following reasons:

- The distance to the closest residential area is approximately 200m, therefore minimizing the effects of the compost facility to surrounding residents.
- Since waste from hotels is transported by Urenco’s trucks to the landfill, there would be no additional cost for transportation of source-separated compostables from the three selected hotels to the landfill.
- There would be no cost for the use of the site.
- Urenco’s staff at the landfill could participate in operating and monitoring the compost process on a daily basis.
- The existing roof could be used to protect the compost workers and compost facility from the excessive rain and sun during the hot and wet weather.
The facility was approximately 6 meters by 5 meters, which is the minimum space required for different steps of the process. The small building at the landfill (Picture 3.1a) was used to house necessary supplies, including rakes, shovels, watering can, typical amendments like rice hulls, wood chips, coconut shells, and potential finished compost products. The empty area (Picture 3.1b – left side) was used for blending, making, and maturing compost. The facility was built with available materials, including bamboo for making triangular aeration and plastic sheets for fencing. It was necessary to build a fence to keep animals, such as dogs and rats, out of the site.

3.2 Process Steps of the Composting System

The windrow composting system that was used includes the main steps shown in Figure 3.1 and described below. A diary of activities is shown in Table 3.1.

3.2.1 Source Separation and Transport of Compostables to the Site.

Compostables from kitchens and gardens in the three chosen hotels was separated at source by hotel staff. During the waste collection period, three or four separate waste baskets were provided and placed nearby waste sources at each hotel (see Picture 3.2). One contained yard waste, including leaves and tree trimmings, placed in the garden. Other baskets were nearby the food processing places in the kitchen. Fruit waste, such as coconut shells, watermelon and pineapple, and vegetable waste like pot-herbs, spinach, or tomatoes were gathered in different baskets, while non-compostable materials were either kept for selling or disposed at the landfill. At the end of the day, hotel staff brought the sorted waste to storage places where Urban Environmental Company’s trucks would pick up and transport it to the compost facility at the landfill, along with the remaining mixed waste to be disposed in the landfill.
3.2.2 Blending and Piling

The incoming material was gathered in the paved receiving area. Waste was weighed and recorded before it was cut and blended. For large materials, hand cutting was used to reduce their size to less than 5 cm in order to increase the air exposure area to speed up decomposition. Then, the materials were mixed well with shovels and rakes, and piled up after “resting” for a few hours at the receiving area (see Picture 3.3 - leftside) before adding to the composting pile. During the mixing, non-compostable materials such as plastic bags, gravels, and small pieces of metal were removed to purify the feedstock.
Figure 3.1 Flow Chart of the Composting Process
Seven days of compostables were added to the compost pile over a 12-day period. Table B.1 shows the detailed record of daily feedstock; there were 340.8 kg of fruit waste, 241.4 kg of vegetable waste, and 62.1 kg of yard waste. No waste was collected and added on several of these days due to the non-cooperation of either hotels or Urenco’s staff, poor accessibility of collection bins, and conflicting schedules among participating partners that will be discussed in Section 3.4.

There was concern about achieving appropriate C/N ratio, moisture content, and aeration:

**C:N ratio:** An efficient composting process needs a C:N ratio with the range of 20:1 to 40:1. According to Rynk et al (1992), the C:N ratio of vegetable ranges from 11:1 to 13:1, that of fruit wastes is 20:1 to 49:1, while yard waste has the ratio of 40:1 to 80:1. Based on calculations displayed in Appendix B.2, the C:N ratio of mixed waste (between wastes from kitchen and garden) collected from hotels ranged from about 21:1 to 38:1 which is within the optimum ratio for composting.

**Moisture content and aeration:** Waste from the hotels was too wet for composting since its initial moisture content is about 80%; therefore rice hulls were added. Coconut shells were also provided to increase the porosity of the pile. A total of 58 kg of these were added to the process, as shown in Table B.1. These additions are noted in Table 3.1 by the term “adding”.

The material was then piled around a bamboo aerator (see Picture 3.3 – right side) with the dimensions of 1.5m long and 0.5 m high which enabled a favourable aeration. At the end of the first 12-day period, the wastes were remixed carefully to avoid the formation of layers in the pile.

### 3.2.3 Turning and Monitoring

Since the composting process was aerobic, oxygen was required for the decomposition. If the supply of oxygen is limited, the composting process will slow down. In addition to adding porous materials such as rice hulls and coconut shells, the pile was turned to provide more air to the windrow and spread it evenly within the pile. Also, moisture and temperature can be adjusted by turning.

The turning was conducted manually with shovels and rakes. As shown in the Picture 3.4 (left-side), the materials from the exterior of the old piles must be moved to the interior of a new pile. The pile was also turned occasionally when the average temperature of the piles reach 55°C or when the moisture content was high. During the second week of decomposition, the composting pile was turned more often (about 3 turnings per week) since the moisture content reached higher than 70% (see Table B.4).
Table 3.1 Diary of Composting Trial

<table>
<thead>
<tr>
<th>Date</th>
<th>Duration (hour)</th>
<th>Task</th>
<th>Date</th>
<th>Duration (hour)</th>
<th>Task</th>
</tr>
</thead>
<tbody>
<tr>
<td>29-Jun</td>
<td>1:00</td>
<td>* Sorting * Blending * Piling</td>
<td>15-Jul</td>
<td>0:30</td>
<td>* Turning</td>
</tr>
<tr>
<td>30-Jun</td>
<td>1:00</td>
<td>* Sorting * Blending * Adding</td>
<td>19-Jul</td>
<td>1:00</td>
<td>* Turning</td>
</tr>
<tr>
<td>1-Jul</td>
<td>1:00</td>
<td>* Sorting * Blending * Adding</td>
<td>24-Jul</td>
<td>0:30</td>
<td>* Turning</td>
</tr>
<tr>
<td>4-Jul</td>
<td>1:00</td>
<td>* Sorting * Blending * Adding</td>
<td>27-Jul</td>
<td>0:30</td>
<td>* Turning</td>
</tr>
<tr>
<td>5-Jul</td>
<td>1:30</td>
<td>* Sorting * Blending * Adding * Turning</td>
<td>1-Aug</td>
<td>0:30</td>
<td>* Turning</td>
</tr>
<tr>
<td>7-Jul</td>
<td>1:30</td>
<td>* Sorting * Blending * Adding * Turning</td>
<td>21-Aug</td>
<td>1:30</td>
<td>* Screening * Piling</td>
</tr>
<tr>
<td>10-Jul</td>
<td>2:00</td>
<td>* Sorting * Remixing * Piling * Turning</td>
<td>29-Aug</td>
<td>1</td>
<td>*Screening</td>
</tr>
</tbody>
</table>
The temperature of the pile was recorded daily by a thermometer during the decomposition period while moisture content was tested by hand-squeezing. Composting materials should be about as moist as a wrung-out sponge. If water trickles out without squeezing, the material too wet; if no water can be squeezed out of the handful; it is too dry. However, simply squeezing material is subjective and inaccurate, and it does not provide a quantitative measure of the moisture content. Therefore, some samples were also taken for moisture content determination by the standard method of drying and weighing. The trends of both temperature and moisture content are discussed in Section 3.3, while the detailed records on temperature and moisture content are presented in Table B.3 and Table B.4.

3.2.4 Maturing and Screening

After 37 days of decomposition, the organics changed to a dark colour and had an earthy odour. Then, the pile was left without adding additives or turning for 23 more days of maturing to make sure that the compost was mature and safe for use.

![Screening the Finished Compost](image)

**Picture 3.5 Screening the Finished Compost**

After 15 days of maturing, the compost was first screened by a wire mesh screen (opening size of 1 cm with the wooden framework 0.8 m x 1.2 m). The less than 1 cm pieces passed through the screen while the larger pieces (or rejects) were retained. The first screened compost continued to be matured for one more week, at which time it was screened by a 4 mm screen. The fine compost was collected, ground, and stored for quality testing while residuals (the larger pieces of organic material) were kept for other purposes, such as for feedstock of a new composting pile if conducted in the future.
3.3 Evaluation of the Composting Process

This section discusses the mass flow, the trends of temperature and moisture content during the decomposition process. Some chemical parameters, including nutrients (N, P, K), pH, and metal, could not determined during the composting process due to the insufficiency of local laboratory facilities. Although only one pile was used, it was carefully implemented and monitored. Also, because of time limitation, financial aspects were not analyzed in this study.

3.3.1 Mass Flow

Weight reduction during the composting process was precisely calculated. Before materials were mixed, matured, and screened, they were weighed to determine the actual loss of the dry matter and the conversion rate of raw material into compost. That means the output is the fine compost (particle size is less than 4 mm) while larger pieces, called organic residuals, were kept in the store house for further use; for example, it can be used as good feedstock for a new composting pile.

Mass flow of the pilot composting pile is displayed in Figure 3.2.

![Mass Flow of the Composting Pile](image)

After two months of the decomposition and maturing period, the material quantity was about 21%\(^2\) of its initial weight. The loss of material weight is through two following process:

* the formation of carbon dioxide; and
* the volatilization of water. The water content decreased from 83.6% (input) to 46.3% (output)

To evaluate the composting process, the conversion rate is of particular concern. In other words, how much fine compost, which is ready for use, can be produced from one ton of compostables.

\[\text{Conversion rate} = \frac{57.4 + 27.3 + 62.5}{702} \times 100\% = 100\% \quad \text{if including organic residuals}\]
In theory, organic waste, sooner or later, will be completely composted to fine product; nevertheless, it will take a longer time for large and rigid pieces. However, in the scope of the composting trial, only fine compost produced during the two month trial was considered product. The conversion rate of the composting trial was 8.9%\(^3\); based on this, 89 kg of compost would be produced from one ton of raw compostable waste.

### 3.3.2 Trends of Temperature

Temperature measurement was taken in the morning to examine the composting process; thus, problems with the temperature being too low or the pile overheating were solved quickly, as required. Also, measurements were taken at two different locations of the pile since temperature can vary within the pile. The detailed temperature readings are shown in Table B.3.

![Figure 3.3 Temperature Curve of the Composting Pile](image)

The average pile temperatures and the ambient air temperatures are shown in Figure 3.3. The drops in temperature are caused by either turnings or the reduction of ambient air temperature. The decomposition process can be divided into two main phases that are based on the temperature of the composting pile. During the preliminary and intensive decomposition process, high temperature was achieved within a relatively short period of time and easily decomposed compostable materials were converted; this period is named the thermophilic phase (>40\( ^\circ \)C). The whole phase lasted only 26 days, during which temperatures of more than 50\( ^\circ \)C were maintained over seven days. The second phase, the mesophilic phase (20-40\( ^\circ \)C), lasted for another 33 days. During this phase, the less easily decomposed materials are broken down and clay-humus complexes are formed; the result is matured compost (Dulac, 2001; Haug, 1993; Satriana, 1974).

\[^3\text{amount of fine compost} \div \text{amount of compostables (excluded additives)} = 57.4 \div 648.3 \times 100\%\]
One important thing to note is that the above temperature conditions were not ideal, since the temperature of the pile was not high enough (for example, a minimum temperature of 55°C over an unbroken period of two weeks, or 65°C over 1 week) needed to kill pathogens (CCME, 2000; Epstein, 1997; Tchobanoglous and Vigil, 1993). Unlike other facilities with addition of animal dung or septic sewage, the pilot composting pile consisted of only compostables from “clean sources” at hotels, such as the kitchen and garden. Also, the collected waste was sorted at source and transported separately to the operation site. Nevertheless, the composting pile may have been infected by pathogenic organisms since the operation site was located next to the landfill which receives mixed solid waste everyday. Hence, pathogenic indicators of finished compost, such as E-coli, were tested, as explained in Chapter 4.

3.3.3 Trends of Moisture Content

The change in moisture content of the material is very dependent on the volatilization of water and the formation of leachate during the composting process. The simple “hand squeezing” test was carried out frequently to ensure the optimum environment for micro-organisms. Nevertheless, some samples for moisture content determination in a laboratory were taken, usually after turning.

![Figure 3.4 Trends of Moisture Content](image)

As seen in Figure 3.4, the initial moisture content of the raw material (source-separated from hotels) was about 80% which is considered too wet for composting; thus more rice hulls or dried sugarcane refuse and frequent turning were provided until the moisture reached the optimum range of 40-65%. In addition, a steel roof protected the pile from the excessive rain since the trial
was carried out during the wet season, and the air moisture was always higher than 80%. For these reasons, no water was added during the process. After the fifth turning, the moisture content reduced to about 67% and then to about 52% before the compost pile was cured.

3.4 Problems and Troubleshooting

This section discusses some concerns and problems that arose when planning and during the composting trial, and solutions that were applied. Problems expressed by involved partners were:

*Problems at hotels*
- No fixed time collection; since Urenco’s trucks sometimes came in the very early morning (4:00 am), but sometimes in the afternoon (4:30 pm);
- Difficulties in separating waste at sources and poor accessibility of collection bins; and
- Waste falls down from the bins when moved to the trucks.

*Problems at the compost facility*
- Odour is emitted from the composting site;
- Leachate runs from the pile; and
- The high level of flies.

To minimize these problems, various solutions were provided and some gained encouraging results. For the unsatisfactory collection system, the pilot project worked with the leaders of BaiChay Urban Environmental Company to improve the collection schedule. The company agreed to go to hotels at a fixed time in the afternoon (from 4:00 pm to 5:00 pm). Staff at hotels could move their sorted waste to the receiving place before that time. Also, some eighty-liter bins covered with plastic bag were provided and placed in the kitchen at the staff’s convenience. Therefore each day, bags of waste, rather than the bins, were moved from the kitchen to the truck collection place.

For the problems caused by the composting process, the pilot project and staff at the landfill deliberated about whether the odour was coming from the composting pile or the landfill. While the answer was not clear, some steps were taken to mitigate odours from composting. Initially, materials were blended with additives, such as rice hulls and sugarcane waste to avoid anaerobic conditions within the compost pile for long periods of time. Also, the use of the bamboo triangular aerator and pile turning allowed the compost pile to receive air to maintain the aerobic process. In addition, to allow leachate to run off and be collected, a layer of sand covered with a plastic sheet with a minimum 2% slope was constructed under the pile. The existing roof
prevented rainfall from getting in the pile. The frequency and timing of turning was also adjusted to help:

- Replenish oxygen in the interstitial air spaces;
- Remove excess water vapour, odours and other gasses; and
- Disrupt the fly breeding cycle by transferring ova and larvae from cooler surface layers to the hot core zone where they are thermally destroyed.

3.5 Conclusions

The composting trial was widely accepted and appreciated by many local institutions and local residents from its beginning to the end. Generally, local people, including hotel and urban environmental company staff, actively participated in establishing, operating and controlling the compost facility. Administrative organizations in QuangNinh, such as the Department of Resources and Environment kept a positive attitude to the pilot project due to some positive results that can be seen from the pilot, including:

- The simple technology of compost production (windrow composting system) was readily applied using materials, including compostables and additives, which were available in the local area.
- The length of a full composting process is about two months.
- The large volume of waste reduced after decomposition with the conversion rate of 8.9%. Therefore, composting is an environmentally friendly approach to reduce waste; not only because there is a nearly 79 %

\( 702 - (57.4 + 27.3 + 62.5) \times 100\% \) if including organic residuals

Since the quality of compost is of concern among involved people, the pilot project tested the quality of the compost as explained in the next chapter.
CHAPTER 4
STANDARDS AND TESTING OF COMPOST QUALITY

This chapter, first, presents information on compost quality standards in some countries around the world, including Canada, the United States, Australia, and some European countries, and the approach to compost quality control in Vietnam. Then, the analysis and results of the quality of the compost produced by the trial are presented in relation to recognized compost standards.

4.1 Review of Compost Quality Standards in Europe, North America, and Australia

There are many success stories on composting in Europe or North America (Haug, 1993; IIA, 2000); however, consumption capacity of compost in many countries has been very low. Many studies (Hansen, 1996; Hoornweg et al., 1999; and Gray-Donald, 2002) have concluded that the poor quality of finished compost that does not meet the market’s requirement is one of the common reasons for this. Therefore, to protect both the environment and consumers, as well as to promote the composting industry through the production of high-quality compost, some countries have established requirements (regulations, guidelines and standards) for both the composting process and the compost quality. In the Australian Standards for Composts, Soil Conditioners and Mulches published in 1999, the stated objective of the standard is

‘to provide manufacturers, local government bodies, consumers and growers with the minimum requirements for the physical, chemical and biological properties of composts, soil conditioners and mulches as well as labelling and marking requirements, in order to facilitate the beneficial recycling and use of organic materials with minimal adverse impact on the environment and public health.’ (Hogg, Barth et al., 2002b).

Concepts of compost quality and compost testing standardization were essentially unknown worldwide as recently as 1985. In particular, the increasing public awareness and the active involvement of health regulators and other stakeholders have promoted the introduction of compost quality standards and regulations (Brinton, 2000). There are three basic approaches to develop regulations that relate to product use: no-net degradation approach, risk-based approach, and best-achievable approach (Epstein, 1997). The no-net degradation concept is based on the premise that application of compost should not increase the level of a heavy metal or other contaminants in the soil (Epstein, 1997). However this approach raises some controversial questions, such as what base levels should be used since soil quality varies greatly within a small
area. For example, soil within industrial areas may contain much higher levels of heavy metals than agricultural areas. As a result, regional standards have to be based on differences in soil quality. The risk-based approach takes the potential risk to individuals and the environment into account, while the best-achievable approach considers technology and economic aspects, rather than health and environment. In practice, the first two approaches, no-net degradation and risk-based, are the two principal methods used to set regulations.

There are no universal criteria for compost quality around the world. However, compost quality assessments that have evolved in different places address the following five main categories which are discussed below:

- Maturity;
- Foreign matter;
- Heavy metals;
- Pathogenic organisms; and
- Other characteristics.

### 4.1.1 Maturity

Maturity is one of the most important indicators used to evaluate the stability and quality of compost since immature product will adversely affect soil and plants. A number of criteria can be used to judge whether or not compost is mature. For example, the Canadian Council Environment Ministry (CCEM, 2000) suggests that the compost is mature if it meets two of the following four sets of criteria (Hogg, Barth et al., 2002c):

- a C/N ratio < 25;
- an oxygen uptake < 150 mg O2/kg volatile solids per hour; and
- a germination and growth test, using cress (*Lepidium sativum*) seeds and radish (*Raphanus sativus*) seeds, demonstrates an absence of phytotoxic effects.

or

- Compost will not reheat upon standing to greater than 20°C above ambient temperature; and
- Compost must be allowed to mature for at least 21 days after the thermophilic phase is completed.

or

- Reduction of organic matter must be roughly 60 percent by weight; and
- Compost must be allowed to mature for at least 21 days after the thermophilic phase is completed.
- If no other determination of maturity is made, the compost must be cured for a six month period. The state of the curing pile must be conducive to aerobic biological activity. The curing stage begins when the pathogen reduction process is complete and the compost no longer reheats to thermophilic temperatures.

4.1.2 Foreign Matter

Foreign matter is any matter with a dimension exceeding 3 mm that may cause damage or injury to humans and animals during or resulting from its intended use. They can be organic or inorganic constituents such as metal, glass and synthetic polymers (e.g., plastic and rubber). As shown in Table 4.1, each country has different criteria for foreign matter. For the CCEM, the compost must not contain any sharp foreign matter measuring over 3 mm in any dimension and any foreign matter greater than 25 mm, while compost in Sweden must contain less than 0.5% of visible impurities, such as plastics, glass, and metal.

### Table 4.1 Standards on Foreign Matter in Some Countries

<table>
<thead>
<tr>
<th>Countries</th>
<th>Description</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Australia</strong></td>
<td>Glass, metal, rigid plastics &gt;2mm</td>
<td>≤ 0.5</td>
</tr>
<tr>
<td></td>
<td>Plastics – light, flexible or film &gt;5 mm</td>
<td>≤ 0.5</td>
</tr>
<tr>
<td></td>
<td>Stones and lumps of clay</td>
<td>≤ 0.5</td>
</tr>
<tr>
<td><strong>Italy</strong></td>
<td>Inert material</td>
<td>≤ 3</td>
</tr>
<tr>
<td></td>
<td>Glass (≥3mm)</td>
<td>≤ 0.3</td>
</tr>
<tr>
<td></td>
<td>Plastics</td>
<td>≤ 1</td>
</tr>
<tr>
<td></td>
<td>Metals</td>
<td>≤ 0.5</td>
</tr>
<tr>
<td><strong>Sweden</strong></td>
<td>Visible impurities (plastics, glass, metal etc.)</td>
<td>≤ 0.5</td>
</tr>
<tr>
<td><strong>Canada</strong></td>
<td>Sharp foreign matter measuring over 3mm</td>
<td>0</td>
</tr>
<tr>
<td>(CCEM)</td>
<td>Any foreign matter greater than 25 mm</td>
<td>0</td>
</tr>
</tbody>
</table>

*Sources: (Hogg, Barth et al., 2002a, 2002b, 2002c, 2002d, 2002e)*

4.1.3 Heavy Metals

Compost can contain high concentrations of heavy metals, depending on the sources of the raw materials. If sludge from a mixed industrial-domestic source is used in the compost, concentrations of lead, zinc, and nickel may be very high (Obeng, Wright, 1987). Figure 4.1 shows that there are great differences across countries in the maximum permissible concentration
of six heavy metals of concern: lead (Pb), copper (Cu), cadmium (Cd), zinc (Zn), Mercury (Hg), and Arsenic (As). For example, the maximum permissible concentration of Zinc in Italy is ten times higher than that in Australia.

![Graph showing heavy metal concentration in different countries](image)


*: Order 28/v/1998 on fertilizer B.O.E.n’m.131.2 June 1998; **: Composting Association Quantily; ***: BNQ Types AA, CCME Category A; ****: Rodale Organic Seal of Compost Quality

**Figure 4.1 Standards on Heavy Metals in Some Countries**

### 4.1.4 Pathogenic Organisms

Pathogenic organisms are any viruses, bacteria, and other substances capable of causing disease (Epstein, 1997). Since faecal coliforms and Salmonella are of the most difficultly controlled bacteria, they are addressed in the majority of standards. To adequately reduce health risks, most countries that have standards require that the faecal coliform be less than 1000 MPN/g and that Salmonellae be less than 3 MPN/4g or absent in 25 g of compost, as shown in Table 4.2.

**Table 4.2 Maximum Level of Pathogens in Composts Offered by Some Countries**

<table>
<thead>
<tr>
<th>Countries</th>
<th>Maximum level of pathogen</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Salmonellae</td>
</tr>
<tr>
<td>Spain</td>
<td>Absence in 25 g</td>
</tr>
<tr>
<td>Italy</td>
<td>Absence in 25 g</td>
</tr>
<tr>
<td>CCEM</td>
<td>Absence in 25 g</td>
</tr>
<tr>
<td>USA</td>
<td>&lt;3MPN/4g</td>
</tr>
</tbody>
</table>

Source: (Hogg, Barth et al., 2002a, 2002b, 2002c, 2002d, 2002e & Brinton, 2000)
4.1.5 Other Characteristics

In addition to foreign matter, maturity, pathogenic organisms and heavy metals, other characteristics, such as organic matter, moisture content, nutrients and pH affect compost quality. Some countries require specific characteristics, as shown in Table 4.3. Compost in Australia, for instance, must have a pH of 5-7.5, and a maximum Ammonium concentration of 300 mg/l. However, some countries, such as Spain, Canada, and Sweden, do not set specific limits for these and certain other characteristics, but instead require that the levels simply be declared before the compost is marketed. The measured values recorded in the declaration must be updated during a certain time period and must be in agreement with the average values of the analyses over that time.

<table>
<thead>
<tr>
<th>ELEMENT</th>
<th>Unit</th>
<th>Massachusetts USA</th>
<th>Canada (CCEM)</th>
<th>Australia</th>
<th>Spain</th>
<th>Italy</th>
<th>Sweden</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td></td>
<td>5.5-7.5</td>
<td>declared</td>
<td>5-7.5</td>
<td>declared</td>
<td>6-8.5</td>
<td>-</td>
</tr>
<tr>
<td>Phosphorous soluble</td>
<td>mg/l</td>
<td>-</td>
<td>declared</td>
<td>≤5 for products which claim to be for phosphorus-sensitive plants. No requirement otherwise.</td>
<td>declared</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Phosphorus total</td>
<td>%</td>
<td>-</td>
<td>declared</td>
<td>≤0.10 for products which claim to be for phosphorus sensitive plants. No requirement otherwise</td>
<td>declared</td>
<td>&gt;0.5</td>
<td>declared</td>
</tr>
<tr>
<td>Ammonium</td>
<td>mg/l</td>
<td>-</td>
<td>declared</td>
<td>&lt;300</td>
<td>declared</td>
<td>-</td>
<td>declared</td>
</tr>
<tr>
<td>Nitrogen, total</td>
<td>%</td>
<td>-</td>
<td>declared</td>
<td>≥0.8 if a contribution to plant nutrition is claimed</td>
<td>declared</td>
<td>&lt;1</td>
<td>declared</td>
</tr>
<tr>
<td>Potassium</td>
<td>%</td>
<td>-</td>
<td>declared</td>
<td>≥25</td>
<td>≥25</td>
<td>≥20</td>
<td>20</td>
</tr>
<tr>
<td>Organic matter</td>
<td>%</td>
<td>-</td>
<td>&gt;30</td>
<td>≥25</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum particle size</td>
<td>mm</td>
<td>&lt;25</td>
<td>-</td>
<td>&lt;15</td>
<td>declared</td>
<td>0.5-25</td>
<td>declared</td>
</tr>
<tr>
<td>Moisture Content</td>
<td>%</td>
<td>35-55</td>
<td>&lt;60</td>
<td>&gt; 25</td>
<td>&gt; 40</td>
<td>&gt; 40</td>
<td>&lt;50</td>
</tr>
</tbody>
</table>

Source: (Hogg, Barth et al., 2002a, 2002b, 2002c, 2002d, 2002e & Brinton, 2000)
4.2 Standards for Compost Quality in Vietnam

Under the government Decree, No 113/2003/NĐ promulgated in 2003, Ministry of Agriculture and Rural Development (MARD) has the following responsibilities:

- Preside over and combine with other ministries and industries involved in developing plans and policies of fertilizer use and organic fertilizer production;
- Edit and promulgate legal documents, procedures, norms, standards and policies on fertilizer use and organic fertilizer production; and
- Arrange for testing and acknowledge new types of fertilizers each year.

Annually, MARD promulgates the catalogue of fertilizers that are allowed to be produced and distributed within Vietnam’s market. This catalogue includes some new types of fertilizers and also excludes some old types that adversely affect production and the environment. As mentioned earlier, Vietnam considers compost as organic fertilizer; however, there are no uniform criteria for it. If a compost producer wants to market its product, it must get approval from MARD by having a sample tested by an authorized institution such as Institute for Soil and Fertilizer or Agriculture Agency. The sample must be tested for certain nutrients (Ammonium, P₂O₅, K₂O), toxicity, including heavy metals (Pb, Hg, Cd, As), and disease causing microorganisms (E. Coli, Salmonella), especially if the fertilizers are produced from municipal waste. After evaluating the test results, MARD will acknowledge the compost as a new type of organic fertilizer. Also, there are no certain standards for compost quality; thus, compost producers have responsibilities for declaring their product quality by providing information on nutrient concentrations (nitrogen (N), phosphate (P₂O₅), potassium (K₂O), organic matter, and water content. These characteristics of the compost that will be marketed must be maintained the same as the declared quality. Local authorized institutions randomly visit the composting plants and analyze the compost quality to make sure that the quality is maintained.

There are several compost plants registered for their product quality, including the Cau Dien plant in Hanoi. This plant adds nitrogen, phosphorous and potassium (NPK) fertilizers into compost before marketing it in order to increase the concentration of nutrients and control the quality of compost near the registered quality. Table 4.4 summarizes some of criteria that the Cau Dien plant registered before marketing their compost. The table also shows the results of a project conducted by Hanoi Agriculture University to produce compost from on-source separation and composting of domestic waste and agricultural by-products. This was allowed to
be sold in Hanoi’s market with the price 700 VND/kg. As can be seen from the table, the criteria used to measure the quality of two compost products mostly emphasize the nutrient concentrations and organic content, not the toxicity which are important concerns among European and North American countries.

Table 4.4 Compost Quality of Some Plants and Projects in Vietnam

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>CauDien Plant (1)</th>
<th>Project conducted by Agriculture University (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organic matter</td>
<td>%</td>
<td>13.27</td>
<td>12.0</td>
</tr>
<tr>
<td>Nitrogen, total</td>
<td>%</td>
<td>0.57</td>
<td>1</td>
</tr>
<tr>
<td>Phosphorous, total</td>
<td>%</td>
<td>0.44</td>
<td>1.8</td>
</tr>
<tr>
<td>Phosphorous, soluble</td>
<td>-</td>
<td>0.37 %</td>
<td>42 (mg/100g)</td>
</tr>
<tr>
<td>Potassium, total</td>
<td>%</td>
<td>1.03</td>
<td>0.92</td>
</tr>
<tr>
<td>Potassium, soluble</td>
<td>-</td>
<td>0.38 %</td>
<td>120 (mg/100g)</td>
</tr>
<tr>
<td>Moisture Content</td>
<td>%</td>
<td>24.95</td>
<td>35</td>
</tr>
<tr>
<td>pH</td>
<td></td>
<td>8</td>
<td>6.8</td>
</tr>
</tbody>
</table>

Source: (1): (Tien, 2003); (2): Provided by Professor Dao Chau Thu, Project Leader

4.3 Trial Compost Testing: Methodology

A methodology was established to test the quality of the compost produced in the single pile at the trial compost facility. First, it was necessary to get a representative sample from the 57.4 kg of fine compost that had been produced. To do this, the compost was mixed well and handfuls of compost were taken from different places of the pile. The compost was mixed thoroughly again and put in small zipped plastic bags to maintain the moisture content of the samples. Eight zipped plastic bags containing about 1.5 kg of well-mixed compost were then transported to the Lab of the Environment Department, Hanoi University for testing certain chemical and physical parameters.

As mentioned in Section 4.2, there are no certain standards for compost quality in Vietnam. Thus, in order to decide which parameters need to be tested, an overview of other countries’ standards and criteria for compost quality assessment is necessary. The choice of parameters also depends on the capacity of local laboratories. Table 4.5 summarizes the chosen chemical and physical parameters and their measurement methods. A test of maturity was done with a temperature test or a visual test that is mentioned in Section 4.1.1. Concentrations of main heavy metals, such as...
Cu, Zn, Cd, and Pb, were determined by an atomic absorption spectrometer, while nutrient levels were measured by an atomic absorption method. Other characteristics, such as pH, organic matter, moisture content, particle size, and foreign matter, were also tested using the methods shown in Table 4.5. In terms of pathogen organisms, E-coli index was measured by either the multiple tube fermentation method or membrane filtration.

Table 4.5 The Methods for Analyzing Chemical and Physical Parameters

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maturity</td>
<td>Comparison with criteria mentioned in Section 4.1.1</td>
</tr>
<tr>
<td>pH</td>
<td>Glass electrode method</td>
</tr>
<tr>
<td>Organic Matter</td>
<td>Dry combustion method</td>
</tr>
<tr>
<td>Ammonium</td>
<td>Kjeldal</td>
</tr>
<tr>
<td>Nitrogen, total</td>
<td>Micro kjeldal method</td>
</tr>
<tr>
<td>Phosphorous soluble</td>
<td>Using a spectrometer by using ammonium molybdate in ascorbic acid</td>
</tr>
<tr>
<td>Phosphorous total</td>
<td>Using a spectrometer by using ammonium molybdate in ascorbic acid</td>
</tr>
<tr>
<td>Potassium total</td>
<td>Using atomic absorption spectrometer</td>
</tr>
<tr>
<td>Potassium soluble</td>
<td>Using atomic absorption spectrometer</td>
</tr>
<tr>
<td>Zn, Cd, Pb, Hg, As, Cu,</td>
<td>Using atomic absorption spectrometer</td>
</tr>
<tr>
<td>E coli</td>
<td>MTF: Multiple Tube Fermentation or MF: Membrane Filtration</td>
</tr>
<tr>
<td>Moisture Content</td>
<td>Gravimetric method</td>
</tr>
<tr>
<td>Foreign matter</td>
<td>Screening, Sorting, and Weighing</td>
</tr>
<tr>
<td>Particle size</td>
<td>Sieve screening</td>
</tr>
</tbody>
</table>

4.4 Trial Compost Quality: Test Results

The results of the testing of the compost are presented below along, with a discussion of how they compare with the quality criteria discussed in section 4.1.

4.4.1 Maturity

Visually, compost from the trial appeared to be mature with a dark brown colour and earthy odour. It also meets some of the criteria required by CCME; for example, the compost pile did not reheat for 23 days after the thermophilic phase was completed and organic matter was reduced around 80 percent by weight.
4.4.2 Foreign Matter

The compost did not contain plastics, sharp pieces of metal or glass; however, Table 4.6 shows that 33.1% of product is sand, grave, and rice hulls. This percentage is much higher than criteria for foreign matter found in other countries (Table 4.1). Since rice hulls are very rigid, it takes a long time for them to decompose completely, and after two months of composting, only a small proportion of rice hulls were decomposed. With regards to sand and grave, one possible reason for the relatively high amounts is that the HaKhau landfill was at the end of its construction phase and transportation of construction materials past the composting site inadvertently caused the addition of construction materials into the pile.

Table 4.6 Percentage of Foreign Matter in the Compost from the Trial

<table>
<thead>
<tr>
<th>Elements</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand</td>
<td>8.3</td>
</tr>
<tr>
<td>Gravel</td>
<td>6.8</td>
</tr>
<tr>
<td>Rice hulls</td>
<td>18</td>
</tr>
</tbody>
</table>

4.4.3 Heavy Metals

Major heavy metals, including Zn, Cd, Pb, Hg, As, and Cu, were tested, and their concentrations are shown in Table 4.7. The concentration of Zinc was the highest with 91.2 ppm, followed by copper at about 26 ppm. Concentrations of Lead and Cadmium are less than 5 ppm and 0.1 ppm respectively. Also, concentrations of other important heavy metals, such as As and Hg, in the compost are negligible as organic waste was separated at source. Compared with maximum allowable concentrations of heavy metals required by many countries that are listed in Figure 4.1, those of the trial compost are much lower.

Table 4.7 Concentration of Some Heavy Metals in the Compost from the Trial

<table>
<thead>
<tr>
<th>Metal</th>
<th>Percentage (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper</td>
<td>26.3</td>
</tr>
<tr>
<td>Lead</td>
<td>&lt;5</td>
</tr>
<tr>
<td>Zinc</td>
<td>91.2</td>
</tr>
<tr>
<td>Cadmium</td>
<td>&lt;0.1</td>
</tr>
<tr>
<td>Arsenic</td>
<td>negligible</td>
</tr>
<tr>
<td>Mercury</td>
<td>negligible</td>
</tr>
</tbody>
</table>
4.4.4 Pathogenic Organisms

The testing showed that there were $10^5$ CFU\(^5\) of E. coli in compost. This is one hundred times higher than the acceptable criteria for pathogens in other countries (Table 4.2). It is not clear why the pathogenic level was so high; however, source-separated organic waste may be contaminated by municipal solid waste since they were both transported to the landfill in the same trucks, and it may be due to the temperatures in the composting pile. As discussed earlier, a high temperature of around 50 °C was maintained for only one week, which is not long enough to kill most of the bacteria in question, such as faecal coliforms (E coli) and Salmonella.

4.4.5 Other Characteristics

Although some characteristics listed in Table 4.3 are not considered in many countries’ standards, compost users are concerned about whether the compost product they choose is suitable for their plants or soil. Thus, organic matter, moisture content, nutrients and pH of the compost from the trial were tested and their results are displayed in Table 4.8.

<table>
<thead>
<tr>
<th>Elements</th>
<th>Unit</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>-</td>
<td>8</td>
</tr>
<tr>
<td>Phosphorous soluble</td>
<td>mg/100g</td>
<td>270</td>
</tr>
<tr>
<td>Phosphorus total</td>
<td>%</td>
<td>0.816</td>
</tr>
<tr>
<td>Ammonium</td>
<td>mg/100g</td>
<td>9.1</td>
</tr>
<tr>
<td>Nitrogen, total</td>
<td>%</td>
<td>0.994</td>
</tr>
<tr>
<td>Potassium total</td>
<td>%</td>
<td>1.868</td>
</tr>
<tr>
<td>Potassium soluble</td>
<td>mg/100g</td>
<td>1688</td>
</tr>
<tr>
<td>Organic matter</td>
<td>%</td>
<td>40.9</td>
</tr>
<tr>
<td>Maximum particle size (mm)</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>&lt;0.25</td>
<td></td>
<td>5.85</td>
</tr>
<tr>
<td>0.25 – 1</td>
<td></td>
<td>51.8</td>
</tr>
<tr>
<td>1-2</td>
<td></td>
<td>21.75</td>
</tr>
<tr>
<td>2-3</td>
<td></td>
<td>4.6</td>
</tr>
<tr>
<td>&gt;3</td>
<td></td>
<td>16</td>
</tr>
<tr>
<td>Moisture content</td>
<td>%</td>
<td>45.2</td>
</tr>
</tbody>
</table>

\(^5\) CFU means “Colony Forming Unit” and MPN is “Most Probable Number”. The traditional membrane filtration tests for bacterial water quality actually count ‘colonies’ of bacteria and thus is reported as CFU. However, the newer defined substrate tests such as Colisure or Coliert report data as MPN which is a statistical representation of what level of E. Coli is likely present in a sample. For the purposes of reporting these terms have been used interchangeably.
With pH = 8, the compost was alkaline, which is more suitable for acidic soil. The compost is high in organic matter (41%) and moisture content (45%), if compared to some compost produced in Vietnam (see Table 4.4). These levels of organic matter and moisture content meet requirements of all countries listed in Table 4.3. Nevertheless, nutrient levels in the trial compost are lower than those of the compost produced by Hanoi Agriculture University, except for the soluble potassium concentration which is fourteen times higher. As described in Section 3.2.4, compost was sieved by a wire mesh screen (with an opening size of 4 mm); therefore, only compost with the size of less than 4mm could pass through while the larger pieces (or rejects) were retained. As a result, the final compost products should be smaller than 4mm. Also, the testing results revealed that around 80% of the trial compost has a size of less than 2 mm which conforms to the standards of Italy, the U.S., and Canada.

4.5 Conclusions

The quality of compost is one of the most important concerns among producers as well as users. In general, users place great value on the appearance of compost, including grain size, colour, smell, foreign matter, and moisture. The compost produced from the trial had acceptable concentrations of nutrients and heavy metals, but contained high levels of foreign matter and pathogenic microorganisms.
CHAPTER 5
CONCLUSIONS AND RECOMMENDATIONS

This chapter summarizes the average generation and disposal rates, and composition of solid wastes produced by the three hotels in HaLong City that were audited during one week in the summer of 2004. It also summarizes results from the trial composting process and the testing of the compost quality with respect to the feasibility of a windrow composting system for hotel waste. Lastly, some recommendations on at-source waste separation, seasonal effects, and composting of compostables for other hotels in HaLong are also discussed.

5.1 Summary of Results from Hotel Waste Audit and Composting Trial

5.1.1 Hotel Waste Audit

A one-week waste audit was carried out at three hotels (SaiGon-HaLong, CongDoan, and TienLong) in HaLong City in June, 2004. Waste from guest rooms, gardens, and kitchen/restaurant was separated into compostables, recyclables, and miscellaneous. Key results related to the feasibility of composting organic wastes from hotels are:

1. The three hotels generated, on average, 359, 182 and 137 kg/day of waste, for a total of 678 kg/day. However, after most leftover food and recyclables were collected by hotel staff for either selling or animal feeding, the average amount of waste disposed (i.e. sent to the landfill) by these hotels was 203, 114 and 89 kg/day, for a total of 405 kg/day, or about 60% of the amount generated.

2. The average amount of waste generated per overnight guest ranged from 0.7 to 0.9 kg/guest/day. While the waste quantities included wastes generated by the restaurants serving patrons, e.g. meeting attendees, who were not overnight guests, the number of such patrons was not included since this data was not available. The quantities of waste disposed by the hotel on a per guest basis ranged from 0.4 to 0.5 kg/guest/day.

3. Compostable made up the largest portion of wastes at all three hotels. Approximately 75% of the wastes generated, and about 60% to 73% of the waste disposed at each of the three hotels were compostables. As shown in Figure 5.1, the amount disposed for landfilling consisted of only about half of the compostables that were generated.

4. The quantities of compostable wastes disposed; on average, by the three hotels were 149, 68 and 52 kg/day. As shown in Figure 5.1, these consist primarily of fruit waste, vegetable waste, and yard waste.
5.1.2 Composting Trial

With support from some local institutions, a composting pilot project, using a “windrow” system, was conducted in the HaKhau landfill over almost two months. Some important points about the project are as follows:

1. The compost production process included seven main steps of source separation, transportation, blending, piling, composting, maturing and screening, as illustrated in Figure 3.1.

2. During the first week of July, 2004, about 644 kilograms of compostables which were separated at source in all three hotels were collected and transported to the compost facility at the landfill. After being well mixed with about 58 kilograms of additives, blended waste was piled around a bamboo aerator.

3. To control the composting process, occasional turning and daily monitoring of temperature and moisture content were carried out, and dry material, such as sugarcane waste and rice hulls, was added to balance the moisture content in compost pile.

4. After sixty days of composting and maturing, 57.4 kg of fine compost was produced from the 644 kg of compostables from the hotels, resulting in a conversion rate of 8.9%. In addition, 90 kg of other organic residuals (mostly coconut shells) were
stored for future uses, such as for adding to a new compost pile to provide more time for them to be fully composted.

5.1.3 Compost Quality

The fine compost was tested for chemical and physical properties listed in Table 4.5, and the results were compared to compost quality standards in Australia, the United States, Canada, and European countries. There are no compost quality standards in Vietnam. Some important findings are:

1. The compost product contains a high percentage of foreign matters that are mostly sand, grave, and rice hulls; 18% was rice hulls, and gravel accounted for nearly 7%.
2. There were $10^5$ CFU of E. Coli in the compost product, which is one hundred times greater than the acceptable level for pathogenic organisms in other countries.
3. The concentrations of heavy metals in the compost were lower than the allowable amounts set by the standards for other countries as shown in Figure 4.1. Other characteristics, such as nutrient level, pH, organic matter, and moisture content, also conform the standards on compost quality of Italy, the U.S., and Canada.

5.2 Conclusions

Some important conclusions drawn from the waste audit and composting trial in HaLong City are:

1. The compositions of the solid wastes from the three participating hotels, which had different quality ratings, appeared to be similar. Compostables, which are essential to the composting process, were present in the largest proportion. However, since non-compostables in the feedstock can affect the composting process, it is important to separate the compostables from the non-compostables.
2. The composting trial showed that the windrow composting process is a simple technology that can produce a high quality compost. While the compost that was produced during the trial was high in foreign matter and pathogens, and there were some operational problems, such as low temperatures, odours and flies, during the compost trial, which affected the compost quality. These can be addressed in the future through actions such as those listed in Table B.5.
3. The testing results of the trial compost quality showed that source separation of waste is an environmentally and technically good way to achieve a good quality final compost.
The compost had acceptable concentrations of nutrients and heavy metals when compared with the standards in Australia, North American, and Europe. Although, the trial compost was high in foreign matter and pathogenic organisms, the major reasons for those issues may be addressed and solved by actions which are mentioned in Table B.5.

5.3 Recommendations for Future Work

Future work can improve the implementation of composting in HaLong City and other cities in Vietnam. Below are some recommendations:

1. The participating hotels in HaLong City showed their high willingness to participate in separating waste at source during the one-week audit period. However, other hotels may not be as willing. Therefore, a study should be carried out to identify the factors that would affect hotel participation in an ongoing source separation program to support composting.

2. Observations revealed that hotel staff had very little knowledge about how to separate waste appropriately and the sites of waste bins were not convenient for both staff and guests. Therefore, studies should be carried out on what information should be provided to hotel staff and guests to improve source separation.

3. To expand to other hotels, the composting trial should be documented in the form of a brochure that provides hotels with information about composting and its benefits, about what the hotel would need to do to participate, and about the experiences gathered during this study (see Table B.5) can be used to improve future composting activities.

4. Since the compost trial was conducted in the summer, the results may not be true for other seasons. Research should be carried out on the effects of seasonal factors, such as ambient temperature and waste composition, on the composting process. Both waste audits and composting trials should be carried out again during the dry season in HaLong.

5. The use of compost in hotel gardens should be studied, especially the appropriate amount and mixture of compost to apply and timing to apply compost. Experiments should be conducted on the use of pure compost and mixtures of compost and soil at different ratios on different types of plant; as a result, the best “recipe” could then be chosen.
REFERENCES


Hogg, D., J. Barth, et al. (2004). Comparison of Compost Standards within the EU, North America and Australasia. WRAP.


U.S. Composting Council (2002). Workshop on Sharing Experience in Composting Municipal Solid Waste, Hanoi Department of Science and Technology.
APPENDIX A

WASTE AUDIT
### Table A.1 Quantity and Composition of Waste in SaiGon-HaLong Hotel during the One-Week Audit Period

<table>
<thead>
<tr>
<th>Material Category</th>
<th>Description</th>
<th>6-Jun</th>
<th>7-Jun</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fruit waste</strong></td>
<td>rambutan, watermelon, dragon fruit, apple pealing, banana, pine-apple, litchi fruit</td>
<td>23.7</td>
<td>disposed</td>
</tr>
<tr>
<td><strong>Leftover food</strong></td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Flower waste</strong></td>
<td>roses, leaves</td>
<td>1.8</td>
<td>disposed</td>
</tr>
<tr>
<td><strong>Non-recyclable Paper</strong></td>
<td>damp napkins, tissue paper</td>
<td>3.4</td>
<td>disposed</td>
</tr>
<tr>
<td><strong>Metal</strong></td>
<td>cans</td>
<td>2</td>
<td>collected for selling</td>
</tr>
<tr>
<td><strong>Glass</strong></td>
<td>bottles</td>
<td>2</td>
<td>collected for selling</td>
</tr>
<tr>
<td><strong>Non-recyclable plastics</strong></td>
<td>plastic bags, hard plastics</td>
<td>5.3</td>
<td>disposed</td>
</tr>
<tr>
<td><strong>Recyclable paper</strong></td>
<td>tissues, cardboard, print paper, newspaper</td>
<td>19.2</td>
<td>collected for selling</td>
</tr>
<tr>
<td><strong>Recyclable plastics</strong></td>
<td>bottles, clear bags</td>
<td>14.5</td>
<td>collected for selling</td>
</tr>
<tr>
<td><strong>Others</strong></td>
<td>wood chips, sand, dust, rubber, cloth, shoes, foam, cigars</td>
<td>8.5</td>
<td>disposed</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>80.4</td>
<td></td>
<td>139.6</td>
</tr>
</tbody>
</table>

**Waste from garden**

<table>
<thead>
<tr>
<th>Material Category</th>
<th>Description</th>
<th>6-Jun</th>
<th>7-Jun</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Leaves</strong></td>
<td>pine needles, brush</td>
<td>21.4</td>
<td>disposed</td>
</tr>
<tr>
<td><strong>Grass clippings</strong></td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Others</strong></td>
<td>wood chips, sand, dust, foam</td>
<td>2.5</td>
<td>disposed</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>23.9</td>
<td></td>
<td>10</td>
</tr>
</tbody>
</table>

**Waste from kitchen and restaurant**

<table>
<thead>
<tr>
<th>Material Category</th>
<th>Description</th>
<th>6-Jun</th>
<th>7-Jun</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Leftover food</strong></td>
<td>rice, poultry, chicken, smoke meat, cake, mash potato, bean.</td>
<td>104.8</td>
<td>collected for animal feeding</td>
</tr>
<tr>
<td><strong>Fruit waste</strong></td>
<td>rambutan, watermelon, dragon fruit, mangosteen, pine-apple</td>
<td>77</td>
<td>disposed</td>
</tr>
<tr>
<td><strong>Vegetable waste</strong></td>
<td>salad, onion peels, dill, carrot, cabbage, tomatoes, potato peels, cucumber, water-morning glory</td>
<td>58.5</td>
<td>disposed, except for 12.5 kg collected for animal feeding</td>
</tr>
<tr>
<td><strong>Egg shell</strong></td>
<td>-</td>
<td>3.5</td>
<td>disposed</td>
</tr>
<tr>
<td><strong>Sea-food waste</strong></td>
<td>shells</td>
<td>0.6</td>
<td>disposed</td>
</tr>
<tr>
<td><strong>Non-recyclable paper</strong></td>
<td>used napkin,</td>
<td>2.1</td>
<td>disposed</td>
</tr>
<tr>
<td><strong>Recyclable paper</strong></td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Glass</strong></td>
<td>kitchen-stuff, bottle</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Non-recyclable plastics</strong></td>
<td>plastic bags, hard plastic</td>
<td>2.3</td>
<td>disposed</td>
</tr>
<tr>
<td><strong>Recyclable Plastics</strong></td>
<td>bottles, clear bags</td>
<td>1.8</td>
<td>collected for selling</td>
</tr>
<tr>
<td><strong>Metal</strong></td>
<td>cans</td>
<td>0.5</td>
<td>collected for selling</td>
</tr>
<tr>
<td><strong>Others</strong></td>
<td>foam, dust</td>
<td>0.2</td>
<td>disposed</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>251.3</td>
<td></td>
<td>329.8</td>
</tr>
</tbody>
</table>

**Total amount of waste generated:**

<table>
<thead>
<tr>
<th>Material Category</th>
<th>Description</th>
<th>6-Jun</th>
<th>7-Jun</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total</strong></td>
<td>355.6</td>
<td></td>
<td>475.4</td>
</tr>
</tbody>
</table>

**Total amount of waste disposed:**

<table>
<thead>
<tr>
<th>Material Category</th>
<th>Description</th>
<th>6-Jun</th>
<th>7-Jun</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total</strong></td>
<td>198.3</td>
<td></td>
<td>328.8</td>
</tr>
</tbody>
</table>
### Table A.1 Quantity and Composition of Waste in SaiGon-HaLong Hotel during the One-Week Audit Period (cont’d)

<table>
<thead>
<tr>
<th>Material Category</th>
<th>Description</th>
<th>8-Jun</th>
<th>9-Jun</th>
<th>8-Jun</th>
<th>9-Jun</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Net weights</td>
<td>Remark</td>
<td>Description</td>
<td>Net weights</td>
</tr>
<tr>
<td>Waste from guest rooms and staff rooms</td>
<td>Fruits</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fruit waste</td>
<td>rambutan, watermelon, dragon fruit, apple peeling, banana, pine-apple, orange</td>
<td>9.4</td>
<td>disposed</td>
<td>litchi fruit, watermelon, dragon fruit, mango, banana,</td>
<td>3.7</td>
</tr>
<tr>
<td>Leftover food</td>
<td>bread, rice</td>
<td>2.9</td>
<td></td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Flower waste</td>
<td>roses, daisy</td>
<td>2.7</td>
<td>disposed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-recyclable Paper</td>
<td>damp napkins, tissue paper, wet paper</td>
<td>9</td>
<td>disposed</td>
<td>damp napkins, tissue paper</td>
<td>3</td>
</tr>
<tr>
<td>Metal</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glass</td>
<td>bottles</td>
<td>1.5</td>
<td>collected for selling</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-recyclable plastics</td>
<td>plastic bags, hard plastics</td>
<td>6.9</td>
<td>disposed</td>
<td>plastic bags, hard plastics</td>
<td>5.3</td>
</tr>
<tr>
<td>Recyclable paper</td>
<td>tissues, cardboard, print paper, newspaper</td>
<td>19.3</td>
<td>collected for selling</td>
<td>tissues, cardboard, print paper, newspaper</td>
<td>9.5</td>
</tr>
<tr>
<td>Recyclable plastics</td>
<td>bottles, clear bags</td>
<td>13.4</td>
<td>collected for selling</td>
<td>bottles, clear bags</td>
<td>6</td>
</tr>
<tr>
<td>Others</td>
<td>wood chips, sand, dust, rubber, cloth, shoes, foam, cigars.</td>
<td>2.7</td>
<td>disposed</td>
<td>wood chips, sand, dust, rubber, cloth, shoes, foam, cigars.</td>
<td>8.5</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Waste from garden</td>
<td>Leaves</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leaves</td>
<td>pine needles, brush, coco nut leaves</td>
<td>7.2</td>
<td>disposed</td>
<td>pine needles, brush</td>
<td>3</td>
</tr>
<tr>
<td>Grass clippings</td>
<td></td>
<td>7.5</td>
<td>disposed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Others</td>
<td>wood chips, sand, dust, foam, cloth</td>
<td>8</td>
<td>disposed</td>
<td>wood chips, sand, dust, foam</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Waste from kitchen and restaurants</td>
<td>Leftover food</td>
<td>rice soup, rice, poultry, chicken, smoke meat, cake, carrot, fish, cookies, bean, …</td>
<td>67.5</td>
<td>collected for animal feeding,</td>
<td>rice, poultry, chicken, smoke meat, cake, mash potato, bean, bean sprout, lemon, cucumber …</td>
</tr>
<tr>
<td>Fruit waste</td>
<td>rambutan, watermelon, dragon fruit, apple peeling</td>
<td>57.5</td>
<td>disposed</td>
<td>watermelon, dragon fruit, pine-apple</td>
<td>43.5</td>
</tr>
<tr>
<td>Vegetable waste</td>
<td>onion peels, pot-herbs, carrot, cabbage, tomatoes, potato peels, cucumber</td>
<td>58.5</td>
<td>disposed except for 7kg of spinach and cabbage collected for animal feeding</td>
<td>onion peels, pot-herbs, carrot, cabbage, tomatoes, potato peels, cucumber</td>
<td>22.5</td>
</tr>
<tr>
<td>Egg shell</td>
<td></td>
<td>11</td>
<td>disposed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sea-food waste</td>
<td>shells</td>
<td></td>
<td>disposed</td>
<td>shells</td>
<td>0.6</td>
</tr>
<tr>
<td>Non-recyclable paper</td>
<td>used napkin,</td>
<td>1</td>
<td>disposed</td>
<td>used napkin,</td>
<td>7.5</td>
</tr>
<tr>
<td>Recyclable paper</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glass</td>
<td>broken kitchen-stuff, bottle</td>
<td>3</td>
<td>disposed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-recyclable plastics</td>
<td>plastic bags, hard plastics</td>
<td>8.7</td>
<td>disposed</td>
<td>plastic bags, hard plastics</td>
<td>0.5</td>
</tr>
<tr>
<td>Recyclable Plastics</td>
<td>bottles, clear bags</td>
<td>0.7</td>
<td>collected for selling</td>
<td>bottles, clear bags</td>
<td>2</td>
</tr>
<tr>
<td>Metal</td>
<td>cans</td>
<td>0.5</td>
<td>collected for selling</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Others</td>
<td>foam, dirt</td>
<td>5.2</td>
<td>disposed</td>
<td>foam, dirt, bone</td>
<td>12.5</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Total amount of waste generated:** 304.1  
**Total amount of waste disposed of:** 194.2
Table A.1 Quantity and Composition of Waste in SaiGon-HaLong Hotel during the One-Week Audit Period (cont’d)

<table>
<thead>
<tr>
<th>Material Category</th>
<th>Description</th>
<th>10-Jun</th>
<th>11-Jun</th>
<th>12-Jun</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waste from guest rooms and staff rooms</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fruit waste</td>
<td>litchi fruit, watermelon, dragon fruit, mango, lemon, banana</td>
<td>8.5 disposed</td>
<td>litchi fruit, watermelon, dragon fruit, mango, banana</td>
<td>25.5 disposed</td>
</tr>
<tr>
<td>Leftover food</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Flower waste</td>
<td>roses, leaves</td>
<td>2.2 disposed</td>
<td>roses, leaves</td>
<td>1 disposed</td>
</tr>
<tr>
<td>Non-recyclable Paper</td>
<td>damp napkins, tissue paper</td>
<td>2.7 disposed</td>
<td>damp napkins, tissue paper</td>
<td>8.5 disposed</td>
</tr>
<tr>
<td>Metal</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Glass</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Non-recyclable plastics</td>
<td>plastic bags, hard plastics...</td>
<td>3.2 disposed</td>
<td>plastic bags, napkin, hard plastics...</td>
<td>15.1 disposed</td>
</tr>
<tr>
<td>Recyclable paper</td>
<td>tissues, cardboard, print paper, newspaper</td>
<td>15.2 collected for selling</td>
<td>tissues, cardboard, print paper, newspaper</td>
<td>23.2 collected for selling</td>
</tr>
<tr>
<td>Recyclable plastics</td>
<td>bottles, clear bags</td>
<td>15.2 collected for selling</td>
<td>bottles, clear bags</td>
<td>6.4 collected for selling</td>
</tr>
<tr>
<td>Others</td>
<td>wood chips, sand, dust, rubber, cloth, shoes, foam, cigars</td>
<td>9.4 disposed</td>
<td>wood chips, sand, dust, rubber, cloth, shoes, foam, cigars</td>
<td>8.2 disposed</td>
</tr>
<tr>
<td>Total</td>
<td>56.4</td>
<td>90.4</td>
<td>87.6</td>
<td></td>
</tr>
<tr>
<td>Waste from garden</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leaves</td>
<td>pine needles, brush</td>
<td>4.6 disposed</td>
<td>pine needles, brush</td>
<td>19.7 disposed</td>
</tr>
<tr>
<td>Grass clippings</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Others</td>
<td>wood chips, sand, dust, foam</td>
<td>5.8 disposed</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td>10.4</td>
<td>19.7</td>
<td>8.5</td>
<td></td>
</tr>
<tr>
<td>Waste from kitchen and restaurant</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leftover food</td>
<td>rice, chicken, smoke meat, cake, bean, cucumber...</td>
<td>107.5 collected for animal feeding</td>
<td>rice, poultry, chicken, cake, mash potato, cucumber...</td>
<td>119 collected for animal feeding</td>
</tr>
<tr>
<td>Fruit waste</td>
<td>watermelon, dragon fruit</td>
<td>43.5</td>
<td>watermelon, pear pine-apple</td>
<td>55</td>
</tr>
<tr>
<td>Vegetable waste</td>
<td>salted, onion, pot-herb, carrot, cabbage, tomatoes, cucumber</td>
<td>22.5 disposed</td>
<td>water morning glory, pot-herbs, onion, carrot,..</td>
<td>32.5 disposed</td>
</tr>
<tr>
<td>Egg shell</td>
<td>-</td>
<td>3 disposed</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Sea-food waste</td>
<td>fish</td>
<td>2.8</td>
<td>shrimp, crap</td>
<td>1.5</td>
</tr>
<tr>
<td>Non-recyclable paper</td>
<td>used napkin,</td>
<td>0.5 disposed</td>
<td>used napkin, wet paper</td>
<td>1 disposed</td>
</tr>
<tr>
<td>Recyclable paper</td>
<td>cardboard</td>
<td>10 collected for selling</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Glass</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Non-recyclable plastics</td>
<td>plastic bags, hard plastics</td>
<td>0.5 disposed</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Recyclable Plastics</td>
<td>bottles, clear bags</td>
<td>5 collected for selling</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Metal</td>
<td>can</td>
<td>2.2 collected for selling</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Others</td>
<td>foam, dirt, bone</td>
<td>35.5 disposed</td>
<td>foam, dirt, bone, cinder</td>
<td>26 disposed</td>
</tr>
<tr>
<td>Total</td>
<td>233</td>
<td>235</td>
<td>341.2</td>
<td></td>
</tr>
<tr>
<td>Total amount of waste generated:</td>
<td>299.8</td>
<td>345.1</td>
<td>437.3</td>
<td></td>
</tr>
<tr>
<td>Total amount of waste disposed of:</td>
<td>144.7</td>
<td>194.0</td>
<td>226.4</td>
<td></td>
</tr>
</tbody>
</table>
### Table A.2 Quantity and Composition of Waste in TienLong Hotel during the One-Week Audit Period

<table>
<thead>
<tr>
<th>Material Categories</th>
<th>Description</th>
<th>15-Jun</th>
<th>16-Jun</th>
<th>Remark</th>
<th>Description</th>
<th>15-Jun</th>
<th>16-Jun</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Net weight</td>
<td></td>
<td></td>
<td>Remark</td>
<td>Net weight</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Waste from guest rooms and staff rooms</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fruit waste</td>
<td>litchi fruit, watermelon, orange, pine-apple</td>
<td>2.8 disposed</td>
<td></td>
<td></td>
<td>itchi fruit, cucumber, mango</td>
<td>2.9 disposed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leftover food</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Flower waste</td>
<td>roses, leaves</td>
<td>0.9 disposed</td>
<td></td>
<td></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>disposed</td>
</tr>
<tr>
<td>Non-recyclable Paper</td>
<td>damp napkins, tissue paper</td>
<td>1.3 disposed</td>
<td></td>
<td></td>
<td>damp napkins, tissue paper</td>
<td>2.5 disposed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metal</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>cans</td>
<td>0.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glass</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Non-recyclable plastics</td>
<td>plastic bags, hard plastics…</td>
<td>2 disposed</td>
<td></td>
<td></td>
<td>plastic bags, hard plastics</td>
<td>0.6 disposed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recyclable paper</td>
<td>tissues, cardboard, print paper, newspaper</td>
<td>2.1 should be collected for selling, but disposed of actually</td>
<td></td>
<td></td>
<td>tissues, cardboard, print paper, newspaper</td>
<td>1.2 should be collected for selling, but disposed of actually</td>
<td></td>
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<td>Recyclable plastics</td>
<td>bottles, clear bags</td>
<td>0.6 should be collected for selling, but disposed of actually</td>
<td></td>
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<td>bottles, clear bags</td>
<td>1.4 should be collected for selling, but disposed of actually</td>
<td></td>
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</tr>
<tr>
<td>Others</td>
<td>sand, rubber, cloth, shoes, soaps, cigars</td>
<td>1.5 disposed</td>
<td></td>
<td></td>
<td>wood chips, tea bags, sand, dust, rubber, cloth</td>
<td>2.7 disposed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>11.2</td>
<td></td>
<td></td>
<td></td>
<td>11.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Waste from garden</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leaves</td>
<td>leaves, brush</td>
<td>18 disposed</td>
<td></td>
<td></td>
<td>brush</td>
<td>82.7 disposed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grass clippings</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Others</td>
<td>wood chips, sand, dust, foam</td>
<td>1.2 disposed</td>
<td></td>
<td></td>
<td>wood chips, sand, dust, foam</td>
<td>1.2 disposed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>19.2</td>
<td></td>
<td></td>
<td></td>
<td>83.9</td>
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</tr>
<tr>
<td>Waste from kitchen and restaurant</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leftover food</td>
<td>rice, poultry, chicken, vegetable, noodle</td>
<td>52 collected for animal feeding</td>
<td></td>
<td></td>
<td>rice, poultry, seafood, cooked vegetable</td>
<td>49 collected for animal feeding,</td>
<td></td>
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</tr>
<tr>
<td>Fruit waste</td>
<td>rambutan, watermelon,</td>
<td>8 disposed</td>
<td></td>
<td></td>
<td>rambutan, watermelon, dragon fruit, pine-apple</td>
<td>disposed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vegetable waste</td>
<td>onion, cucumber, water-morning glory</td>
<td>2 disposed</td>
<td></td>
<td></td>
<td>onion peels, tomatoes, cucumber, pot-herbs,</td>
<td>9.5 disposed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Egg shell</td>
<td>-</td>
<td>1.3 disposed</td>
<td></td>
<td></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Sea-food waste</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>shells, crabs</td>
<td>0.9 disposed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-Recyclable paper</td>
<td>used napkin,</td>
<td>2.5 disposed</td>
<td></td>
<td></td>
<td>used napkin, wet paper</td>
<td>2.6 disposed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recyclable paper</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Glass</td>
<td>kitchen-stuff, bottle</td>
<td>2.8 disposed</td>
<td></td>
<td></td>
<td>plates, bottles</td>
<td>0.7 disposed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-recyclable plastics</td>
<td>plastic bags, napkin, hard plastics</td>
<td>5.1 disposed</td>
<td></td>
<td></td>
<td>Plastic bags, hard plastics</td>
<td>4.9 disposed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recyclable Plastics</td>
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<td>-</td>
<td>-</td>
<td>-</td>
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<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Metal</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>cans</td>
<td>0.6 collected for selling</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Others</td>
<td>foam, cloth, mixed food</td>
<td>29.5 disposed</td>
<td></td>
<td></td>
<td>foam, dirt, bone, cloth</td>
<td>9 disposed</td>
<td></td>
<td></td>
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<td>Total</td>
<td></td>
<td>103</td>
<td></td>
<td></td>
<td></td>
<td>77.2</td>
<td></td>
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</tbody>
</table>

Total amount of waste generated: 133.4
Total amount of waste disposed of: 81.4
Table A.2 Quantity and Composition of Waste in TienLong Hotel during the One-Week Audit Period (cont’d)

<table>
<thead>
<tr>
<th>Material Categories</th>
<th>Description</th>
<th>Net weight</th>
<th>Remark</th>
<th>Description</th>
<th>Net weight</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>17-Jun</td>
<td></td>
<td></td>
<td>18-Jun</td>
<td></td>
</tr>
<tr>
<td>Fruit waste</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>peach, pine-apple, orange, banana, cucumber</td>
<td>8.2</td>
<td>disposed</td>
<td>litchi fruit, watermelon, dragon fruit, banana, mandarin fruit.</td>
<td>4.9</td>
<td>disposed</td>
</tr>
<tr>
<td>Leftover food</td>
<td>bread, shell</td>
<td>0.3</td>
<td>disposed</td>
<td>Cake, rice</td>
<td>0.2</td>
<td>disposed</td>
</tr>
<tr>
<td>Flower waste</td>
<td>roses</td>
<td>0.3</td>
<td>disposed</td>
<td></td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Non-recyclable Paper</td>
<td>damp napkins, tissue paper, wet paper</td>
<td>5.4</td>
<td>disposed</td>
<td>damp napkins, tissue paper, wet newspaper</td>
<td>1.8</td>
<td>disposed</td>
</tr>
<tr>
<td>Metal</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Glass</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Non-recycled plastics</td>
<td>plastic bags, hard plastics</td>
<td>1.5</td>
<td>disposed</td>
<td>plastic bags, hard plastics</td>
<td>0.7</td>
<td>disposed</td>
</tr>
<tr>
<td>Recyclable paper</td>
<td>tissues, cardboard, print paper, newspaper</td>
<td>0.8</td>
<td>should be collected for selling, but disposed of actually</td>
<td>tissues, cardboard, print paper, newspaper</td>
<td>0.6</td>
<td>should be collected for selling, but disposed of actually</td>
</tr>
<tr>
<td>Recyclable plastics</td>
<td>bottles, clear bags</td>
<td>1.6</td>
<td>should be collected for selling, but disposed of actually</td>
<td>bottles, clear bags</td>
<td>1.9</td>
<td>should be collected for selling, but disposed of actually</td>
</tr>
<tr>
<td>Others</td>
<td>sand, dust, rubber, cloth, foam, cigars,</td>
<td>3.5</td>
<td>disposed</td>
<td>sand, dust, cloth, shoes, foam, soap</td>
<td>3.5</td>
<td>disposed</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>21.6</td>
<td></td>
<td></td>
<td>13.6</td>
<td></td>
</tr>
<tr>
<td>Waste from garden</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leaves</td>
<td>brush, leaves</td>
<td>20.7</td>
<td>disposed</td>
<td>brush, leaves</td>
<td>27.4</td>
<td>disposed</td>
</tr>
<tr>
<td>Grass clippings</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Others</td>
<td>wood chips, sand, dust, cloth</td>
<td>4</td>
<td>disposed</td>
<td>wood chips, sand, dust, cloth</td>
<td>4</td>
<td>disposed</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>24.7</td>
<td></td>
<td></td>
<td>31.4</td>
<td></td>
</tr>
<tr>
<td>Waste from kitchen and restaurant</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leftover food</td>
<td>rice, chicken, vegetable, seafood, noodle</td>
<td>35</td>
<td>collected for animal feeding</td>
<td>rice, poultry, chicken, cooked vegetable,</td>
<td>42</td>
<td>collected for animal feeding</td>
</tr>
<tr>
<td>Fruit waste</td>
<td>watermelon, litchi fruit</td>
<td>4.2</td>
<td>disposed</td>
<td>watermelon, dragon fruit, pine-apple</td>
<td>23.4</td>
<td>disposed</td>
</tr>
<tr>
<td>Vegetable waste</td>
<td>onion peels, spinach, carrot, tomatoes, water-morning glory</td>
<td>16.4</td>
<td>disposed of, except for 6kg of water-morning collected for animal feeding</td>
<td>onion, pot-herbs, carrot, water-morning</td>
<td>16.1</td>
<td>disposed of, except for 7.1 kg of water-morning collected for animal feeding</td>
</tr>
<tr>
<td>Egg shell</td>
<td>-</td>
<td>0.9</td>
<td>disposed</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Sea-food waste</td>
<td>shrimps</td>
<td>1.5</td>
<td>disposed</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Non-Recyclable paper</td>
<td>used napkin,</td>
<td>4</td>
<td>disposed</td>
<td>used napkin,</td>
<td>4</td>
<td>disposed</td>
</tr>
<tr>
<td>Recyclable paper</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Glass</td>
<td>broken kitchen-stuff, bottle</td>
<td>3</td>
<td>disposed</td>
<td>broken kitchen-stuff, bottle</td>
<td>0.3</td>
<td>disposed</td>
</tr>
<tr>
<td>Non-recycled plastics</td>
<td>plastic bags, hard plastics</td>
<td>2.1</td>
<td>disposed</td>
<td>plastic bags, hard plastics</td>
<td>4.8</td>
<td>disposed</td>
</tr>
<tr>
<td>Recyclable Plastics</td>
<td>bottles, clear bags</td>
<td>1.4</td>
<td>collected for selling</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Metal</td>
<td>cans</td>
<td>0.7</td>
<td>collected for selling</td>
<td>sand, dirt, cloth, bone</td>
<td>16.1</td>
<td>disposed</td>
</tr>
<tr>
<td>Others</td>
<td>foam, rice straw, cloth</td>
<td>4</td>
<td>disposed</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>73.2</td>
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<td>106.7</td>
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<td>Total amount of waste generated:</td>
<td>119.5</td>
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<td>Total amount of waste disposed of:</td>
<td>78.4</td>
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<td></td>
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<td>102.6</td>
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</table>
Table A.2 Quantity and Composition of Waste in TienLong Hotel during the One-Week Audit Period (cont’d)

<table>
<thead>
<tr>
<th>Material Categories</th>
<th>19-Jun</th>
<th></th>
<th></th>
<th>20-Jun</th>
<th></th>
<th></th>
<th>21-Jun</th>
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<tbody>
<tr>
<td>Description</td>
<td>Net weight</td>
<td>Remark</td>
<td>Description</td>
<td>Net weight</td>
<td>Remark</td>
<td>Description</td>
<td>Net weight</td>
</tr>
<tr>
<td>Fruit waste</td>
<td>4.4</td>
<td>disposed</td>
<td>watermelon, orange, mango, lemon, banana,</td>
<td>4.4</td>
<td>main litchi; disposed</td>
<td>litchi fruit, orange, watermelon, mango, peach</td>
<td>13.4</td>
</tr>
<tr>
<td>Leftover food</td>
<td>2.5</td>
<td>disposed</td>
<td>poultry, sticky rice</td>
<td>1.4</td>
<td>disposed</td>
<td>bread, seafood, rice,</td>
<td>4.2</td>
</tr>
<tr>
<td>Flower waste</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Non-recyclable Paper</td>
<td>2.2</td>
<td>disposed</td>
<td>napkins, tissue paper</td>
<td>2.3</td>
<td>disposed</td>
<td>damp napkins, tissue paper</td>
<td>2.7</td>
</tr>
<tr>
<td>Fruit waste</td>
<td>0.2</td>
<td>should be collected for selling, but disposed of actually</td>
<td>cans</td>
<td>0.2</td>
<td>should be collected for selling, but disposed of actually</td>
<td>cans</td>
<td>0.2</td>
</tr>
<tr>
<td>Glass</td>
<td>0.2</td>
<td>disposed</td>
<td>broken bottles</td>
<td>0.3</td>
<td>disposed</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Non-recyclable plastics</td>
<td>1.5</td>
<td>disposed</td>
<td>plastic bags, napkin, hard plastics</td>
<td>0.7</td>
<td>disposed</td>
<td>plastic bags, napkin, hard plastics</td>
<td>1.5</td>
</tr>
<tr>
<td>Recyclable paper</td>
<td>1.8</td>
<td>should be collected for selling, but disposed of actually</td>
<td>tissues, cardboard, print paper, newspaper</td>
<td>1.7</td>
<td>should be collected for selling, but disposed of actually</td>
<td>tissues, cardboard, print paper, newspaper</td>
<td>1.4</td>
</tr>
<tr>
<td>Recyclable plastics</td>
<td>1.0</td>
<td>should be collected for selling, but disposed of actually</td>
<td>bottles, clear bags</td>
<td>1.7</td>
<td>should be collected for selling, but disposed of actually</td>
<td>bottles, clear bags</td>
<td>1.4</td>
</tr>
<tr>
<td>Others</td>
<td>4.9</td>
<td>disposed</td>
<td>wood chips, sand, dust, rubber, cloth, shoes</td>
<td>3.4</td>
<td>disposed</td>
<td>used pen, cloth, rubber, sanitary pads, wood chips,</td>
<td>3.3</td>
</tr>
<tr>
<td>Total</td>
<td>18.7</td>
<td>-</td>
<td>-</td>
<td>14.8</td>
<td>-</td>
<td>-</td>
<td>28.4</td>
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</table>

Waste from guest rooms and staff rooms

<table>
<thead>
<tr>
<th>Material Categories</th>
<th>Description</th>
<th>Net weight</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fruit waste</td>
<td>watermelon, orange, mango, lemon, banana,</td>
<td>4.4</td>
<td>disposed</td>
</tr>
<tr>
<td>Leftover food</td>
<td>poultry, sticky rice</td>
<td>2.5</td>
<td>disposed</td>
</tr>
<tr>
<td>Flower waste</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Non-recyclable Paper</td>
<td>napkins, tissue paper</td>
<td>2.2</td>
<td>disposed</td>
</tr>
<tr>
<td>Metal</td>
<td>cans</td>
<td>0.2</td>
<td>should be collected for selling, but disposed of actually</td>
</tr>
<tr>
<td>Glass</td>
<td>broken bottles</td>
<td>0.2</td>
<td>disposed</td>
</tr>
<tr>
<td>Non-recyclable plastics</td>
<td>plastic bags, napkin, hard plastics</td>
<td>1.5</td>
<td>disposed</td>
</tr>
<tr>
<td>Recyclable paper</td>
<td>tissues, cardboard, print paper, newspaper</td>
<td>1.8</td>
<td>should be collected for selling, but disposed of actually</td>
</tr>
<tr>
<td>Recyclable plastics</td>
<td>bottles, clear bags</td>
<td>1.0</td>
<td>should be collected for selling, but disposed of actually</td>
</tr>
<tr>
<td>Others</td>
<td>wood chips, sand, dust, rubber, cloth, shoes</td>
<td>4.9</td>
<td>disposed</td>
</tr>
<tr>
<td>Total</td>
<td>13</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

Waste from garden

<table>
<thead>
<tr>
<th>Material Categories</th>
<th>Description</th>
<th>Net weight</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leaves</td>
<td>leaves, brush</td>
<td>11</td>
<td>disposed</td>
</tr>
<tr>
<td>Grass clippings</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Others</td>
<td>sand, dust, foam</td>
<td>2</td>
<td>disposed</td>
</tr>
<tr>
<td>Total</td>
<td>13</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

Waste from kitchen and restaurant

<table>
<thead>
<tr>
<th>Material Categories</th>
<th>Description</th>
<th>Net weight</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leftover food</td>
<td>rice, poultry, chicken, vegetable, noodle</td>
<td>43</td>
<td>collected for animal feeding,</td>
</tr>
<tr>
<td>Fruit waste</td>
<td>Watermelon, litchi fruit</td>
<td>3</td>
<td>disposed</td>
</tr>
<tr>
<td>Vegetable waste</td>
<td>onion, carrot, cabbage</td>
<td>9.2</td>
<td>disposed</td>
</tr>
<tr>
<td>Egg shell</td>
<td>craps, shells</td>
<td>0.2</td>
<td>disposed</td>
</tr>
<tr>
<td>Sea-food waste</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Non-Recyclable paper</td>
<td>used napkin</td>
<td>4.5</td>
<td>disposed</td>
</tr>
<tr>
<td>Recyclable paper</td>
<td>kitchen-stuff, bottle</td>
<td>13.9</td>
<td>disposed</td>
</tr>
<tr>
<td>Glass</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Non-recyclable plastics</td>
<td>plastic bags, napkin, hard plastics</td>
<td>2.9</td>
<td>disposed</td>
</tr>
<tr>
<td>Recyclable plastics</td>
<td>bottles, clear bags</td>
<td>1.0</td>
<td>disposed</td>
</tr>
<tr>
<td>Metal</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Others</td>
<td>sand, dirt, bone</td>
<td>2</td>
<td>disposed</td>
</tr>
<tr>
<td>Total</td>
<td>80.6</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

Total amount of waste generated: 112.3

Total amount of waste disposed of: 68.3

A-7
# Table A.3 Quantity and Composition of Waste in CongDoan Hotel during the One-Week Audit Period

<table>
<thead>
<tr>
<th>Material Category</th>
<th>Description</th>
<th>Net weight</th>
<th>16-Jun</th>
<th>Remark</th>
<th>17-Jun</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fruit waste</td>
<td>rambutan, watermelon, jack fruit, banana, pine-apple</td>
<td>36</td>
<td></td>
<td>mainly litchi fruit disposed</td>
<td>29.6</td>
<td>disposed</td>
</tr>
<tr>
<td>Leftover food</td>
<td>crap, bread</td>
<td>1</td>
<td></td>
<td>disposed</td>
<td>2.5</td>
<td>disposed</td>
</tr>
<tr>
<td>Flower waste</td>
<td>roses, daisies</td>
<td>2.1</td>
<td>disposed</td>
<td></td>
<td>1</td>
<td>disposed</td>
</tr>
<tr>
<td>Non-recyclable Paper</td>
<td>napkins, tissue paper</td>
<td>8.9</td>
<td>disposed</td>
<td></td>
<td>8.7</td>
<td>disposed</td>
</tr>
<tr>
<td>Metal</td>
<td>cans</td>
<td>0.3</td>
<td>disposed</td>
<td></td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Glass</td>
<td>kitchen-stuff</td>
<td>0.3</td>
<td>disposed</td>
<td></td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Recyclable plastics</td>
<td>tissues, cardboard, print paper, newspaper</td>
<td>2.8</td>
<td>should be collected, but disposed of actually</td>
<td>2.6</td>
<td>should be collected for selling, but disposed of actually</td>
<td></td>
</tr>
<tr>
<td>Recyclable plastics</td>
<td>bottles, clear bags</td>
<td>1.9</td>
<td>should be collected for selling, but disposed of actually</td>
<td>1.3</td>
<td>should be collected for selling, but disposed of actually</td>
<td></td>
</tr>
<tr>
<td>Others</td>
<td>wood chips, sand, dust, rubber, cloth, foam,</td>
<td>2.9</td>
<td>disposed</td>
<td></td>
<td>2.6</td>
<td>disposed</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>58.8</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Waste from garden           |                                                  |            |            |                         |            |              |
| Leaves                     | leaves, brush                                    | 4.7        | disposed   |                         | 4          | disposed     |
| Grass clippings            | -                                                | -          | -          | -                       | -          | -            |
| Others                     | -                                                | -          | -          | wood chips, sand, dust, foam | 2.3        | disposed     |
| Total                      |                                                  | 4.7        |            |                         |            |              |

| Waste from kitchen and restaurant |                                                  |            | 51          | collected for animal feeding | 51.5       | collected for animal feeding |
| Leftover food                | rice, poultry, seafood, cooked vegetable        | 51         | collected for animal feeding | 51.5       | collected for animal feeding |
| Fruit waste                  | rambutan, watermelon, dragon fruit, mangosteens, pine-apple | 6          | disposed   | watermelon, litchi fruit   | 16.5       | disposed     |
| Vegetable waste             | garlic, onion peels, carrot, cabbage, tomatoes, cucumber, spinach, water-morning glory | 38         | disposed, except for 18kg of water-morning glory collected for animal feeding | 22.8       | collected for animal feeding, except for 9kg of spinach and onion, carrot |
| Egg shell                   | -                                                | 0.4        | disposed   |                         | 0.3        | disposed     |
| Sea-food waste              | craps, shell, fish                               | 12.3       | disposed   | shells                  | 2.5        | disposed     |
| Non-recyclable paper        | used napkin, wet paper                           | 0.5        | disposed   | used napkins             | 6          | disposed     |
| Recyclable paper            | -                                                | -          | -          | -                       | -          | -            |
| Glass                       | bottles                                          | 1          | disposed   |                         | -          | -            |
| Non-recyclable plastics     | plastic bags, hard plastics                      | 2.9        | disposed   |                         | 2          | disposed     |
| Recyclable Plastics         | -                                                | -          | -          | -                       | -          | -            |
| Metal                       | cans                                             | 0.5        | collected for selling | cans          | 2.5        | collected for selling |
| Others                      | foam, cloth, dirt, bone, ash                    | 8          | disposed   | foam, bone, cloth       | 9          | disposed     |
| Total                       |                                                  | 120.6      |            |                         | 113.1      |              |

Total amount of waste generated: 184.1
Total amount of waste disposed of: 114.6
Table A.3 Quantity and Composition of Waste in CongDoan Hotel during the One-Week Audit Period (cont’d)

<table>
<thead>
<tr>
<th>Material Category</th>
<th>Description</th>
<th>18-Jun</th>
<th>19-Jun</th>
<th>Remark</th>
<th>Description</th>
<th>Net weight</th>
<th>19-Jun</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fruit waste</td>
<td>watermelon, dragon fruit, orange, litchi fruit</td>
<td>21.8</td>
<td>disposed</td>
<td></td>
<td>litchi fruit, watermelon, peach, jack fruit</td>
<td>34.6</td>
<td>disposed</td>
<td></td>
</tr>
<tr>
<td>Leftover food</td>
<td>bread, rice</td>
<td>0.8</td>
<td>disposed</td>
<td></td>
<td>bread, noodle</td>
<td>0.7</td>
<td>disposed</td>
<td></td>
</tr>
<tr>
<td>Flower waste</td>
<td>roses, daisy</td>
<td>0.4</td>
<td>disposed</td>
<td></td>
<td>rose, leaves</td>
<td>0.4</td>
<td>disposed</td>
<td></td>
</tr>
<tr>
<td>Non-recyclable Paper</td>
<td>napkins, tissue paper,</td>
<td>5.7</td>
<td>disposed</td>
<td></td>
<td>napkins, tissue paper</td>
<td>7.9</td>
<td>disposed</td>
<td></td>
</tr>
<tr>
<td>Metal</td>
<td>cans</td>
<td>0.6</td>
<td>should be collected for selling, but disposed of actually</td>
<td></td>
<td>cans</td>
<td>2.9</td>
<td>disposed</td>
<td></td>
</tr>
<tr>
<td>Glass</td>
<td>glasses</td>
<td>0.6</td>
<td>disposed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-recycled plastics</td>
<td>plastic bags, hard plastics…</td>
<td>3.2</td>
<td>disposed</td>
<td></td>
<td>plastic bags, hard plastics…</td>
<td>4.8</td>
<td>disposed</td>
<td></td>
</tr>
<tr>
<td>Recyclable paper</td>
<td>tissues, cardboard, print paper, newspaper</td>
<td>3.6</td>
<td>should be collected for selling, but disposed of actually</td>
<td></td>
<td>tissues, cardboard, print paper, newspaper</td>
<td>2.2</td>
<td>should be collected for selling, but disposed of actually</td>
<td></td>
</tr>
<tr>
<td>Recyclable plastics</td>
<td>bottles, clear bags</td>
<td>1.7</td>
<td>should be collected for selling, but disposed of actually</td>
<td></td>
<td>bottles, clear bags</td>
<td>0.6</td>
<td>should be collected for selling, but disposed of actually</td>
<td></td>
</tr>
<tr>
<td>Others</td>
<td>sand, dust, rubber, cloth, shoes, foam,</td>
<td>7.4</td>
<td>disposed</td>
<td></td>
<td>wood chips, sand, dust, rubber, cloth, shoes, foam</td>
<td>4.2</td>
<td>disposed</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>45.8</td>
<td></td>
<td></td>
<td></td>
<td>58.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Waste from garden</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leaves</td>
<td>brush, leaves</td>
<td>5.6</td>
<td>disposed</td>
<td></td>
<td>pine, brush</td>
<td>5</td>
<td>mainly pine</td>
<td></td>
</tr>
<tr>
<td>Grass clippings</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Others</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>5.6</td>
<td></td>
<td></td>
<td></td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Waste from kitchen and restaurant</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leftover food</td>
<td>rice, poultry, …</td>
<td>52</td>
<td>collected for animal feeding</td>
<td></td>
<td>rice, poultry, sea-food, bean sprout, cucumber …</td>
<td>50</td>
<td>collected for animal feeding,</td>
<td></td>
</tr>
<tr>
<td>Fruit waste</td>
<td>watermelon, pine-apple</td>
<td>13.8</td>
<td>disposed</td>
<td></td>
<td>watermelon, pine-apple</td>
<td>17</td>
<td>disposed</td>
<td></td>
</tr>
<tr>
<td>Vegetable waste</td>
<td>onion, carrot, cabbage, tomatoes, water-morning glory</td>
<td>22.3</td>
<td>collected for animal feeding, except for 6.3kg of onion, carrot</td>
<td></td>
<td>Onion, pot-herbs, cabbage, tomatoes, potato peels, cucumber, spinach, water-morning glory</td>
<td>46.6</td>
<td>disposed, except for 17kg of water-morning glory</td>
<td></td>
</tr>
<tr>
<td>Egg shell</td>
<td>-</td>
<td>-</td>
<td>disposed</td>
<td></td>
<td></td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Sea-food waste</td>
<td>craps, shells</td>
<td>7.9</td>
<td>disposed</td>
<td></td>
<td>shells, craps</td>
<td>7.9</td>
<td>disposed</td>
<td></td>
</tr>
<tr>
<td>Non-recyclable paper</td>
<td>used napkin,</td>
<td>5.7</td>
<td>disposed</td>
<td></td>
<td>used napkin, wet paper</td>
<td>3.6</td>
<td>disposed</td>
<td></td>
</tr>
<tr>
<td>Recyclable paper</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Glass</td>
<td>kitchen-stuff, bottle</td>
<td>1.2</td>
<td>disposed</td>
<td></td>
<td>plates and glasses</td>
<td>1.2</td>
<td>disposed</td>
<td></td>
</tr>
<tr>
<td>Non-recycled plastics</td>
<td>plastic bags, hard plastics</td>
<td>1.5</td>
<td>disposed</td>
<td></td>
<td>plastic bags, hard plastics</td>
<td>1.8</td>
<td>disposed</td>
<td></td>
</tr>
<tr>
<td>Recyclable Plastics</td>
<td>-</td>
<td>-</td>
<td>collected for selling</td>
<td></td>
<td>bottles</td>
<td>0.2</td>
<td>collected for selling</td>
<td></td>
</tr>
<tr>
<td>Metal</td>
<td>cans</td>
<td>0.4</td>
<td>collected for selling</td>
<td></td>
<td>cans</td>
<td>0.4</td>
<td>disposed</td>
<td></td>
</tr>
<tr>
<td>Others</td>
<td>foam, dirt</td>
<td>14</td>
<td>disposed</td>
<td></td>
<td>dirt, sand, cloth, bone</td>
<td>16.8</td>
<td>disposed</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>118.8</td>
<td></td>
<td></td>
<td></td>
<td>145.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total amount of waste generated:</td>
<td></td>
<td>170.2</td>
<td></td>
<td></td>
<td></td>
<td>208.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total amount of waste disposed of:</td>
<td></td>
<td>101.8</td>
<td></td>
<td></td>
<td></td>
<td>141.6</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

A-9
# Table A.3 Quantity and Composition of Waste in CongDoan Hotel during the One-Week Audit Period (cont’d)

<table>
<thead>
<tr>
<th>Material Category</th>
<th>20-Jun</th>
<th></th>
<th>21-Jun</th>
<th></th>
<th>22-Jun</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Description</td>
<td>Net weight</td>
<td>Remark</td>
<td>Description</td>
<td>Net weight</td>
<td>Remark</td>
</tr>
<tr>
<td>Waste from guest rooms and staff rooms</td>
<td>Waste from guest rooms and staff rooms</td>
<td>Waste from guest rooms and staff rooms</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fruit waste</td>
<td>litchi fruit, watermelon, dragon fruit,</td>
<td>25.4</td>
<td></td>
<td>litchi fruit, watermelon, dragon fruit, mango, banana,</td>
<td>38</td>
<td></td>
</tr>
<tr>
<td>Leftover food</td>
<td>bread, rice</td>
<td>0.97</td>
<td>disposed</td>
<td>rice, noodle</td>
<td>0.6</td>
<td>disposed</td>
</tr>
<tr>
<td>Flower waste</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>roses, leaves</td>
<td>1.2</td>
<td>disposed</td>
</tr>
<tr>
<td>Non-recyclable Paper</td>
<td>damp napkins, tissue paper</td>
<td>7</td>
<td>disposed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metal</td>
<td>cans</td>
<td>1.5</td>
<td>should be collected for selling, but disposed of actually</td>
<td>cans</td>
<td>1</td>
<td>disposed</td>
</tr>
<tr>
<td>Glass</td>
<td>broken plates</td>
<td>0.4</td>
<td>disposed</td>
<td>bottles</td>
<td>7</td>
<td>should be collected for selling, but disposed of actually</td>
</tr>
<tr>
<td>Non-recyclable plastics</td>
<td>plastic bags, hard plastics...</td>
<td>4.3</td>
<td>disposed</td>
<td>plastic bags, hard plastics...</td>
<td>7</td>
<td>disposed</td>
</tr>
<tr>
<td>Recyclable paper</td>
<td>tissues, cardboard, print paper, newspaper</td>
<td>3.4</td>
<td>should be collected for selling, but disposed of actually</td>
<td>tissues, cardboard, print paper, newspaper</td>
<td>11.7</td>
<td>should be collected for selling, but disposed of actually</td>
</tr>
<tr>
<td>Recyclable plastics</td>
<td>bottles, clear bags</td>
<td>1.8</td>
<td>should be collected for selling, but disposed of actually</td>
<td>bottles, clear bags</td>
<td>3.5</td>
<td>should be collected for selling, but disposed of actually</td>
</tr>
<tr>
<td>Others</td>
<td>wood chips, sand, dust, rubber, cloth, shoes, foam,</td>
<td>2.3</td>
<td>disposed</td>
<td>wood chips, sand, dust, rubber, cloth, shoes,</td>
<td>2</td>
<td>disposed</td>
</tr>
<tr>
<td>Total</td>
<td>47.1</td>
<td>83.7</td>
<td>44.9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Waste from kitchen and restaurant</td>
<td>Waste from kitchen and restaurant</td>
<td>Waste from kitchen and restaurant</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leftover food</td>
<td>rice, poultry, vegetable</td>
<td>50.5</td>
<td>collected for animal feeding</td>
<td>rice, poultry</td>
<td>51</td>
<td>collected for animal feeding,</td>
</tr>
<tr>
<td>Fruit waste</td>
<td>watermelon, dragon fruit, pine-apple</td>
<td>6</td>
<td>disposed</td>
<td>watermelon, dragon fruit, pine-apple</td>
<td>6</td>
<td>disposed</td>
</tr>
<tr>
<td>Vegetable waste</td>
<td>onion, garlic, water-morning glory,, cabbage, tomatoes,</td>
<td>37.2</td>
<td>disposed, except for 17.2kg of water-morning glory</td>
<td>water-morning glory,, carrot, pot-herbs</td>
<td>28.7</td>
<td>disposed, except for 12kg of water-morning glory</td>
</tr>
<tr>
<td>Egg shell</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Sea-food waste</td>
<td>lobsters, crabs,, shells</td>
<td>4.5</td>
<td>disposed</td>
<td>shrimp, crabs, shells</td>
<td>10</td>
<td>disposed</td>
</tr>
<tr>
<td>Non-recyclable paper</td>
<td>used napkin,</td>
<td>7.2</td>
<td>disposed</td>
<td>used napkin, wet paper</td>
<td>6.5</td>
<td>disposed</td>
</tr>
<tr>
<td>Recyclable paper</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Glass</td>
<td>kitchen-stuff, bottle</td>
<td>5.5</td>
<td>disposed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-recyclable plastics</td>
<td>plastic bags, hard plastics</td>
<td>3.8</td>
<td>disposed</td>
<td>plastic bags, hard plastics</td>
<td>2</td>
<td>disposed</td>
</tr>
<tr>
<td>Recyclable Plastics</td>
<td>bottles, clear bags</td>
<td>0.3</td>
<td>collected for selling</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metal</td>
<td>can</td>
<td>0.3</td>
<td>collected for selling</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Others</td>
<td>bones, dirt, mixed food</td>
<td>2.3</td>
<td>disposed</td>
<td>foam, dirt, bone, cinder</td>
<td>10</td>
<td>disposed</td>
</tr>
<tr>
<td>Total</td>
<td>117.6</td>
<td>119</td>
<td>115</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total amount of waste generated:</td>
<td>169.2</td>
<td>208.3</td>
<td>163.1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total amount of waste disposed of:</td>
<td>100.5</td>
<td>144.3</td>
<td>91.6</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
A.4 Statistical Procedure (McBean and Rovers, 1998)

1. Mean
The arithmetic mean is the first moment about the origin (sometimes referred to as the data’s centre of gravity) as calculated by the following equation:

\[
\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n}
\]

Where: \( \bar{x} \): arithmetic mean
\( n \): the number of samples

2. Standard Deviation
The more representative of the measures of dispersion of the data (in that they reflect the array of data) is standard deviation which is defined as

\[
S = \sqrt{\frac{\sum_{i=1}^{n} (x_i - \bar{x})^2}{n-1}}
\]

Where: \( S \): standard deviation;
\( x_i \): the value of observation \( i \)

3. Measures of the Range of Data
An additional measure of dispersion or spread of data is the range. The range of a data set is simply the difference between the largest and the smallest value. Since only two of the values from the entire data set are utilized, the range is not a very useful parameter because it is sensitive to only these two values.

4. Confident Interval
A confident interval establishes a concentration range to contain a specified proportion of the population with a specified confidence, so that a specified proportion of monitoring observations should fall within this interval. The steps to determine the confidence interval as follows:
- Compute the mean and standard deviation as presented above.
- Construct the upper and lower intervals as

\[
CI = \bar{x} \pm k \cdot S \quad \text{where } k \text{ : the one-sided normal tolerance factor}
\]

5. Box-Whisker Plots
The Box-Whisker plots present a useful and quick graphical summary of data from different locations. Box-Whisker plots are potentially useful ways of summarizing the various measures of the spread or dispersion of the data. Box-Whisker plots are effective for exploratory data analysis as a way to visualize the spread of the data. Specifics of Box Whisker plots vary from one application to another, but the essence involves depiction of the mean, a measure of the spread, and the range. The spread is the “box” and the range is the “Whiskers”. Figure 2.3 provides an example of a Box-Whisker plot.
Table A.5a Waste Generated per Guest per Day

**SaiGon-HaLong Hotel**

<table>
<thead>
<tr>
<th>Date</th>
<th>Number of Overnight Guests</th>
<th>Total Weight of waste kg/day</th>
<th>Waste Weight per guest per day kg/guest/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day 1</td>
<td>429</td>
<td>355.6</td>
<td>0.83</td>
</tr>
<tr>
<td>Day 2</td>
<td>337</td>
<td>479.4</td>
<td>1.42</td>
</tr>
<tr>
<td>Day 3</td>
<td>341</td>
<td>304.1</td>
<td>0.89</td>
</tr>
<tr>
<td>Day 4</td>
<td>343</td>
<td>292.1</td>
<td>0.85</td>
</tr>
<tr>
<td>Day 5</td>
<td>378</td>
<td>299.8</td>
<td>0.79</td>
</tr>
<tr>
<td>Day 6</td>
<td>484</td>
<td>345.1</td>
<td>0.71</td>
</tr>
<tr>
<td>Day 7</td>
<td>484</td>
<td>437.3</td>
<td>0.90</td>
</tr>
<tr>
<td>Average</td>
<td>399.4</td>
<td>359.1</td>
<td>0.90*</td>
</tr>
</tbody>
</table>

**CongDoan Hotel**

<table>
<thead>
<tr>
<th>Date</th>
<th>Number of Overnight Guests</th>
<th>Total Weight of waste kg/day</th>
<th>Waste Weight per guest per day kg/guest/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day 1</td>
<td>293</td>
<td>184.1</td>
<td>0.63</td>
</tr>
<tr>
<td>Day 2</td>
<td>248</td>
<td>173.4</td>
<td>0.70</td>
</tr>
<tr>
<td>Day 3</td>
<td>309</td>
<td>170.2</td>
<td>0.55</td>
</tr>
<tr>
<td>Day 4</td>
<td>274</td>
<td>208.8</td>
<td>0.76</td>
</tr>
<tr>
<td>Day 5</td>
<td>267</td>
<td>169.2</td>
<td>0.63</td>
</tr>
<tr>
<td>Day 6</td>
<td>250</td>
<td>208.3</td>
<td>0.83</td>
</tr>
<tr>
<td>Day 7</td>
<td>217</td>
<td>163.1</td>
<td>0.75</td>
</tr>
<tr>
<td>Average</td>
<td>265.4</td>
<td>182.4</td>
<td>0.69*</td>
</tr>
</tbody>
</table>

**TienLong Hotel**

<table>
<thead>
<tr>
<th>Date</th>
<th>Number of Overnight Guests</th>
<th>Total Weight of waste kg/day</th>
<th>Waste Weight per guest per day kg/guest/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day 1</td>
<td>174</td>
<td>133.4</td>
<td>0.77</td>
</tr>
<tr>
<td>Day 2</td>
<td>166</td>
<td>172.7</td>
<td>1.04</td>
</tr>
<tr>
<td>Day 3</td>
<td>153</td>
<td>119.5</td>
<td>0.78</td>
</tr>
<tr>
<td>Day 4</td>
<td>226</td>
<td>151.7</td>
<td>0.67</td>
</tr>
<tr>
<td>Day 5</td>
<td>201</td>
<td>112.3</td>
<td>0.56</td>
</tr>
<tr>
<td>Day 6</td>
<td>118</td>
<td>126.1</td>
<td>1.07</td>
</tr>
<tr>
<td>Day 7</td>
<td>147</td>
<td>144.8</td>
<td>0.99</td>
</tr>
<tr>
<td>Average</td>
<td>169.3</td>
<td>137.2</td>
<td>0.81*</td>
</tr>
</tbody>
</table>

Note: * The average guest-based amount is determined by Equation 2.3a (2).
Table A.5b Waste Disposed per Guest per Day

### SaiGon-HaLong Hotel

<table>
<thead>
<tr>
<th>Date</th>
<th>Number of Overnight Guests</th>
<th>Total Weight of waste kg/day</th>
<th>Waste Weight per guest per day kg/guest/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day 1</td>
<td>429</td>
<td>198.3</td>
<td>0.46</td>
</tr>
<tr>
<td>Day 2</td>
<td>337</td>
<td>328.8</td>
<td>0.98</td>
</tr>
<tr>
<td>Day 3</td>
<td>341</td>
<td>194.2</td>
<td>0.57</td>
</tr>
<tr>
<td>Day 4</td>
<td>343</td>
<td>136.6</td>
<td>0.40</td>
</tr>
<tr>
<td>Day 5</td>
<td>378</td>
<td>144.7</td>
<td>0.38</td>
</tr>
<tr>
<td>Day 6</td>
<td>484</td>
<td>194.0</td>
<td>0.40</td>
</tr>
<tr>
<td>Day 7</td>
<td>484</td>
<td>226.4</td>
<td>0.47</td>
</tr>
<tr>
<td>Average</td>
<td>399.4</td>
<td>203.3</td>
<td>0.51*</td>
</tr>
</tbody>
</table>

### CongDoan Hotel

<table>
<thead>
<tr>
<th>Date</th>
<th>Number of Overnight Guests</th>
<th>Total Weight of waste kg/day</th>
<th>Waste Weight per guest per day kg/guest/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day 1</td>
<td>293</td>
<td>114.6</td>
<td>0.39</td>
</tr>
<tr>
<td>Day 2</td>
<td>248</td>
<td>105.6</td>
<td>0.43</td>
</tr>
<tr>
<td>Day 3</td>
<td>309</td>
<td>101.8</td>
<td>0.33</td>
</tr>
<tr>
<td>Day 4</td>
<td>274</td>
<td>141.6</td>
<td>0.52</td>
</tr>
<tr>
<td>Day 5</td>
<td>267</td>
<td>100.5</td>
<td>0.38</td>
</tr>
<tr>
<td>Day 6</td>
<td>250</td>
<td>144.3</td>
<td>0.58</td>
</tr>
<tr>
<td>Day 7</td>
<td>217</td>
<td>91.6</td>
<td>0.42</td>
</tr>
<tr>
<td>Average</td>
<td>265.4</td>
<td>114.3</td>
<td>0.43*</td>
</tr>
</tbody>
</table>

### TienLong Hotel

<table>
<thead>
<tr>
<th>Date</th>
<th>Number of Overnight Guests</th>
<th>Total Weight of waste kg/day</th>
<th>Waste Weight per guest per day kg/guest/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day 1</td>
<td>174</td>
<td>81.4</td>
<td>0.47</td>
</tr>
<tr>
<td>Day 2</td>
<td>166</td>
<td>123.1</td>
<td>0.74</td>
</tr>
<tr>
<td>Day 3</td>
<td>153</td>
<td>76.4</td>
<td>0.50</td>
</tr>
<tr>
<td>Day 4</td>
<td>226</td>
<td>102.6</td>
<td>0.45</td>
</tr>
<tr>
<td>Day 5</td>
<td>201</td>
<td>68.3</td>
<td>0.34</td>
</tr>
<tr>
<td>Day 6</td>
<td>118</td>
<td>77.1</td>
<td>0.65</td>
</tr>
<tr>
<td>Day 7</td>
<td>147</td>
<td>95.8</td>
<td>0.65</td>
</tr>
<tr>
<td>Average</td>
<td>169.3</td>
<td>89.2</td>
<td>0.53*</td>
</tr>
</tbody>
</table>

Note: * The average guest-based amount is determined by Equation 2.3b (2).

A-13
Table A.6 Generation-based Waste Composition in SaiGon-HaLong Hotel

<table>
<thead>
<tr>
<th>Material Category</th>
<th>Description</th>
<th>Day 1</th>
<th></th>
<th>Day 2</th>
<th></th>
<th>Day 3</th>
<th></th>
<th>Day 4</th>
<th></th>
<th>Day 5</th>
<th></th>
<th>Day 6</th>
<th></th>
<th>Day 7</th>
<th></th>
<th>One-week Audit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Weight</td>
<td>%</td>
<td>Weight</td>
<td>%</td>
<td>Weight</td>
<td>%</td>
<td>Weight</td>
<td>%</td>
<td>Weight</td>
<td>%</td>
<td>Weight</td>
<td>%</td>
<td>Weight</td>
<td>%</td>
<td>Average*</td>
</tr>
<tr>
<td>Compostables</td>
<td>Leftover food, fruit, yard, vegetable, seafood waste, and egg shells</td>
<td>291.3</td>
<td>81.9</td>
<td>348.2</td>
<td>72.6</td>
<td>224.2</td>
<td>73.7</td>
<td>236.3</td>
<td>80.9</td>
<td>194.6</td>
<td>64.9</td>
<td>254.2</td>
<td>73.7</td>
<td>328.3</td>
<td>75.1</td>
<td>268.2</td>
</tr>
<tr>
<td>Recyclables</td>
<td>Paper, plastics, metal, and glass</td>
<td>42.3</td>
<td>11.9</td>
<td>50.3</td>
<td>10.5</td>
<td>38.4</td>
<td>12.6</td>
<td>17.5</td>
<td>6.0</td>
<td>47.6</td>
<td>15.9</td>
<td>32.1</td>
<td>9.3</td>
<td>40.9</td>
<td>9.4</td>
<td>38.4</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>Rubber, cloth, dirt, cigars, bones Non-recyclable paper, non-recyclable plastics</td>
<td>22.0</td>
<td>6.2</td>
<td>80.9</td>
<td>16.9</td>
<td>41.5</td>
<td>13.7</td>
<td>38.3</td>
<td>13.1</td>
<td>57.6</td>
<td>19.2</td>
<td>58.8</td>
<td>17.0</td>
<td>68.1</td>
<td>15.5</td>
<td>52.5</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>355.6</td>
<td>100</td>
<td>479.4</td>
<td>100.0</td>
<td>304.1</td>
<td>100</td>
<td>292.1</td>
<td>100</td>
<td>299.8</td>
<td>100</td>
<td>345.1</td>
<td>100</td>
<td>437.3</td>
<td>100</td>
<td>359.1</td>
</tr>
</tbody>
</table>

Note: * the average generation-based composition is determined by Equation 2.4 (2).
Table A.7 Generation-based Waste Composition in TienLong Hotel

<table>
<thead>
<tr>
<th>Material Category</th>
<th>Description</th>
<th>Day 1</th>
<th>Day 2</th>
<th>Day 3</th>
<th>Day 4</th>
<th>Day 5</th>
<th>Day 6</th>
<th>Day 7</th>
<th>One-week Audit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Weight</td>
<td>Weight</td>
<td>Weight</td>
<td>Weight</td>
<td>Weight</td>
<td>Weight</td>
<td>Weight</td>
<td>Weight</td>
</tr>
<tr>
<td></td>
<td></td>
<td>kg</td>
<td>kg</td>
<td>kg</td>
<td>kg</td>
<td>kg</td>
<td>kg</td>
<td>kg</td>
<td>kg</td>
</tr>
<tr>
<td></td>
<td></td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
</tr>
<tr>
<td>Compostables</td>
<td>Leftover food, fruit, yard, vegetable, seafood waste, and egg shells</td>
<td>85.0</td>
<td>145.0</td>
<td>84.0</td>
<td>87.5</td>
<td>114.0</td>
<td>74.2</td>
<td>90.2</td>
<td>106.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>63.7</td>
<td>84.0</td>
<td>73.2</td>
<td>75.1</td>
<td>66.1</td>
<td>71.5</td>
<td>73.5</td>
<td>73.1</td>
</tr>
<tr>
<td>Recyclables</td>
<td>Paper, plastics, metal, and glass</td>
<td>5.3</td>
<td>4.2</td>
<td>7.5</td>
<td>2.8</td>
<td>2.0</td>
<td>18.1</td>
<td>2.3</td>
<td>4.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.0</td>
<td>2.4</td>
<td>6.3</td>
<td>2.0</td>
<td>16.1</td>
<td>3.0</td>
<td>6.5</td>
<td>4.7</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>Rubber, cloth, dirt, cigars, bones Non-recyclable paper, non-recyclable plastics</td>
<td>43.1</td>
<td>23.5</td>
<td>13.6</td>
<td>24.5</td>
<td>20.5</td>
<td>20.0</td>
<td>33.0</td>
<td>30.4</td>
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<tr>
<td></td>
<td></td>
<td>32.3</td>
<td>13.6</td>
<td>24.5</td>
<td>20.5</td>
<td>17.8</td>
<td>26.2</td>
<td>23.5</td>
<td>22.2</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>133.4</td>
<td>172.7</td>
<td>199.5</td>
<td>151.7</td>
<td>112.3</td>
<td>126.1</td>
<td>144.8</td>
<td>137.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

Note: * the average generation-based composition is determined by Equation 2.4 (2).
Table A.8 Generation-based Waste Composition in CongDoan Hotel

<table>
<thead>
<tr>
<th>Material Category</th>
<th>Description</th>
<th>Day 1</th>
<th>Day 2</th>
<th>Day 3</th>
<th>Day 4</th>
<th>Day 5</th>
<th>Day 6</th>
<th>Day 7</th>
<th>One-week Audit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Weight</td>
<td>Percentage</td>
<td>Weight</td>
<td>Percentage</td>
<td>Weight</td>
<td>Percentage</td>
<td>Weight</td>
<td>Percentage</td>
</tr>
<tr>
<td>Compostables</td>
<td>Leftover food, fruit, yard, vegetable, seafood waste, and egg shells</td>
<td>150.5</td>
<td>81.7</td>
<td>130.7</td>
<td>75.4</td>
<td>124.6</td>
<td>73.2</td>
<td>162.2</td>
<td>77.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>109.2</td>
<td>67.0</td>
<td>135.3</td>
<td>74.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recyclables</td>
<td>Paper, plastics, metal, and glass</td>
<td>6.8</td>
<td>3.7</td>
<td>6.4</td>
<td>3.7</td>
<td>8.1</td>
<td>4.8</td>
<td>7.4</td>
<td>3.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>17.1</td>
<td>10.5</td>
<td>12.4</td>
<td>6.8</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>Rubber, cloth, dirt, cigars, bones Non-recyclable paper, non-recyclable plastics</td>
<td>26.8</td>
<td>14.6</td>
<td>36.3</td>
<td>20.9</td>
<td>37.5</td>
<td>22.0</td>
<td>39.2</td>
<td>18.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>36.8</td>
<td>22.5</td>
<td>34.7</td>
<td>19.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>184.1</td>
<td>100</td>
<td>173.4</td>
<td>100</td>
<td>170.2</td>
<td>100</td>
<td>208.8</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td></td>
<td>163.1</td>
<td>100</td>
<td>182.4</td>
<td>100.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: * the average generation-based composition is determined by Equation 2.4 (2).
Table A.9 Disposal-based Waste Composition in SaiGon-HaLong Hotel

<table>
<thead>
<tr>
<th>Material Category</th>
<th>Description</th>
<th>Day 1</th>
<th>Day 2</th>
<th>Day 3</th>
<th>Day 4</th>
<th>Day 5</th>
<th>Day 6</th>
<th>Day 7</th>
<th>One-week Audit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Weight (kg)</td>
<td>Percentage (%)</td>
<td>Weight (kg)</td>
<td>Percentage (%)</td>
<td>Weight (kg)</td>
<td>Percentage (%)</td>
<td>Weight (kg)</td>
<td>Percentage (%)</td>
</tr>
<tr>
<td>Compostables</td>
<td>Leftover food, fruit, yard, vegetable, seafood waste, and egg shells</td>
<td>174.0</td>
<td>87.8</td>
<td>239.7</td>
<td>72.9</td>
<td>149.7</td>
<td>77.1</td>
<td>98.3</td>
<td>72.0</td>
</tr>
<tr>
<td>Recyclables</td>
<td>Paper, plastics, metal, and glass</td>
<td>2.3</td>
<td>1.1</td>
<td>8.2</td>
<td>2.5</td>
<td>3.0</td>
<td>1.5</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>Rubber, cloth, dirt, cigars, non-recyclable paper, non-recyclable plastics</td>
<td>22</td>
<td>11.1</td>
<td>80.9</td>
<td>24.6</td>
<td>41.5</td>
<td>21.4</td>
<td>38.3</td>
<td>28.0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>198.3</strong></td>
<td><strong>100.0</strong></td>
<td><strong>328.8</strong></td>
<td><strong>100</strong></td>
<td><strong>194.2</strong></td>
<td><strong>100</strong></td>
<td><strong>136.6</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

Note: * the average generation-based composition is determined by Equation 2.5 (2).
Table A.10 Disposal-based Waste Composition in CongDoan Hotel

<table>
<thead>
<tr>
<th>Material Category</th>
<th>Description</th>
<th>Day 1</th>
<th>Day 2</th>
<th>Day 3</th>
<th>Day 4</th>
<th>Day 5</th>
<th>Day 6</th>
<th>Day 7</th>
<th>One-week Audit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Weight</td>
<td>Percentage</td>
<td>Weight</td>
<td>Percentage</td>
<td>Weight</td>
<td>Percentage</td>
<td>Weight</td>
<td>Percentage</td>
</tr>
<tr>
<td>Compostables</td>
<td>Leftover food, fruit, yard, vegetable, seafood waste, and egg shells</td>
<td>82.5</td>
<td>72.0</td>
<td>65.4</td>
<td>61.9</td>
<td>56.6</td>
<td>55.6</td>
<td>95.2</td>
<td>67.2</td>
</tr>
<tr>
<td>Recyclables</td>
<td>Paper, plastics, metal, and glass</td>
<td>5.3</td>
<td>4.6</td>
<td>3.9</td>
<td>3.7</td>
<td>7.7</td>
<td>7.6</td>
<td>7.2</td>
<td>5.1</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>Rubber, cloth, dirt, cigars, bones Non-recyclable paper, non-recyclable plastics</td>
<td>26.8</td>
<td>23.4</td>
<td>36.3</td>
<td>34.4</td>
<td>37.5</td>
<td>36.8</td>
<td>39.2</td>
<td>27.7</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>114.6</td>
<td>100</td>
<td>105.6</td>
<td>100</td>
<td>101.8</td>
<td>100</td>
<td>141.6</td>
<td>100</td>
</tr>
</tbody>
</table>

Note: * the average generation-based composition is determined by Equation 2.5 (2).
Table A.11 Disposal-based Waste Composition in TienLong Hotel

<table>
<thead>
<tr>
<th>Material Category</th>
<th>Description</th>
<th>Day 1</th>
<th>Day 2</th>
<th>Day 3</th>
<th>Day 4</th>
<th>Day 5</th>
<th>Day 6</th>
<th>Day 7</th>
<th>One-week Audit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Weight</td>
<td>Percentage</td>
<td>Weight</td>
<td>Percentage</td>
<td>Weight</td>
<td>Percentage</td>
<td>Weight</td>
<td>Percentage</td>
<td>Weight</td>
</tr>
<tr>
<td>Compostables</td>
<td>33.0</td>
<td>40.5</td>
<td>96.0</td>
<td>78.0</td>
<td>46.5</td>
<td>60.9</td>
<td>64.9</td>
<td>63.3</td>
<td>31.2</td>
</tr>
<tr>
<td>Recyclables</td>
<td>5.3</td>
<td>6.5</td>
<td>3.6</td>
<td>2.9</td>
<td>5.4</td>
<td>7.1</td>
<td>2.8</td>
<td>2.7</td>
<td>17.1</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>43.1</td>
<td>53.0</td>
<td>23.5</td>
<td>19.1</td>
<td>24.5</td>
<td>32.0</td>
<td>34.9</td>
<td>34.0</td>
<td>20.0</td>
</tr>
<tr>
<td>Total</td>
<td>81.4</td>
<td>100</td>
<td>123.1</td>
<td>100</td>
<td>76.4</td>
<td>100</td>
<td>102.6</td>
<td>100</td>
<td>68.3</td>
</tr>
</tbody>
</table>

Note: * the average generation-based composition is determined by Equation 2.5 (2).
Table A.12 Quantification and Composition of Compostables in SaiGon-HaLong Hotel

<table>
<thead>
<tr>
<th>Categories compostables</th>
<th>Day 1</th>
<th>Day 2</th>
<th>Day 3</th>
<th>Day 4</th>
<th>Day 5</th>
<th>Day 6</th>
<th>Day 7</th>
<th>Average*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Weight (kg)</td>
<td>Percentage (%)</td>
<td>Weight (kg)</td>
<td>Percentage (%)</td>
<td>Weight (kg)</td>
<td>Percentage (%)</td>
<td>Weight (kg)</td>
<td>Percentage (%)</td>
</tr>
<tr>
<td>Fruit waste</td>
<td>100.7</td>
<td>34.6</td>
<td>147.1</td>
<td>42.2</td>
<td>66.9</td>
<td>29.8</td>
<td>47.2</td>
<td>20.0</td>
</tr>
<tr>
<td>Disposed</td>
<td>100.7</td>
<td>57.9</td>
<td>147.1</td>
<td>61.4</td>
<td>66.9</td>
<td>44.7</td>
<td>47.2</td>
<td>48.0</td>
</tr>
<tr>
<td>Leftover food</td>
<td>104.8</td>
<td>36.0</td>
<td>133.7</td>
<td>38.4</td>
<td>70.4</td>
<td>31.4</td>
<td>138.0</td>
<td>58.4</td>
</tr>
<tr>
<td>Disposed</td>
<td>0.0</td>
<td>0.0</td>
<td>72.0</td>
<td>30.0</td>
<td>2.9</td>
<td>1.9</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Vegetable waste</td>
<td>58.5</td>
<td>20.1</td>
<td>51.8</td>
<td>14.9</td>
<td>58.5</td>
<td>26.1</td>
<td>22.5</td>
<td>9.5</td>
</tr>
<tr>
<td>Disposed</td>
<td>46.0</td>
<td>26.4</td>
<td>5.0</td>
<td>2.1</td>
<td>51.5</td>
<td>34.4</td>
<td>22.5</td>
<td>22.9</td>
</tr>
<tr>
<td>Yard waste (leaves and glass clippings)</td>
<td>21.4</td>
<td>7.3</td>
<td>7.0</td>
<td>2.0</td>
<td>14.7</td>
<td>6.6</td>
<td>27.0</td>
<td>11.4</td>
</tr>
<tr>
<td>Disposed</td>
<td>21.4</td>
<td>12.3</td>
<td>7.0</td>
<td>2.9</td>
<td>14.7</td>
<td>9.8</td>
<td>27.0</td>
<td>27.5</td>
</tr>
<tr>
<td>Others (egg shells, seafood, flower)</td>
<td>5.9</td>
<td>2.0</td>
<td>8.6</td>
<td>2.5</td>
<td>13.7</td>
<td>6.1</td>
<td>1.6</td>
<td>0.7</td>
</tr>
<tr>
<td>Disposed</td>
<td>5.9</td>
<td>3.4</td>
<td>8.6</td>
<td>3.6</td>
<td>13.7</td>
<td>9.2</td>
<td>1.6</td>
<td>1.6</td>
</tr>
<tr>
<td>Total</td>
<td>291.3</td>
<td>100</td>
<td>348.2</td>
<td>100</td>
<td>224.2</td>
<td>100</td>
<td>236.3</td>
<td>100</td>
</tr>
<tr>
<td>Disposed/Generated</td>
<td>%</td>
<td>59.7</td>
<td>68.8</td>
<td>66.8</td>
<td>41.6</td>
<td>44.8</td>
<td>53.2</td>
<td>48.2</td>
</tr>
</tbody>
</table>

Note: * the average generation-based composition is determined by Equation 2.6 (2).
Table A.13 Quantification and Composition of Compostables in CongDoan Hotel

<table>
<thead>
<tr>
<th>Categories of compostables</th>
<th>Day 1</th>
<th>Day 2</th>
<th>Day 3</th>
<th>Day 4</th>
<th>Day 5</th>
<th>Day 6</th>
<th>Day 7</th>
<th>Average*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Weight (kg)</td>
<td>Percentage (%)</td>
<td>Weight (kg)</td>
<td>Percentage (%)</td>
<td>Weight (kg)</td>
<td>Percentage (%)</td>
<td>Weight (kg)</td>
<td>Percentage (%)</td>
</tr>
<tr>
<td><strong>Fruit waste</strong></td>
<td>Generated 42.0</td>
<td>27.9</td>
<td>46.1</td>
<td>35.3</td>
<td>35.6</td>
<td>28.6</td>
<td>51.6</td>
<td>31.8</td>
</tr>
<tr>
<td></td>
<td>Disposed 42.0</td>
<td>50.9</td>
<td>46.1</td>
<td>70.5</td>
<td>35.6</td>
<td>62.9</td>
<td>51.6</td>
<td>54.2</td>
</tr>
<tr>
<td><strong>Leftover food</strong></td>
<td>Generated 51.0</td>
<td>33.9</td>
<td>54.0</td>
<td>41.3</td>
<td>52.8</td>
<td>42.4</td>
<td>50.7</td>
<td>31.3</td>
</tr>
<tr>
<td></td>
<td>Disposed 1.0</td>
<td>1.2</td>
<td>2.5</td>
<td>3.8</td>
<td>0.8</td>
<td>1.4</td>
<td>0.7</td>
<td>0.7</td>
</tr>
<tr>
<td><strong>Vegetable waste</strong></td>
<td>Generated 38.0</td>
<td>25.2</td>
<td>22.8</td>
<td>17.4</td>
<td>22.3</td>
<td>17.9</td>
<td>46.6</td>
<td>28.7</td>
</tr>
<tr>
<td></td>
<td>Disposed 20.0</td>
<td>24.2</td>
<td>9.0</td>
<td>13.8</td>
<td>6.3</td>
<td>11.1</td>
<td>29.6</td>
<td>31.1</td>
</tr>
<tr>
<td><strong>Yard waste (leaves and glass clippings)</strong></td>
<td>Generated 4.7</td>
<td>3.1</td>
<td>4.0</td>
<td>3.1</td>
<td>5.6</td>
<td>4.5</td>
<td>5.0</td>
<td>3.1</td>
</tr>
<tr>
<td></td>
<td>Disposed 4.7</td>
<td>5.7</td>
<td>4.0</td>
<td>6.1</td>
<td>5.6</td>
<td>9.9</td>
<td>5.0</td>
<td>5.3</td>
</tr>
<tr>
<td><strong>Others (egg shells, seafood, flower)</strong></td>
<td>Generated 14.8</td>
<td>9.8</td>
<td>3.8</td>
<td>2.9</td>
<td>8.3</td>
<td>6.7</td>
<td>8.3</td>
<td>5.1</td>
</tr>
<tr>
<td></td>
<td>Disposed 14.8</td>
<td>17.9</td>
<td>3.8</td>
<td>5.8</td>
<td>8.3</td>
<td>14.7</td>
<td>8.3</td>
<td>8.7</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>Generated 150.5</td>
<td>100</td>
<td>130.7</td>
<td>100</td>
<td>124.6</td>
<td>100</td>
<td>162.2</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>Disposed 82.5</td>
<td>100</td>
<td>65.4</td>
<td>100</td>
<td>56.6</td>
<td>100</td>
<td>95.2</td>
<td>100</td>
</tr>
<tr>
<td>Disposed/Generated</td>
<td>%</td>
<td>54.8</td>
<td>50.0</td>
<td>45.4</td>
<td>53.6</td>
<td>47.6</td>
<td>55.4</td>
<td>43.7</td>
</tr>
</tbody>
</table>

Note: * the average generation-based composition is determined by Equation 2.6 (2).
Table A.14 Quantification and Composition of Compostables in TienLong Hotel

<table>
<thead>
<tr>
<th>Categories of compostables</th>
<th>Day 1</th>
<th>Day 2</th>
<th>Day 3</th>
<th>Day 4</th>
<th>Day 5</th>
<th>Day 6</th>
<th>Day 7</th>
<th>Average*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Weight</td>
<td>Percentage</td>
<td>Weight</td>
<td>Percentage</td>
<td>Weight</td>
<td>Percentage</td>
<td>Weight</td>
<td>Percentage</td>
</tr>
<tr>
<td>Fruit waste</td>
<td>Generated</td>
<td>10.8</td>
<td>12.7</td>
<td>2.9</td>
<td>2.0</td>
<td>12.4</td>
<td>14.2</td>
<td>28.3</td>
</tr>
<tr>
<td></td>
<td>Disposed</td>
<td>10.8</td>
<td>32.7</td>
<td>2.9</td>
<td>3.0</td>
<td>12.4</td>
<td>26.7</td>
<td>28.3</td>
</tr>
<tr>
<td>Leftover food</td>
<td>Generated</td>
<td>52.0</td>
<td>61.2</td>
<td>49</td>
<td>33.8</td>
<td>35.3</td>
<td>40.3</td>
<td>42.2</td>
</tr>
<tr>
<td></td>
<td>Disposed</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.3</td>
<td>0.6</td>
<td>0.2</td>
</tr>
<tr>
<td>Vegetable waste</td>
<td>Generated</td>
<td>2.0</td>
<td>2.4</td>
<td>9.5</td>
<td>6.6</td>
<td>16.4</td>
<td>18.7</td>
<td>16.1</td>
</tr>
<tr>
<td></td>
<td>Disposed</td>
<td>2.0</td>
<td>6.1</td>
<td>9.5</td>
<td>9.9</td>
<td>10.4</td>
<td>22.4</td>
<td>9.0</td>
</tr>
<tr>
<td>Yard waste (leaves and glass clippings)</td>
<td>Generated</td>
<td>18.0</td>
<td>21.2</td>
<td>82.7</td>
<td>57.0</td>
<td>20.7</td>
<td>23.7</td>
<td>27.4</td>
</tr>
<tr>
<td></td>
<td>Disposed</td>
<td>18.0</td>
<td>54.5</td>
<td>82.7</td>
<td>86.1</td>
<td>20.7</td>
<td>44.5</td>
<td>27.4</td>
</tr>
<tr>
<td>Others (egg shells, seafood, flower)</td>
<td>Generated</td>
<td>2.2</td>
<td>2.6</td>
<td>0.9</td>
<td>0.6</td>
<td>2.7</td>
<td>3.1</td>
<td>0.0</td>
</tr>
<tr>
<td></td>
<td>Disposed</td>
<td>2.2</td>
<td>6.7</td>
<td>0.9</td>
<td>0.9</td>
<td>2.7</td>
<td>5.8</td>
<td>0.0</td>
</tr>
<tr>
<td>Total</td>
<td>Generated</td>
<td>85.0</td>
<td>100</td>
<td>145.0</td>
<td>100</td>
<td>87.5</td>
<td>100</td>
<td>114.0</td>
</tr>
<tr>
<td></td>
<td>Disposed</td>
<td>33.0</td>
<td>100</td>
<td>96.0</td>
<td>100</td>
<td>46.5</td>
<td>100</td>
<td>64.9</td>
</tr>
<tr>
<td>Disposed/Generated</td>
<td>%</td>
<td>38.8</td>
<td>66.2</td>
<td>53.1</td>
<td>56.9</td>
<td>42.0</td>
<td>45.7</td>
<td>53.9</td>
</tr>
</tbody>
</table>

Note: * the average generation-based composition is determined by Equation 2.6 (2)
APPENDIX B

COMPOSTING TRIAL
Table B.1 The Record of Weigh of the Daily Feedstock

<table>
<thead>
<tr>
<th>Date</th>
<th>Fruit Waste</th>
<th>Yard waste</th>
<th>Vegetable Waste</th>
<th>Additives</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Composition</td>
<td>Weight (kg)</td>
<td>Weight (kg)</td>
<td>Composition</td>
</tr>
<tr>
<td>29-Jun</td>
<td>litchi fruit, mango, pine apple, water lemon,</td>
<td>35.2</td>
<td>leaves, tree trimmings</td>
<td>35.4</td>
</tr>
<tr>
<td></td>
<td>rambutan, mango, pine apple, water lemon,</td>
<td>48.7</td>
<td>leaves, tree trimmings</td>
<td>7</td>
</tr>
<tr>
<td>1-Jul</td>
<td>rambutan, mango, pine apple, water lemon,</td>
<td>45</td>
<td>leaves, tree trimmings</td>
<td>7</td>
</tr>
<tr>
<td>4-Jul</td>
<td>rambutan pine apple, water lemon, mangosteen</td>
<td>43.5</td>
<td>leaves, pine needle</td>
<td>7.2</td>
</tr>
<tr>
<td>5-Jul</td>
<td>pine apple, watermelon, plum</td>
<td>38</td>
<td>leaves, pine needle</td>
<td>3.4</td>
</tr>
<tr>
<td>7-Jul</td>
<td>litchi fruit, pine apple, water melon, rambutan</td>
<td>41.4</td>
<td>pine needle, leaves</td>
<td>6</td>
</tr>
<tr>
<td>10-Jul</td>
<td>litchi fruit, pine apple, water melon, rambutan, mango, mangosteen, plum</td>
<td>89</td>
<td>pine needle</td>
<td>3</td>
</tr>
</tbody>
</table>

Sub-Total | 340.8 | 62.1 | 241.4 | 57.6 |

Total | 701.9 |
B.2 Calculation of C: N Ratio:

According to on-farm composting handbook (Rynk et al., 1992)

<table>
<thead>
<tr>
<th>Elements</th>
<th>Minimum C:N ratio</th>
<th>Maximum C:N ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vegetable waste</td>
<td>11:1</td>
<td>13:1</td>
</tr>
<tr>
<td>Fruit waste</td>
<td>20:1</td>
<td>49:1</td>
</tr>
<tr>
<td>Yard waste</td>
<td>40:1</td>
<td>80:1</td>
</tr>
</tbody>
</table>

The minimum C:N ratio of waste collected from hotels: \[ \frac{11*340.8 + 20*62.1 + 241.4*40}{340.8 + 62.1 + 241.2} = 20.9 \]

The maximum C:N ratio of waste collected from hotels: \[ \frac{13*340.8 + 49*62.1 + 241.4*80}{340.8 + 62.1 + 241.2} = 38.2 \]
<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Ambient Air</th>
<th>Composting heap</th>
<th>Temperature (F)</th>
<th>Temperature (F)</th>
<th>Average Temperature (F)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Temperature (F)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-Jul</td>
<td>10:00 a.m.</td>
<td>82 (27.8°C)</td>
<td>sunny</td>
<td>point 1: 120</td>
<td>48.9°C</td>
<td>117.5 (47.5°C)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>point 2: 115</td>
<td>46.1°C</td>
<td></td>
</tr>
<tr>
<td>4-Jul</td>
<td>9:00 a.m.</td>
<td>82.5 (28.1°C)</td>
<td>sunny</td>
<td>point 1: 115</td>
<td>46.1°C</td>
<td>117.5 (47.5°C)</td>
</tr>
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<td></td>
<td>point 2: 120</td>
<td>48.9°C</td>
<td></td>
</tr>
<tr>
<td>5-Jul</td>
<td>10:00 a.m.</td>
<td>81 (27.2°C)</td>
<td>rainy</td>
<td>point 1: 127</td>
<td>52.8°C</td>
<td>123.5 (50.8°C)</td>
</tr>
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<td>point 2: 120</td>
<td>48.9°C</td>
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<td>6-Jul</td>
<td>10:00 a.m.</td>
<td>82 (27.8°C)</td>
<td>sunny</td>
<td>point 1: 130</td>
<td>54.4°C</td>
<td>131.5 (55.3°C)</td>
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<td>point 2: 133</td>
<td>56.3°C</td>
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<td>7-Jul</td>
<td>10:00 a.m.</td>
<td>83 (28.3°C)</td>
<td>sunny</td>
<td>point 1: 127</td>
<td>53.6°C</td>
<td>128.5 (53.6°C)</td>
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<td>54.4°C</td>
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<td>10:00 a.m.</td>
<td>80 (26.7°C)</td>
<td>rainy</td>
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<td>50.0°C</td>
<td>123.5 (50.0°C)</td>
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<td>point 2: 125</td>
<td>51.1°C</td>
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<td>10-Jul</td>
<td>10:30 a.m.</td>
<td>76 (24.4°C)</td>
<td>sunny</td>
<td>point 1: 141</td>
<td>60.0°C</td>
<td>124 (51.1°C)</td>
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<td>point 2: 110</td>
<td>43.3°C</td>
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<td>-</td>
<td>sunny</td>
<td>point 1: 117</td>
<td>47.2°C</td>
<td>125.5 (51.9°C)</td>
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<td>123.5 (50.8°C)</td>
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<td>48.9°C</td>
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<td>13-Jul</td>
<td>10:00 a.m.</td>
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<td>sunny</td>
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<td>110 (43.3°C)</td>
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<td>46.1°C</td>
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<td>rainy</td>
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<td>41.7°C</td>
<td>106 (41.1°C)</td>
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<td>16-Jul</td>
<td>8:00 a.m.</td>
<td>73 (22.8°C)</td>
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<td>17-Jul</td>
<td>8:00 a.m.</td>
<td>75 (23.9°C)</td>
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<td>40.6°C</td>
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<td>18-Jul</td>
<td>8:30 a.m.</td>
<td>80 (26.7°C)</td>
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<td>40.6°C</td>
<td>104.5 (40.3°C)</td>
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<td>19-Jul</td>
<td>9:00 a.m.</td>
<td>77 (25.0°C)</td>
<td>sunny</td>
<td>point 1: 105</td>
<td>40.6°C</td>
<td>104 (40.6°C)</td>
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<td>point 2: 103</td>
<td>39.4°C</td>
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<tr>
<td>20-Jul</td>
<td>9:00 a.m.</td>
<td>79 (26.1°C)</td>
<td>rainy</td>
<td>point 1: 112</td>
<td>44.4°C</td>
<td>111 (43.9°C)</td>
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<td>point 2: 110</td>
<td>43.3°C</td>
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<td>22-Jul</td>
<td>4:00 p.m.</td>
<td>75 (23.9°C)</td>
<td>rainy</td>
<td>point 1: 105</td>
<td>40.6°C</td>
<td>105 (40.6°C)</td>
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<td>40.6°C</td>
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<tr>
<td>24-Jul</td>
<td>9:00 a.m.</td>
<td>75 (23.9°C)</td>
<td>rainy</td>
<td>point 1: 110</td>
<td>43.3°C</td>
<td>108.5 (42.5°C)</td>
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<td>point 2: 107</td>
<td>41.7°C</td>
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<tr>
<td>25-Jul</td>
<td>3:00 p.m.</td>
<td>74 (23.3°C)</td>
<td>cloudy</td>
<td>point 1: 105</td>
<td>40.6°C</td>
<td>104.5 (40.3°C)</td>
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<td>point 2: 104</td>
<td>40.0°C</td>
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<tr>
<td>26-Jul</td>
<td>9:00 a.m.</td>
<td>85 (29.4°C)</td>
<td>sunny</td>
<td>point 1: 105</td>
<td>40.6°C</td>
<td>105 (40.6°C)</td>
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<td>point 2: 105</td>
<td>40.6°C</td>
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<tr>
<td>27-Jul</td>
<td>9:00 a.m.</td>
<td>85 (29.4°C)</td>
<td>sunny</td>
<td>point 1: 103</td>
<td>39.4°C</td>
<td>102.5 (39.2°C)</td>
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<td>point 2: 102</td>
<td>38.9°C</td>
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<td>28-Jul</td>
<td>9:00 a.m.</td>
<td>75 (23.9°C)</td>
<td>rainy</td>
<td>point 1: 100</td>
<td>37.8°C</td>
<td>101 (38.3°C)</td>
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</table>
### Table B.4 Record of Moisture Content of the Compost Pile

<table>
<thead>
<tr>
<th>Date</th>
<th>Weight of dish with waste before heating (g)</th>
<th>Weight of dish with waste after heating (g)</th>
<th>Moisture (%)</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-Jul</td>
<td>405.5</td>
<td>83.5</td>
<td>79.4</td>
<td>after sorting (source- separated raw materials from hotels)</td>
</tr>
<tr>
<td>10-Jul</td>
<td>562.0</td>
<td>138.0</td>
<td>75.4</td>
<td>after 3rd turning</td>
</tr>
<tr>
<td>19-Jul</td>
<td>459.5</td>
<td>153.2</td>
<td>66.7</td>
<td>after 5th turning</td>
</tr>
<tr>
<td>27-Jul</td>
<td>350.0</td>
<td>156.0</td>
<td>55.4</td>
<td>after 7th turning</td>
</tr>
<tr>
<td>1-Aug</td>
<td>497.5</td>
<td>240</td>
<td>51.8</td>
<td>after the last turning (before curing)</td>
</tr>
</tbody>
</table>

Note: $^\circ F = \frac{9}{5} \times (^\circ C)$
<table>
<thead>
<tr>
<th>Problems</th>
<th>Possible Reasons</th>
<th>Trouble-shooting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waste Separation at Source</td>
<td>- Low participation level of hotels and their staff</td>
<td>- Lack of easily-accessible facilities</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Low awareness and understandings of source separation</td>
</tr>
<tr>
<td>Composting Process</td>
<td>- Odour (rotten smell)</td>
<td>- Material mixture low in bulking material</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Lack of oxygen or compacted material</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Too high in nitrogen</td>
</tr>
<tr>
<td></td>
<td>- High levels of flies</td>
<td>- Food remain are near surface and not covered</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Seepage water</td>
<td>- Material too wet</td>
</tr>
<tr>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Pile fail to heat</td>
<td>- Material too wet (especially moisture content &gt;60%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Small size pile (with the height of less than 1 m)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Low oxygen</td>
</tr>
<tr>
<td>Composting Quality</td>
<td>- High in foreign matter</td>
<td>- Mixed with plastics, metals, sand, etc.</td>
</tr>
<tr>
<td></td>
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</tr>
<tr>
<td></td>
<td>- Pathogens</td>
<td>- Low temperature</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Infected by external factors.</td>
</tr>
</tbody>
</table>