AUDIT AND SEPARATION OF COMPOSTABLE SOLID WASTES AT HOUSEHOLDS IN DANANG, VIETNAM

by

Nguyen Thi Thuc Thuy

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ABSTRACT

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Nguyen Thi Thuc Thuy

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Department of Civil Engineering, University of Toronto

The quantity of compostable waste and residents' willingness to separate waste at home are important to the feasibility of a waste composting program. In order to estimate the proportion and quantity of compostable waste for a composting program in Danang, Vietnam, a two-week waste-audit was conducted at 74 representative households in the city. The results show that 63% of residential waste (an estimate of approximately 239 tonnes discharged daily for the city) is compostable. Consequently, a composting program could significantly reduce the amount of this waste going to Danang landfills.

Following the two-week audit, a one-week pilot project of at-source compostable waste separation was conducted in 67 residences. The results show the high purity of the separated compostable waste and an ability of residents to differentiate wastes properly. As well, the high number of participants (44 out of 67) separating waste correctly indicates their willingness to participate in a waste separation program.

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I. INTRODUCTION

The research presented in this report addresses waste management in Danang, Vietnam and was done as part of a capacity-building program on waste and the economy (WASTE-ECON program) in Vietnam, Laos and Cambodia.

1.1. GENERAL OVERVIEW OF VIETNAM

Figure 1.1 Map of Vietnam

The Socialist Republic of Vietnam is located in Southeastern Asia and bordered by China in the north, Laos in the northwest and Cambodia in the southwest (Figure 1.1). It has the total area of 329,560 km^2 and the population of approximately 82,689,518 people in July 2004 *(CIA, 2004)*. Vietnam has primarily an agricultural economy, with 63% of the labour force in agriculture and 37% in industry and services *(CIA, 2004)*.

Several decades ago, Vietnam was not overly concerned about solid waste issues because of its poor economic status which had not recovered yet after the war. As well, not a lot of garbage was generated. Solid waste was dumped freely into rivers or burnt outside. However, Vietnam has achieved rapid economic growth since the introduction of the new reform policy called 'Doi Moi' in December, 1986. As a result, the amount of solid waste has been rapidly increasing in recent years *(JBIC, 2005)*. The average daily quantity of solid waste generated in Vietnam was 16,237 tonnes in 1996 and 19,315 tonnes in 1997. This increased to 22,210 tonnes per day in 1998 *(Solid Waste State and Impact, 2001)*. Therefore, Vietnam faces environmental pollution and human health problems resulting from the improper control of solid waste discharge. As the economy develops, an enhancement of life quality is also required. Thus, there have been more considerations about solid waste management in order to reduce pollution, especially in Vietnam's large cities. For example, for the last 2-3 years, many urban centres have started to invest in the installation of incinerators for the treatment of hazardous solid wastes released by hospitals *(Environmental concerns, 2001)*.

1.2. SOLID WASTE MANAGEMENT IN DANANG CITY

Danang, which is located in the central part of the country (see figure 1.1), is the fourth largest city in Vietnam. Danang is bordered by Hue Province to the north; Quang Nam Province to the south and west; and the Eastern Sea to the east. It is 764 km south of Hanoi, the capital of Vietnam, and 964 km north of Hochiminh City *(Danang City – Preface, 2004)*. In 2003, the total population of Danang was about 747,100 people *(General Statistics Office of Vietnam, 2005)*.

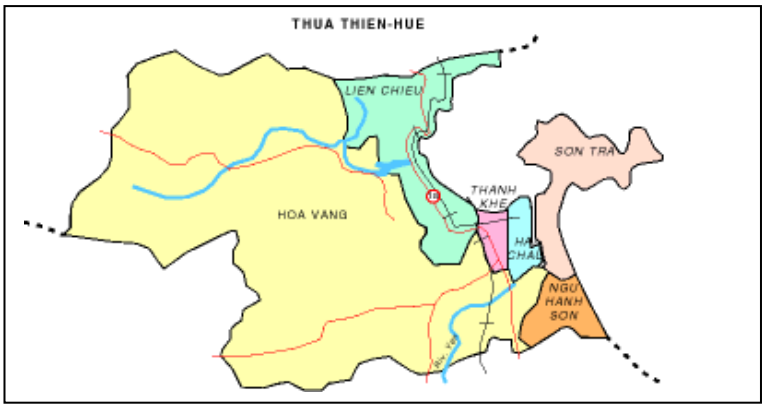


Figure 1.2 Map of Danang City

URENCO Danang is the company in charge of managing solid waste generated in Danang. In 2004, the estimated quantity of waste collected from residential areas was roughly 400 to 500 tonnes per day *(Tran, V.T., 2004)*. URENCO, which collects solid waste in Danang's five urban districts, but not the suburban one, collects approximately 85% of the total quantity of solid waste discharged by the residential sector. Consequently, URENCO collects waste from approximately 149,420 households *(Tran, V.T., 2004)*. URENCO uses motor-vehicles and tricycles (which are pulled by hand or ridden) for waste collection. URENCO does not separate waste neither before nor after collecting it, though an "informal sector" of waste pickers scavenge for recyclables. The collected wastes are taken either first to one of the three transfer stations and then to the landfill or directly to the city's Khanh Son landfill.

A composting plant, with a capacity of 23,000 tonnes per year, is expected to be built on the old landfill site sometime in the near future *(Tran, V.T., 2004)*. URENCO believes that the plant would be suitable for handling Danang's waste since the waste from residences has been estimated to be mostly composed of organic matter (50%); the remainder is inert waste (20%), purchasable materials, such as plastic, nylon, aluminum, and construction debris *(Tran, V.T., 2004)*. However, for the operation of the composting plant to be successful (i.e. have good quality compost end products), Danang's waste must be properly separated before the composting process occurs.

1.3. COMPOSTING AND SEPARATING COMPOSTABLE WASTE

Composting is a process in which compostable matter (e.g. compostable waste) biologically decomposes to a complex and stable material *(Ecorecycle, 2003)*, which is very useful for agriculture and landscaping. In aerobic composting, micro-organisms break down the compostable material using the oxygen in the air to produce carbon dioxide, water and the stabilized granular residue known as compost *(Organic and food, 2005)*.Various types of compostable wastes are suitable for composting. Primary compostable wastes from households are mostly food waste, residuals of raw materials for cooking, and garden waste. These compostable materials are easily degradable and can be composted to produce soil-conditioning fertilizer.

Composting has three major phases. First, inert materials (glass, plastic, metal, etc.) are separated out and the remaining compostable waste is reduced in size to enhance microbial reactions. Then, the material is placed in a pile, and microorganisms decompose it into simpler compounds. In this phase, heat generated due to metabolic activities destroys many pathogens and the volume of the compost pile is reduced. Finally, the compost product is "cured", a process during which the microorganisms slow down their activities because they start to use up the nutrients available in the pile. Consequently, heat is not generated and the mass dries to a mature or stable material.

Compost product can be used as soil fertilizer which has various agricultural benefits. *(Rytz, 2001)*. Compost product:

- improves the structure of soil which allows better water and air circulation by stimulating biological activities;
- contains nutrients and trace elements which enhance the soil fertility;
- releases nutrients slowly because they are in the organic form, which makes them available through the whole growing season;
- improves moisture retention which is very good in the dry season; and
- reduces soil erosion.

Moreover, composting waste reduces the amount of waste going to the landfill, and thus, increases the landfill's lifespan. This reduces expenditures on building another landfill for a while, and reduces pollution caused by landfilling activity, which is currently the only method of disposing waste in Danang. For example, leachate from landfills can

contaminate ground and surface water, and pathogenic organisms, harmful insects and weed seeds can be released into the environment. Moreover, gas emissions (e.g., methane [CH_4], carbon dioxide [CO_2], and sulfur hydroxide [H_2S], etc.) produced by the decomposition of compostable matters in landfills contribute to climate change, and since they are highly flammable, they pose a risk of explosion if not properly managed.

However, if inappropriate feed materials are used or the compost process is not properly run, low quality compost (i.e., containing inert materials such as glass, and contaminants such as heavy metals) will be produced. Depending on the quality, the compost products may not be used or sold. It is therefore very important to carefully separate the compostable waste from the mixed waste before composting.

Two methods of separating compostable waste from the waste stream are popular now. The first one is to separate compostable waste at the generation source and the second one is to separate it after the waste collection.

a. Residential waste separation at source

Compostable and non-compostable waste are sorted by household members and stored in two different containers. For this system to work, an advanced collection regimen is required. In Vietnam, where the temperature is always high (around 35^{o}C) throughout the year, compostable waste easily decomposes and this generates unpleasant odours. Therefore, compostable waste must be collected daily or at least every two days; non-compostable waste can be collected less frequently though households have limited space for holding these materials. Once separated at source, compostable waste can be transported to a composting plant, where machines can sort it again before composting. This procedure helps increase the quality of compost products. Meanwhile, the separated non-compostable waste is transported to a landfill for disposal.

At-source waste separation has certain advantages. Most importantly, it increases awareness of environmental protection issues. When a program of at-source waste separation is launched, extensive educational activities will have to occur. These will increase resident awareness of the importance of separating compostable waste. Participating in such a program at home every day can repeatedly remind those involved that they are protecting the environment. Moreover, if residents have the ability to differentiate waste, separating waste at source can ensure the quality of the compostable

waste, thus increasing the quality of compost products. This can also reduce the need for further sorting at a composting plant.

However, this method has several disadvantages. It depends on both the residents' willingness to participate in the program and their ability to differentiate waste properly. These circumstances require the consideration of two specific scenarios. In the first, residents are willing to participate in a waste separation program but they cannot differentiate compostable waste from non-compostable waste; therefore, their separated waste may have low quality. However, residents can learn to distinguish compostable from non-compostable waste through educational activities conducted in their communities. But this, in turn, requires expenditures. The second scenario is less optimistic: residents do not want to participate in the program. This can result in poorly separated wastes and/or inadequate quantities of compostable feedstock.

A second drawback of the waste separation at source is an increase in the costs of collecting and transporting waste in order to collect two types of wastes (compostable and non-compostable separately) and then transporting these wastes to two different places: composting plants for compostable waste and landfills for non-compostable waste. In developing countries, it is more popular to situate a composting plant on the landfill site in order to reduce the cost of transporting two types of waste *(Sound practices-Composting)*.

There is a significant interest in at-source waste separation in some areas of Vietnam. In Hochiminh City, two projects were proposed, one for a single district of Hochiminh City, district 5 *(Infrastructure and Transportation Company of district 5, 2003)* and one for the entire Hochiminh City *(Urban Sanitation Company of Hochiminh City, 2002)*. In addition, several existing programs of at-source waste separation have been conducted in Hanoi, Hochiminh City and the province of Quangnam, which will be discussed in detail in section 2.2.

b. Residential waste separation at waste facility

In contrast to the above method, waste separation at a waste facility does not require resident participation or depend on the ability of residents to differentiate wastes. Mixed waste (compostable and non-compostable together) is collected and then transported to destinations, such as transfer stations, landfill sites, or composting plants where workers separate compostable from non-compostable waste. Various methods, including mechanical, can be used for this procedure. Non-compostable waste is then transported to a

landfill while compostable waste goes to a composting plant. There are, therefore, additional costs to separate the wastes, and, depending on the location of facilities, to transport the separated wastes.

1.4. PURPOSE AND THE SCOPE OF THE PROJECT

This project addresses the potential for separating compostable and non-compostable wastes at the household level in Danang, and had the following four main objectives:

- review several selected existing programs of at-source waste separation in Vietnam;
- estimate the average amount, as well as percentages, of compostable waste in household waste in Danang;
- estimate the effectiveness of a program of at-source residential waste separation; and
- based on the above, offer recommendations on an compostable waste separation program for Danang.

The research primarily consisted of a waste audit and a pilot project of at-household waste separation at 70 households in two areas of Danang in July 2004.

1.5. ORGANIZATION OF THE REPORT

The remainder of this report is organized as follows. In Chapter 2, information on waste management in Danang is addressed in detail, and several existing programs of at-source waste separation in Vietnam (especially in Hanoi Capital and Hochiminh City) are presented in order to provide information on the feasibility or failure of waste separation programs.

In Chapter 3, the methodology for the study in Danang is presented in detail. This includes descriptions and explanations of the study area and the choice of representative households, the waste audit and pilot separation project, and two surveys conducted by the College of Technology in Danang before and after the pilot project.

In Chapter 4, the results of each part of the study described in Chapter 3 are presented along with analyses and discussions of these results.

In Chapter 5, conclusions and recommendations concerning compostable waste separation are presented. Recommendations on further research are also proposed in this chapter.

II. SOLID WASTE MANAGEMENT IN DANANG AND AT-SOURCE SEPARATION PROJECTS IN VIETNAM

This chapter provides an overview on solid waste management in Danang and on several programs of at-source residential waste separation in some areas of Vietnam.

2.1. SOLID WASTE MANAGEMENT IN DANANG, VIETNAM

URENCO Danang is contracted by the government to collect and dispose of all types of Danang's solid waste. However, URENCO collects solid waste mostly in urban areas but not in rural areas. The collected waste is currently disposed of in the city's Khanh Son landfill.

2.1.1. Quantity of solid waste collected

In 2004, the total quantity of waste collected from residential areas was estimated to be 400 to 500 tonnes per day *(Tran, V.T., 2004)*. During the Lunar New year holiday, the waste quantity increased to 2,000 tonnes per day (equal to 4,000 m^3 per day) *(Transfer station model in Danang City, 2003)*. In 2003, the total quantity of solid waste collected in the city was 208,000 tonnes of which about 149,000 tonnes was from the residential sector *(Tran, V.T., 2004)*. URENCO, which collects wastes from only the five urban districts (Hai Chau, Thanh Khe, Lien Chieu, Son Tra, Ngu Hanh Son districts), collected approximately 85% of the total quantity of waste discharged by the residential sector of the city, the equivalent of roughly 149,420 households *(Tran, V.T., 2004)*.

Figure 2.1 A tricycle carries a waste collection-container

2.1.2. Waste collection activity

URENCO has 68 motor-vehicles (with the capacity of 16 tons, 3 tons, 7 tons, 5 tons, and 10 tons), and 120 tricycles[1] to collect and transport waste. Motor vehicles (i.e., compactor trucks) are used in some areas

[1] Most tricycles are powered by male workers like bicycles, but with three wheels. Few tricycles powered by female workers are wheeled carts.

surrounding Lien Chieu district, Son Tra district, and Ngu Hanh Son district. Tricycles are used to carry either waste collection-containers or waste curbside-containers to the rest of Danang's residential areas *(Tran, V.T., 2004)* (see Figure 2.1). Waste collection-containers are containers that a waste collector carries on his tricycle to collect waste door-to-door.

Waste curbside-containers are containers placed on appointed places along large or medium roads and close to residential areas. In areas in which the streets are too narrow for waste collection tricycles to go in, people have to place their waste on sidewalks of large or medium roads, or into curbside-containers. In Danang, there are about 4,000 curbside-containers with a capacity of 660L each *(Tran, V.T., 2004)*. The tricycles are used to carry empty curbside-containers to replace the full ones and then bring the full ones back to transfer stations for unloading the waste. This container is cleaned by an automatic cleaning machine and ready for being carried to other places to replace the full one.

Figure 2.2 Dong Da market transfer station

Currently, URENCO operates three transfer stations which are located in Dong Da market (Figure 2.2), Nguyen Tri Phuong Park, and Phan Thanh Tai Street. Compared to other provinces in Vietnam, these transfer stations are an advanced waste facility with multi-functions that URENCO invented to handle Danang waste. They were built close to large markets or residential areas but they do not pollute the environment because they are operated in an enclosed environment. The collected waste is unloaded into a closed room in which waste is sprayed with EM (Effective Micro-Organisms) chemical to reduce bad odours. The waste is then compressed in a large container which is delivered to the landfill by a truck. Each transfer station can receive and compress about 30 m^3 of waste in two hours *(Transfer station model in Danang City, 2003)*. URENCO estimated that approximately 17 transfer stations would be needed to handle waste of the entire city *(Tran, V.T., 2004)*.

The current procedures of collecting waste are summarized as follows:

- In the areas having transfer stations:

  + *Areas in which waste-collection tricycles can not collect directly;*

    Garbage (from households) → waste curbside-containers along medium or large streets → collected by tricycles → carried to transfer stations → closed-compressed into ten-ton containers → Garbage trucks carry ten-ton containers to the Khanh Son landfill site.

  + *Areas in which waste- collection tricycles can collect directly;*

    Garbage (from households) → collected by collection tricycles → carried to transfer stations → close-compressed into ten-ton containers → Garbage trucks carry ten-ton containers to the Khanh Son landfill site

- In the areas which have no transfer station:

  + *Areas in which waste collection tricycles can not collect directly;*

    Garbage (from households) → placed in waste curbside-containers along medium or large streets → loaded into closed-compressed trucks → carried to the Khanh Son landfill site.

    Garbage (from households) → collected by closed-compressed trucks → carried to the Khanh Son landfill site.

  + *Areas in which waste collection tricycles can collect directly;*

    Garbage (from households) → collected door-to-door by waste collection tricycles → loaded into closed-compressed trucks → Khanh Son landfill site

➢ *Note: in the future, URENCO intends to collect waste from curbside-containers located along the large or medium streets instead of using collectors to collect waste door-to-door (Tran, V.T., 2004).*

2.1.3. Waste collection fee

The waste collection fee for each household varies depending on the width of the road on which the household is located. It also depends on whether the household runs a business at home. Information about waste collection fees according to Danang's new regulation is

presented in Table 2.1, as obtained from an interview with an officer of URENCO Danang *(Tran, V.T., 2004)*. As seen in the table, the collection fee for households on small roads is lower than that of other roads. The purpose of this fee system is to encourage residents to pay the collection fee because most residents living in small road areas have low income. In addition, there is a cross compensation strategy which allows money from high-income areas to subsidize low-income areas. For example, approximately 30,000 VND per month is paid by each commercial store and about 80,000 VND per m^3 of waste is paid by restaurants. (VND is a Vietnam Dong. $1.00 U.S. is equivalent to approximately 16,000 VND.)

Table 2.1 Waste collection fee in Danang *(Tran, V.T., 2004)*

Type of road	Collection method	Collection fee (VND/month/household)
Large roads	Truck (2 times/day)	15,000
Medium and small-medium	Tricycle, door-to-door (1 time/day)	8,500
Small	No waste collection, using waste curbside-containers	4,000

The collection fees from residences contribute to the operation of the city's waste management system. The collection fee from residential and non-residential sources covers 45% of the total cost for the system. The rest, 55%, comes from the governmental budget.

2.1.4. Waste disposal activities

The Khanh Son landfill, which is 15 km from Danang City, is the only landfill of the city. This landfill was expected to be closed by the end of 2004. A new landfill will be built 2 km away from the original site with the total area of 50 ha. Its expected life-span is about 50 years without accounting for the source separation and composting activities *(Tran, V.T., 2004)*. This long expected lifetime of the new landfill (i.e., 50 years) may be a problem for any future programs of at-source waste separation and composting plants because simply dumping waste in the landfill is cheaper than separating and composting the compostable fraction.

A composting plant, with the capacity of 23,000 tons per year, is planned to be built in the old landfill site *(Tran, V.T., 2004)*. The plant is planned to be built in the old landfill instead of in the new one since the old landfill already has the infrastructure of an old composting plant that has not been in use for a long time due to its low efficiency in producing good quality compost

products. The new plant is initially designed to receive mixed waste. Also, this plant is planned to be equipped with advanced technology waste separators. As a result, the new plant is expected to avoid problems of bad quality feed-in material which contributed to the failure to the previous plant *(Tran, V.T., 2004)*. However, since the tendency of separating waste at source is being encouraged by Vietnam government *(Nguyen, T.S., 2004)*, this plant would receive only separated compostable waste if a program of at-source waste separation is implemented in Danang.

2.1.5. Salary of sanitary workers and waste collectors

Depending on their tasks, waste collectors earn on average 850,000VND (approximately $56 U.S.) per month. Sanitary workers in transfer stations or landfill sites have a higher salary due to the higher risk associated with working in these locations.

2.2. SEVERAL PROGRAMS OF AT-HOUSEHOLD WASTE SEPARATION

Several programs, projects or pilot projects on organic/compostable waste separation at households have been conducted in some areas in Vietnam, especially in large cities, such as Hanoi and Hochiminh City.

In other to have information about several programs of at-source waste separation that have been taken place in other parts of Vietnam, formal interviews with people responsible for these programs were conducted (see Appendix 2.A).

In Hanoi, with the purpose of observing the operation of two programs of at-source waste separation, the researcher followed two hand-carts in Sai Dong community (Gia Lam district's program) and collection trucks collecting compostable waste in Phanchutrinh ward (Phanchutrinh ward's program). Through these observations, the researcher learned differences between two ways of collecting separated wastes by two companies (Gia Lam Urban Sanitation Enterprise versus URENCO Hanoi). The two observed collection methods in Hanoi can be used in further studies about at-source waste separation in Danang.

2.2.1. In Hanoi

a) Program in Gia Lam district

Gia Lam Urban Sanitation Enterprise is in charge of an at-source compostable waste separation program in Gia Lam district. This program is taking place in three communities: (i) Sai Dong community (started in June 2001); (ii) Duc Giang community (since this area is large, it was divided into three sub-areas that started separating compostable waste in June 2002, August 2002 and November 2002); and (iii)Yen Vien community (started in April 2003) *(Nguyen, H.N., 2004)*. Table 2.2 shows the population and number of residents participating in the program, and that most residents are participating. Duc Giang has the highest population and the highest number of households participating in the program. Duc Giang community is more urbanized than Sai Dong community and in turn, Sai Dong community is more urbanized than Yen Vien community.

Table 2.2 Population and number of households participating in the program of compostable waste separation at source

Communities	Sai Dong	Duc Giang	Yen Vien
Population (person)	11,920	21,000	10,000
Total households (household)	3,920	7,500	2,675
Number of households agree to separate compostable waste (households)	3,794	5,500 (*)	2,020
Percent of households participating in separating compostable waste (%)	96.8	73.3	75.5

Source: Gia Lam Urban Sanitation Enterprise. Hanoi, June 2004 (Nguyen, H.N., 2004)

(*) Japan Bank for International Cooperation (2004) JIBC Pilot Study

Compostable and non-compostable waste is stored in red and blue waste bins, respectively, by residents. These bins were distributed free of charge by the Gia Lam Urban Sanitation Enterprise from the beginning of the program. Every day in each area, two waste collectors push two hand-carts (as seen in Figure 2.3) to collect waste door-to-door on medium and large roads. If the road is too small for a hand-cart to collect waste door-to-door, waste collectors stand in a larger road and wait for the residents to bring their waste out to the hand-carts. When the carts are full, the collectors take them to waste transfer places for unloading. Figure 2.4 shows a waste transfer place in Sai Dong community in which two different types of waste are placed in two piles. The collectors continue using the now empty carts to collect waste in

other areas. At about 7 pm, two compactor trucks take all the waste from the transfer places to the dumping site and the composting plant at Kieu Ky.

Figure 2.3 A resident dumps waste into two hand-carts in Sai Dong

Figure 2.4 A waste transfer place in Sai Dong community

In general, the quantity of compostable waste collected was estimated to be about 0.6 kg per person. The amount of compostable waste collected in the year 2003 is shown in Table 2.3. Table 2.4 summarizes the monthly quantity of separated compostable waste collected in 2004. The average amount of compostable waste collected daily is shown in Table 2.5.

Table 2.3 Total amount of compostable waste collected in 2003

Community	Quantity (tons/year)
Sai Dong	1,116.64
Duc Giang	2,299.19
Yen Vien	617.42 (from May to Dec, 2003)

Source: Gia Lam Urban Sanitation Enterprise, Hanoi, June 2004 (Nguyen, H.N., 2004)

Table 2.4 Amount of compostable waste collected in each month in 2004 (tonnes)

Months	Sai Dong	Duc Giang	Yen Vien
January	102.5	178.55	113.9
February	94.4	179.46	104.85
March	104.91	231.28	128.17
April	114.54	206.99	132.84

Source: Gia Lam Urban Sanitation Enterprise, Hanoi, June 2004 (Nguyen, H.N., 2004).

Table 2.5 Average amount of compostable waste collected daily

Community	Quantity (tonnes/day)
Sai Dong	2.3-2.5
Duc Giang	6.5-7
Yen Vien	3.5-4

Source: Gia Lam Urban Sanitation Enterprise, Hanoi, June 2004 (Nguyen, H.N., 2004)

The separated compostable waste consists of about 95% compostable matter *(Nguyen, H.N., 2004; Japan Bank for International Cooperation, 2004*), which means that 5% is non-compostable mixed with the compostable waste. In the Kieu Ky composting plant, compostable matter is mixed with chemicals and left to mature for six months. Then the mature product is screened to sort out non-biodegradable materials and it is then used for agricultural purposes.

The waste separation program conducted in the three communities in Gia Lam district can be considered successful compared to other programs which will be discussed later because (i) over 73% of households participated in the program and (ii) the purity of the separated compostable waste was 95%. Moreover, this program also includes a composting plant receiving compostable waste from the waste streams which gives an important solution for the waste reduction. However, no data shows the positive revenue from the program due to the lack of market for composting products which could be caused by a number of different reasons but not because of the low quality of compost products. This program shows that the residents have the willingness and the ability to separate waste effectively.

b) Program in Phanchutrinh ward

A program of waste separation at households was started by URENCO Hanoi in October 2003 and is still in operation. The first pilot area of this program was Phanchutrinh ward. URENCO wanted to extend this program to two other wards by the end of 2004 *(Nguyen, V.D., 2004)*.

A report of URENCO *(URENCO Hanoi, 2003)* contains general information about Phanchutrinh ward. Phanchutrinh ward has a total area of 0.48 km^2 with 1719 households (approximately 8000 people). It includes eight residential blocks, six schools, 120 offices and enterprises, two markets, and a park. In this ward, about 11 tonnes of waste are generated daily, of which 40% is compostable waste. URENCO chose Phanchutrinh ward for this program for the following reasons: (i) the population density is not too high (8,000

persons/0.48km^2); (ii) the social and living conditions are typical for Hanoi residents; (iii) most of the infrastructure has been built recently; and (iv) the majority of residents have a high educational level.

To investigate residential opinion on the compostable waste separation program, URENCO conducted a survey in Phanchutrinh ward before launching the program. URENCO encouraged residents to participate in the program through numerous community meetings and distributed information leaflets (See Appendix 2.B). The company also had contracts with the local residents, which is a legal paper having residents' signatures to indicate that they agree to participate in the project. At the beginning of each month, each household was given for free two types of plastic bags, black (for non-compostable waste) and white (for compostable waste) to separate their waste accordingly.

The compostable and non-compostable wastes are collected as follows:

* *For residential houses along and close to large streets*: Waste bags are carried by the residents to assigned places along the streets. At each place, two rectangular signs with two colors, which are about 3 meters far away from each other, were drawn on the pavement corresponding to the colors of the nylon bags. Residents place each of their two waste bags onto the corresponding rectangular drawing. Two waste trucks come and pick up waste bags (Figure 2.5), one truck for the compostable wastes and one for the non-compostable wastes. However, the residents sometimes store non-compostable waste in white bags and compostable waste in black bags, or they use bags with other colors rather than white and black to keep their wastes (see in Figure 2.5). Therefore, waste collectors have to check carefully the types of waste in the bags before picking it.

* *For residential houses far away from large streets:* Waste bags are collected by two 600 L hand-carts, which are colored corresponding to the color of the bags, and carried to "meeting points" on larger streets. There, the bags are loaded onto two waste trucks (Figure 2.6), one for compostable wastes and one for non-compostable wastes.

In both cases, the compostable waste is transported by a compactor truck with the capacity of 3.5 tonnes to the Cau Dien composting plant for composting purpose. Non-compostable waste is carried to the Nam Son landfill site by a six-ton truck for being buried.

Figure 2.5 Waste collector picks organic waste bags from appointed locations and dumps into the truck

Figure 2.6 Hand-cart unloads organic waste into the truck after collecting this waste in small roads

In Phanchutrinh ward, 14 hand-carts are used to collect wastes from households living along narrow roads, and 46 places along large streets are assigned for keeping waste bags. Time to collect waste is from 6pm to 10pm. Waste collectors use hand-bells to announce the pick-up. URENCO also encourages households to separate plastic, metal, glass and wood from the waste stream for recycling purposes.

The program has achieved the following results:

About 2 tonnes of separated compostable waste and 8 tonnes of separated non-compostable waste are collected everyday *(URENCO Hanoi, 2003)*. The purity of the separated compostable waste was about 85% to 90% *(Nguyen, V.D., 2004)*, i.e., about 10% to 15% of the waste was non-compostable matter. The quantities of wastes varied depending on the time of the year. For example, in November 2003, about 55,105 kg of compostable waste and 225,900 kg of the other waste were collected, while in January 2004, 103,490 kg of compostable waste and 223,275 kg of non-compostable waste were collected for the full month. Approximately 12% to 38% of waste collected daily in November 2003 was compostable, while in January 2004, 26% to 43% of the daily collected waste was compostable *(URENCO Hanoi, 2003)*. The higher amount in January is due to the Lunar New Year celebrations when residents tend to consume a larger amount of food.

This pilot program serves local residents living in both narrow and large streets. It can be considered successful since the purity of the separated compostable waste is over 85% *(Nguyen, V.D., 2004)*. However, the ratio between the quantities of separated compostable and

separated non-compostable waste is 1:4 *(URENCO Hanoi, 2003)*, i.e., the percentage of compostable waste collected is only 20% of the total amount of waste in this ward. As a result, the amount of waste reduced from the waste stream going to the landfill through this program is not significant; as well, the amount of composting products in the output stream is slightly small. Moreover, additional fuel is consumed when the 3.5 ton truck goes around large streets several times to collect bags that some residents put out after the regular collection time.

c) Unsuccessful program in Kim Lien community

A pilot program of waste separation at households in Kim Lien community was conducted by URENCO Hanoi five years ago (1999). However, this pilot program could not continue after three months because of the lack of financial support from the government. Also, at that time, residents were asked to separate waste into four types (plastic, paper, organic and other waste), which was difficult for residents to follow. Moreover, after collecting the separated wastes, URENCO had no clear plans or means for treating those types of separated wastes, which discouraged the residents to continue separating their wastes *(Nguyen, V.D., 2004)*.

d) Pilot project in Trau Quy ward

This pilot project started in 2002 and was organized through the Agricultural University, Hanoi (Gia Lam district). It was first applied to three community groups (in Trau Quy ward) located near the University with the intention to expand to the whole ward. The population of Trau Quy ward is about 9600 people (up to December 2004) *(Dao, 2004a)*. The main purpose of the project is to encourage people in the ward to separate organic waste at the household level for composting. An educational program was conducted in the three community groups. During the educational program, posters (see Appendix 2.C) were distributed, and students went to each household to explain the organic waste separation program (Figure 2.7). Each household in the three community groups was provided with a waste bin to keep their organic waste (Figure 2.8). Then, waste collectors picked up the organic waste and took it to a pilot composting place at the Agricultural University.

An audit program of mixed waste collected from households in two sub-wards (Cuu Viet and An Phu) in December 2003 showed that the average quantity of organic waste per capita was approximately 0.49 kg/capita/day and that of inorganic waste per capita was approximately 0.17 kg/capita/day *(Pham, 2004)*. The rate between organic waste and inorganic waste is 3:1, which is similar to waste in rural areas. The high ratio between organic waste and inorganic

waste, as well as the agricultural activities of local residents, show that it is suitable to compost organic waste and then sell it for agricultural purposes in that same area. However, according to Dr. Dao Chau Thu *(Dao, 2004a)*, it is difficult to require residents to change their habits from throwing mixed waste into one waste bin to separating wastes and putting them into the corresponding types of bins. She also stated that in order to expand the separation program to the whole Trau Quy ward, it is necessary to have support from the government, such as providing waste bins or garbage bags, and launching extensive educational programs *(Dao, 2004a)*.

Figure 2.7 Distributing waste bins to store organic waste

Figure 2.8 Information and educational program for each resident

The average quantity and quality of separated organic waste (i.e., the percent of real organic waste contained inside separated organic waste bag of each household) per capita are shown in Table 2.6. This data comes from the results of a four-week survey from May to June 2004 in the three pilot communities.

As seen in Table 2.6, each person in these areas daily separated about 0.34 kg of organic waste with the high purity of 97.6%. This quantity is significantly lower than the quantity of

generated organic waste found in the audit in two sub-wards (Cuu Viet and An Phu): 0.34 kg/capita/day versus 0.49 kg/capita/day. One explanation for this difference is that in different areas, residents having different living and economic status generated different amount of organic waste *(UNEP International Environmental Technology Center, 1996)*. Another explanation may be that residents in the three communities put some of their organic waste into the inorganic waste stream due to their lack of ability to differentiate organic waste from inorganic waste. Moreover, since the quantity of waste generated also depends on the season of the year, the difference in the results of the two studies may come from the difference of season in which the studies were conducted. The waste audit was conducted in December, i.e. winter, while the waste survey was conducted in May and June, i.e. summer *(Dao, 2004b)*.

Table 2.6 Average quantity and quality of separated organic waste generated in 3 community groups

Community group	Number of households and residents	Quantity of separated organic waste (kg/person/day)	Purity of separated organic waste (%)
Group I	20 households (62 residents)	0.34	99.3
Group II	20 households (73 residents)	0.35	97.1
Group III	20 households (68 residents)	0.32	96.5
Total	60 households (203 residents)	0.34	97.6

Source: Report of "Collecting, separating and composting organic waste", September 2004 (Dao, 2004b).

An estimate of about ten tonnes of organic compost products were produced in 2004 *(Dao, 2004b)*. These fertilizers were initially given to local residents to produce chemical-free vegetables. The quality of composting products was examined in Italy and evaluated to be a good fertilizer *(Dao, 2004b)*.

However, while the initial plan was to expand this project to the whole Trau Quy ward, this is no longer possible because: (i) there is no available land for building a larger composting plant; and (ii) the waste collection activity of Trau Quy ward is now controlled by the Hanoi government, not by the ward itself as it was before 2004. Instead, the project is expected to be expanded to some community groups in Dang Xa ward, Gia Lam district in 2005 *(Dao, 2004b)*.

2.2.2. In Hochiminh City

a) Pilot project of compostable waste separation at source in sub-ward no. 3, ward 12, district 5

This project, known as "Sorting waste at source", started in June 1997 and lasted for two years. It is considered to have been the first residential at-source waste separation project in Vietnam. The project took place in sub-ward 3, ward 12, district 5, Hochiminh City. In the second year, the project expanded to the rest of ward 12 based on experiences obtained from the first year. ENDA (Environmental Development Action) Vietnam, ENCO (Environment Committee of Ho Chi Minh City), and the People Committee of ward 12, district 5 were partners of this project *(Doan, 1999)*. The program lasted for only two years due to the lack of financial support from the Vietnamese government after the first two years *(Doan, 2004)*.

This project received financial support from Siddhi-ENDA Mumbai Bombay – PRECEUP. The purposes of this project were: (i) to experiment on possibilities of sorting waste at source through verbal and visual communication activities; and (ii) to develop awareness and responsibility among households on waste management and the environmental impacts of solid waste separation at sources *(Bang et. al., 1999a)*.

The project provided a waste bin to each household for storing easy-decomposed waste *(Bang et. al., 1999a)*. An educational program was conducted with several activities, such as distributing leaflets, flyers, and posters (see Appendix 2.D). A group from Youth Union which is involved in investigating and protecting the environment (KBM), worked closely with residents to provide information on the type of waste that can be separated and how to separate them properly *(Bang et. al., 1999b)*.

Table 2.7 shows the results of a survey of at-source waste separation in 8 community groups in May 1999. Each community group had 7 to 40 households. As seen in table 2.7, the proportion of separated easy-decomposed waste was high (on average, 86.2%). Therefore, if the easy-decomposed waste generated in this area had been composted, the waste stream going to the landfill would have been reduced significantly.

Table 2.7 Average quantity of separated waste in community groups

Type of waste	Group 17 (9 houses) /24 days	Group 18 (40 houses) /24 days	Group 6 (7 houses) /24 days	Group 16 (25 houses) /24 days	Group 10 (17 houses) /31 days	Group 20 (24 houses) /31 days	Group 3 (18 houses) /31 days	Group 28 (19 houses) /31 days	Total
Easy-decomposed (kg)(*)	69.5 (88%)	646.9 (91.8%)	55.5 (86%)	346.2 (88.3%)	536.4 (89%)	682 (80%)	1219 (87.7%)	1211 (84.2%)	4766.5 (86.2%)
Difficult – decomposed (kg)(*)	9.5 (12%)	57.5 (8.2%)	9 (14%)	46.2 (11.7%)	66.8 (11%)	172 (20%)	171.6 (12.3%)	227.3 (15.8%)	759.9 (13.8%)
Total (kg)	79	704.4	64.5	392.4	603.2	854	1390.6	1438.3	5526.4

Source: ENDA Vietnam, 1999 (Bang et. al., 1999b)

Note: (*) There is no explanation about the terms "Easy-decomposed" and "Difficult – decomposed" in the original information source.

b) Pilot project in sub-ward 18, ward 3, district 11

This project focuses on encouraging a reduction in waste discharged into the Tan Hoa – Lo Gom channel. It is a small part of this large project aimed at increasing awareness of the residents living in this area to protect the environment. The pilot project began in 2003 and was expected to last for two years. It received financial support from the Asia Foundation and the US-AEP (United States – Asia Environmental Protection) which both cooperate with US-AID. The partners involved in this pilot project are: (i) The Institute of Environment and Resources; (ii) the Water and Environmental Technology Institute; and (iii) the People Committee of district 11 (*Institute of Environment and Resources. 2003).*

About 35 households living in the sub-ward are involved in the pilot project. The project consisted of the following activities. First, community workshops took place to inform residents of the pilot project (Figure 2.10). Then, leaflets were distributed to residents to show them how to separate waste (see Appendix 2.E). Finally, two waste bins and a small scale were provided to each household (Figure 2.9). Residents were asked to separate waste and then measure and record the quantities of compostable and non-compostable waste they generated every day. The results of a survey conducted from May 12th to June 12th 2004 show that the average daily quantities of compostable and non-compostable waste were 1.77 kg/household/day and 0.38kg/household/day, respectively. Compostable waste, therefore,

makes up 82.4% of the total household waste generated *(Institute of Environment and Resources, 2003)*.

Figure 2.9 Waste bins distributed to households

Figure 2.10. A community workshop to inform residents the pilot project

2.2.3. In Quangnam Province (Hoi An town)

A program of household waste separation was expected to be conducted for the whole Hoi An town (Quangnam province) in 2001. The Hoi An Public Construction Company was responsible for this program with financial support from the Quangnam government (total investment of 227,210,000 VND) *(Nguyen, 2001)*. On 15 May 2001, a pilot project was launched in Minh An ward to investigate the residents' attitude and the feasibility of such a program. The pilot project lasted until the end of 2001 *(Nguyen, 2001)*. However, since the pilot project in Minh An ward was not successful, the program was not expanded to the entire of Hoi An town.

Steps that were conducted to implement the waste separation program (Tran, 2001):

- Step 1: The People Committee of Hoi An town promulgated Direction no.4/CT-UB to promote environmental sanitation and solid waste management. They cooperated with other organizations to implement this direction at every household and provided guidance leaflets to instruct households on how to separate waste at home (see Appendix 2.F).
- Step 2: The responsible organization raised capital investment, built a composting plant, prepared chemicals EM1-EMU6 (Effective Micro-Organisms) which is used to treat bad odor from compostable waste and help compostable waste decompose

faster), prepared equipment (dustbins of 20L to 200L capacity, plastic containers of 20L as well as weight measurement instruments).

- Step 3: Training classes on waste separation at source were set up.
- Step 4: The pilot project of waste separation at sources in Minh An ward was started. If the pilot project is successful, the program would be extended to the whole Hoi An town.

For urban areas, compostable waste was spread with EM1 and collected every two days. It was then taken to the composting plant (in the Cam Ha landfill) and then treated with EM6. After 6-8 weeks, decomposed waste was used for fertilizing plants. Non-compostable waste was collected every two days and then transported to the Cam Ha landfill to be buried.

For rural areas, after the compostable waste was treated with EM1, some residents were encouraged to compost it in their backyard gardens as fertilizer; for the rest of the residents, the waste was collected as in urban areas. Non-compostable waste was collected once per week but residents were also encouraged to sell purchasable.

Residents in Minh An ward were required to separate their compostable and non-compostable waste at home. The organizers bought EM1 chemical and distributed it for free to households in order to reduce the odour of separated compostable waste. Residents had to buy two 20L to 200L waste bins to store their separated waste. Organizers also cooperated with the People Committee of Minh An ward and the local media system to encourage residents to participate in this program (Nguyen, 2001).

According to the plan, compostable waste would be collected by handcarts door-to-door on Monday, Tuesday, Thursday and Friday while in non-compostable waste would be collected on Sunday. However, because residents did not separate compostable waste well, the amount of this waste separated was less than non-compostable waste. The company, therefore, adjusted the schedule to collect waste as follows: Monday and Thursday (compostable waste from community groups 1, 2 and 3), Tuesday and Friday (compostable waste from community group 4), and Wednesday and Saturday (non-compostable waste from 4 communities groups) *(Nguyen, 2001).*

Results of the pilot project in Minh An ward (Nguyen, 2001):

The pilot project in Minh An ward showed that since leaders in community no.4 willingly participated, local residents had more motivation to participate in the program. Therefore, 70% of the total residents in this community separated their wastes. However, 75% of the households used plastic bags to keep their wastes in order not to spend money for purchasing waste bins. In contrast, since the leaders in communities 1, 2 and 3 did not encourage residents to participate, only about 40% of the residents separated waste at home.

Some of the causes for the failure of the pilot program in Minh An ward included inadequate promotion of the program and unclear guidance for using EM chemicals. Moreover, after several educational programs, there were no more activities constantly reminding residents to separate their waste. Also, improperly built-hand collection carts led to the contamination of streets with leachate from compostable waste. Finally, there was a lack of heavy penalties for households that did not separate their waste.

2.2.4. Summary and implementations

Table 2.8 summarizes major characteristics of the programs of at-source waste separation, which are described above.

Table 2.8 Summary of selected waste separation programs in Vietnam

No.	Location	Duration	Organization	Waste separation requirement	Support	Collection and transportation system	Purity level of separated compostable waste	Composting plant
1.	3 communities (Sai Dong, Duc Giang and Yen Vien) in Gia Lam district, Hanoi	June 2001 up to now	Gia Lam Urban sanitation Enterprise	2 types: compostable and non-compostable	Providing free red and blue waste bins for each household	- 2 hand-carts daily collect 2 types of waste door-to-door - 2 compactor trucks carry waste to disposal places	95%	Kieu Ky
2.	Phanchutrinh ward, Hanoi	October 2003 up to now	URENCO Hanoi	2 types: compostable and non-compostable	Providing free plastic bags (black and white) at beginning of each month	Two waste trucks daily pick up waste bags which (i) are placed along the streets or (ii) are collected by hand-carts	85% to 90%	Cau Dien
3.	Kim Lien community	Started in 1999 and lasted for 3 months	URENCO Hanoi	4 types: plastic, paper, organic and other waste	-	-	-	-
4.	3 communities in Trau Quy ward, Gia Lam district, Hanoi	2002 up to now	Agricultural University, Hanoi	2 types: organic and inorganic waste	Providing a free waste bin for each household	- Organic waste is picked up daily by a hired waste collector door-to-door - Inorganic waste is collected through a	97.6%	In Agricultural University

No.	Location	Duration	Organization	Waste separation requirement	Support	Collection and transportation system	Purity level of separated compostable waste	Composting plant
						regular waste collection system		
5.	Sub-ward no. 3, ward 12, district 5, Hochiminh City	1997-1999	ENDA (Environmental Development Action) Vietnam	2 types: easy-decomposed and difficult-decomposed waste	Providing a free waste bin for each household	Separated wastes were collected through a regular waste collection system	-	No plant
6.	Sub-ward 18, ward 3, district 11, Hochiminh City	2003 until now	Institute for Environment and Resources	2 types: compostable and non-compostable	Providing free two waste bins and a small scale	Separated wastes were collected through a regular waste collection system	-	No plant
7.	Minh An ward, Hoi An town, Quangnam	15 May 2001 until the end of 2001	Hoi An Public Construction Company	2 types: compostable and non-compostable	Providing free EM1-EMU6 (Effective Micro-Organisms)	Handcarts collected separated wastes door-to-door twice a week	-	In Cam Ha landfill

In addition to the several programs listed above, two new at-source waste separation programs were proposed in Hochiminh City, further indicating the concern of organic/compostable waste separation in Vietnam. The successful programs seem to have been well organized with broad and extensive informational and educational campaigns that reached every household in the selected areas. Moreover, these programs were designed carefully so that the separated compostable and noncompostable waste are daily collected door-to-door and disposed of in composting plants and landfills, respectively. As can be seen in Table 2.8, not all programs were completely successful. The failure of a few projects can be accounted for by the lack of financial support and the resident low cooperation in separating waste. Finding markets for composting products and generating revenue are also difficult problems.

Based on the failures and successes of these programs, it is concluded that in order to implement the waste separation program in Danang, extensive informational and educational programs should be conducted to each household. As well, a collection and transportation system should be designed carefully to collect separated waste efficiently and economically. Since the revenue from composting products is unpredictable, URENCO Danang should also consider how much subsidies can be obtained from the government and how much the collection fee should be increased in order to maintain the program.

III. METHODOLOGY

During two weeks in June and July of 2004, a waste audit was conducted in: (1) households living close to Dong Da market area, Thanh Binh ward, Hai Chau district, from June 21st, 2004 to June 27th, 2004 and (2) households living close to the Hospital of District 1 in Thanh Binh ward from June 28th, 2004 to July 04th, 2004. Then, in the week from July 26th, 2004 to August 1st, 2004, a pilot project on at-source waste separation was conducted at most of the same households in the same areas. In this study, the waste data were addressed per household instead of per capita since the waste was collected and recorded on a household basis and the exact number of people in each household had not been identified.

This chapter addresses the procedures used for conducting the waste audit and pilot project as well as the methods of selecting households for the study.

3.1. STUDY AREAS

The three areas selected to conduct the waste audit program are shown in Figure 3.1.

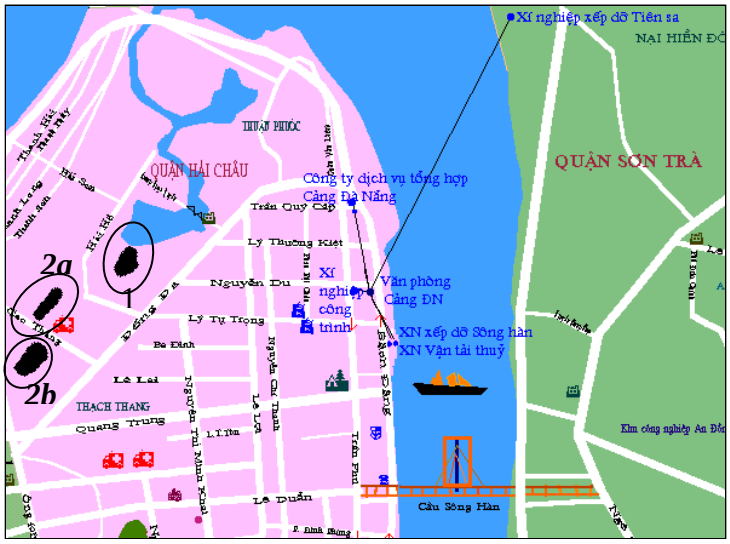


Figure 3.1 Studied households location

1)Residential area close to DongDa market

2a) & 2b) Residential areas close to the Hospital of District 1

All three of the residential areas were selected because they have common characteristics:

(1) Few commercial buildings: participants living in these areas discharge mostly residential waste (commercial waste is not part of the project's scope). Even though the researcher could actively select households having no business at home in any areas having commercial buildings, the results may be affected due to the following reasons: (i) it is difficult for a waste collector to collect waste samples door-to-door from selected households when purchasing activities occur nearby (i.e., the areas are crowded and busy with customers and vehicles); and (ii) selected households may cook less or eat more than usual when they can have close-by food stalls;

(2) Households in these areas are typical for Danang households because Hai Chau district is an old district in Danang city. This means that these households are representative of most households in Danang City and therefore, the amount of waste they discharge can be extrapolated to the whole city.

(3) Most households discharge their waste every day: the waste audit program can record the amount of waste collected daily, and the pilot program of waste separation at household can evaluate the residents' waste separation activities;

(4) Most households have at least one member staying at home who is in charge of bringing their waste out and giving it to the waste collector every day: this activity prevents losing waste samples. It is also necessary to have at least one person in each household who can handle compostable waste separation.

(5) Over half of the selected households are located on small-medium and medium-large roads, where collection tricycles can go door-to-door to collect waste. Also, since the majority of residents in Danang live in areas with small-medium and medium-large roads, the results of this study should be applicable to the rest of the city. Moreover, when the waste audit and the pilot program of at-source waste separation were conducted, missed waste collections could be reduced.

However, there are also some differences between each area, such as the number of members in each household as well as the economic status. Information on these differences came from surveys conducted by the College of Technology in Danang *(College of Technology, Danang, 2004)*. These differences will be presented in the following section to show that the study includes the various types of residential areas in Danang City.

3.1.1. Residential area close to Dong Da market

This residential area is shown in Figure 3.1 with a circle labeled number 1. Thirty-one households were selected in this area. The area is located along a medium-large road which is larger than that in the other study areas. Most families live in well built houses having one to two floors. The average number of people in each family is about five to six people. In this area, people mainly work in Dong Da market. However, their economic status is above the average income of Vietnamese household *(College of Technology, Danang, 2004).*

3.1.2. Residential areas close to the hospital of District 1

The other two areas are shown with numbers 2a and 2b in Figure 3.1. In Area 2a, 26 households were chosen for the study. More than half of the households live along a small-medium road while the remaining are on small roads, a little further from the small-medium road. The average number of residents in each household is five people. Their economic status is lower than the residents in Area 1 *(College of Technology, Danang, 2004).*

In Area 2b, 17 households were selected in this area. These households are living along a medium road, which is larger than the main one in Area 2a. Several families live in areas on small roads further from the main road. On average, each family has about four members, and in several households, there are only two people in a family. Their economic status is stable and higher than other areas *(College of Technology, Danang, 2004).*

Because the waste audit was conducted in the second week for both of these areas, they are labeled as areas 2a and 2b and will be considered together as Area 2 in the remainder of the study. Together, 43 households were selected for the study in these areas.

3.2. PROCEDURES FOR CONDUCTING THE WASTE AUDIT

Since the purpose of the study was to assess the possibility of composting compostable solid waste, the audit focused only on compostable and non-compostable waste, regardless of the sub-compositions of each. In order to have time to gather information of several programs of at-source waste separation in other places in Vietnam, the researcher intended to complete the waste audit and the pilot project of at-source waste separation in the period of one and a half month (from mid of June to end of July). Due to the

limited time available, the waste audit was done over one week for households in each of the two areas.

The procedures for conducting the waste audit were as follows:

a) Step 1: Selection of households

In order to identify suitable households for the waste audit, waste collectors were consulted. In this step, two waste collectors in charge of the two selected areas were interviewed by the researcher. They suggested which households should be selected based on the following criteria:

- (i) residents that tend to discharge waste every day. Choosing households who discharge their waste everyday allows the researcher to obtain daily records of waste generation;
- (ii) households that have no business at home (i.e. not selling food or beverage at home). If selected households have business at home, the amount of waste collected may not be generated from only living activities but also from commercial activities. As a result, the amount of waste collected may be higher than the actual quantity generated by members of those households. Since this study focuses only on residential waste, the selected households should not have commercial waste.

Also, due to labour and time constraints, there were limits on the number of households that could be audited.

A waste collector took the researcher to each selected household to introduce the program and ask for the residents' participation. As a result, 31 households in Area 1 and 43 households in Area 2 agreed to participate in the audit.

b) Step 2: Distribution of plastic bags to households

A plastic bag was daily given to each participating household, who was asked to use it for storing their waste. The black color of the bags helps waste collector recognize sample bags from other waste bags discharged from non-participating households. However, the residents sometimes used bags with other colors to store their waste. Every day, after a waste sample bag was collected, another plastic bag was given to the household for the next day; the waste collector put these bags inside a household's waste

bin. The households were given one bag every day instead of seven bags for the whole week in order to reduce the likelihood that residents would use the bags for things other than storing waste.

c) Step 3: Collection of waste samples

One waste collector was hired to collect waste in each area. The researcher also went to each household with the waste collector to assist in getting waste bags and labeling the bags with the address of the household. The same collection procedure was performed in the second week for Area 2. Figure 3.2 and 3.3 show the waste collector picking up waste bags from the households and from waste bins outside the houses.

Figure 3.2 A waste collector picking up a waste bag directly from a household

Figure 3.3 A waste collector picking up a waste bag from a waste bin outside

Figure 3.4 A waste collector carrying waste bags on her collection vehicle

Since the waste collector collected waste from all households (participating and non-participating) at the same time, the sample (audit) waste bags were placed outside the waste container, and the regular (non-audited) waste was dumped into the container (Figure 3.4). Then the sample bags were carried to a place for analyzing the composition of the waste.

Some waste bags placed outside the houses for collection were open because recyclable items in these bags were taken by waste scavengers. The scavengers sometimes took the non-compostable waste bags away from a house for checking items inside the bag and then placed it outside another house. Therefore, the households that generated some of the waste bags could not be properly identified.

d) Step 4: Analysis of waste composition

Figure 3.5 A 5-kilogram scale and a container for weighing waste sample

Each bag was weighed with a 5 kg scale and the weight was recorded (Figure 3.5 and Figure 3.6). Then the contents of each bag were separated into: compostable and non-compostable waste (Figure 3.7 and Figure 3.8). An assistant was hired to help with this. The compostable waste were put back into the bag and the bag was weighed again to record the weight of compostable fraction (Figure 3.9).

Even though paper and cardboard are compostable matter, this study did not include them in the compostable waste list because residents are encouraged to recycle and reuse paper and cardboard. Since plastic and nylon materials can not decompose easily, they are listed in the non-compostable list (see Appendix 3.A). Therefore, when the analysis was conducted, compostable waste fraction referred mostly to foods, vegetables, leaves, and plants.

Figure 3.6 Weighing a waste bag to get the total weight

Figure 3.7 Non-compostable waste of a waste bag

Figure 3.8 Compostable waste remains inside a waste bag

Figure 3.9. Recording the total weights of bags and the weight of the compostable portion

e) Step 5: Disposal of analyzed waste

After the waste was separated and weighed from all the bags on each day, a waste collector picked up the waste and took it to the Dong Da transfer station for disposal.

3.3. PROCEDURES FOR CONDUCTING THE PILOT PROJECT OF COMPOSTABLE WASTE SEPARATION AT SOURCE

The pilot project of compostable waste separation at household was conducted to investigate the effectiveness of at-source waste separation. It involved most of the households that participated in the audit and lasted over one week (July 26th, 2004 to August 1st, 2004). Approximately two weeks were taken to design the pilot program. The steps for conducting the pilot project were as follows:

a) Step 1: Selection of households and the information program

An initial list of participating households, in which most of households (i.e., 70 households) had participated in the waste audit, was prepared. A small information program was then conducted at each of these households. A group of three people, including two assistants who had been trained about the purposes and goals of the pilot project, went to each household, met family members and explained the program.

To help with this, a two-page leaflet was designed to explain to residents the importance of separating compostable waste (see Appendix 3.B). In this leaflet, the reasons why people should separate waste were given on the first page; on the second page, two streams of waste are shown by a series of pictures which help residents understand easily the procedures for handling different types of waste. The leaflet was designed to improve

the resident awareness of protecting the environment through separating waste. In the leaflet, a list of compostable waste is introduced, which is mostly vegetables, fruits, foods, and leaves.

Each of the households was asked at the information session if they wanted to participate in the pilot program. Two households did not want to participate, and their reasons for not participating were recorded. These households were eliminated from the list. In addition, 6 households not at home when the information group came were also removed from the initial list. As a result, 62 households who had participated in the waste audit program participated in the waste separation pilot project. Some neighboring households were also asked to participate. If they agreed, they were included in the list in order to increase the number of participating households. Consequently, a total of 70 households agreed to participate in the pilot project. However, after the pilot project was conducted for 2 days, three households withdrew, which finally made the project involve 67 households.

b) Step 2: Distribution of waste bins:

Since most of the households already had at least one waste bin in their house, each household was distributed a waste bin to store their separated compostable waste (Figure 3.10). The residents were asked to place compostable waste in the provided waste bin and non-compostable waste in the waste bin they have before. A sticker with instructions was put on the top of the lid of the waste bin. This helped residents differentiate compostable waste that should be put in this waste bin. A picture of this sticker is shown in Appendix 3.C. Even though the sticker on the bin's lid shows the picture of food waste which is just one type of compostable waste,

Figure 3.10 A waste bin with an instruction sticker on top of its lid

Figure 3.11. Collecting two bags of waste from each household

other types of compostable waste, as described in the leaflet and in the information session (see Appendix 3.A and 3.B), should also be placed in the bin.

c) Step 3: Collection of separated waste bags

This step was essentially the same as the collection step of the waste audit program, except that two waste collectors were hired to collect waste bags for only one week. Each day, they collected two waste bags from each household (Figure 3.11) and gave each household two empty plastic bags for the next day. After collecting waste, the waste collectors carried these bags to a place for analyzing the contents of each bag.

d) Step 4: Analysis of the amount of compostable and non-compostable waste in each sample bag

Figure 3.12 Two different waste bags

With the help of an assistant, the contents of the waste bags were analyzed. The contents of each bag were separated into compostable and non-compostable waste (Figure 3.12). Compostable waste is mostly fruit and food scraps, leaves and vegetables while non-compostable waste includes nylon, plastic, glass, metal scraps and other non-compostable matter (see appendix 3.A). The definition of compostable waste in this pilot project was consistent with the definition used in the source separation study which was conducted earlier. The two types of separated waste were then weighed. This data was used to estimate the effectiveness of the separation program, i.e. amount of non-compostable waste presented in the compostable waste bags, and the amount of compostable waste in the non- compostable waste bags.

e) Step 5: Disposal of the sample waste

As in the waste audit program, a waste collector picked up the analyzed waste bags and took them to Dong Da transfer station for disposal.

Overall, the number of households that refused to participate in this program was very small compared to the rest of households that did participate. Only two households actually refused to participate before the program started. Being afraid of their children not knowing how to separate waste was the reason these households provided. Three

households initially agreed to participate in the program but withdrew after the program ran for two days. They did not want to separate waste because of the time it would take[1]. Thus, the total refusal rate was 7% (i.e., 5/72)[2], showing that residents in these selected areas are mostly willing to participate in separating compostable waste.

3.4. USING THE RESULTS OF QUESTIONNAIRE SURVEYS

Two questionnaire surveys using multiple choice questionnaires were conducted by the College of Technology in Danang to determine the residents' willingness to participate in the program of at-source waste separation. One survey was conducted before the pilot project of waste separation. A paper questionnaire (see Appendix 3.D) was given to the selected households (i.e. 70 households in the initial list of the pilot project). Based on the first survey, it was easy to evaluate the residents' awareness of the benefits of separating waste, which assisted the researcher in better informing residents about waste separation. For the two households that did not want to participate in the waste separation program, the survey also asked the reasons for this.

After the pilot project ended, another questionnaire survey was carried out for the 67 (3 out of 70 initial households withdrew after 2 days) households that had participated in the pilot project (See Appendix 3.E). The purpose of this survey was to determine opinions of the residents on the compostable waste separation activities they did, the strengths and the weaknesses of the pilot project, and their willingness to participate in similar future projects.

[1] As reported by these residents.
[2] 72 households were actually asked to participate in the pilot project.

IV. RESULTS AND ANALYSIS

This chapter presents the results of the waste audit and the pilot project of at-source compostable waste separation.

4.1. WASTE AUDIT RESULTS AND ANALYSIS

4.1.1. Waste quantification

As described in the previous chapter, the one-week waste audits were conducted in two different areas. The amount of waste collected from a household on a given day generally refers to the amount of waste that the household generated on the day before as daily collection takes place early in the morning (from 8.30 am to 9.30 am) of each day. For example, waste collected on Monday was largely generated on Sunday and Monday morning.

Appendices 4.A and 4.B contain the quantities of waste collected from 31 households in Area 1 in the first week and 43 households in Area 2 in the second week. The statistic calculations were carried out using Microsoft Excel software. The average daily quantities of waste collected from each specific household are presented in the "Average" column on the right of tables in those appendices. The average quantities of waste collected per household for each specific day are also shown on the "$W_{avergae}$" row on the bottom. The average quantity of waste collected per day per household in each week was calculated by averaging all the records of household waste quantities of that week.

Also, in Appendix 4.A and 4.B, the standard deviations of the daily waste quantities from each specific household during each one-week period were calculated and presented in the "STDEV" column. The standard deviations of the waste quantities per household for each day are shown in the "STDEV" row. The two overall standard deviations associated with the two overall averages of waste per day per household for the two areas were calculated based on all records of waste quantities in those two weeks.

No waste was collected from some households on certain days, which is reflected in blank data cells in Appendix 4.A and 4.B. For example, on the third audit day of the first week (Wednesday), five households were out all day for the traditional Mid-Lunar-year occasion[1]; thus no waste of these five households was collected (although the waste

[1] As reported in an oral interview with the researcher.

generated on Tuesday maybe included in the waste collected on Thursday). On other days, waste from some households was lost because it might have been collected by someone else before the researcher came[2]. As a result, no data of waste was collected from those household on those days. If no waste was collected from a household by the researcher on a specific day, even if the waste might be collected by someone else, a value of 0 was used as a fill-in record of household waste quantity for that day for further statistical calculations. This assumption was used in order to simplify the analysis and because there are relative few such waste records (i.e., 7 out of 7x74 records), the study's results would be only slightly affected.

The average quantity of waste per day of each specific household was calculated by summing the amounts of waste from that household over a week period and then dividing by the number of days for which waste was collected (i.e., 7 days). For example, for household no.3 in week 1, the average quantity of waste collected per day of this household is: Average no.3 = (1.5+1.1+0.0+0.0+0.9+0.3+0.9)/7 = 0.67 kg/day. Because missed waste collection in household no.3 occurred on Thursday and no waste was discharged on Wednesday, two zero values were used as fill-in records to calculate the daily average quantity of waste collected from household no.3. However, if the missed waste collection on Thursday is ignored, thereby assuming that waste was generated though not collected by the researcher, the result will be (1.5+1.1+0.0+0.9+0.3+0.9)/6 = 0.78 kg/day, which is slightly higher than the study's result.

Similarly, the average quantity of waste per household on each specific day was calculated by summing the amounts of waste from 34 households (if calculated for week 1) or 41 households (if calculated for week 2) and then dividing by the number of households of which waste was collected (34 household for week 1 or 41 household for week 2). These results are shown in Table 4.1.

[2] As reported in an oral interview with the researcher.

Table 4.1 Average quantities of waste collected each day (kg/day/household)

Audit period and area	Mon	Tues	Wed	Thurs	Fri	Sat	Sun
Week 1 and Area 1	3.02 (31/31)	2.26 (31/31)	2.80 (26/31)	2.07 (30/31)	2.09 (29/31)	1.91 (30/31)	2.45 (31/31)
Week 2 and Area 2	2.71 (43/43)	2.95 (41/43)	2.43 (42/43)	2.65 (43/43)	2.56 (43/43)	2.62 (43/43)	2.83 (43/43)

Note: (26/31) means that waste was collected from 26 households on that day out of the total of 31 participating households.

Table 4.2 summarizes the statistical results (averages, standard deviations, ranges and the 95% confidence intervals) for each of the two one-week waste audits. The data from the results waste audits in these two periods were also combined and analyzed; the results are also shown in the table.

Table 4.2 Summary of waste quantity audit results

Audit period and area	Number of households	Average (kg/day/ household)	STDEV (kg/day/ household)	Range of Data (kg/day/household)		95% confidence interval of mean (kg/day/household)
				Min	Max	
Week 1 and Area 1	31	2.37	1.93	0.0	12.1	1.69 to 3.05
Week 2 and Area 2	43	2.68	1.68	0.0	9.3	2.18 to 3.18
Two weeks and areas	74	2.55	1.80	0.0	12.1	2.14 to 2.96

As shown in Table 4.2, the average quantity of collected waste in the two areas is approximately 2.55 kg per day per household. In Area 1, the average daily waste quantity collected per household is less than that in Area 2 (2.37 kg/day/household versus 2.68 kg/day/household).

A household in the study areas has, on average, 4 to 5 people *(College of Technology, 2004)*. Therefore, the average daily quantity of waste collected from each person ranges from 0.51 (i.e., 2.55/5) to 0.64 (i.e., 2.55/4) kg/day/capita. Table 4.3 presents information about the daily quantities of waste per person in several developing countries. Compared with the data in Table 4.3, the estimation of average daily amount of waste per capita in this study seems similar to that of other cities in developing countries.

Table 4.3 Average daily quantity of waste per capita in developing countries

Location	Average (kg/day/capita)	Source of information
Africa: Accra, Ibadan, Dakar, Abidjan, and Lusaka	0.5-0.8	*International environmental technology center, 1996.*
South and West Asia (Indian sub-continental countries)	less than 0.5 to 0.8	
Pakistan	0.5	*Hogland and Marques, 2000.*
Developing countries with economic growth	0.6	
Bangalore, India	0.4	*Grover and Grover, 2000.*
Israel	0.4	
Manila, Philippines	0.4	
Sri Lanka	1	
Class I cities in India (6430 persons/km^2)	0.376	*Biswas, Chakrabarti and A.B. Akolkar, 2000.*
Bombay (India) 1996-97	0.2	*Ludwig, Hellweg and Stucki, 2003.*
Delhi (India) 1996-97	0.44	
Bhiwanda (India) 1996-97	0.1	
Hyderabad (India) 1996-97	0.35	*Galab, Reddy and Post, 2004.*
Typical cities in China in 1996:		*Ludwig, Hellweg, Samuel Stucki, 2003.*
Beijing	1.20	
Tianjin	0.99	
Shanghai	1.23	
Shenyang	1.02	
Dalian	1.03	
Hangzhou	0.92	
Shenzhen	2.62	
Guangzhou	1.20	
Maanshan	0.66	
Anshan	0.76	

Table 4.1 also shows that on most days, except Monday and Wednesday, the waste quantities per household in Area 1 are less than those in Area 2. On average, a family in Area 1 has five members while a family in Area 2 has four to five *(College of Technology, Danang, 2004)*. Therefore, the fact that the average amounts of waste per household for each day in Area 1 are less than those in Area 2 is not due to a difference in the number of people per household living in Area 1 versus Area 2. Some possible reasons for the differences in the amounts of waste in these two areas are:

- Since Area 1 is located in a close proximity to the market, it can be speculated that the majority of residents in this area may work in the market from morning until night, which keeps them from staying at home where they would generate waste.

- Missed waste collections occurred more often in Area 1 than in Area 2. These collections were given zero values as discussed above.

Also as shown in table 4.1, the average amount of waste collected per household for each day fluctuated day by day. The average quantities in Area 1 have a wider range (1.91 to 3.02 kg/day/household) compared to those in Area 2 (2.43 to 2.95 kg/day/household). In addition, in Table 4.2, the overall standard deviation value in Area 1 is higher than that in Area 2 (1.93 versus 1.68 kg/day/household), which also demonstrates a larger variation of the waste generation in Area 1. Perhaps a one-week period for the waste audits was not sufficient to reflect the general tendency of waste generation in these areas. As well, the different variations between Area 1 and Area 2 may be caused by the missed collections as mentioned before.

Table 4.1 also shows that the average quantities of waste collected on Sunday and Monday are higher than those on the other days, except on Wednesday in Area 1 and Tuesday in Area 2. Since most of the waste generated in one day is collected on the following day, waste collected on Sunday and Monday may mostly be generated on weekends. One of the possible reasons for this is that residents may have more free time on weekends to stay at home, where they generated waste. Moreover, traditionally, extended families often gather together for parties and entertainment on weekends, which also may explain the observation that more solid waste was generated on weekends. However, because of the random nature and the uncertainties in the results, in the case of the entire city the actual amount of waste on weekends may not in fact be higher on weekdays.

In Table 4.2, the statistical results with the 95% confidence interval of mean show that the average quantity of waste collected in Area 1 is in the range of 1.69 to 3.05 kg/day/household, while in Area 2 it is from 2.18 to 3.18 kg/day/household, and for the two combined areas it is in the range of 2.14 to 2.96 kg/day/household. Even though there are uncertainties about this average range due to the small scale of the audit program, the range of waste quantity of the combined area will be used to estimate the quantity of waste collected for the entire city in section 4.1.3.

4.1.2. Waste composition

In the two-week period of the waste audits described in the previous section, the waste from each participating household was separated into compostable and non-compostable waste and then weighed. All recorded values of these two types of waste are shown in Appendix 4.C and 4.D. The standard deviations and the average quantities of compostable and non-compostable waste per household for specific days are also shown in there. Appendices 4.E and 4.F present data of compostable and non-compostable waste for each household audited during the first week (Area 1) and second week (Area 2), respectively, in percentage values.

As explained in 4.1.1, no waste was collected from specific households on several occasions due to missed waste collections or no waste being discharged from households. Therefore, in Appendix 4.C and 4.D, the value of 0 kg/day/household was used for the amount of compostable and non-compostable waste collected from households on days on which no waste was collected. Also in these cases, no percentages of compostable and non-compostable waste were used in Appendices 4.E and 4.F in order not to affect the calculations of the overall percentages of waste at the household level.

In Appendix 4.C and 4.D, the overall quantities of compostable and non-compostable waste per day per household over a week were calculated by averaging all the records of waste quantities collected on that week. These records are also presented in those appendices. For example, in week 1, all 217 records (i.e., 31 (households) x 7 (days)) were averaged. Similarly, the overall standard deviations of the daily quantities of compostable and non-compostable waste per household were calculated from all the records of that week. These standard deviations are also presented in table 4.5.

As seen in Appendix 4.E and 4.F, the average daily percentages of compostable and non-compostable waste for each specific household are shown in the “Average” column, and

the average percentages of these wastes per household for each specific day are presented in the "Average" row. The latter figures also appear in the lower row named "% CW" in table 4.5. In addition, these appendices contain the overall percentages of compostable and non-compostable waste per household per day of each audit week; these were calculated by averaging all records in the tables of those appendices. For example, the overall percentage of compostable waste of Area 1 (week 1) was obtained by averaging all 217 daily records (31 households x 7 days) of percentage of compostable waste from each household. Similarly, the weekly standard deviations, which are also presented in table 4.5, were calculated from all the records of percentages of compostable and non- compostable waste of each household of that week.

Table 4.4 presents the average quantities of compostable and non-compostable waste per household and the percentages of compostable waste for each specific day during the audit, which were calculated by the two methods explained below.

Table 4.4 Average quantities (kg/day/household) and percentages of compostable and non-compostable waste collected every day in households during two weeks

Week	Waste type	Mon	Tues	Wed	Thurs	Fri	Sat	Sun	Average
Week 1 and Area 1	CW	1.70	1.38	1.63	1.17	1.16	0.60	1.30	1.39
	NW	1.33	0.88	1.17	0.90	0.87	0.35	1.00	0.97
	% CW	56% *	61% *	58% *	57% *	57% *	63% *	61% *	59% *
		57%**	62%**	59%**	56%**	58%**	67%**	63%**	60%**
Week 2 and Area 2	CW	1.67	1.87	1.50	1.76	1.71	1.79	1.92	1.75
	NW	1.04	1.08	0.93	0.90	0.85	0.83	0.91	0.93
	% CW	62% *	63% *	62% *	66% *	67% *	68% *	68% *	65% *
		65%**	67%**	64%**	69%**	69%**	73%**	70%**	68%**

Note: CW: compostable waste; NW: non-compostable waste;
(*) calculated using method 1 (based on the average quantities of compostable and non-compostable waste), (**) calculated using method 2 (based on the percentages of compostable and non-compostable waste collected from each household. See Appendix 4.E and 4.F)

The two methods of calculating compostable waste percentage give slightly different results. The first method, whose results are presented in the upper row, is based on the average quantities of compostable waste and non-compostable waste per household for each day. For example, on Monday of week 1, the compostable percentage is 56.1% (i.e., 1.7/(1.7+1.33)*100%). The average daily percentages of compostable waste at the household level using the second method are shown in the lower row. In the second

method, the daily percentages of compostable waste from all households in each week are averaged to obtain the average compostable fraction per household on each specific day. For example, on Monday in week 1, the 31 household percentages of compostable waste were averaged to get 57%.

Of the two methods, the first one is more appropriate for calculating the amount of compostable waste if the total amount of mixed waste is known. But method 2, which uses daily percentages of wastes at the household level, is better for understanding waste composition at this level. The following example explains the difference between the two methods: household A has 2 kg of compostable and 8 kg of non-compostable waste, i.e., 20% is compostable and 80% is non-compostable, while household B has 4 kg of compostable and 1 kg of non-compostable waste, i.e., 80% is compostable and 20% is non-compostable. The average quantity of compostable waste from 2 households A and B is (2kg+4kg)/2 = 3kg and the average quantity of non-compostable waste is (8kg+1kg)/2 = 4.5kg. Therefore, if using method 1, the compostable fraction will be (3kg)/(3kg+4.5kg) = 40% (This also can be calculated using the total amounts: (2kg + 4kg)/(2kg + 8kg+ 4kg + 1kg) = 40%). Using method 2, the compostable fraction will be (20% + 80%)/2 = 50%. Therefore, if the total amount of waste collected from the 2 households A and B is known (i.e., 15kg), the amount of compostable waste can be calculated based on method 1, i.e., 40%*15kg = 6kg. It would be incorrect to use 50% from method 2. Since one of the purposes of the audit is to estimate the compostable fraction in order to establish the amount of compostable waste that can be collected for composting activity, the compostable fraction of the waste stream generated by method 1 should be used. However, method 2 can be used to evaluate the tendency of generating compostable waste at the household level.

Table 4.5 shows the statistical results for the quantities of compostable and non-compostable waste (the averages, standard deviations, ranges, and 95% confidence intervals) based on the data shown in Appendix 4.C and 4.D.

Table 4.5 Summary of statistical results of waste composition

Audit period and area and waste type	Number of households	Average (kg/day/ household)	STDEV (kg/day/ household)	Range of Data (kg/day/household)		95% confidence interval of mean (kg/day/ household)
				Min	Max	
Week 1, Area 1 Compostable waste	31	1.39 (59%)*	1.09	0.15	6.60	1.00 to 1.78
Week 1, Area 1 Non-compostable waste	31	0.97 (41%)*	0.91	0.00	5.50	0.65 to 1.29
Week 2, Area 2 Compostable waste	43	1.75 (65%)*	1.07	0.20	5.30	1.43 to 2.06
Week 2, Area 2 Non-compostable waste	43	0.93 (35%)*	0.76	0.00	4.00	0.71 to 1.16
Two weeks and areas Compostable waste	74	1.60 (63%)*	1.10	0.15	6.60	1.35 to 1.85
Two weeks and areas Non- compostable waste	74	0.95 (37%)*	0.83	0.00	5.50	0.76 to 1.14

*Note: * the percentages of compostable/non-compostable were calculated using method 1*

Table 4.6 summarizes the statistical results of the percentages of compostable and non-compostable waste at household level (the averages, standard deviations, ranges, and 95% confidence intervals) based on the data shown in Appendices 4.E and 4.F, and based on method 2 discussed above.

Table 4.6 Summary of statistical results of waste composition in term of percentages of waste at the household level

Audit period and area and waste type	Number of households	Average (%)	STDEV (%)	Range of Data (%)		95% confidence interval of mean (kg/day/ household)
				Min	Max	
Week 1, Area 1 Compostable waste	31	60%	12%	23%	100 %	56% to 65%
Week 1, Area 1 Non-compostable waste	31	40%	12%	0%	77%	35% to 44%
Week 2, Area 2 Compostable waste	43	68%	15%	50%	100 %	64% to 73%
Week 2, Area 2 Non-compostable waste	43	32%	15%	0%	50%	27% to 36%
Two weeks and areas Compostable waste	74	65%	15%	23%	100 %	62% to 68%
Two weeks and areas Non- compostable waste	74	35%	15%	0%	77%	32% to 38%

Note: the percentages of compostable/non-compostable wastes resulted from method 2

As shown in table 4.4, the average percentages of compostable waste per household for each day are always between 56% and 68% (based on method 1). The average percentages in Area 1 are in the range of 56% to 63%, while in Area 2, their values are always above 62%. It shows that using method 1, the portion of compostable waste for each day tends to be higher in Area 2 than in Area 1. For the seven days, as shown in tables 4.4 and 4.5, the overall percentage of compostable waste in Area 2 was estimated to be 65%, which is higher than the percentage in Area 1 (59%). Similar tendencies are found using method 2, as shown in Tables 4.4 and 4.6: the percentage of compostable waste at the household level in Area 2 is greater than that in Area 1, 68% versus 60%, respectively. Various reasons can contribute to these results. One possible reason is that since Area 1 is close to the market, residents living in this area may bring more cooked food home which would increase the quantity of plastic and nylon bags used for packaging and thus, lead to the increase in the total amount of non-compostable waste.

As seen in table 4.5, for the combined areas that were audited, on average, 1.6 kg of compostable waste and 0.95 kg of non-compostable waste were collected per day from each household. Therefore, on average, approximately 1.7 times more compostable waste than non-compostable waste was collected. The average percentage of compostable waste for the combined areas is 63% (calculated by method 1). Within the confidence of 95%, from 1.35 kg to 1.85 kg of compostable waste and from 0.76 kg to 1.14 kg of non-compostable waste were collected daily from each household. The overall averages and the ranges within the confidence of 95% of the combined areas will be used to estimate the quantity of compostable and non-compostable waste collected for the entire city in section 4.1.3.

In table 4.6, the average compostable fraction at the household level for the combined areas is shown as 65%, which is calculated by method 2. This means that a household in these two areas on average has 65% compostable waste in its mixed waste per day. Also, this table shows that within the confidence of 95%, this average is in the range of 62% to 68% of total waste. The compostable fractions calculated by both methods 1 (i.e., 63%) and method 2 (i.e., 65%) indicate that compostable waste makes up almost two-thirds of the collected household waste. This demonstrates that composting compostable waste has high potential.

URENCO Danang estimated that 50% of the Danang residential waste is composed of compostable matter *(Tran, V.T., 2004)*, which is lower than the amount calculated in this study (63%). The difference may be due to the fact that URENCO's estimate was based on waste that included additional non-compostable material, such as construction debris. However, survey results reported in the *Danang Sanitation Project (1998)* show that the compostable fraction was estimated to be approximately 77% of the total waste mass, which is higher than the amount reported in the present study. The possible explanation for this is that the survey of waste composition was conducted 6 years ago. Waste composition, which partly reflects life style, may change with time with the city's economy development *(UNEP International Environmental Technology Center, 1996).*

Table 4.7 presents estimated values of the putrescible wastes for several cities of developing countries. These values were estimated in a number of studies conducted in Asia and Africa. As seen in Table 4.7, the percentage of compostable ranges broadly from 24% to about 80%. The value estimated in this study (about 63% to 65%), falls near the middle of most of the reported data. However, care must be taken in comparing these numbers due to differences in methodologies and reliability of the data.

Table 4.7 Waste composition in cities of developing countries

Location	Compostable waste	Source of information
Africa: Accra, Ibadan, Dakar, Abidjan, and Lusaka	35%-80%	*International environmental technology center, 1996.*
Bangalore, India	75.2%	*Grover and Grover, 2000.*
Israel	71.3%	
Manila, Philippines	45.5%	
Iraq	68.6%	
Lahore, Pakistan	49%	
Sri Lanka	80%	
Delhi, India	38.6%	*Biswas, Chakrabarti and Akolkar, 2000.*
Class I cities in India (6430 persons/km^2)	24%-58%	
Hyderabad (India) 1997	55%	*S. Galab, S. Sudhakar Reddy and*

Location	Compostable waste	Source of information
		Johan Post, 2004.
Typical cities in China in 1998 determined in landfills:	Food waste and ashes	
Beijing	59.6%	*Ludwig, Hellweg and Stucki, 2003.*
Shanghai	65.7%	
Dalian	82.1%	

Although the audit did not include an analysis of the components of the compostable waste, visual observations were made. From this, it appeared that there was a significant amount of plastic and nylon bags and small papers for packaging. Plastic and nylon bags are often used for carrying food. The more important fact is that plastic bags cannot be recycled after they are used. Thus, the more plastic bags are used, the more non-compostable waste is generated.

4.1.3. Estimation of Danang's residential waste

URENCO Danang collected waste from approximately 149,420 households in the year 2003 *(Tran, V.T., 2004)*. The results of the waste audit shown in Table 4.2 and 4.5 were combined with the total number of households to get an estimation of the daily total quantity of residential waste as well as the daily quantities of compostable and non-compostable waste for the entire city. For example, for compostable waste, the average of 1.60 kg/household/day x 149,420 households x 365 days/year = 87,261 tonnes/year. The resulting estimates are shown in table 4.6.

Table 4.8 Estimation of residential waste collection in Danang City

Type of waste	Annual average (tonnes/year)	Daily average (tonnes/day)	Range of waste generation (95% confidence) (tonnes/day)
Compostable waste (*)	87,300	239	from 202 to 276
Non-compostable waste (*)	51,800	142	from 114 to 170
Total waste (**)	139,100	381	from 320 to 442

Note: (*) Compostable and non-compostable waste was calculated based on data in table 4.5; (**) Total waste was calculated based on data in table 4.2

From the table 4.8, the average amount of residential waste per day in Danang is estimated to be about 381 tonnes per day. On a yearly basis, this is equivalent to approximately 139 thousand tonnes. This compares closely with an URENCO Danang estimate of about 149 thousand tonnes per year *(Tran, V.T., 2004)*. However, the difference may be due to different estimation methods; the estimation method used by URENCO is unknown. In addition, since the audit program took place only in two small areas during a two-week period, the average amount of waste estimated from the waste audit may not reflect the city-wide, year-round situation. Another reason for this difference is that URENCO Danang might have included construction debris in their estimate of the quantity of residential waste.

The amounts of compostable and non-compostable waste in all of Danang are estimated to be about 239 tonnes per day (87,300 tonnes per year) and 142 tonnes per day (51,800 tonnes per year), respectively. Although these amounts are rough estimates, which can be improved through further research, they provide useful information for planning and designing composting facilities in Danang.

4.2 PILOT PROJECT OF AT-SOURCE COMPOSTABLE WASTE SEPARATION – RESULTS AND ANALYSIS

This section summarizes the results of the pilot project of compostable waste separation at household, which was conducted during one week in the same areas in which the waste audit was carried out. The main purpose of this pilot project was to estimate the effectiveness of an at-source separation program for Danang residents. This section also presents the results of the two questionnaire surveys that were conducted in these areas.

4.2.1 Results of questionnaire surveys

The results of the two surveys on selected households in the study areas *(College of Technology, Danang, 2004)* which were carried out before and after the pilot project are presented in the next two sub-sections.

a. Survey on households before participating in the pilot project

A total of 70 households received the survey questionnaire before the pilot project. However, only 59 households returned their completed questionnaires. Their data were analyzed by the Danang University College of Technology which designed the questionnaires. The analysis reported that a household in the survey areas has, on average,

four to five people, and the average household income is in the range of 500,000 VND (Vietnamese dollars) to above 1,000,000 VND per month. This rate is equivalent to $48 to $90 CDN (Canadian dollars) per month.

Forty percent of the respondents said that the wife is responsible for waste management (especially organic waste). About 93% of the households said that they can differentiate organic waste from inorganic waste. The remaining 7% wanted more information about the types of solid waste. The respondents were asked to identify whether separating waste has any benefits; if their answer is yes, they were required to select the benefits they are aware of from a list provided. In response to that question, 88% of the respondents selected at least some of the benefits from the suggested list. However, only 40% of the respondents identified all of the benefits listed in the questionnaire. The results of the survey show that the residents think they are able to differentiate the two types of waste; however, they do not know clearly all the meanings and the benefits of separating waste at home.

Almost all of the households (91%) agreed to participate in the pilot project of organic waste separation if they were provided free waste bins. About 7% of respondents said that they could not participate in the project for reasons such as having no free time or their children not knowing how to separate waste. One respondent did not provide a definite answer about her/his participation.

Ninety percent of the respondents stated that after the pilot program was completed, they would want to continue to separate waste if the Company of Urban Environment (URENCO) of Danang requires waste separation. Meanwhile, 3% said that they would not continue and the remaining 7% did not have an answer to this question.

b. Survey on households after participating in the pilot project

After the end of the pilot project, the follow-up survey was given to the 67 households that had participated in the project. Of these, 58 completed the questionnaires. The number of people in each household participating in the project varied among families; on average, 60% of the members in each family participated. Ninety-one percent of the respondents thought that it was “easy to carry out” while only 7% of the respondents thought that this project was “difficult to carry out” and 2% indicated “other opinion” without giving a specific opinion. These 91% of the respondents also thought that the waste separation program should be implemented in all households in Danang. Responding to the question asking about methods of improving this program, which allowed multiple choices, the

residents thought that URENCO and the Danang government should launch information and educational programs to inform and train residents to separate waste at home (57% of these 91%), and URENCO should supply initial basic facilities, such as waste bins and plastic bags for waste storage (79% of these 91%). Fifty-one percent of those 91% agreed that the government should make an incentive policy to optimize waste separation at home. Five percent of respondents, however, thought that this program was too complicated and should not be implemented in the entire city while 4% gave no answer. The responses to the survey also indicated that 72% and 62% of residents preferred organic and inorganic waste to be collected on a daily basis, respectively.

Overall, the results of the two surveys show that Danang residents are interested in participating in a program which required them to separate organic waste at home.

4.2.2. Results of the pilot project of compostable waste separation at source

The raw data of waste collected during the pilot project are presented in Appendix 4.G. This includes the amounts (kg) of compostable and non-compostable waste in compostable and non-compostable bags collected from each of the 67 participating households for each day. Four times, as shown in the appendix, no waste was collected from a household because their waste bags may have been collected by someone else before the researcher arrived[3]. For these cases, the amounts were assumed to be zero. This should have insignificant effects on the results, since it occurred in only 4 out of the 7 x 67 sets of data.

Compostable bags should contain only compostable waste. However, sometimes non-compostable waste is put into a compostable bag together with the compostable waste; this circumstance is considered to be a “contamination”. Likewise, non-compostable bags sometimes contained compostable waste. The data in Appendix 4.G were used to calculate the percentages of non-compostable contaminants in compostable bags and of compostable waste in non- compostable bags of each household. These are shown in Appendix 4.H. In the few cases where a household’s waste may have been collected by someone else, as mentioned above, the contamination levels for on those days were not known and therefore not accounted in further statistical calculations.

Table 4.9 presents the average amounts (kg) of compostable and non-compostable waste per household in each type of bag (i.e., compostable and non-compostable bags) for each day of the pilot project. These amounts were calculated from raw data in Appendix 4.G.

[3] As told by these households to the researcher.

Based on these averages, the average levels of contamination in the waste bags for each day and the average percentages of contamination for the 7-day period were calculated (Table 4.9). The method of this calculation is discussed further below.

Table 4.10 shows the averages, standard deviations and ranges of the contamination levels at households on each day, and table 4.11 presents the statistical summary of these contamination levels over the full week of the pilot project. As discussed below, these were calculated using a method different from that used for the results in table 4.9.

Table 4.9 Average amounts of compostable and non-compostable waste and contamination in each bag on each day

Day	Compostable bag (kg/day/household)		Non-compostable bag (kg/day/household)		Contamination (%)	
	Compostable waste	Non-compostable waste	Compostable waste	Non-compostable waste	Compostable bag	Non-compostable bag
Monday	0.89	0.05	0	0.82	5.32%	0 %
Tuesday	0.84	0.02	0.00(*)	0.7	2.33%	0 %
Wednesday	0.79	0.05	0.00(*)	0.48	5.95%	0 %
Thursday	0.72	0.01	0.04	0.59	1.37%	6.35%
Friday	0.93	0.01	0	0.48	1.06%	0%
Saturday	1.03	0.02	0.05	0.70	1.9%	6.67%
Sunday	0.92	0.01	0.01	0.63	1.08%	1.56%
AVERAGE	**0.88**	**0.02**	**0.01**	**0.63**	**2.22%**	**1.56%**

Note: (*): this value is not absolute zero. However, it is small enough to be rounded to zero value.

Table 4.10 Average contamination in separated compostable and non-compostable waste at the household level

Day	Monday		Tuesday		Wednesday		Thursday		Friday		Saturday		Sunday	
Parameters	**Cbag**	**Nbag**	**Cbag**	**Nbag**	**Cbag**	**Nbag**	**Cbag**	**Nbag**	**Cbag**	**Nbag**	**Cbag**	**Nbag**	**Cbag**	**Nbag**
Number of bags collected	67	67	66	66	66	66	66	66	67	67	67	67	66	66
Average (%)	2.90	0	1.24	0.14	3.15	0.15	1.60	2.02	0.41	0	1.62	2.64	0.51	0.50
STDEV (%)	11.4	0	6.8	1.1	10	1.2	7.3	9.6	2.3	0	10.6	10.8	3.2	3
Min (%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Max (%)	75	0	44	9	50	10	50	55	17	0	83	60	25	21

Note: Cbag: compostable bag; Nbag: non-compostable bag

Table 4.11 Statistical summary of contamination at the household level

Type of bag	Average contamination	Standard deviation of contamination	Range of contamination (95% confidence)
Compostable bag	1.63 %	8.08 %	from 0% to 3.6%
Non-compostable bag	0.78%	5.69 %	from 0% to 2.1%

The average contamination levels for each day and the entire week presented in table 4.9 are different from those in tables 4.10 and 4.11. Two different methods were used to calculate the two different values of average contaminations for each day. The method that was used to get the results in table 4.9 is based on the average quantities of compostable and non-compostable waste collected per household for each day. The other method, which yielded the results in tables 4.10 and 4.11, is based on 67 contamination values of 67 households' waste bags collected on each day and was used to calculate the average contamination at the household level. For example, in table 4.9, on Monday the average contamination level of the compostable waste stream is approximately 5.32% (i.e., 0.05/(0.89+0.05)). This means that about 5.32 kg of non-compostable waste was found in 100 kg of waste in the compostable waste that were collected. However, table 4.10 shows that the average household contamination level in the Monday's compostable bags was 2.9%. This means that on Monday 2.9% of a household's separated compostable waste was, on average, non- compostable waste.

Since the levels of contamination in the compostable waste bags shown in tables 4.9, 4.10 and 4.11 are low (the maximum is 5.95%), it appears that the participating households have the ability to differentiate types of waste.

From table 4.9, the average contamination level in the compostable waste stream for the entire period is 2.22%, which translates to a purity level of 97.8%. This is higher than the amounts reported for some other separation programs being conducted in Vietnam. The purity of separated compostable waste reported in the Gia Lam (Hanoi) program was reported 95% *(Nguyen, H.N., 2004 and Japan Bank for International Cooperation, 2004)*; in the Phanchutrinh (Hanoi) program the figure was lower at 85% - 90% *(URENCO Hanoi, 2003*). Since the purity of separated compostable waste is very important to the quality of composting products, the high level of household separation achieved in the pilot project could result in high quality compost products without requiring additional labour to further separate the waste after collection.

As shown in table 4.9, the average contamination level of non-compostable waste stream for the entire period is only 1.56%. This indicates that a small amount of compostable waste will go to the landfill through the non-compostable waste stream. However, compared to the amount of separated compostable waste, this amount is too small to be of concern.

During the weighing process, it was observed that specific types of non-food waste such as paper, cardboard, plastic and nylon bags, glass bottles, and fiber mater were always in non-compostable bags and very seldom in compostable bags. As mentioned in section 3: Methodology, these items are not included in the compostable waste in this study. Therefore, this observation shows that the residents can identify clearly what waste does not belong to the category of listed compostable waste. However, they tended to put waste in the compostable bags when they did not know whether it is compostable or non-compostable. As shown in table 4.10, for each day of the pilot project, the household contamination levels in compostable bags are generally higher than in non-compostable bags. No non-compostable bags had contamination on the first and the fifth days while compostable bags always had contamination. Also, as seen in table 4.9, the average contamination of compostable waste stream is higher than that of non-compostable waste stream for most of the days, except Thursday, Saturday, and Sunday. Another explanation for the higher contamination in compostable bags is that some people have a tendency to throw the raw and left-over food and its bags directly into the compostable dust bins without separating the bags from the contents because it is cleaner and more convenient for them.

As shown in table 4.10, the average household contamination level in compostable bags on the first day of the pilot project (i.e., Monday) is highest compared to other days, except for Wednesday. It is possible that the residents were not familiar with separating waste and differentiating waste in the beginning. Therefore, on other days except for Wednesday, the average household contamination levels in compostable bags fluctuated but were less than the contamination level on the first day. Moreover, the average contamination on Sunday, the last day of the pilot project, is almost lowest (0.5% contamination in compostable waste bags) except for that on Friday, which demonstrates that the ability of participating households in differentiating the two types of waste increased after one week into the project. As well, it can be hypothesized that on weekends the residents had more free time to separate waste, which resulted in the high quality of their separated compostable waste.

However, since the pilot project was conducted only in a week, the results may contain uncertainties; therefore, it is not possible to conclude that Danang residents have this tendency of separating waste better after a participating period.

The minimum contamination level of 0% presented in table 4.10 shows that during the pilot project, some households separated compostable and non-compostable waste very thoroughly. In contrast, the maximum contamination values on the sixth day (83% and 60% for compostable and non-compostable bags respectively) indicate that at least one household did not try to separate these wastes. These numbers show that there is a large difference among households in terms of the willingness to separate waste properly. However, 44 out of 67 households separated compostable and non-compostable waste without any contamination for the whole week (see Appendix 4.G). In addition, as seen in Table 4.11, within the confidence of 95%, the average contamination at household levels in compostable bags were in the range of 0% to 3.6%, and contamination levels in non-compostable bags were in the range of 0% to 2.1%. Therefore, it can be concluded that the majority of the participating households can and are willing to separate waste properly.

Most of the people who agreed to participate in the program were probably fairly confident that they can differentiate compostable and non-compostable waste. However, this may not be the case with the rest of the city. Therefore, if the City wants to implement a separation program in the entire city, it should have ways to inform or instruct residents on how to differentiate between compostable and non-compostable waste in order to make the program more successful.

As shown in Table 4.9, the average quantities of compostable and non-compostable wastes collected from a household are approximately 0.89 kg/day/household (i.e., 0.88 + 0.01) and 0.65 kg/day/household (i.e., 0.02 + 0.63), respectively. These amounts are much lower than the average quantities of compostable and non-compostable wastes obtained from the waste audit (1.6 and 0.95 kg/day/household, respectively). The differences may be due to either or both of the following:

- The quantity of waste discharged by the residents may fluctuate in different weeks. Therefore, the residents might have generated more waste in the week of waste audit but less in the week of the pilot project.
- During the week of pilot project, some residents may have separated only a part of their waste. It was possible that they might have given their separated wastes to the

researcher and kept their non-separated waste which may have been thrown into the curbside waste bin nearby later.

If the differences were dominantly caused by the first reason, the waste audit should have been carried out in a longer period in order to obtain more accurate quantities of wastes collected in the study areas.

However, since the main purpose of the pilot project is to identify the participation level of the residents in separating wastes and the residents' ability to differentiate the 2 types of waste, if the second reason is the dominant cause, the results of the pilot project can be affected. If this case is true, it seems that the residents did not sincerely participate in the program. In the long term, these residents may stop "hiding" their non-separated wastes and discharge them into either compostable or non-compostable waste streams. Thus, the purity of the compostable waste may lower than the current result.

The pilot program was conducted in three different areas. Table 4.12 presents the average contamination levels of separated compostable and non-compostable bags as well as the number of households discharging waste without contamination in each of the three areas. The contamination levels were calculated in the same way as those in tables 4.10 and 4.11.

Table 4.12 Contamination levels at households in three areas

Area	No. of households	No. of households have no contamination in 2 bags	Average contamination in compostable bags (%)	Average contamination in non-compostable bags (%)
Area 1	25	15	1.94%	1.21%
Area 2a	26	22	0.75%	0.39%
Area 2b	16	7	2.62%	0.75%

Note:

- *Area 1: living along medium-large road*
- *Area 2a: living along small roads and small-medium road*
- *Area 2b: living along medium road*

As shown in table 4.12, for both 2 types of waste bags, the small differences in the contamination levels between the 3 areas indicate that there is no meaningful difference between the abilities of people in these areas to separate their wastes. Therefore, the characteristics of communities living along different types of roads seem not affecting the purity of separated waste.

As a result of conducting the pilot program on waste separation at household, the researcher has several additional observations that may help in the implementation of an on-going program in Danang:

- Many households were eager to participate in the pilot program. However, a few households that agreed to separate wastes did not separate the waste thoroughly. Therefore, if Danang City wants to implement a waste separation program across the entire city, it will be inevitable that carelessness or inability of some households to properly separate wastes would decrease the quality of input material for composting activities, unless steps are taken to educate and encourage them.
- A few households stored their mixed waste in one bag, and only began to sort out their waste when the collector came. Even though the quality of the separated waste was good, it is still not an appropriate way to separate waste in the long run, when the program does not just last for a week. For an on-going program, residents need to be instructed on the best way to separate waste.
- In households where the senior people were responsible for managing waste, it took more time to explain and instruct them how to differentiate wastes. Thus, when conducting an education and information campaign, more time should be spent to instruct and inform seniors.
- Some households agreed to participate in the waste separation program when they knew they would be provided with a waste bin. For an expanded program, the city should consider providing waste bins to initially encourage residents to participate. However, this does not guarantee that all of the residents will separate their waste properly in the long run.

V. SUMMARY AND RECOMMENDATIONS

5.1. SUMMARY OF PROGRAMS OF WASTE SEPARATION AT SOURCE IN VIETNAM

Several programs on organic/compostable waste separation have been conducted in some provinces in Vietnam. For example, Hanoi had a number of programs of at-source waste separation, such as the program in Gia Lam district (2001), the pilot project in Trau Quy ward (2002), and the one in Phanchutrinh ward (2003). Hanoi also had an unsuccessful program in Kim Lien community (1999), which lasted for only three months. Hochiminh City had two projects, one in district 5, which ended in 1999, and the other program in district 11, which is still being conducted. The authorities of Hochiminh City have also made proposals to implement several new programs. As well, in Quangnam province, a pilot project of waste separation at source was conducted in 2001 in Hoi An town.

Those programs listed above indicate that there is an interest in organic/compostable waste separation at source by the Vietnamese government and by the non-governmental organizations in Vietnam. Even though there are a few unsuccessful projects due mainly to the lack of financial support and the low cooperation of residents, some projects are being conducted successfully and have received very good results, especially in Hanoi.

5.2. SUMMARY OF RESULTS OF THE WASTE AUDIT PROGRAM

The waste audit that was conducted at 74 households (31 households in the first week and 43 households in the second week) in June and July 2004 provides information on wastes collected in two residential areas in the dry season. This data may also be used to estimate the quantity and the composition of waste for the rest of Danang City.

5.2.1. Quantity and composition of waste

A summary of the estimated daily quantities and the composition of solid waste per household is presented in table 5.1.

The most important findings from the results of the waste audit are:

- On average, about 2.55 kg of total waste per household was collected per day in the combined areas.

- The average daily quantity of waste per capita ranging from 0.51 to 0.64 kg/day/capita is consistent to the published data of waste quantity of a number of developing countries.
- On average, about 1.6 kg of compostable waste per household was collected per day in the combined areas. This makes up 63% of the total waste collected.
- The percentage of compostable waste estimated in the study (i.e., 63%) is similar to the percentages reported in the literature of various cities of developing countries.
- The average percentage of compostable waste per household is 65%.
- Most of the non-food waste observed in the waste bags is plastic and nylon bags, and small pieces of paper.

These results show the potential for a compostable waste separation and composting program in Danang.

Table 5.1 Summary of average waste quantities and composition

Audit period and area	Week 1 and Area 1	Week 2 and Area 2	Two weeks and areas
No. of households	31	43	74
Average (kg/day/ household)	2.37	2.68	2.55
Compostable waste quantity (kg/day/ household)	1.39	1.75	1.60
Percentage of compostable waste in the waste stream (%)	59%	65%	63%
Percentage of compostable waste per household (%)	60%	68%	65%
Non-compostable (kg/day/ household)	0.97	0.93	0.95
Percentage of non- compostable waste in the waste stream (%)	41%	35%	37%
Percentage of non- compostable waste per household (%)	40%	32%	35%

5.2.2. Danang's residential waste quantity

Based on the average quantities of total waste (2.55 kg/day/household) obtained from of the waste audit, the total amount of residential waste collected from approximately 149,420 households in Danang is estimated to be around 139 thousand tonnes per year, which is similar to a URENCO Danang estimate of 149 thousand tonnes per year. Table 5.2 presents a breakdown of the estimate into compostable and non-compostable waste

quantities which based on the estimates of compostable and non-compostable waste collected daily (1.6 and 0.95 kg/day/household, respectively).

Overall, the quantity of waste per household obtained from the waste audit program can be considered reliable because of the relative similarity in the quantity of waste estimated for the whole city based on the audit compared to the real records. Thus, the estimate of compostable waste generation of the whole city (approximately 239 tonnes per day) can be used to design the capacity of a composting plant.

Table 5.2 Estimation of residential waste collection in Danang City

Type of waste	Average per day (tonnes/day)	Average per year (tonnes/year)
Compostable waste	239	87,300
Non-compostable waste	142	51,800
Total waste	381	139,100

5.3. SUMMARY OF RESULTS OF THE PILOT PROJECT OF COMPOSTABLE WASTE SEPARATION AT SOURCE

The waste separation pilot project was conducted over one week in July 2004 at 67 households, of which 62 had participated in the waste audit. Prior to separating wastes, participants were given information on how to differentiate and separate their wastes. The results of the project can be used to estimate residents' willingness to separate waste and their ability to differentiate compostable waste from non-compostable waste. The results also show the quality of the separated compostable waste.

Table 5.3 shows the two types of contamination values in compostable and non-compostable bags collected from the participating households.

Table 5.3 Contamination levels in compostable and non-compostable bags in the pilot project

Type of bag	Average of contamination percentages in the waste stream (from table 4.9)	Average of contamination percentages at household level (from table 4.11)
Compostable	2.22%	1.63 %
Non-compostable	1.56%	0.78%

Some important findings from the results of the waste separation pilot project are:

- The high purity of the separated compostable waste (i.e., 98%) indicates an excellent ability of the participating households to differentiate compostable from non-compostable wastes and properly separate them.
- Of the 67 households that participated in the program, 44 households separated their waste without contamination on each of the seven days of the project. It can be inferred that the majority of the participating households can and are willing to separate waste properly.
- Of the 72 households asked to participate in the pilot program, only two households refused to participate and three households withdrew after participating for two days. The common reasons given by these households are that they were too busy to separate waste and/or they were afraid their children were not capable of properly separating the waste.

However, whether or not waste separation at source will be implemented depends not only on residents, but also on other external factors, such as subsidies from the government, market opportunities and revenues from composting products, and capital, operating and maintenance costs for collecting and transporting separated wastes and composting plants.

5.4. RECOMMENDATIONS FOR A PROGRAM OF COMPOSTABLE WASTE SEPARATION AT SOURCE IN DANANG

The results from several programs on waste separation at source in Vietnam show that it is necessary to design a complete plan for launching a program of at-source waste separation. Developing information campaigns is one of the most important tasks because the success of the program will depend on residents' willingness to participate in the program and their ability to separate waste properly.

Separating waste into two types (compostable and non-compostable) requires an appropriate collection schedule. Because compostable waste is degradable and the temperature in Danang is always over 37^{o}C, compostable waste needs to be collected on a daily basis to reduce pollution. Non-compostable waste, on the other hand, is relatively inert, so it can be collected less often.

URENCO Danang is currently using curbside-containers located along large or medium streets to store mixed waste from households living further away and on small roads. Therefore, installing two curbside-containers next to each other to receive two types of separated wastes and encourage residents to place their wastes in these containers can

reduce the number of collectors to collect waste door-to-door. As a result, Danang waste collection system could be improved if these curbside-containers are employed properly.

5.5. RECOMMENDATIONS FOR FUTURE WORK

In order to come to a final decision on whether or not a program of waste separation at source in the combination with composting waste should be conducted in Danang City, the following areas of research are recommended for future work:

- A waste audit should be conducted during a rainy season in order to get more accurate data on waste generation and composition for the full year;
- A pilot program on waste separation at households should be conducted during the rainy season to assess the willingness of residents to participate, and the quality of the separated compostable waste, in different seasons of the year;
- A study should be carried out of alternative designs of a system for collecting and transporting compostable waste to the composting plant and non-compostable waste to the landfill;
- Several information and education programs should be designed to educate and encourage residents to participate in a waste separation program;
- An investigation of potential markets for the compost end products should be carried out to estimate the revenue from them;
- A cost-benefit analysis of the two types of compostable waste separation: (i) at household and (ii) at waste facility should be done to identify the economically preferred method.

APPENDIX 2.A

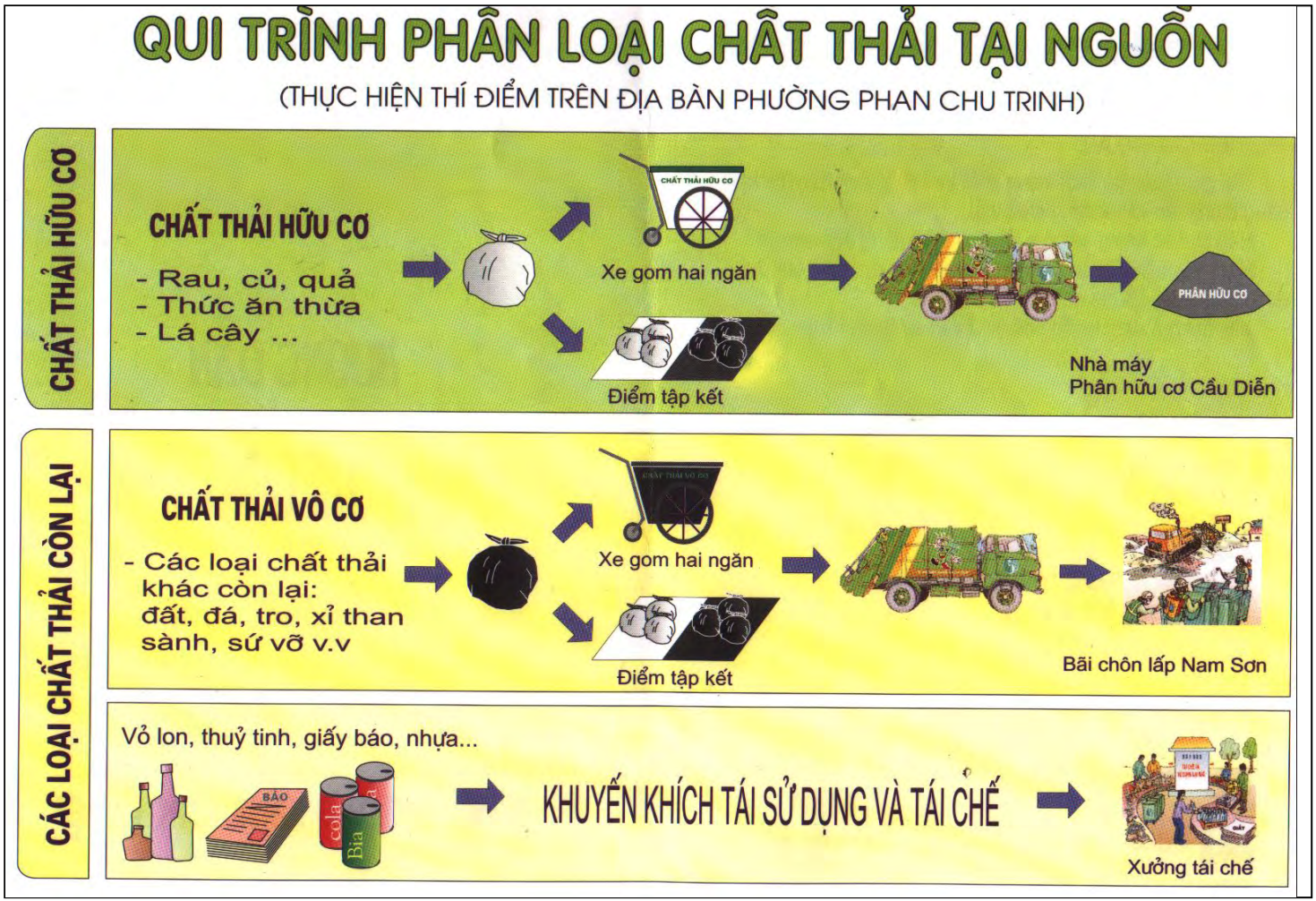
LIST OF INTERVIEWEES

In order to gather information of at-source waste separation programs in several places in Vietnam and information about Danang solid waste management, a number of people were interviewed:

- In Hanoi:
  - ✓ Mr. Nguyen Huy Nam: Deputy director of Gia Lam urban sanitation Enterprise. Interviewed on June 3, 2004.
  - ✓ Mr. Nguyen Van Duc: Director of Environmental Urban Enterprise No.1 (URENCO Hanoi). Interviewed on June 5, 2004.
  - ✓ Dr. Dao Chau Thu: Deputy director of Center of agriculturally sustainable research and development, Agricultural University No.1, Trau Quy, Gia Lam, Hanoi, Vietnam. Interviewed on May 28, 2004.
- In Hochiminh City:
  - ✓ Mr. Doan Van Khai: A member of ENDA. Interviewed on June 20, 2004.
- In Quangnam:
  - ✓ Mr. Tran Ha: Director of Hoi An public construction Company. Interviewed on July 10, 2004.
- In Danang:
  - ✓ Mr. Tran Van Tien: Deputy manager of Planning office of URENCO, Danang City. Interviewed on June 17, 2004.
  - ✓ Mr. Nguyen Thanh Sanh: Manager of Khanh Son landfill, URENCO, Danang City. Interviewed on June 22, 2004.

APPENDIX 2.B

LEAFLETS DISTRIBUTED TO RESIDENTS IN PHANCHUTRINH WARD FOR WASTE SEPARATION PROGRAM

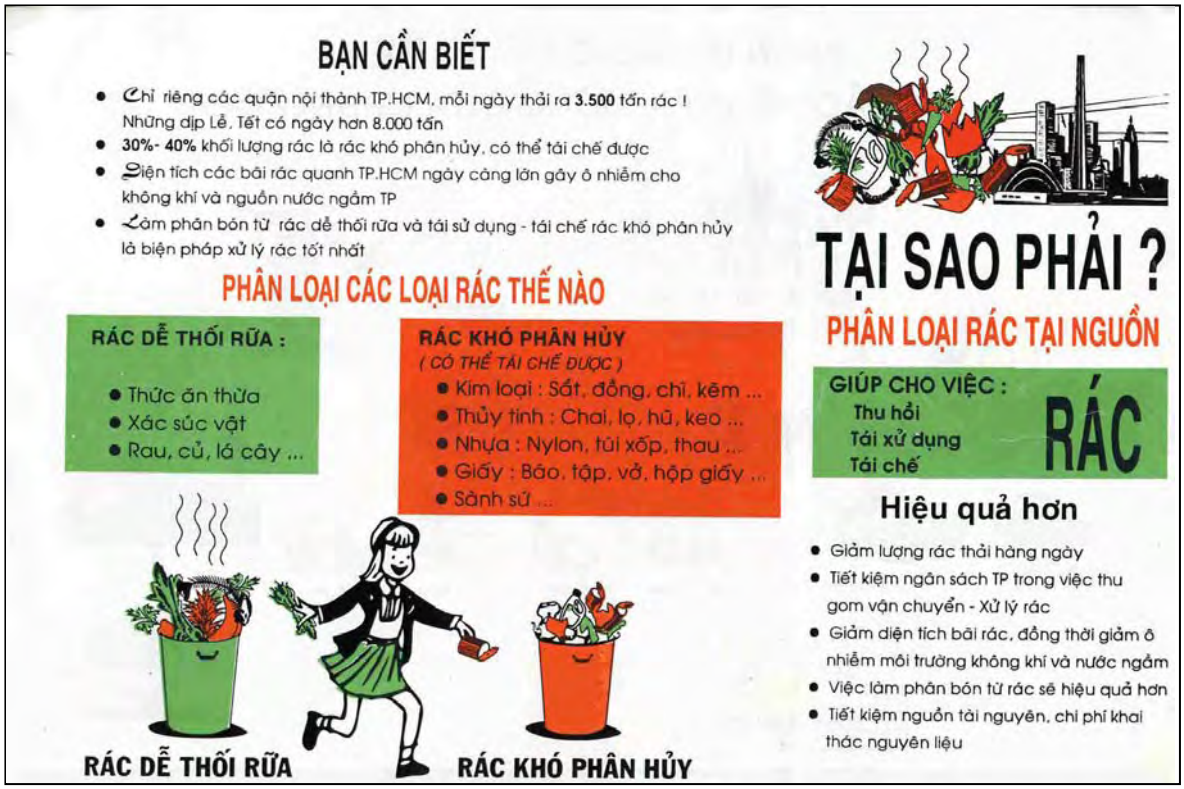


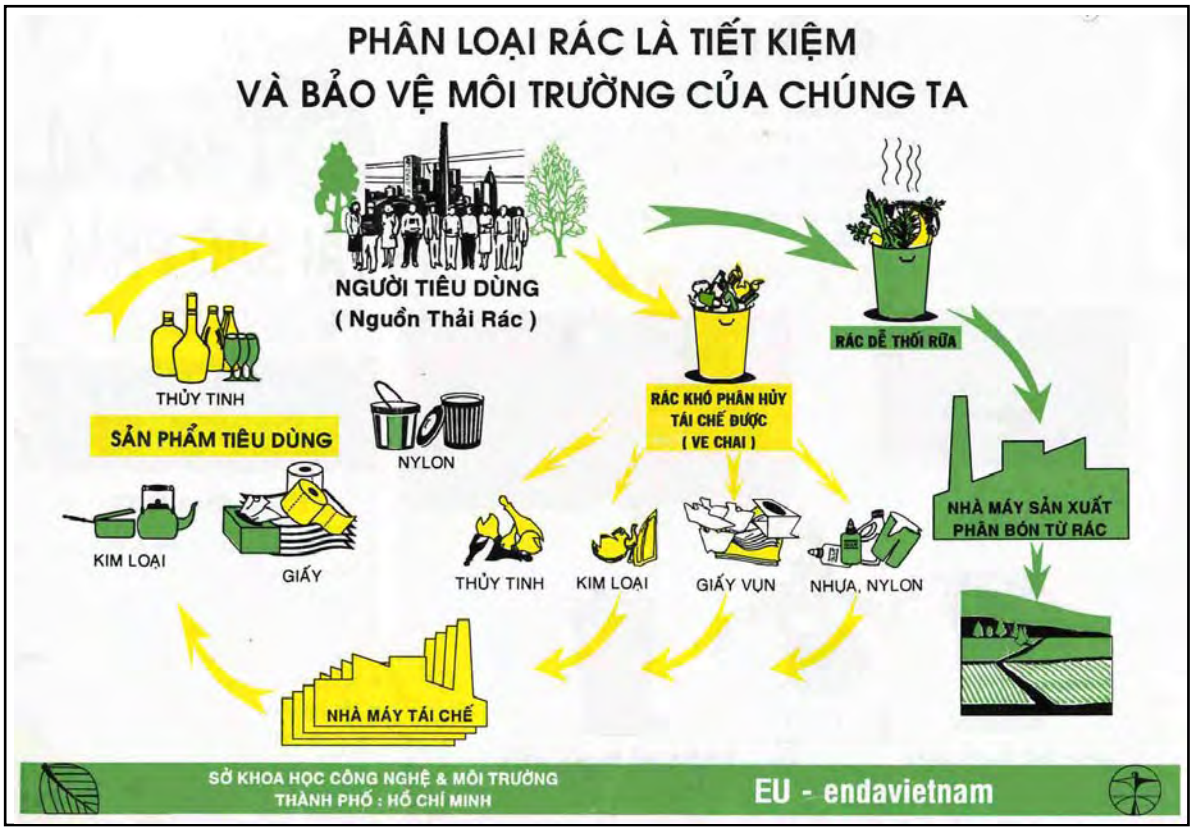
APPENDIX 2.C

POSTERS DISTRIBUTED TO RESIDENTS IN THREE COMMUNITY GROUPS OF TRAU QUY WARD FOR WASTE SEPARATION PROGRAM

APPENDIX 2.D

1. LEAFLETS DISTRIBUTED TO RESIDENTS IN SUB-WARD 3, WARD 12, DISTRICT 5, HOCHIMINH CITY FOR WASTE SEPARATION PROGRAM

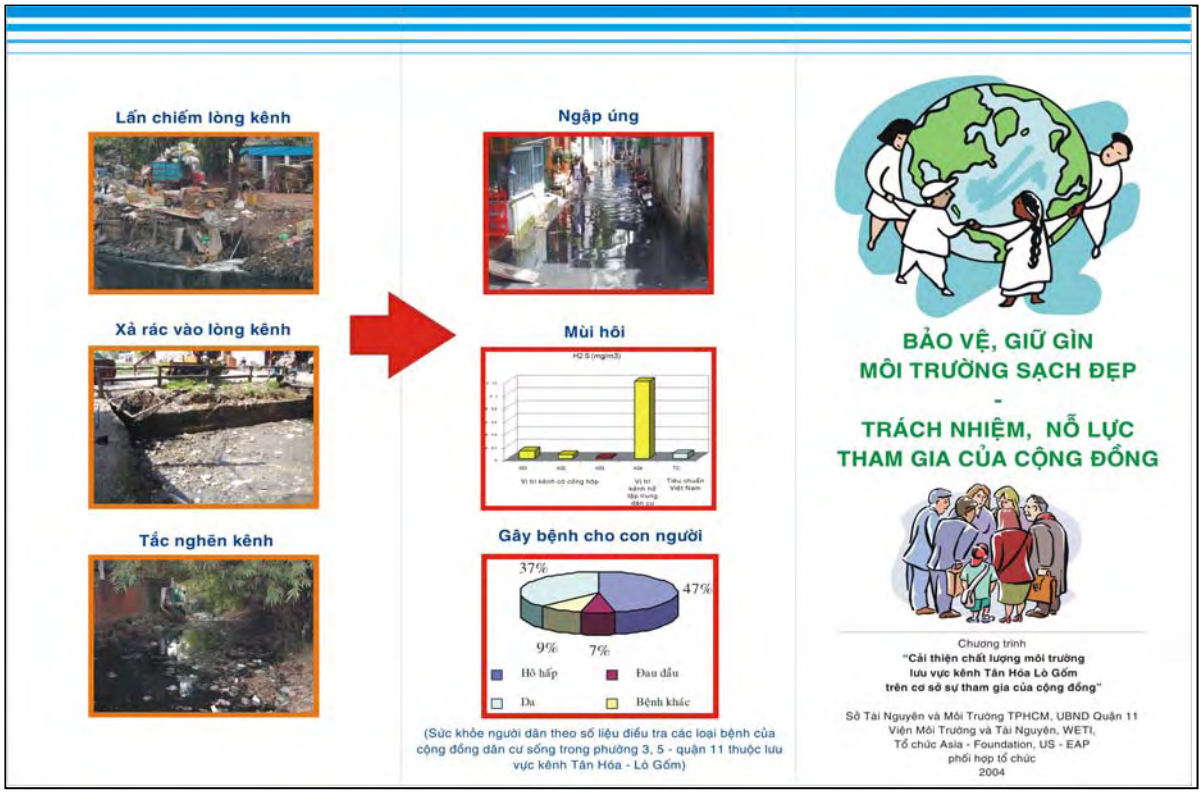




2. POSTERS PASTED ON DUSTBINS DISTRIBUTED TO RESIDENTS IN SUB-WARD 3, WARD 12, DISTRICT 5, HOCHIMINH CITY FOR WASTE SEPARATION PROGRAM

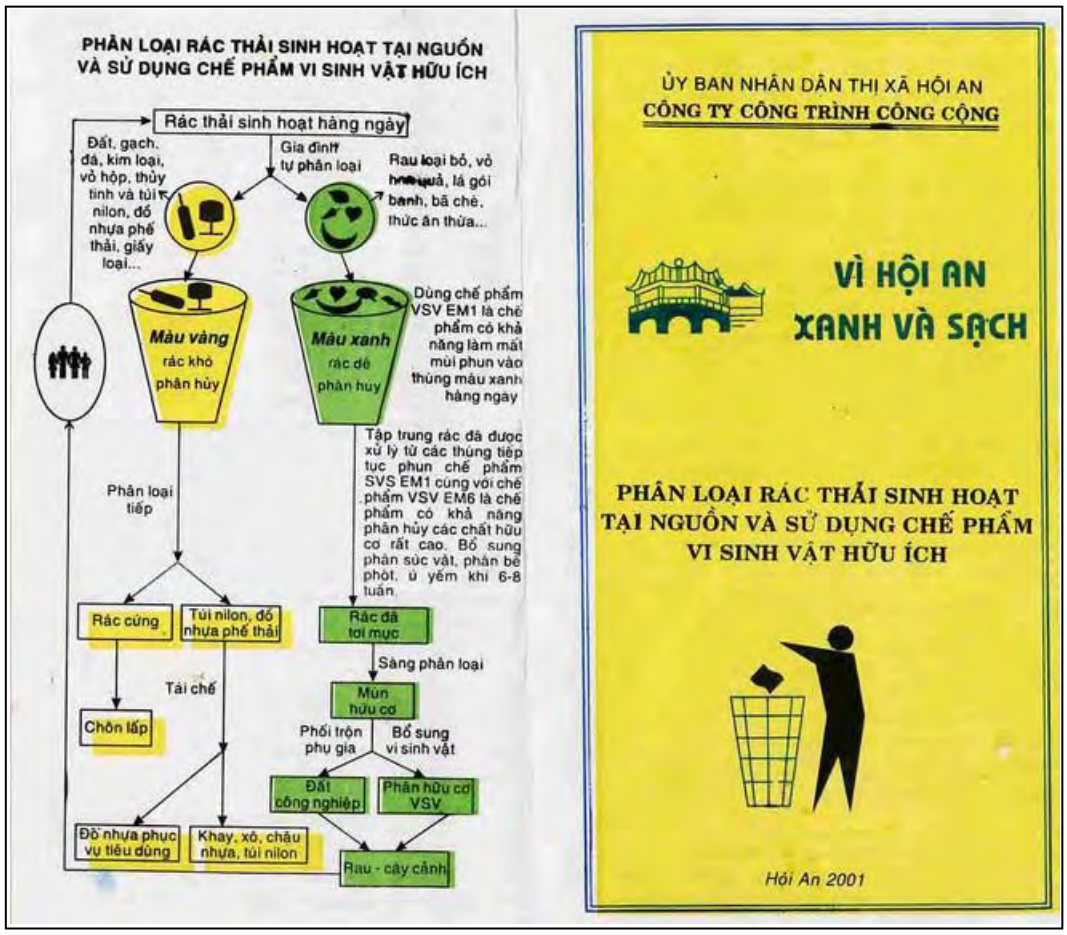
APPENDIX 2.E

LEAFLETS DISTRIBUTED TO RESIDENTS IN THE SUB-WARD 18, WARD 3, DISTRICT 11, HOCHIMINH CITY FOR WASTE SEPARATION PROGRAM



APPENDIX 2.F

LEAFLETS DISTRIBUTED TO RESIDENTS IN HOI AN TOWN FOR WASTE SEPARATION PROGRAM



APPENDIX 3.A

LISTS OF COMPOSTABLE AND NONCOMPOSTABLE CATEGORY WHICH WERE USED IN THE WASTE AUDIT AND SEPARATION PROJECT

1. *LIST OF COMPOSTABLE SOLID WASTE*

- Grains (dry)
- Vegetable and fruit scraps
- Kitchen scraps
- Bread
- Fruit rinds and peels
- Tea bags
- Coffee grounds
- Leaves and plant's branches

2. *LIST OF NON-COMPOSTABLE SOLID WASTE*

- Plastic and nylon
- Cloths, fabric
- Glass
- Ceramic
- Metal scraps
- Paper and cardboard (*)

Note: (*) even though paper and cardboard can be composted, they are not listed in the list of compostable waste because they are required to be recycled and reused.

APPENDIX 3.B

LEAFLET FOR INFORMATION PROGRAM (2 PAGES)

QUI TRÌNH PHÂN LOẠI CHẤT THẢI TẠI NGUỒN

CHẤT THẢI HỮU CƠ

CHẤT THẢI HỮU CƠ

-Rau, củ, quả

-Thức ăn thừa (trừ các loại vỏ sò, vỏ nghêu, vỏ dừa…)

- Lá cây…

CHẤT THẢI VÔ CƠ

CHẤT THẢI VÔ CƠ

-Toàn bộ các thành phần rác còn lại: đá, sành sứ vỡ, tro, xỉ than, giấy vụn,…

-Vỏ lon, thủy tinh, giấy báo, nhựa, …

TẠI SAO PHẢI ?

PHÂN LOẠI RÁC TẠI NGUỒN

GIÚP CHO VIỆC:

- **Thu hồi**
- **Tái sử dụng**
- **Tái chế**

Hiệu quả hơn

- Giảm lượng rác thải hàng ngày
- Tiết kiệm ngân sách thành phố trong việc thu gom, vận chuyển, xử lý rác
- Giảm diện tích bãi rác, đồng thời giảm ô nhiễm môi trường không khí và nước ngầm
- Việc làm phân bón vi sinh từ rác hiệu quả hơn vì không lẫn tạp chất
- Tiết kiệm nguồn tài nguyên, chi phí khai thác nguyên liệu

PHÂN LOẠI RÁC LÀ TIẾT KIỆM VÀ BẢO VỆ MÔI TRƯỜNG CỦA CHÚNG TA

HÃY XEM "RÁC" LÀ NGUỒN LỢI CẦN KHAI THÁC

+ 30% - 40% rác vô cơ có thể tái chế được

+ Rác hữu cơ được chế biến thành phân bón vi sinh

APPENDIX 3.C

GUIDELINE STICKER (PASTED ON THE TOP OF WASTE BINS' LIDS)

APPENDIX 3.D

A questionnaire form for a survey before conducting pilot project on organic waste separation at households

WASTE-ECON

Survey questionnaires

Waste separation at households

Please fill this questionnaire to answer the following questions, if agree, you use X to choose. Thank you for your participation.

1. How many members are in your family?
2. How much is your family's average income?

☐ a. Less than 300.000 VND/month ☐ c. From 300.000 to 500.000 VND/month

☐ b. From 500.000 to1.000.000 VND/month ☐ d. Over 1.000.000/month

3. In your family, who is responsible for waste management (especially organic waste)?

☐ a. Wife ☐ b. Husband ☐ c. Children ☐ d. No answer

4. Can you distinguish organic waste and inorganic waste?

☐ a. Yes ☐ b. No ☐ c. No answer

5. If answer No in question 4, do you want to be provided information of inorganic and organic waste?

☐ a. Yes ☐ b. No ☐ c. No answer

6. Do you know the benefits of waste separation at households?

☐ a. Yes ☐ b. No ☐ c. No answer

7. If Yes, can you choose the following benefits of waste separation at household?

a. Reduce waste discharged daily ☐

b. Save city budget in collecting, transporting and treating waste ☐

c. Reduce landfill area and reduce environmental pollution for atmosphere and water ☐

d. Produce composting fertilizers from waste ☐

e. Save natural resource and cost for exploiting materials ☐

g. Others ☐

8. If provided dustbin for free of charge, do you agree to participate in waste separation at household?

☐ a. Yes ☐ b. No ☐ c. No answer

9. If not, can you choose the following reasons why you do not want to participate?

a. No free time ☐ c. No body separates waste now ☐

b. Do not need to separate waste ☐ d. Other ☐

10. After ending this pilot project, if the Company of urban sanitation requires waste separation at household, do you want to participate or not?

☐ a. Yes ☐ b. No ☐ c. No answer

Danang, date…….. 200

Signature

APPENDIX 3.E

A questionnaire form for a survey after conducting pilot project on organic waste separation at households

WASTE-ECON

Questionnaires

Pilot project of waste separation at households

Please answer the questions below by ticking X in the box where you agree to. Thank you for your participation.

1. How many people are there in your family? .....

2. How many members of your family participate in the Pilot project of waste separation at households?

☐ a. 01 person
☐ b. 02 persons
☐ c. 03 persons
☐ d. 04 persons and more
☐ e. no answer

3. After participating in this project, what do you think about waste separation at households?

☐ a. easy to carry out
☐ b. no answer
☐ c. difficult to carry out
☐ d. other

if you have any idea, please write down:

.....

.....

.....

4. According to you, should be waste separation at households applied in the whole Danang City?

☐ a. yes ☐ b. No ☐ c. No answer

5. If yes, what should be done to make the project optimum?

a. Propagandise and organize workshops on waste separation for households ☐
b. Make incentive policy to optimise waste separation at households ☐
c. Fix the time for collection of separated wastes ☐
d. Offer containers for waste separation (basket, plastic bags...) ☐
e. others ☐

6. If no, why waste separation at households can not be applied in the whole City?

a. No benefits ☐
b. Difficult to carry out ☐
c. others ☐

7. According to you, how many times a day should organic wastes be collected?

☐ a. once a day
☐ b. twice a day
☐ c. three times a day
☐ d. other

8. According to you, how many times a day should inorganic wastes be collected?

☐ a. once a day
☐ b. twice a day
☐ c. three times a day
☐ d. other

Danang, day.....month..... 200

Interviewee's signature

APPENDIX 4.A:

Waste quantification audit (31 households in the first area – first week)

No	Name	Mon, 21-Jun-04	Tues, 22-Jun-04	Wed, 23-Jun-04	Thurs, 24-Jun-04	Fri, 25-Jun-04	Sat, 26-Jun-04	Sun, 27-Jun-04	Average	STDEV
		(Kg/day/household)								
1	K140/14	1.52	1.90	1.30	4.80	6.40	2.70	2.40	3.00	1.89
2	K140/16 HH	1.10	2.10	3.20	1.85	0.75	1.25	0.65	1.56	0.90
3	K140/15	1.50	1.10	- (*)	- (**)	0.90	0.30	0.90	0.67	0.58
4	Anh Duong K140/17	3.70	2.72	- (*)	0.88	1.60	3.30	1.50	1.96	1.34
5	Nha ong to truong	1.90	0.75	- (*)	0.65	- (**)	2.80	5.60	1.67	2.01
6	Nha cua go nau (duong Hai Ho)	3.41	0.60	1.80	2.20	2.20	0.20	1.60	1.72	1.07
7	Nha di bon	2.60	5.30	2.10	1.04	1.30	1.20	0.60	2.02	1.60
8	Nha pho Dung	2.31	5.35	3.62	3.20	3.40	4.70	3.25	3.69	1.02
9	Anh Luong	12.10	6.90	10.35	2.90	8.40	9.40	7.30	8.19	2.94
10	Chi Linh	3.45	6.30	- (*)	1.80	2.60	- (**)	0.60	2.11	2.27
11	Nha ban kem	2.10	3.40	3.60	4.80	1.50	0.90	2.10	2.63	1.36
12	Nha canh nha ban kem	2.11	1.90	1.60	1.50	1.30	1.60	1.25	1.61	0.31
13	Chi Lan	5.10	3.65	4.10	2.45	0.80	4.25	1.30	3.09	1.61
14	Chi Tram	3.20	0.70	8.70	1.95	2.60	0.60	3.10	2.98	2.73
15	Nha Phi	1.65	2.50	3.90	3.50	3.40	0.20	3.20	2.62	1.30
16	Nha lam ga vit	7.70	4.85	4.20	1.05	1.80	1.70	3.05	3.48	2.32
17	Nha cua xanh gan cho	4.30	1.02	1.50	1.58	1.80	1.30	0.95	1.78	1.15
18	Chi Thuy	3.45	2.50	3.30	1.40	2.95	1.05	2.30	2.42	0.92
19	Anh Nghieu	1.55	0.52	2.60	1.30	1.50	2.30	1.55	1.62	0.68
20	Nha cua xam, doi dien bo ho	4.10	1.20	2.30	1.30	0.55	0.50	2.30	1.75	1.27
21	Nha di Ha	2.00	2.15	4.90	4.00	2.20	3.00	2.80	3.01	1.08
22	Nha lam Inox	0.70	0.90	3.20	4.30	- (**)	1.90	1.10	2.02	1.32
23	Nha canh nha di Ha	0.80	0.70	1.68	0.95	0.55	0.85	1.10	0.95	0.37
24	Nha canh cay vu sua	2.90	0.50	2.10	3.10	1.70	0.70	4.40	2.20	1.39
25	Nha Ai	5.00	2.70	2.38	1.65	0.80	1.40	2.80	2.39	1.36
26	Nha xanh voi xanh	0.37	1.30	3.15	1.25	1.50	0.90	1.00	1.35	0.87
27	Nha chu Ta	3.52	1.50	4.20	2.90	1.20	1.70	8.50	3.36	2.52
28	Nha Ha em	3.02	1.15	0.70	0.92	0.70	1.30	0.50	1.18	0.86

No	Name	Mon, 21-Jun-04	Tues, 22-Jun-04	Wed, 23-Jun-04	Thurs, 24-Jun-04	Fri, 25-Jun-04	Sat, 26-Jun-04	Sun, 27-Jun-04	Average	STDEV
		(Kg/day/household)								
29	Nha Kiem	1.90	0.80	- (*)	2.85	2.10	0.95	2.30	1.56	1.00
30	Nha chi Giang	1.79	0.43	4.99	1.30	4.70	4.60	4.45	3.18	1.93
31	Nha tho may	2.85	2.62	1.30	0.90	1.70	1.70	1.35	1.77	0.71
	$W_{average}$ (kg/day/household)	**3.02**	**2.26**	**2.80**	**2.07**	**2.09**	**1.91**	**2.45**	**2.37**	
	STDEV (kg/day/household)	2.26	1.80	2.34	1.26	1.74	1.88	1.92		1.93
	$N_{households}$	31	31	26	30	29	30	31		
	W_{total} (kg/day)	93.70	70.01	86.77	64.27	64.92	59.25	75.80		

(*) No waste was collected because the household went out entire day due to traditional Mid-Lunar year occasion. It is considered as zero value.
(**) No waste was collected because waste might have been collected by someone else. It is considered as zero value.

APPENDIX 4.B:

Waste quantification audit (43 households in the second area – second week)

No	Name	Mon, 28-Jun-04	Tues, 29-Jun-04	Wed, 30-Jun-04	Thurs, 1-Jul-04	Fri, 2-Jul-04	Sat, 3-Jul-04	Sun, 4-Jul-04	Average	STDEV
		(kg/day/household)								
1	K115/07 Ong Ich Khiem	3.8	3.2	- (*)	4.4	3.5	4.8	4.2	3.41	1.48
2	K115/18 Ong Ich Khiem	4	3.6	3.9	3.4	2	1.4	3.4	3.10	0.92
3	K115/12B Ong Ich Khiem	4.6	7.1	2.5	3.8	5.7	5.5	5	4.89	1.36
4	K115/17 Ong Ich Khiem	2.9	5.5	2.2	5.5	4.1	5	0.5	3.67	1.75
5	K115/18D Ong Ich Khiem	0.7	0.3	1	1.1	1.8	1.8	0.7	1.06	0.53
6	K115/20 Ong Ich Khiem	2.8	7.6	1.7	4.7	2.55	3.8	6.5	4.24	2.01
7	K115/26 Ong Ich Khiem	0.8	9.3	6.8	5.2	3.6	4	4.4	4.87	2.47
8	K115/31 Ong Ich Khiem	2	1.8	2.9	1	1.6	2	1.3	1.80	0.56
9	K115/28 Ong Ich Khiem	3.1	2.1	3.4	1.6	3.7	1.4	2.9	2.60	0.83
10	K115/34 Ong Ich Khiem	4.55	3.9	0.7	0.45	1	3.5	3.7	2.54	1.62
11	K115/33 Ong Ich Khiem	0.8	2	4.9	1.2	2.3	3.1	5.3	2.80	1.61
12	K115/36A Ong Ich Khiem	6.35	3.4	5.1	4.3	3.5	3.7	1.9	4.04	1.31
13	K115/36B Ong Ich Khiem	2.9	2.1	2.3	3.6	0.8	1.4	2.9	2.29	0.89
14	K115/43 Ong Ich Khiem	5.9	7	3.6	7	5.5	5.3	5.1	5.63	1.09
15	K33/02 Cao Thang	0.65	2.3	3.5	2.8	6.35	2.1	4.5	3.17	1.71
16	K33A/15 Cao Thang	1.5	0.7	0.2	0.55	0.77	3.5	0.9	1.16	1.02
17	K33A/11 Cao Thang	2.6	0.9	0.8	2	1.2	1.3	2.1	1.56	0.63
18	K46/38 Cao Thang	1.5	3.8	3.9	2	2.3	1.3	3.3	2.59	1.00
19	K46/60 Cao Thang	2.5	4.2	2	3.7	1.8	0.2	1	2.20	1.31
20	K46/19 Cao Thang	2.2	8.5	3.8	3.7	2.4	6.1	2.9	4.23	2.12
21	K46/13 Cao Thang	1.8	4.4	2.6	1.4	2.7	1.7	1.2	2.26	1.02
22	K46/56 Cao Thang	2.4	3.3	2.6	4.3	0.95	1.9	2.4	2.55	0.98
23	K46/52 Cao Thang	6.7	4	2.4	3.5	4.55	2.9	2.3	3.76	1.42
24	K46/07 Cao Thang	1	1.9	0.4	1.1	1.4	0.8	2.4	1.29	0.63
25	H38/6 Cao Thang	2.4	2.55	3.5	3.9	6.5	7.1	6.5	4.64	1.86
26	H38/04 Cao Thang	2.8	- (*)	3.9	4	2.9	3.7	7.2	3.50	1.97
27	H38/02 Cao Thang	3.3	- (*)	1.75	1.7	2.1	3.7	1.1	1.95	1.17

No	Name	Mon, 28-Jun-04	Tues, 29-Jun-04	Wed, 30-Jun-04	Thurs, 1-Jul-04	Fri, 2-Jul-04	Sat, 3-Jul-04	Sun, 4-Jul-04	Average	STDEV
		(kg/day/household)								
28	H38/10 Cao Thang	3.45	2.15	1.8	2.8	1.2	1	2.5	2.13	0.81
29	K46/36 Cao Thang	2.15	1.3	2.5	3.4	2.55	2.6	1.85	2.34	0.61
30	K46/03 Cao Thang	4	1.5	3	4.5	1.5	0.7	1.2	2.34	1.38
31	K46/26 Cao Thang	1.05	1.95	2.4	1.9	0.8	3.3	2.8	2.03	0.83
32	K46/24 Cao Thang	1.6	1.45	1.2	1.1	0.7	1.55	1.7	1.33	0.32
33	H30/14 Cao Thang	1.5	1.2	2.8	0.6	1.95	2.2	0.9	1.59	0.72
34	H30/11 Cao Thang	1.8	1.7	1.7	1.6	4.1	1.6	5.4	2.56	1.43
35	K46/20 Cao Thang	1.3	2.8	1.4	1.1	1.1	1.8	2.6	1.73	0.65
36	K46/18 Cao Thang	1.25	1.5	1.6	2	2.1	1.6	2.1	1.74	0.31
37	H16/03 Cao Thang	3.9	3.2	1.6	3.3	5.3	1	1.6	2.84	1.41
38	H16/02 Cao Thang	2.7	1.5	4.9	2.4	1.9	2.3	2	2.53	1.03
39	H16/11 CT	3.5	1.2	1.9	2.1	2.5	2.9	3.1	2.46	0.73
40	H16/23 CT	4.05	6.5	1.2	1.2	1.4	0.8	1.3	2.35	1.97
41	K46/H16/27 CT	3.25	0.3	1.9	0.9	2.6	1.1	2.7	1.82	1.01
42	K127/07 Ly Tu Trong	3.25	1.6	0.6	2.9	2.1	1.6	3.5	2.22	0.97
43	K127/21 Ly Tu Trong	1.35	1.6	1.5	0.4	0.6	3.5	1.05	1.43	0.94
	$W_{average}$ (kg/day/household)	**2.71**	**2.95**	**2.43**	**2.65**	**2.56**	**2.62**	**2.83**	**2.68**	
	STDEV (kg/day/household)	1.48	2.30	1.44	1.58	1.58	1.60	1.70	1.10	1.68
	$N_{households}$	43	41	42	43	43	43	43		
	W_{total} (kg/day)	80.25	77.10	69.25	77.45	74.62	72.55	82.10		

(*) No waste was collected because waste might have been collected by someone else. It is considered as zero value.

APPENDIX 4.C:

Waste composition audit (31 households in the first week)
Weighs of compostable and non-compostable waste

No	Name	Mon, 21-Jun-04		Tues, 22-Jun-04		Wed, 23-Jun-04		Thurs, 24-June-04		Fri, 25-Jun-04		Sat, 26-Jun-04		Sun, 27-Jun-04		Average		Standard deviation	
		CW	NW	CW	NW	CW	NW	CW	NW	CW	NW	CW	NW	CW	NW	CW	NW	CW	NW
		(kg/day/household)																	
1	K140/14	0.90	0.62	1.10	0.80	0.70	0.60	2.30	2.50	3.40	3.00	1.50	1.20	1.70	0.70	1.66	1.35	0.94	0.99
2	K140/16 HH	0.60	0.50	0.90	1.20	1.70	1.50	0.95	0.90	0.40	0.35	0.65	0.60	0.45	0.20	0.81	0.75	0.44	0.47
3	K140/15	0.80	0.70	0.60	0.50	- (*)	-(*)	- (**)	- (**)	0.50	0.40	0.15	0.15	0.50	0.40	0.36	0.31	0.31	0.27
4	Anh Duong K140/17	2.00	1.70	1.36	1.36	- (*)	- (*)	0.48	0.40	1.50	0.10	1.80	1.50	1.00	0.50	1.16	0.79	0.72	0.71
5	Nha ong to truong	1.00	0.90	0.45	0.30	- (*)	- (*)	0.15	0.50	- (**)	- (**)	2.00	0.80	4.10	1.50	1.10	0.57	1.50	0.54
6	Nha cua go nau (duong Hai Ho)	1.75	1.66	0.60	0.00	1.10	0.70	1.40	0.80	1.20	1.00	0.20	0.00	0.90	0.70	1.02	0.69	0.51	0.58
7	Nha di bon	1.40	1.20	3.30	2.00	1.20	0.90	0.60	0.44	0.70	0.60	0.60	0.60	0.30	0.30	1.16	0.86	1.02	0.58
8	Nha pho Dung	1.31	1.00	4.80	0.55	3.30	0.32	1.80	1.40	2.50	0.90	4.40	0.30	1.85	1.40	2.85	0.84	1.35	0.47
9	Anh Luong	6.60	5.50	3.80	3.10	5.35	5.00	1.50	1.40	4.40	4.00	5.00	4.40	4.00	3.30	4.38	3.81	1.58	1.37
10	Chi Linh	2.20	1.25	3.20	3.10	- (*)	- (*)	1.20	0.60	1.40	1.20	- (**)	- (**)	0.50	0.10	1.21	0.89	1.18	1.11
11	Nha ban kem	1.20	0.90	2.55	0.85	2.00	1.60	2.90	1.90	0.80	0.70	0.90	0.00	1.40	0.70	1.68	0.95	0.82	0.63
12	Nha canh nha ban kem	1.20	0.91	1.10	0.80	0.85	0.75	0.80	0.70	0.70	0.60	1.00	0.60	0.70	0.55	0.91	0.70	0.20	0.13
13	Chi Lan	3.10	2.00	2.10	1.55	2.90	1.20	1.50	0.95	0.50	0.30	2.65	1.60	0.70	0.60	1.92	1.17	1.05	0.60
14	Chi Tram	1.60	1.60	0.40	0.30	4.70	4.00	1.10	0.85	1.40	1.20	0.40	0.20	1.80	1.30	1.63	1.35	1.46	1.28
15	Nha Phi	0.95	0.70	1.30	1.20	2.00	1.90	1.90	1.60	1.80	1.60	0.20	0.00	2.20	1.00	1.48	1.14	0.71	0.65
16	Nha lam ga vit	4.10	3.60	2.45	2.40	3.00	1.20	0.65	0.40	1.05	0.75	1.10	0.60	2.30	0.75	2.09	1.39	1.24	1.18
17	Nha cua xanh gan cho	2.50	1.80	0.60	0.42	0.80	0.70	0.80	0.78	1.40	0.40	0.80	0.50	0.50	0.45	1.06	0.72	0.70	0.50
18	Chi Thuy	1.80	1.65	2.40	0.10	1.80	1.50	0.80	0.60	1.55	1.40	0.55	0.50	1.60	0.70	1.50	0.92	0.63	0.59
19	Anh Nghieu	0.80	0.75	0.30	0.22	1.40	1.20	0.70	0.60	0.80	0.70	1.20	1.10	0.80	0.75	0.86	0.76	0.36	0.32
20	Nha cua xam, doi dien bo ho	2.70	1.40	0.65	0.55	2.10	0.20	0.70	0.60	0.30	0.25	0.50	0.00	1.50	0.80	1.21	0.54	0.91	0.47
21	Nha di Ha	1.30	0.70	1.10	1.05	2.70	2.20	2.30	1.70	1.20	1.00	1.80	1.20	2.00	0.80	1.77	1.24	0.60	0.53
22	Nha lam Inox	0.50	0.20	0.55	0.35	1.70	1.50	2.20	2.10	- (**)	- (**)	1.00	0.90	1.10	0.00	1.18	0.84	0.75	0.82
23	Nha canh nha di Ha	0.40	0.40	0.40	0.30	0.90	0.78	0.50	0.45	0.30	0.25	0.55	0.30	0.80	0.30	0.55	0.40	0.22	0.18
24	Nha canh cay vu sua	1.60	1.30	0.30	0.20	1.30	0.80	1.60	1.50	0.90	0.80	0.40	0.30	2.40	2.00	1.21	0.99	0.74	0.65

No	Name	Mon, 21-Jun-04		Tues, 22-Jun-04		Wed, 23-Jun-04		Thurs, 24-June-04		Fri, 25-Jun-04		Sat, 26-Jun-04		Sun, 27-Jun-04		Average		Standard deviation	
		CW	NW	CW	NW	CW	NW	CW	NW	CW	NW	CW	NW	CW	NW	CW	NW	CW	NW
		(kg/day/household)																	
25	Nha Ai	2.60	2.40	1.90	0.80	1.20	1.18	0.90	0.75	0.50	0.30	1.35	0.05	1.60	1.20	1.44	0.95	0.69	0.77
26	Nha xanh voi xanh	0.20	0.17	0.70	0.60	1.60	1.55	0.70	0.55	0.80	0.70	0.50	0.40	0.60	0.40	0.73	0.62	0.43	0.44
27	Nha chu Ta	1.90	1.62	0.80	0.70	2.30	1.90	2.60	0.30	0.70	0.50	1.10	0.60	4.30	4.20	1.96	1.40	1.27	1.37
28	Nha Ha em	1.62	1.40	0.70	0.45	0.50	0.20	0.50	0.42	0.40	0.30	0.70	0.60	0.30	0.20	0.67	0.51	0.44	0.42
29	Nha Kiem	1.10	0.80	0.80	0.00	- (*)	- (*)	1.60	1.25	1.10	1.00	0.60	0.35	1.30	1.00	1.08	0.73	0.52	0.51
30	Nha chi Giang	1.35	0.44	0.25	0.18	2.64	2.35	0.70	0.60	2.70	2.00	2.40	2.20	2.30	2.15	1.76	1.42	0.99	0.96
31	Nha tho may	1.50	1.35	1.42	1.20	0.80	0.50	0.50	0.40	1.10	0.60	1.50	0.20	0.90	0.45	1.10	0.67	0.39	0.43
	$W_{average}$ (kg/day/household)	**1.70**	**1.33**	**1.38**	**0.88**	**1.63**	**1.17**	**1.17**	**0.90**	**1.16**	**0.87**	**1.21**	**0.70**	**1.50**	**0.95**	**1.39**	**0.97**		
	STDEV (kg/day/household)	1.24	1.05	1.16	0.82	1.31	1.13	0.74	0.59	0.97	0.85	1.14	0.87	1.08	0.91			**1.11**	**0.91**
	$N_{households}$	31		31		26		30		29		30		31					
	W_{total} (kg/day)	52.58	41.12	42.88	27.13	50.54	36.23	36.33	27.94	36.33	27.94	37.50	21.75	46.40	29.40				

CW: compostable waste NW: Non-compostable waste

(*) No waste was collected because the household went out entire day due to traditional Mid-Lunar year occasion. It is considered as zero value.
(**) No waste was collected because waste might have been collected by someone else. It is considered as zero value.

APPENDIX 4.D:

Waste composition audit (43 households in the second week)
Weighs of compostable and non-compostable waste

No	Name	Mon, 28-Jun-04		Tues, 29-Jun-04		Wed, 30-Jun-04		Thurs, 1-Jul-04		Fri, 2-Jul-04		Sat, 3-Jul-04		Sun, 4-Jul-04		Average		STDEV	
		CW	NW	CW	NW	CW	NW	CW	NW	CW	NW	CW	NW	CW	NW	CW	NW	CW	NW
		(kg/day/household)																	
1	K115/07 Ong Ich Khiem	2	1.8	1.9	1.3	- (*)	- (*)	2.4	2	2	1.5	2.8	2	2.7	1.5	1.97	1.44	0.94	0.69
2	K115/18 Ong Ich Khiem	2.5	1.5	2.1	1.5	2.2	1.7	1.9	1.5	1.7	0.3	1.3	0.1	2.4	1	2.01	1.09	0.42	0.64
3	K115/12B Ong Ich Khiem	2.4	2.2	4.1	3	1.3	1.2	2	1.8	3.7	2	3	2.5	2.8	2.2	2.76	2.13	0.96	0.56
4	K115/17 Ong Ich Khiem	1.5	1.4	3	2.5	1.2	1	5	0.5	2.3	1.8	2.7	2.3	0.5	0	2.31	1.36	1.47	0.92
5	K115/18D Ong Ich Khiem	0.4	0.3	0.3	0	0.6	0.4	0.6	0.5	1.1	0.7	1.1	0.7	0.5	0.2	0.66	0.40	0.32	0.26
6	K115/20 Ong Ich Khiem	1.8	1	4.1	3.5	1.6	0.1	2.7	2	1.5	1.05	2.3	1.5	3.6	2.9	2.51	1.72	1.01	1.17
7	K115/26 Ong Ich Khiem	0.5	0.3	5.3	4	4.3	2.5	2.7	2.5	2.6	1	2.3	1.7	3.4	1	3.01	1.86	1.53	1.25
8	K115/31 Ong Ich Khiem	1.5	0.5	1.8	0	1.7	1.2	0.6	0.4	1.6	0	1.2	0.8	0.8	0.5	1.31	0.49	0.46	0.43
9	K115/28 Ong Ich Khiem	1.6	1.5	1.1	1	1.8	1.6	0.9	0.7	2	1.7	1.2	0.2	1.6	1.3	1.46	1.14	0.40	0.54
10	K115/34 Ong Ich Khiem	2.55	2	2.7	1.2	0.5	0.2	0.45	0	0.8	0.2	2	1.5	2.2	1.5	1.60	0.94	0.98	0.80
11	K115/33 Ong Ich Khiem	0.8	0	1.3	0.7	3.2	1.7	0.8	0.4	1.6	0.7	1.9	1.2	3.3	2	1.84	0.96	1.04	0.71
12	K115/36A Ong Ich Khiem	3.35	3	1.9	1.5	3.6	1.5	2.3	2	2	1.5	3.5	0.2	1.1	0.8	2.54	1.50	0.96	0.88
13	K115/36B Ong Ich Khiem	1.7	1.2	1.1	1	1.3	1	2.1	1.5	0.5	0.3	0.9	0.5	1.6	1.3	1.31	0.97	0.54	0.43
14	K115/43 Ong Ich Khiem	3.4	2.5	5	2	2.1	1.5	5	2	5	0.5	3.3	2	3.1	2	3.84	1.79	1.16	0.64
15	K33/02 Cao Thang	0.65	0	1.4	0.9	2.3	1.2	2.1	0.7	3.8	2.55	1.6	0.5	2.5	2	2.05	1.12	0.99	0.88
16	K33A/15 Cao Thang	0.8	0.7	0.5	0.2	0.2	0	0.55	0	0.45	0.32	2.3	1.2	0.6	0.3	0.77	0.39	0.70	0.43
17	K33A/11 Cao Thang	1.4	1.2	0.5	0.4	0.5	0.3	1.2	0.8	0.7	0.5	0.8	0.5	1.2	0.9	0.90	0.66	0.37	0.32
18	K46/38 Cao Thang	1	0.5	2.3	1.5	2.1	1.8	1.3	0.7	1.4	0.9	1.1	0.2	2.8	0.5	1.71	0.87	0.69	0.58
19	K46/60 Cao Thang	1.4	1.1	2.2	2	1.1	0.9	1.9	1.8	1	0.8	0.2	0	0.6	0.4	1.20	1.00	0.70	0.71
20	K46/19 Cao Thang	1.2	1	4.5	4	2	1.8	1.9	1.8	1.3	1.1	3.1	3	2.7	0.2	2.39	1.84	1.16	1.29
21	K46/13 Cao Thang	1	0.8	3.4	1	1.6	1	1	0.4	1.8	0.9	1.3	0.4	1	0.2	1.59	0.67	0.86	0.33
22	K46/56 Cao Thang	1.6	0.8	2.8	0.5	1.5	1.1	2.8	1.5	0.55	0.4	1.4	0.5	1.6	0.8	1.75	0.80	0.80	0.39

No	Name	Mon, 28-Jun-04		Tues, 29-Jun-04		Wed, 30-Jun-04		Thurs, 1-Jul-04		Fri, 2-Jul-04		Sat, 3-Jul-04		Sun, 4-Jul-04		Average		STDEV	
		CW	NW	CW	NW	CW	NW	CW	NW	CW	NW	CW	NW	CW	NW	CW	NW	CW	NW
		(kg/day/household)																	
23	K46/52 Cao Thang	3.7	3	2.5	1.5	1.4	1	3	0.5	3	1.55	2.4	0.5	1.8	0.5	2.54	1.22	0.78	0.91
24	K46/07 Cao Thang	1	0	1.2	0.7	0.4	0	0.8	0.3	0.8	0.6	0.5	0.3	2.2	0.2	0.99	0.30	0.60	0.27
25	H38/6 Cao Thang	2.4	0	1.55	1	2	1.5	2.4	1.5	5	1.5	4.9	2.2	5	1.5	3.32	1.31	1.57	0.68
26	H38/04 Cao Thang	1.6	1.2	- (*)	- (*)	2.4	1.5	2.5	1.5	2.1	0.8	2.3	1.4	5	2.2	2.27	1.23	1.48	0.68
27	H38/02 Cao Thang	2.8	0.5	- (*)	- (*)	1	0.75	1.2	0.5	1.2	0.9	3.2	0.5	0.8	0.3	1.46	0.49	1.14	0.29
28	H38/10 Cao Thang	2.65	0.8	1.2	0.95	1	0.8	2.8	0	1.2	0	1	0	2.5	0	1.76	0.36	0.84	0.46
29	K46/36 Cao Thang	1.65	0.5	0.8	0.5	2	0.5	3.4	0	2.5	0.05	2.1	0.5	1.65	0.2	2.01	0.32	0.81	0.23
30	K46/03 Cao Thang	2.5	1.5	1.5	0	1.8	1.2	3	1.5	0.85	0.65	0.7	0	0.7	0.5	1.58	0.76	0.91	0.65
31	K46/26 Cao Thang	0.55	0.5	1.1	0.85	1.4	1	1.4	0.5	0.8	0	2.8	0.5	1.9	0.9	1.42	0.61	0.75	0.34
32	K46/24 Cao Thang	0.9	0.7	0.8	0.65	0.75	0.45	0.7	0.4	0.7	0	0.9	0.65	1.5	0.2	0.89	0.44	0.28	0.26
33	H30/14 Cao Thang	1.3	0.2	0.8	0.4	1.5	1.3	0.6	0	1	0.95	1.3	0.9	0.9	0	1.06	0.54	0.32	0.52
34	H30/11 Cao Thang	1.8	0	1.2	0.5	1.7	0	1.2	0.4	2.3	1.8	1.5	0.1	3.4	2	1.87	0.69	0.77	0.85
35	K46/20 Cao Thang	0.7	0.6	2.3	0.5	1.1	0.3	1.1	0	1.1	0	1.5	0.3	1.5	1.1	1.33	0.40	0.51	0.38
36	K46/18 Cao Thang	0.65	0.6	1	0.5	1.1	0.5	1.3	0.7	1.3	0.8	1.6	0	1.7	0.4	1.24	0.50	0.36	0.26
37	H16/03 Cao Thang	2.1	1.8	2.2	1	1	0.6	1.9	1.4	3.5	1.8	0.9	0.1	1.2	0.4	1.83	1.01	0.91	0.68
38	H16/02 Cao Thang	1.4	1.3	1	0.5	2.9	2	1.4	1	1.05	0.85	1.3	1	1.2	0.8	1.46	1.06	0.65	0.48
39	H16/11 CT	2.2	1.3	1.2	0	1.2	0.7	1.6	0.5	1.5	1	1.9	1	2.1	1	1.67	0.79	0.41	0.43
40	H16/23 CT	2.2	1.85	4.5	2	0.7	0.5	0.6	0.6	1	0.4	0.5	0.3	0.8	0.5	1.47	0.88	1.45	0.72
41	K46/H16/27 CT	1.8	1.45	0.3	0	1.1	0.8	0.5	0.4	1.5	1.1	0.9	0.2	1.4	1.3	1.07	0.75	0.54	0.56
42	K127/07 Ly Tu Trong	1.9	1.35	1.1	0.5	0.4	0.2	1.5	1.4	1.2	0.9	0.9	0.7	2	1.5	1.29	0.94	0.56	0.50
43	K127/21 Ly Tu Trong	0.95	0.4	0.9	0.7	0.8	0.7	0.4	0	0.6	0	2.5	1	0.85	0.2	1.00	0.43	0.69	0.39
	$W_{average}$ (kg/day/household)	***1.67***	***1.04***	***1.87***	***1.08***	***1.5***	***0.93***	***1.76***	***0.9***	***1.71***	***0.85***	***1.79***	***0.83***	***1.92***	***0.91***	**1.75**	**0.93**		
	STDEV (kg/day/household)	0.82	0.77	1.36	1.03	0.89	0.62	1.1	0.71	1.12	0.63	0.98	0.76	1.12	0.73			**1.07**	**0.76**
	$N_{households}$	43		41		42		43		43		43		43					
	W_{total} (kg/day)	50.90	29.35	50.85	26.25	42.35	26.90	53.15	24.30	50.70	23.92	51.60	20.95	57.80	24.30				

CW: compostable waste NW: Non-compostable waste

No	Name	Mon, 28-Jun-04		Tues, 29-Jun-04		Wed, 30-Jun-04		Thurs, 1-Jul-04		Fri, 2-Jul-04		Sat, 3-Jul-04		Sun, 4-Jul-04		Average		STDEV	
		CW	NW	CW	NW	CW	NW	CW	NW	CW	NW	CW	NW	CW	NW	CW	NW	CW	NW
		(kg/day/household)																	

(*) No waste was collected because waste might have been collected by someone else. It is considered as zero value.

APPENDIX 4.E:

Waste composition audit (31 households in the first week)

Percentages of compostable and non-compostable waste at household level

No	Name	Mon, 21-Jun-04		Tues, 22-Jun-04		Wed, 23-Jun-04		Thurs, 24-June-04		Fri, 25-Jun-04		Sat, 26-Jun-04		Sun, 27-Jun-04		Average		Standard deviation	
		CW	NW	CW	NW	CW	NW	CW	NW	CW	NW	CW	NW	CW	NW	CW	NW	CW	NW
		(%)		(%)		(%)		(%)		(%)		(%)		(%)		(%)		(%)	
1	K140/14	59.21	40.79	57.89	42.11	53.85	46.15	47.92	52.08	53.13	46.88	55.56	44.44	70.83	29.17	56.91	43.09	6.62	6.62
2	K140/16 HH	54.55	45.45	42.86	57.14	53.13	46.88	51.35	48.65	53.33	46.67	52.00	48.00	69.23	30.77	53.78	46.22	7.25	7.25
3	K140/15	53.33	46.67	54.55	45.45	- (*)	- (*)	- (**)	- (**)	55.56	44.44	50.00	50.00	55.56	44.44	53.80	46.20	2.07	2.07
4	Anh Duong K140/17	54.05	45.95	50.00	50.00	- (*)	- (*)	54.55	45.45	93.75	6.25	54.55	45.45	66.67	33.33	62.26	37.74	14.99	14.99
5	Nha ong to truong	52.63	47.37	60.00	40.00	- (*)	- (*)	23.08	76.92	- (**)	- (**)	71.43	28.57	73.21	26.79	56.07	43.93	18.14	18.14
6	Nha cua go nau (duong Hai Ho)	51.32	48.68	100	0.00	61.11	38.89	63.64	36.36	54.55	45.45	100	0.00	56.25	43.75	69.55	30.45	19.62	19.62
7	Nha di bon	53.85	46.15	62.26	37.74	57.14	42.86	57.69	42.31	53.85	46.15	50.00	50.00	50.00	50.00	54.97	45.03	4.09	4.09
8	Nha pho Dung	56.71	43.29	89.72	10.28	91.16	8.84	56.25	43.75	73.53	26.47	93.62	6.38	56.92	43.08	73.99	26.01	16.18	16.18
9	Anh Luong	54.55	45.45	55.07	44.93	51.69	48.31	51.72	48.28	52.38	47.62	53.19	46.81	54.79	45.21	53.34	46.66	1.35	1.35
10	Chi Linh	63.77	36.23	50.79	49.21	- (*)	- (*)	66.67	33.33	53.85	46.15	- (**)	- (**)	83.33	16.67	63.68	36.32	11.47	11.47
11	Nha ban kem	57.14	42.86	75.00	25.00	55.56	44.44	60.42	39.58	53.33	46.67	100.00	0.00	66.67	33.33	66.87	33.13	15.17	15.17
12	Nha canh nha ban kem	56.87	43.13	57.89	42.11	53.13	46.88	53.33	46.67	53.85	46.15	62.50	37.50	56.00	44.00	56.22	43.78	3.08	3.08
13	Chi Lan	60.78	39.22	57.53	42.47	70.73	29.27	61.22	38.78	62.50	37.50	62.35	37.65	53.85	46.15	61.28	38.72	4.80	4.80
14	Chi Tram	50.00	50.00	57.14	42.86	54.02	45.98	56.41	43.59	53.85	46.15	66.67	33.33	58.06	41.94	56.59	43.41	4.80	4.80
15	Nha Phi	57.58	42.42	52.00	48.00	51.28	48.72	54.29	45.71	52.94	47.06	100.00	0.00	68.75	31.25	62.40	37.60	16.32	16.32
16	Nha lam ga vit	53.25	46.75	50.52	49.48	71.43	28.57	61.90	38.10	58.33	41.67	64.71	35.29	75.41	24.59	62.22	37.78	8.43	8.43
17	Nha cua xanh gan cho	58.14	41.86	58.82	41.18	53.33	46.67	50.63	49.37	77.78	22.22	61.54	38.46	52.63	47.37	58.98	41.02	8.47	8.47
18	Chi Thuy	52.17	47.83	96.00	4.00	54.55	45.45	57.14	42.86	52.54	47.46	52.38	47.62	69.57	30.43	62.05	37.95	14.98	14.98
19	Anh Nghieu	51.61	48.39	57.69	42.31	53.85	46.15	53.85	46.15	53.33	46.67	52.17	47.83	51.61	48.39	53.45	46.55	1.95	1.95
20	Nha cua xam, doi dien bo ho	65.85	34.15	54.17	45.83	91.30	8.70	53.85	46.15	54.55	45.45	100.00	0.00	65.22	34.78	69.28	30.72	17.49	17.49
21	Nha di Ha	65.00	35.00	51.16	48.84	55.10	44.90	57.50	42.50	54.55	45.45	60.00	40.00	71.43	28.57	59.25	40.75	6.43	6.43
22	Nha lam Inox	71.43	28.57	61.11	38.89	53.13	46.88	51.16	48.84	- (**)	- (**)	52.63	47.37	100.00	0.00	64.91	35.09	17.16	17.16
23	Nha canh nha di Ha	50.00	50.00	57.14	42.86	53.57	46.43	52.63	47.37	54.55	45.45	64.71	35.29	72.73	27.27	57.90	42.10	7.43	7.43
24	Nha canh cay vu sua	55.17	44.83	60.00	40.00	61.90	38.10	51.61	48.39	52.94	47.06	57.14	42.86	54.55	45.45	56.19	43.81	3.45	3.45

No	Name	Mon, 21-Jun-04		Tues, 22-Jun-04		Wed, 23-Jun-04		Thurs, 24-June-04		Fri, 25-Jun-04		Sat, 26-Jun-04		Sun, 27-Jun-04		Average		Standard deviation	
		CW	NW	CW	NW	CW	NW	CW	NW	CW	NW	CW	NW	CW	NW	CW	NW	CW	NW
		(%)		(%)		(%)		(%)		(%)		(%)		(%)		(%)		(%)	
25	Nha Ai	52.00	48.00	70.37	29.63	50.42	49.58	54.55	45.45	62.50	37.50	96.43	3.57	57.14	42.86	63.34	36.66	14.91	14.91
26	Nha xanh voi xanh	54.05	45.95	53.85	46.15	50.79	49.21	56.00	44.00	53.33	46.67	55.56	44.44	60.00	40.00	54.80	45.20	2.64	2.64
27	Nha chu Ta	53.98	46.02	53.33	46.67	54.76	45.24	89.66	10.34	58.33	41.67	64.71	35.29	50.59	49.41	60.77	39.23	12.52	12.52
28	Nha Ha em	53.64	46.36	60.87	39.13	71.43	28.57	54.35	45.65	57.14	42.86	53.85	46.15	60.00	40.00	58.75	41.25	5.84	5.84
29	Nha Kiem	57.89	42.11	100	0.00	*- (*)*	*- (*)*	56.14	43.86	52.38	47.62	63.16	36.84	56.52	43.48	64.35	35.65	16.26	16.26
30	Nha chi Giang	75.42	24.58	58.14	41.86	52.91	47.09	53.85	46.15	57.45	42.55	52.17	47.83	51.69	48.31	57.37	42.63	7.73	7.73
31	Nha tho may	52.63	47.37	54.20	45.80	61.54	38.46	55.56	44.44	64.71	35.29	88.24	11.76	66.67	33.33	63.36	36.64	11.31	11.31
	Average (%)	***56.73***	***43.27***	***61.94***	***38.06***	***59.34***	***40.66***	***55.63***	***44.37***	***58.10***	***41.90***	***67.04***	***32.96***	***63.09***	***36.91***	**60.28**	**39.72**		
	STDEV (%)	6.03	6.03	14.79	14.79	11.21	11.21	9.63	9.63	9.21	9.21	17.71	17.71	11.02	11.02			**12.34**	**12.34**
	$N_{households}$	31		31		26		30		29		30		31					

CW: compostable waste
NW:Non-compostable waste

(*) No waste was collected because the household went out entire day due to traditional Mid-Lunar year occasion.

(**) No waste was collected because waste might have been collected by someone else.

APPENDIX 4.F:

Waste composition audit (43 households in the second week)
Percentages of compostable and non-compostable waste at household level

No	Name	Mon, 28-Jun-04		Tues, 29-Jun-04		Wed, 30-Jun-04		Thurs, 1-Jul-04		Fri, 2-Jul-04		Sat, 3-Jul-04		Sun, 4-Jul-04		Average		STDEV	
		CW	NW	CW	NW	CW	NW	CW	NW	CW	NW	CW	NW	CW	NW	CW	NW	CW	NW
		(%)		(%)		(%)		(%)		(%)		(%)		(%)		(%)		(%)	
1	K115/07 Ong Ich Khiem	52.63	47.37	59.38	40.63	*- (*)*	*- (*)*	54.55	45.45	57.14	42.86	58.33	41.67	64.29	35.71	57.72	42.28	3.71	3.71
2	K115/18 Ong Ich Khiem	62.50	37.50	58.33	41.67	56.41	43.59	55.88	44.12	85.00	15.00	92.86	7.14	70.59	29.41	68.80	31.20	13.70	13.70
3	K115/12B Ong Ich Khiem	52.17	47.83	57.75	42.25	52.00	48.00	52.63	47.37	64.91	35.09	54.55	45.45	56.00	44.00	55.72	44.28	4.24	4.24
4	K115/17 Ong Ich Khiem	51.72	48.28	54.55	45.45	54.55	45.45	90.91	9.09	56.10	43.90	54.00	46.00	100.00	0.00	65.97	34.03	18.84	18.84
5	K115/18D Ong Ich Khiem	57.14	42.86	100.00	0.00	60.00	40.00	54.55	45.45	61.11	38.89	61.11	38.89	71.43	28.57	66.48	33.52	14.53	14.53
6	K115/20 Ong Ich Khiem	64.29	35.71	53.95	46.05	94.12	5.88	57.45	42.55	58.82	41.18	60.53	39.47	55.38	44.62	63.50	36.50	12.89	12.89
7	K115/26 Ong Ich Khiem	62.50	37.50	56.99	43.01	63.24	36.76	51.92	48.08	72.22	27.78	57.50	42.50	77.27	22.73	63.09	36.91	8.26	8.26
8	K115/31 Ong Ich Khiem	75.00	25.00	100.00	0.00	58.62	41.38	60.00	40.00	100.00	0.00	60.00	40.00	61.54	38.46	73.59	26.41	17.47	17.47
9	K115/28 Ong Ich Khiem	51.61	48.39	52.38	47.62	52.94	47.06	56.25	43.75	54.05	45.95	85.71	14.29	55.17	44.83	58.30	41.70	11.29	11.29
10	K115/34 Ong Ich Khiem	56.04	43.96	69.23	30.77	71.43	28.57	100.00	0.00	80.00	20.00	57.14	42.86	59.46	40.54	70.47	29.53	14.50	14.50
11	K115/33 Ong Ich Khiem	100.00	0.00	65.00	35.00	65.31	34.69	66.67	33.33	69.57	30.43	61.29	38.71	62.26	37.74	70.01	29.99	12.50	12.50
12	K115/36A Ong Ich Khiem	52.76	47.24	55.88	44.12	70.59	29.41	53.49	46.51	57.14	42.86	94.59	5.41	57.89	42.11	63.19	36.81	13.95	13.95
13	K115/36B Ong Ich Khiem	58.62	41.38	52.38	47.62	56.52	43.48	58.33	41.67	62.50	37.50	64.29	35.71	55.17	44.83	58.26	41.74	3.81	3.81
14	K115/43 Ong Ich Khiem	57.63	42.37	71.43	28.57	58.33	41.67	71.43	28.57	90.91	9.09	62.26	37.74	60.78	39.22	67.54	32.46	10.91	10.91
15	K33/02 Cao Thang	100.00	0.00	60.87	39.13	65.71	34.29	75.00	25.00	59.84	40.16	76.19	23.81	55.56	44.44	70.45	29.55	14.02	14.02
16	K33A/15 Cao Thang	53.33	46.67	71.43	28.57	100.00	0.00	100.00	0.00	58.44	41.56	65.71	34.29	66.67	33.33	73.65	26.35	17.52	17.52
17	K33A/11 Cao Thang	53.85	46.15	55.56	44.44	62.50	37.50	60.00	40.00	58.33	41.67	61.54	38.46	57.14	42.86	58.42	41.58	2.92	2.92
18	K46/38 Cao Thang	66.67	33.33	60.53	39.47	53.85	46.15	65.00	35.00	60.87	39.13	84.62	15.38	84.85	15.15	68.05	31.95	11.20	11.20
19	K46/60 Cao Thang	56.00	44.00	52.38	47.62	55.00	45.00	51.35	48.65	55.56	44.44	100.00	0.00	60.00	40.00	61.47	38.53	15.94	15.94
20	K46/19 Cao Thang	54.55	45.45	52.94	47.06	52.63	47.37	51.35	48.65	54.17	45.83	50.82	49.18	93.10	6.90	58.51	41.49	14.18	14.18
21	K46/13 Cao Thang	55.56	44.44	77.27	22.73	61.54	38.46	71.43	28.57	66.67	33.33	76.47	23.53	83.33	16.67	70.32	29.68	8.99	8.99
22	K46/56 Cao Thang	66.67	33.33	84.85	15.15	57.69	42.31	65.12	34.88	57.89	42.11	73.68	26.32	66.67	33.33	67.51	32.49	8.74	8.74

No	Name	Mon, 28-Jun-04		Tues, 29-Jun-04		Wed, 30-Jun-04		Thurs, 1-Jul-04		Fri, 2-Jul-04		Sat, 3-Jul-04		Sun, 4-Jul-04		Average		STDEV	
		CW	NW	CW	NW	CW	NW	CW	NW	CW	NW	CW	NW	CW	NW	CW	NW	CW	NW
		(%)		(%)		(%)		(%)		(%)		(%)		(%)		(%)		(%)	
23	K46/52 Cao Thang	55.22	44.78	62.50	37.50	58.33	41.67	85.71	14.29	65.93	34.07	82.76	17.24	78.26	21.74	69.82	30.18	11.37	11.37
24	K46/07 Cao Thang	100.00	0.00	63.16	36.84	100.00	0.00	72.73	27.27	57.14	42.86	62.50	37.50	91.67	8.33	78.17	21.83	17.23	17.23
25	H38/6 Cao Thang	100.00	0.00	60.78	39.22	57.14	42.86	61.54	38.46	76.92	23.08	69.01	30.99	76.92	23.08	71.76	28.24	13.61	13.61
26	H38/04 Cao Thang	57.14	42.86	- (*)	- (*)	61.54	38.46	62.50	37.50	72.41	27.59	62.16	37.84	69.44	30.56	64.20	35.80	5.15	5.15
27	H38/02 Cao Thang	84.85	15.15	- (*)	- (*)	57.14	42.86	70.59	29.41	57.14	42.86	86.49	13.51	72.73	27.27	71.49	28.51	11.67	11.67
28	H38/10 Cao Thang	76.81	23.19	55.81	44.19	55.56	44.44	100.00	0.00	100.00	0.00	100.00	0.00	100.00	0.00	84.03	15.97	19.56	19.56
29	K46/36 Cao Thang	76.74	23.26	61.54	38.46	80.00	20.00	100.00	0.00	98.04	1.96	80.77	19.23	89.19	10.81	83.75	16.25	12.32	12.32
30	K46/03 Cao Thang	62.50	37.50	100.00	0.00	60.00	40.00	66.67	33.33	56.67	43.33	100.00	0.00	58.33	41.67	72.02	27.98	17.94	17.94
31	K46/26 Cao Thang	52.38	47.62	56.41	43.59	58.33	41.67	73.68	26.32	100.00	0.00	84.85	15.15	67.86	32.14	70.50	29.50	15.89	15.89
32	K46/24 Cao Thang	56.25	43.75	55.17	44.83	62.50	37.50	63.64	36.36	100.00	0.00	58.06	41.94	88.24	11.76	69.12	30.88	16.37	16.37
33	H30/14 Cao Thang	86.67	13.33	66.67	33.33	53.57	46.43	100.00	0.00	51.28	48.72	59.09	40.91	100.00	0.00	73.90	26.10	19.72	19.72
34	H30/11 Cao Thang	100.00	0.00	70.59	29.41	100.00	0.00	75.00	25.00	56.10	43.90	93.75	6.25	62.96	37.04	79.77	20.23	16.75	16.75
35	K46/20 Cao Thang	53.85	46.15	82.14	17.86	78.57	21.43	100.00	0.00	100.00	0.00	83.33	16.67	57.69	42.31	79.37	20.63	16.89	16.89
36	K46/18 Cao Thang	52.00	48.00	66.67	33.33	68.75	31.25	65.00	35.00	61.90	38.10	100.00	0.00	80.95	19.05	70.75	29.25	14.36	14.36
37	H16/03 Cao Thang	53.85	46.15	68.75	31.25	62.50	37.50	57.58	42.42	66.04	33.96	90.00	10.00	75.00	25.00	67.67	32.33	11.19	11.19
38	H16/02 Cao Thang	51.85	48.15	66.67	33.33	59.18	40.82	58.33	41.67	55.26	44.74	56.52	43.48	60.00	40.00	58.26	41.74	4.27	4.27
39	H16/11 CT	62.86	37.14	100.00	0.00	63.16	36.84	76.19	23.81	60.00	40.00	65.52	34.48	67.74	32.26	70.78	29.22	12.86	12.86
40	H16/23 CT	54.32	45.68	69.23	30.77	58.33	41.67	50.00	50.00	71.43	28.57	62.50	37.50	61.54	38.46	61.05	38.95	7.09	7.09
41	K46/H16/27 CT	55.38	44.62	100.00	0.00	57.89	42.11	55.56	44.44	57.69	42.31	81.82	18.18	51.85	48.15	65.74	34.26	16.74	16.74
42	K127/07 Ly Tu Trong	58.46	41.54	68.75	31.25	66.67	33.33	51.72	48.28	57.14	42.86	56.25	43.75	57.14	42.86	59.45	40.55	5.61	5.61
43	K127/21 Ly Tu Trong	70.37	29.63	56.25	43.75	53.33	46.67	100.00	0.00	100.00	0.00	71.43	28.57	80.95	19.05	76.05	23.95	17.46	17.46
	Average (%)	***64.71***	***35.29***	***67.17***	***32.83***	***64.18***	***35.82***	***69.06***	***30.94***	***68.89***	***31.11***	***72.56***	***27.44***	***70.30***	***29.70***	**68.15**	**31.85**		
	STDEV (%)	15.62	15.62	14.65	14.65	12.95	12.95	16.56	16.56	16.09	16.09	15.22	15.22	13.89	13.89			**15.37**	**15.37**
	$N_{households}$	43		41		42		43		43		43		43					

CW: compostable waste NW: Non-compostable waste

(*) No waste was collected because waste might have been collected by someone else.

APPENDIX 4.G:

Raw data of a pilot project of compostable waste separation at household (67 households in one week) (kg/day/household)

		26th July, 2004				27th July, 2004				28th July, 2004				29th July, 2004				30th July, 2004				31st July, 2004				1st August, 2004			
No	Name of households	Cbag		Nbag		Cbag		Nbag		Cbag		Nbag		Cbag		Nbag		Cbag		Nbag		Cbag		Nbag		Cbag		Nbag	
		CW	NW	CW	NW	CW	NW	CW	NW	CW	NW	CW	NW	CW	NW	CW	NW	CW	NW	CW	NW	CW	NW	CW	NW	CW	NW	CW	NW
1	K140/14	1	0	0	0.1	1.7	0	0	0.4	0.2	0	0	0.4	1.2	0	0	0.2	4	0	0	0.2	4	0	0	0.3	0.6	0	0	0.4
2	K140/16 HH	1.4	0	0	0.2	0.6	0	0	1.4	1.1	0	0	0	0.9	0	0	0.2	1.1	0	0	0.3	2	0	0	0.2	1	0	0	0.6
3	K140/15	2.15	0	0	0.25	0.2	0	0	0.1	0.3	0	0	0.5	0.3	0	0	0.05	0.3	0	0	0.1	0.7	0	0.1	0.2	0.6	0	0	0.8
4	Anh Duong K140/17	1	0	0	1.4	1.2	0	0	0.3	2	0	0	0	1.2	0	0	0.1	3	0	0	0	3	0	0	0.3	0.5	0	0	0.5
5	Nha di bon	0.9	0.2	0	0	0.3	0	0	0.6	0	0	0	0.6	0.9	0	0	0	0.4	0	0	0.1	0.25	0	0	0.2	0.5	0	0	1.2
6	Pho Dung	1	0	0	5	0.9	0	0	5	0.2	0	0	5	0.3	0	0	2.1	0.5	0	0	3.5	0.2	0	0	5	0.7	0	0	4.3
7	Nha Linh	0.3	0	0	1.5	0	0	0	1.7	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	1.1	0	0	0.4	0.5	0	0	0.6	0.8	0	0	1.3
8	Nha ban kem	4	0	0	1.1	2.3	0	0	1.4	1	0	0	4.2	1.8	0	1	1	1.4	0	0	2.05	0.7	0	0	1.5	0.8	0	0	1
9	Canh nha ban kem	1.1	0	0	0.5	(*)	(*)	(*)	(*)	1	0.7	0	0	0	0	0	0.4	1.2	0	0	0.3	2.5	0	0	0	0	0	0	0.3
10	Chi Lan	0.5	0	0	0	0.6	0	0	0.2	0.45	0	0	0	0.55	0	0	0.3	0.7	0	0	0.5	0.65	0	0	0.25	0.9	0	0	0.6
11	Nha Tram	0	0	0	0.2	0.9	0	0	0	0.8	0.8	0	0	0.4	0	0	0.5	0	0	0	1	0.2	0	0	0	0.4	0	0	0.45
12	Nha gan cho, cua xanh	0	0	0	2.8	1	0.5	0	0.5	0.8	0.4	0	0	1.4	0.05	0	0.05	0	0	0	1.4	0.2	1	1.4	1.8	1.2	0.4	0.2	1.5
13	Anh Nghieu	0.5	0	0	1.4	1	0	0	1	0.8	0	0	0.7	0	0	0	1.2	0.4	0	0	0.9	0.4	0	0	0.8	1.4	0	0	1
14	Nha cua xam	0.9	0	0	1.6	0.9	0	0	0.15	0.4	0.1	0	0.4	0.3	0	0	0.1	0.7	0.05	0	0.1	0.4	0	0	0.1	0.4	0	0	0.2
15	Nha di Ha	1	0.2	0	0.2	0.9	0	0	0	0.3	0	0	0	0.2	0	0	0.1	0.7	0	0	0.05	0	0	0	0.5	0.2	0	0	0.5
16	Canh nha di Ha	0	0	0	2.8	0.4	0	0	0.2	0.45	0	0	0.3	0.5	0	0	0.3	0.85	0	0	0.15	0.8	0	0	0.5	0.3	0	0	0.8
17	Nha Ai	1.4	0	0	0.3	1.1	0	0	0.5	0.4	0	0	1	0.1	0	0	0.3	1.1	0	0	0.7	0	0	0	1.7	1.2	0	0	1.5
18	Nha voi xanh	1.6	0	0	0.4	1.5	0	0	0.1	1.2	0	0	0.2	0.85	0	0	0.2	0.45	0	0	0.1	0.3	0	0	0.3	0.4	0	0	0.15
19	Nha chu Ta	0.6	0	0	0.1	0.5	0	0	0.1	0.4	0	0	0.1	0.8	0	0	0.1	0.3	0	0	0.1	0.2	0	0	0.5	0.4	0	0	0.5
20	Nha di Ha em	3.4	0	0	0.35	0.7	0	0	0.2	0	0	0	0.2	1	0	0	0.1	0.3	0	0	0.3	0.35	0	0	0.25	0.7	0	0	0.3
21	Nha tho may	0	0	0	0.15	0.3	0	0	0	0.3	0	0	1.2	0.2	0	0	1	0.2	0	0	0.9	1.4	0	0	0.8	2.2	0	0	0.3
22	Nha chi Nguyet	1.7	0	0	0.2	0.8	0	0	0.1	0.5	0	0	0.9	0.4	0	0	0.1	0.6	0	0	0.1	1	0	0	0.5	1.1	0	0	0.1
23	Nha cau Hoa	0.8	0	0	0.2	2.2	0	0	0.4	0	0	0	0.8	0.7	0	0	0	0.3	0	0	0.1	0.6	0	0	0.4	1.2	0	0	0.1
24	Nha anh Luong	1.1	0	0	1.1	1.4	0	0	0.4	1.4	0	0	0.2	1.5	0	0	0.7	2.5	0.05	0	0	3	0	1.2	0.8	3.6	0	0	0
25	Nha Tuan	1.8	0	0	3.3	0.7	0	0.1	1	0.8	0	0	0.5	0.95	0	0	0.6	1.7	0	0	0.7	1.5	0	0	0.85	1.9	0	0	0.2
26	K115/18 Ong Ich Khiem	0	0	0	1	0.3	0	0	0.15	0	0	0	0.4	1.3	0.1	0	0.6	0.05	0	0	0.2	1.8	0	0	1	2	0	0	1
27	K115/20B Ong Ich Khiem	1.3	0	0	0.4	0.45	0	0	0.1	0.7	0	0	0.3	0.9	0	0	0.3	0.6	0	0	0.1	1	0	0	0.5	0.2	0	0	0.3
28	K115/17 Ong Ich Khiem	0	0	0	1.4	1.6	0	0	1.4	0.9	0.2	0	0	0.1	0	0	1	0.4	0	0	0.7	0.5	0	0	0.65	0.9	0	0	0.3
29	K115/18D Ong Ich Khiem	1.8	1.5	0	1.2	0	0	0	1.2	1.05	0	0	0.2	0.4	0	0	0.7	0.4	0	0	0.2	0.7	0	0	0.2	0.2	0	0	0.3
30	K115/20 Ong Ich Khiem	1.5	0.5	0	1.5	2.3	0.1	0	0	1	0	0	0.2	0.9	0.3	0.6	0.5	2.1	0	0	0.3	1.5	0	0	0	1.1	0	0	1
31	K115/26 Ong Ich Khiem	1.2	0	0	0.6	1.2	0	0	2.2	1.1	0	0	0.5	1.05	0	0	0.4	1	0	0	0.4	0.7	0	0	2.4	(*)	(*)	(*)	(*)
32	K115/31 Ong Ich Khiem	0	0	0	0.1	0.6	0	0	0.8	0.7	0	0	0.2	0.35	0	0	1	0.3	0	0	1.1	0.5	0	0	0	0.35	0	0	1

		26th July, 2004				27th July, 2004				28th July, 2004				29th July, 2004				30th July, 2004				31st July, 2004				1st August, 2004			
No	Name of households	Cbag		Nbag		Cbag		Nbag		Cbag		Nbag		Cbag		Nbag		Cbag		Nbag		Cbag		Nbag		Cbag		Nbag	
		CW	NW	CW	NW	CW	NW	CW	NW	CW	NW	CW	NW	CW	NW	CW	NW	CW	NW	CW	NW	CW	NW	CW	NW	CW	NW	CW	NW
33	K115/28 Ong Ich Khiem	1.2	0	0	0.2	0.9	0	0	0.1	0.65	0	0	0.5	0.6	0	0	1.2	1.5	0.02	0	0.05	0.9	0	0	0.2	0.7	0	0	1
34	K115/34 Ong Ich Khiem	0.5	0	0	0.25	0.5	0	0	0.3	1	0	0	0.2	0.7	0	0	0.3	0.8	0	0	0.4	0.4	0	0	0.3	1.2	0	0	1
35	K115/33 Ong Ich Khiem	1.2	0	0	1	0.8	0	0	0.7	2	0	0	0.1	1.6	0	0	1	0.8	0	0	1.2	1	0	0	1.3	1.2	0	0	1.1
36	K115/36A Ong Ich Khiem	0.6	0	0	0	0.2	0	0	0.4	0	0	0	0.3	0.7	0	0	0.2	0.8	0	0	0.25	1	0	0	0	1.1	0.1	0	0.2
37	K115/36B Ong Ich Khiem	1.8	0	0	0.5	1.1	0	0	0.6	2	0	0	0.7	1.2	0	0	0.2	1	0	0	0.15	1	0	0	0.1	0.6	0	0	0.1
38	K115/43 Ong Ich Khiem	0	0	0	3.5	4	0	0	0.6	0.4	0	0	0.5	0.3	0.3	0.8	2	2.4	0.5	0	0	3	0	0	1.6	2.8	0	0	0.4
39	K33/02 Cao Thang	0.2	0.6	0	0.05	2	0	0	0.35	1	0	0	0.5	1	0	0	0.2	1.8	0	0	0.2	2	0	0	0.8	2.1	0	0	0.7
40	K33A/15 Cao Thang	1.1	0	0	0.2	0.4	0	0	0.1	1.7	0	0	0.1	1.7	0	0	0.1	1.1	0	0	0.15	0.5	0	0	0.1	1.8	0	0	0.5
41	K33A/11 Cao Thang	0.3	0.05	0	0	1.8	0	0	0	0.6	0	0	0	0	0	0	2.1	0	0	0	0.35	0.7	0	0	0.6	0.2	0	0	0.8
42	K46/38 Cao Thang	0.3	0	0	0.1	1	0	0	0.55	0.6	0	0	1	2	0	0	1	1.8	0	0	0.3	1	0	0	0.3	2	0	0	0.5
43	K46/60 Cao Thang	0	0	0	0.4	1	0	0	0.2	0.1	0	0	0.4	0.2	0	0	0.4	0.55	0	0	0.45	0.5	0	0	0.45	0.5	0	0	0.4
44	K46/19 Cao Thang	2	0	0	0.3	1.2	0	0	0.2	1.4	0	0	0.4	1.4	0	0	0.3	2	0	0	0.1	2.2	0	0	0.5	1.5	0	0	0.15
45	K46/13 Cao Thang	1.3	0	0	0.4	0.3	0	0	1.5	1.1	0	0	0.1	0.9	0	0	0.6	0.95	0	0	0.55	0.5	0	0	0.4	0	0	0	0.6
46	K46/56 Cao Thang	0.75	0	0	0.5	0	0	0	1.1	0.6	0	0	0.5	1.6	0	0	0.1	1.3	0	0	0	1.4	0	0	0.2	0.5	0	0	0.4
47	K46/46 Cao Thang	0	0	0	2.1	1.1	0	0	0.4	1.4	0	0	0.3	0.8	0	0	1.2	2.2	0	0	0.6	1.4	0	0	0.5	1.2	0	0	1.4
48	K46/07 Cao Thang	1.5	0	0	0.8	0	0	0	0.4	0.9	0	0	0.4	0.8	0	0	0.4	0.8	0	0	0.3	0.8	0	0	0.6	0.9	0	0	0.4
49	H38/6 Cao Thang	0.4	0	0	0.1	0	0	0	3.8	2	0.8	0	0	0.4	0	0	1.7	0.35	0	0	2.6	0.8	0	0	0.95	0.9	0	0	1
50	H38/04 Cao Thang	0.5	0	0	0.9	0	0	0	2.6	0	0	0	1.7	1.2	0	0	1	1.5	0	0	0.5	1.6	0	0	1.8	0.7	0	0	0.2
51	H38/02 Cao Thang	0	0	0	2	1.4	0	0	0.9	2	0	0	0.5	0.3	0	0	0.3	1.8	0	0	0.1	1.9	0	0	0.5	0.4	0	0	0.8
52	H38/10 Cao Thang	0.7	0	0	0.2	0	0	0	1.5	0.4	0	0	0	0.3	0	0	1.3	0.45	0	0	0.7	2	0	0	2.5	2.1	0	0	0.6
53	K46/36 Cao Thang	0	0	0	1	0.6	0	0	0.8	0.5	0.1	0.1	0.9	0.4	0.1	0	0	0.6	0	0	0.55	0.6	0	0.8	1.2	0.7	0	0.3	1.1
54	K46/03 Cao Thang	0.9	0	0	0.2	0.05	0	0	1.2	0.8	0	0	0.2	0.1	0	0	1.5	0	0	0	0.5	1	0	0	1.2	1	0	0	0.3
55	K46/26 Cao Thang	0.8	0	0	2.7	0.4	0	0	0.1	0.5	0	0	0.9	0.6	0	0	2.5	0.5	0	0	0.2	1.9	0	0	0.5	1	0	0	0.1
56	K46/24 Cao Thang	0.9	0	0	0.3	0.7	0	0	0.4	0.65	0	0	0.2	0.2	0	0	0.1	0.55	0	0	0.2	0.6	0.2	0	0	0.8	0	0	0.2
57	H30/14 Cao Thang	0.4	0	0	0.1	1	0.8	0	0	0.9	0	0	0.1	0.4	0	0	1.3	1.2	0	0	0.1	1.1	0	0	0.1	0.4	0	0	0.5
58	H30/11 Cao Thang	1.1	0	0	0.4	0.4	0	0	2	1	0	0	0.2	1.7	0	0	0.1	0.4	0	0	1	1	0	0	3	1.2	0	0	1.8
59	K46/22 Cao Thang	1.1	0	0	0	0.5	0	0	0.6	1.1	0	0	0.1	0.8	0	0	0.5	0.7	0	0	0.6	0.7	0	0	0.3	0.6	0	0	0.5
60	K46/18 Cao Thang	0.9	0	0	0	1.1	0	0	0.5	1.8	0	0	0.1	1.2	0	0	0.4	0.8	0	0	0.3	1.2	0	0	0	1.4	0	0	0.4
61	H16/03 Cao Thang	0	0	0	0.6	1.6	0	0	0.1	1.2	0	0	0.3	1	0	0	0.6	1.2	0	0	0.4	1.1	0	0	0.7	0.5	0	0	0.3
62	H16/02 Cao Thang	0	0	0	3.4	0.6	0	0	0.9	1.5	0	0	0.6	1	0	0	0.8	0.3	0	0	0.2	0.8	0	0	1.7	1.1	0	0	0.2
63	H16/11 CT	1.4	0	0	0.2	0.2	0	0	1.1	0.5	0	0	0.3	1	0	0	0.1	0.1	0	0	1.1	0.5	0	0	0.6	0.5	0	0	0.7
64	H16/23 CT	0.4	0	0	0.2	0.1	0	0	0.1	0.5	0	0	0.2	0.05	0	0	0.05	0.6	0	0	0.05	0.3	0	0	0.2	0.6	0	0	0.1
65	K46/H16/27 CT	0	0	0	0.3	0.9	0	0	0.55	0.5	0	0	0.4	0.2	0	0	0.1	0.75	0	0	1	0.65	0	0	0.4	0.5	0	0	0.6
66	K46/01 Cao Thang	1.5	0	0	0.3	0.6	0	0	0.1	0.65	0	0	0.2	0.2	0	0	0.15	0.4	0	0	0.25	0.9	0	0	0.2	0.9	0	0	0.1
67	K115/12B	1.6	0	0	0.6	1.4	0	0	0.3	1.05	0	0	0.2	0.2	0	0	1.7	1.6	0	0	0.02	0.8	0	0	0.25	0.5	0	0	0.4

Cbag: compostable bag CW: compostable waste
Nbag: non-compostable bag NW: non-compostable waste

(*) No waste was collected in that day because waste might have been collected by someone else This record is assumed as zero value.

APPENDIX 4.H:

Pilot project of compostable waste separation at household
Percentages of contamination in compostable and compostable bags

		26th July, 2004		27th July, 2004		28th July, 2004		29th July, 2004		30th July, 2004		31st July, 2004		1st August, 2004		Average		STDEV	
No	Name of households	Cbag	Nbag	Cbag	Nbag	Cbag	Nbag	Cbag	Nbag	Cbag	Nbag	Cbag	Nbag	Cbag	Nbag	Cbag	Nbag	Cbag	Nbag
		(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)
1	K140/14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	K140/16 HH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	K140/15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.76	0.00	0.00	0.00	33.33	0.00	0.00	0.00	11.66
4	Anh Duong K140/17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	Nha di bon	18.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.87	0.00
6	Pho Dung	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	Nha Linh	0.00	0.00	0.00	0.00	- (*)	- (*)	- (*)	- (*)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	Nha ban kem	0.00	0.00	0.00	0.00	0.00	0.00	0.00	50.00	0.00	7.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	17.50
9	Canh nha ban kem	0.00	0.00	- (*)	- (*)	41.18	0.00	0.00	0.00	5.88	0.00	0.00	0.00	0.00	0.00	0.00	0.00	15.56	0.00
10	Chi Lan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	Nha Tram	0.00	0.00	0.00	0.00	50.00	0.00	0.00	0.00	7.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	18.90	0.00
12	Nha gan cho, cua xanh	0.00	0.00	33.33	0.00	33.33	0.00	3.45	0.00	25.49	7.93	0.00	0.00	83.33	43.75	25.00	11.76	29.59	15.18
13	Anh Nghieu	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	Nha cua xam	0.00	0.00	0.00	0.00	20.00	0.00	0.00	0.00	3.81	0.00	6.67	0.00	0.00	0.00	0.00	0.00	7.56	0.00
15	Nha di Ha	16.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.30	0.00
16	Canh nha di Ha	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	Nha Ai	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	Nha voi xanh	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	Nha chu Ta	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	Nha di Ha em	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	Nha tho may	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	Nha chi Nguyet	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	Nha cau Hoa	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	Nha anh Luong	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.28	8.57	1.96	0.00	0.00	60.00	0.00	0.00	0.74	21.00
25	Nha Tuan	0.00	0.00	0.00	9.09	0.00	0.00	0.00	0.00	0.00	1.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.18
26	K115/18 Ong Ich Khiem	0.00	0.00	0.00	0.00	0.00	0.00	7.14	0.00	1.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.70	0.00
27	K115/20B Ong Ich Khiem	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	K115/17 Ong Ich Khiem	0.00	0.00	0.00	0.00	18.18	0.00	0.00	0.00	2.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.87	0.00

		26th July, 2004		27th July, 2004		28th July, 2004		29th July, 2004		30th July, 2004		31st July, 2004		1st August, 2004		Average		STDEV	
No	Name of households	Cbag	Nbag	Cbag	Nbag	Cbag	Nbag	Cbag	Nbag	Cbag	Nbag	Cbag	Nbag	Cbag	Nbag	Cbag	Nbag	Cbag	Nbag
		(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)
29	K115/18D Ong Ich Khiem	45.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	17.18	0.00
30	K115/20 Ong Ich Khiem	25.00	0.00	4.17	0.00	0.00	0.00	25.00	54.55	7.74	7.79	0.00	0.00	0.00	0.00	0.00	0.00	11.89	19.09
31	K115/26 Ong Ich Khiem	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	- (*)	- (*)	0.00	0.00	0.00	0.00
32	K115/31 Ong Ich Khiem	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
33	K115/28 Ong Ich Khiem	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.00	1.32	0.00	0.00	0.00	0.00	0.00	0.50	0.00
34	K115/34 Ong Ich Khiem	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
35	K115/33 Ong Ich Khiem	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
36	K115/36A Ong Ich Khiem	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.19	0.00	0.00	0.00	0.00	0.00	8.33	0.00	3.15	0.00
37	K115/36B Ong Ich Khiem	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
38	K115/43 Ong Ich Khiem	0.00	0.00	0.00	0.00	0.00	0.00	50.00	28.57	9.61	4.08	17.24	0.00	0.00	0.00	0.00	0.00	18.94	10.00
39	K33/02 Cao Thang	75.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	28.35	0.00
40	K33A/15 Cao Thang	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
41	K33A/11 Cao Thang	14.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.40	0.00
42	K46/38 Cao Thang	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
43	K46/60 Cao Thang	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
44	K46/19 Cao Thang	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
45	K46/13 Cao Thang	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
46	K46/56 Cao Thang	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
47	K46/46 Cao Thang	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
48	K46/07 Cao Thang	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
49	H38/6 Cao Thang	0.00	0.00	0.00	0.00	28.57	0.00	0.00	0.00	4.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.80	0.00
50	H38/04 Cao Thang	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
51	H38/02 Cao Thang	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
52	H38/10 Cao Thang	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
53	K46/36 Cao Thang	0.00	0.00	0.00	0.00	16.67	10.00	20.00	0.00	5.24	10.20	0.00	0.00	0.00	40.00	0.00	21.43	9.00	14.29
54	K46/03 Cao Thang	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
55	K46/26 Cao Thang	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
56	K46/24 Cao Thang	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.57	0.00	0.00	0.00	25.00	0.00	0.00	0.00	9.45	0.00
57	H30/14 Cao Thang	0.00	0.00	44.44	0.00	0.00	0.00	0.00	0.00	6.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.80	0.00
58	H30/11 Cao Thang	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
59	K46/22 Cao Thang	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
60	K46/18 Cao Thang	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

		26th July, 2004		27th July, 2004		28th July, 2004		29th July, 2004		30th July, 2004		31st July, 2004		1st August, 2004		Average		STDEV	
No	**Name of households**	**Cbag**	**Nbag**	**Cbag**	**Nbag**	**Cbag**	**Nbag**	**Cbag**	**Nbag**	**Cbag**	**Nbag**	**Cbag**	**Nbag**	**Cbag**	**Nbag**	**Cbag**	**Nbag**	**Cbag**	**Nbag**
		(%)	**(%)**	**(%)**	**(%)**	**(%)**	**(%)**	**(%)**	**(%)**	**(%)**	**(%)**	**(%)**	**(%)**	**(%)**	**(%)**	**(%)**	**(%)**	**(%)**	**(%)**
61	H16/03 Cao Thang	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
62	H16/02 Cao Thang	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
63	H16/11 CT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
64	H16/23 CT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
65	K46/H16/27 CT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
66	K46/01 Cao Thang	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
67	K115/12B	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Average	***2.90***	***0.00***	***1.24***	***0.14***	***3.15***	***0.15***	***1.60***	***2.02***	***0.41***	***0.00***	***1.62***	***2.64***	***0.51***	***0.50***	**1.63**	**0.78**		
	STDEV	11.39	0.00	6.80	1.12	9.98	1.23	7.25	9.63	2.26	0.00	10.58	10.84	3.23	2.99			**8.08**	**5.69**
	Min	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00				
	Max	75.00	0.00	44.44	9.09	50.00	10.00	50.00	54.55	17.24	0.00	83.33	60.00	25.00	21.43				

(*) This value can not be identified due to the missed waste collection.