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# Physical compositions of municipal solid waste and recyclable waste discharged from households in Hanoi, Vietnam

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## Abstract

In this paper, analysis on the physical composition of recyclable waste discharged from households as well as of municipal solid waste in Hanoi, Vietnam was conducted, especially focusing on containers and packaging wastes. In addition, Not only weight, but also volume were measured. Samples of municipal solid waste and recyclable waste for sorting were collected from households in 3 areas which consist of a middle-income collective housing area, a high-income collective housing area and a solitary housing area. All of collected samples of municipal solid waste and recyclable waste were sorted respectively into 65 items and 38 items. As the result, the average 0.551 kg (2.6 L) of municipal solid waste per capita per day is discharged from households in these areas, while the average 0.058 kg (1.3 L) of recyclable waste is discharged. More than half of municipal solid waste is food waste. The potentially recyclable items such as paper tubs, plastic bags tend to be disposed as municipal solid waste. Products and containers and packaging are mainly discharged as recyclable waste. Cartons for beverages or EPS trays which developed countries have already the system to recycle are not yet recycled in Vietnam.

## 1. Introduction

Recent growth in economy, improved living standards and a change of lifestyle have resulted in the increase of the amount and the kinds of solid waste in Vietnam. This situation of solid waste has occurred in urban areas where the population has concentrated and economic activities have increased, rather than in rural areas. Since densely-populated areas hardly possess disposal sites nearby, solid waste discharged in urban areas should be collected and transported to remote disposal sites in suburban areas, while solid waste discharged in rural areas

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tends to be disposed of near disposal sites. Collecting rate of municipal solid waste (MSW) in large cities such as Hanoi, Da Nang, Ho Chi Minh is consequently higher, and Urban Environment Companies (URENCO) are in charge of collecting, transporting and disposing MSW in large cities.

MSW is usually disposed on open dumping sites or landfill sites in Vietnam as in the case of other countries in Southeast Asia (Idris et al., 2004). They don't have intermediate treatment systems such as incineration, which is the main intermediate treatment system in Japan (Sakai, 1996), but dispose MSW directly on open dumping sites or landfill sites. Increase of MSW to be disposed accelerates full space of disposal sites. Dumping or landfilling organic waste (food waste) brings emission of  $CH_4$  and  $CO_2$  which are the end products of degradation of organic waste and alleged to contribute to a greenhouse effect, unless proper treatment to control and collect these gases is implemented. MSW contains more plastic than before because of the consumption of more products covered with containers and packaging induced by change in lifestyle. Obviously plastic never degrade naturally.

It is necessary to overcome various problems and to develop a new approach to treat and dispose MSW environmentally-friendly and cost effectively in Vietnam. International organizations as well as foreign countries have supported Vietnam on solid waste management since the late 1990s. Researches on solid waste in Vietnam have just started at universities, institutes in Vietnam in cooperation with ones in developed countries. Municipal solid waste is discharged from various sources such as markets, restaurants, businesses, households. Although the analyses on the physical composition of MSW in Vietnam have been conducted (World Bank et al., 2004), the physical composition of MSW and recyclable waste from households have not been revealed yet. Moreover the amount of recyclable waste discharged from households by weight and by volume has been unclear.

In this paper, analysis on the physical composition of recyclable waste discharged from households in Hanoi, Vietnam as well as of MSW was implemented, especially focusing on containers and packaging waste. In addition, Not only weight, but also volume were measured. This paper is the beginning of research on MSW and recyclable waste especially in urban areas in Vietnam and accumulated information will contribute the municipal solid waste management in the near future.

## 2. Material and Methods

### 2.1. Collection systems of MSW recyclable waste

Mainly Hanoi Urban Environment Limited Company Ltd. (URENCO) is in

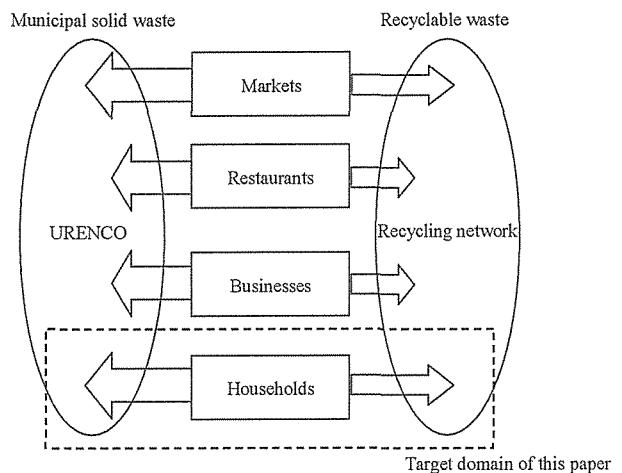


Fig. 1. Municipal solid waste and recyclable waste discharged from various sources.

charge of collecting, transporting and disposing MSW discharged from various sources such as markets, restaurants, businesses, households in urban districts in Hanoi (Fig.1.). The workers of URENCO go along the streets with handcarts and collect MSW discharged from households every evening. MSW is transported to and disposed on the landfill site, 50 km far from urban area in Hanoi. On the other hand, recyclable waste such as PET bottles, boxes of paper, cans for beverage is rarely disposed with MSW but given to someone or sold to junk buyers as valuable resources and dealt with in the informal recycling network.

## *2.2. Sampling*

Each area in a municipality has various forms of habitation. Some areas have wealthy households, and some have necessitous households. In order to find representative statistical values of MSW and recyclable waste discharged in Hanoi, it is essential to collect samples of MSW and recyclable waste from various types of areas. At the same time, questionnaires should be taken for grasping family composition.

The population of Hanoi is approximately 3 million and two-thirds of citizens live in the urban area, which consists of 9 districts (Ba Dinh, Hoan Kiem, Tay Ho, Long Bien, Cau Giay, Dong Da, Hai Ba Trung, Hoang Mai and Thanh Xuan) (Hanoi Statistical Office, 2006). Samples of MSW and recyclable waste for sorting were collected from households in 3 areas in Cau Giay district that is one of urban districts, has 175.8 thousand citizens, and is located in the west of urban area. Selected 3 areas consist of middle-income collective housing area (Nghia Tan), high-income collective housing area (Lang Quoc Te Thang Long), and solitary housing area (Yen Hoa).

For collecting samples of MSW, five plastic bags in order to put MSW in were distributed for each household. The households discharged MSW every evening filled in the distributed plastic bags for 5 days. In order to avoid change in quantity and quality of MSW, that is, to collect MSW discharged as usual, they weren't noticed when the MSW would be collected as samples.

For collecting samples of recyclable waste, a plastic bag was distributed for each household in order to put recyclable waste in, which is larger than ones for collecting samples of MSW. The households stored recyclable waste for a week, which would be commonly given to someone or sold to junk buyers. Stored recyclable waste was collected a week later.

Plastic bags for collecting samples of MSW and recyclable waste were numbered for identification when distributed.

## *2.3. Sorting and measuring*

Collected samples of MSW and recyclable waste were transported to the institution of Hanoi URENCO for sorting. The weight and the volume of MSW were measured before sorting. All of collected samples of MSW were sorted into 65 items. Although fractional sampling (method of quartering) is usually adopted for analysis on

the rough physical composition of MSW sorted into some materials (Tanikawa, 2000), in this analysis all of samples were sorted. The way of Sorting MSW was divided into 2 steps. At first, MSW was sorted roughly into 12 materials; paper, plastic, textile, rubber, leather, glass, metal, plants/garden, wood, ceramics, food waste and miscellaneous. At second, MSW that was roughly sorted into materials was again sorted into some more details; products, consumables, containers and packaging materials, and so on. All of collected samples of recyclable waste were sorted into 38 items. Because samples of recyclable waste didn't contain food waste but mostly papers and plastic, it was easy to sort them into items directly.

With regard to sorting compound materials, if a mark which indicated a material (paper, plastic, metal and so on) was attached, the item was sorted following the mark. If the mark wasn't attached, the item was sorted taking proportion of materials into account. For example, a container of tablets for medicine consist of plastic and metal. It was sorted as metal material. In order to input and to total the weight and the volume of MSW easily and fast, each item had a code number. After sorting all samples of MSW and recyclable waste into items, the weight and the volume of items were measured. Because of code numbers of items, it got easy and fast to measure them. The weight was measured with the digital scale measuring minimum 0.001 kg.

### 3. Results and discussion

In this analysis, not only weight but also volume are important indicators. Hanoi URENCO transports MSW from the urban area in Hanoi to the landfill site by MSW collection trucks. MSW collection trucks shuttle several times between urban area and landfill site. Pay load of MSW collection trucks depends on volume of MSW, therefore the volume of MSW influences directly expenditure of transporting MSW.

Table 1 shows the information of collected samples of MSW and recyclable waste. Samples of recyclable waste contained some contaminations which couldn't be sold nor un-recyclable (e.g. paper of carton for beverage, plastic of EPS tray, broken ceramics), therefore the amount of samples of recyclable waste which was actually measured after sorting decreased. As the result of this analysis, the average 0.551 kg (2.6 L) of MSW per capita per day is discharged from households in these areas, while the average 0.058 kg (1.3 L) of recyclable waste is discharged, which means the average total amount of solid waste discharged from each household is 0.609 kg (3.9L).

Table 1  
Collected samples of municipal solid waste and recyclable waste for sorting

| Area                    | Municipal solid waste |                  |         |      | Recyclable waste |                  |         |      |
|-------------------------|-----------------------|------------------|---------|------|------------------|------------------|---------|------|
|                         | Households            | Number of people | kg      | L    | Households       | Number of people | kg      | L    |
| Nghia Tan               | 30                    | 109              | 60.731  | 291  | 37               | 146              | 84.103  | 1577 |
| Lang Quoc Te Thang Long | 34                    | 138              | 58.799  | 290  | 34               | 131              | 61.62   | 988  |
| Yen Hoa                 | 37                    | 171              | 110.768 | 523  | 44               | 202              | 86.204  | 1692 |
| Total                   | 101                   | 418              | 230.298 | 1104 | 115              | 479              | 231.927 | 4257 |

Table 2 shows the results of analysis on physical composition of MSW and recyclable waste collected from households in Cau Giay district by weight and by volume (on a wet basis). MSW from households contains a

large proportion of food waste (59 % by weight), in which shellfish and bones are included. If these undegradable food waste are excluded, degradable waste or organic waste (without Plants/Garden) is at 52.7 %. Meanwhile proportion of plastic by weight is less than 10 %, it takes over more than 30 % by volume, approximately as much as that of food waste. Recyclable waste contains large proportion of paper and plastic, which approach to 78 % of recyclable waste by weight and 85 % by volume. Textile, plants/garden, wood and ceramic aren't dealt with in the recycling network. Although food waste is usually discharged as MSW, if a good amount can be collected at the same place, for example at restaurants, hotels and complex housings, it can be sold for feeding animals.

Table 2  
Physical compositions of municipal solid waste and recyclable waste from households in Cau Giay district, Hanoi (%)

| Materials     | Municipal solid Waste |           | Recyclable waste |           |
|---------------|-----------------------|-----------|------------------|-----------|
|               | by Weight             | by Volume | by Weight        | by Volume |
| Paper         | 9.9                   | 16.1      | 49.0             | 44.0      |
| Plastic       | 8.3                   | 31.1      | 29.1             | 41.0      |
| Rubber        | 0.2                   | 0.2       | 0.5              | 0.1       |
| Leather       | 0.1                   | 0.2       | 0.9              | 0.4       |
| Glass         | 0.7                   | 0.4       | 11.8             | 4.2       |
| Metal         | 0.4                   | 1.8       | 8.6              | 10.3      |
| Textile       | 1.3                   | 1.0       |                  |           |
| Plants/Garden | 5.5                   | 10.2      |                  |           |
| Wood          | 0.9                   | 2.1       |                  |           |
| Ceramic       | 0.7                   | 0.5       |                  |           |
| Food waste    | 59.0                  | 30.6      |                  |           |
| Miscellaneous | 12.9                  | 5.9       |                  |           |
| Total         | 100.0                 | 100.0     | 100.0            | 100.0     |

Table 3 shows in-depth data describing the content of items of each material in MSW and recyclable waste by weight and by volume. The content of items is calculated as below:

$$P(i) = a(i) / (A_{MSW} + A_{RW}) * 100$$

Where  $P(i)$  is the content of item  $i$  (%),  $a(i)$  is the amount of item  $i$ ,  $A_{MSW}$  is total amount of MSW per capita per day and  $A_{RW}$  is the total amount of recyclable waste per capita per day.

Most of newspapers discharged as MSW are shredded into little pieces. Paper products are mainly discharged as recyclable waste. Because paper consumables are not sanitary, tissue paper, diapers and sanitary-napkins are disposed of as MSW. Vietnam has no system to recycle paper cartons for beverage which contains high-quality paper, many developed countries promote the recycling of paper cartons for beverage in other paper products such as toilet paper though. As with the newspapers, the corrugated card boards discharged as MSW are shredded into little pieces and most corrugated card boards are discharged as recyclable waste. Paper bags are not recycled because it is difficult to remove the attached plastic film on them and to get out only paper materials. If a certain amount of tubs are stored in households, they can be sold to junk buyers. But some households discard them without storing.

Plastic waste has a wide variety of materials and items. PET bottles have broadly distributed in Vietnam and any shop or supermarket supplies beverages filled in PET bottles these days. Regardless of PET or NON-PET, most plastic bottles are discharged as recyclable waste. Generally, EPS trays and buffer materials do not be collected as recyclable waste, a clean and big mass of EPS can be sold as a recyclable though. Plastic bags is one

Table 3

In-depth data of physical compositions of municipal solid waste and recyclable waste from households in Cau Giay district, Hanoi (%)

| Materials     | Types                    | Items  | Municipal solid waste |           | Recyclable waste |           |
|---------------|--------------------------|--|-----------------------|-----------|------------------|-----------|
|               |                          |  | by Weight             | by Volume | by Weight        | by Volume |
| Paper         | Products                 | Newspapers                                     | 0.91                  | 1.20      | 1.36             | 1.24      |
|               |                          | Books  |                       |           | 0.63             | 0.37      |
|               | Consumables              | Other products (calendar, sketchbook)          | 0.03                  | 0.01      | 0.12             | 0.18      |
|               |                          | Tissue paper                                   | 1.57                  | 0.91      |                  |           |
|               | Containers and packaging | Diapers, Sanitary-napkins                      | 3.65                  | 2.34      |                  |           |
|               |                          | Carton for beverage (milk, juice)              | 0.23                  | 1.25      |                  |           |
|               | Products                 | Boxes for food                                 | 0.47                  | 1.48      | 0.50             | 2.19      |
|               |                          | Boxes for NON-food                             | 0.31                  | 1.14      | 0.28             | 1.23      |
|               | Others                   | Corrugated card board                          | 0.12                  | 0.29      | 1.02             | 6.25      |
|               |                          | Bags   |                       |           | 0.06             | 0.32      |
| Plastics      | Products                 | Tubs (cores of toilet paper and Kitchen rolls) | 0.24                  | 0.37      | 0.02             | 0.09      |
|               |                          | Cushions/buffer materials                      | 0.09                  | 0.14      |                  |           |
|               | Consumables              | Others   | 1.33                  | 2.08      | 0.76             | 1.29      |
|               |                          | Products                                       | 0.26                  | 0.44      | 1.28             | 2.81      |
|               | Containers and packaging | Consumables                                    | 0.07                  | 0.11      | 0.02             | 0.04      |
|               |                          | PET bottles for beverage                       | 0.02                  | 0.09      | 0.23             | 1.95      |
|               | Products                 | PET bottles for food                           | 0.05                  | 0.20      | 0.31             | 2.38      |
|               |                          | Bottles for beverage                           | 0.01                  | 0.05      | 0.08             | 0.43      |
|               | Containers and packaging | Bottles for food & spices                      | 0.03                  | 0.07      | 0.02             | 0.09      |
|               |                          | Bottles for NON-food                           | 0.08                  | 0.12      | 0.47             | 1.88      |
| Rubber        | Products                 | EPS trays                                      | 0.02                  | 0.37      |                  |           |
|               |                          | Other trays                                    | 0.06                  | 0.91      |                  |           |
|               | Consumables              | Buffer materials (EPS)                         | 0.01                  | 0.29      |                  |           |
|               |                          | Bags (supermarket carrier bags)                | 4.43                  | 9.07      | 0.13             | 0.89      |
|               | Containers and packaging | Wrap/Clingfilm                                 | 0.02                  | 0.03      |                  |           |
|               |                          | Cups (w/o lid)                                 | 0.12                  | 0.63      | 0.03             | 0.20      |
|               | Products                 | Package for food                               | 0.74                  | 4.22      | 0.03             | 0.21      |
|               |                          | Package for NON-food                           | 0.77                  | 3.65      | 0.09             | 0.53      |
|               | Others                   | Sheets   | 0.01                  | 0.03      |                  |           |
|               |                          | Lids   | 0.04                  | 0.03      | 0.03             | 0.05      |
| Leather       | Products                 | Other containers and packaging                 | 0.10                  | 0.19      | 0.11             | 0.78      |
|               |                          | Others   | 0.63                  | 1.33      |                  |           |
|               | Products                 | Products (Tubes)                               | 0.21                  | 0.15      | 0.05             | 0.04      |
|               |                          | Products (Shoes, Belt)                         | 0.12                  | 0.11      | 0.09             | 0.11      |
|               | Glass                    | Products (drinking glass, plate)               | 0.33                  | 0.14      | 0.00             | 0.00      |
|               |                          | Containers and packaging                       | 0.00                  | 0.00      | 0.61             | 0.80      |
| Metals        | Products                 | Beverage bottles                               | 0.20                  | 0.10      | 0.53             | 0.45      |
|               |                          | Bottles and jars for food                      | 0.07                  | 0.01      |                  |           |
|               | Containers and packaging | Bottles and jars for NON-food                  | 0.00                  | 0.00      |                  |           |
|               |                          | Beverage bottles                               | 0.00                  | 0.00      |                  |           |
|               | Products                 | Kitchen utensils (teaspoon)                    | 0.00                  | 0.01      | 0.06             | 0.13      |
|               |                          | Dry cell batteries                             | 0.24                  | 0.04      | 0.01             | 0.00      |
|               | Containers and packaging | Other products (umbrella, electric cable)      | 0.05                  | 0.01      | 0.17             | 0.23      |
|               |                          | Beverage cans (Aluminium)                      | 0.01                  | 0.02      | 0.19             | 1.44      |
|               | Products                 | Beverage cans (Steel)                          | 0.02                  | 0.02      | 0.00             | 0.00      |
|               |                          | Food cans                                      | 0.04                  | 0.05      | 0.28             | 1.01      |
| Textiles      | Products                 | Cans for NON-food                              |                       |           | 0.02             | 0.04      |
|               |                          | Boxes for food (biscuit)                       |                       |           | 0.01             | 0.11      |
|               | Containers and packaging | Spray canisters                                | 0.01                  | 0.03      | 0.03             | 0.09      |
|               |                          | Aluminium foils                                | 0.07                  | 1.03      |                  |           |
|               | Products                 | Take-away tubes                                | 0.01                  | 0.01      | 0.00             | 0.00      |
|               |                          | Other containers and packaging (for medicine)  | 0.05                  | 0.08      | 0.05             | 0.04      |
|               | Others                   | Others   |                       |           |                  |           |
|               |                          | Products (clothes)                             | 1.18                  | 0.68      |                  |           |
| Plants/Garden | Products                 | leaves, flower                                 | 4.94                  | 7.18      |                  |           |
|               |                          | Products (pencil, broom)                       | 0.05                  | 0.03      |                  |           |
|               | Wood                     | Consumables                                    | 0.12                  | 0.11      |                  |           |
|               |                          | Containers and packaging                       | 0.66                  | 1.31      |                  |           |
| Ceramics      | Products                 | Others   | 0.01                  | 0.03      |                  |           |
|               |                          | Products                                       | 0.67                  | 0.36      |                  |           |
|               | Food waste               | Unused food                                    | 1.68                  | 0.60      |                  |           |
|               |                          | Fruits   | 17.01                 | 6.10      |                  |           |
|               | Products                 | Tea leaves, medicine                           | 2.43                  | 1.43      |                  |           |
|               |                          | Shellfish (shrimp shell, clamshell)            | 3.20                  | 1.60      |                  |           |
|               | Products                 | Bones (chicken, pork)                          | 2.45                  | 1.03      |                  |           |
|               |                          | Other products                                 | 26.47                 | 10.66     |                  |           |
| Miscellaneous | Products                 | Coal   | 6.67                  | 3.31      |                  |           |
|               |                          | Cigarette butt                                 | 0.06                  | 0.06      |                  |           |
|               | Others                   | Cat litters/Animal bedding                     | 0.11                  | 0.06      |                  |           |
|               |                          | Sand   | 4.44                  | 0.63      |                  |           |
|               | Products                 | Others-Liquid                                  | 0.29                  | 0.05      |                  |           |
|               |                          | Others-Solid                                   | 0.03                  | 0.05      |                  |           |
|               | Others                   | Total  | 90.31                 | 70.09     | 9.69             | 29.91     |

of the largest amount of wastes and they can be sold as recyclable waste, but junk buyers don't buy the small amount of them and it takes a long time to store them until they can be sold because of their very light weight. As a result, most households do not store but just discard them. Adhesion of dirt of organic materials on plastic packages for food prevents junk buyers from buying them as recyclable waste, therefore only clean plastic packages can be sold.

As far as glass concerned, only bottles which distribute in Vietnam and be used for refilling can be sold. On the other hand, imported bottles filling such as wine can't be sold as recyclable waste. Any metal waste can be sold, moreover beverage cans of aluminum are dealt with at good rate. Textile, plants/garden, ceramic and food waste are not dealt with as recyclables. Although the use of gas for cooking has increased in Vietnam, there are still many households that use coal for cooking. Therefore, some amount of coal is discharged as MSW every day.

As shown in Table 4, products in MSW by weight account for a significant fraction of the total mass of MSW. Compared to the weight of containers and packaging in MSW, the volume of them (27.2 %) approximately approaches that of product (28.0 %). Moreover, the weight of containers and packaging in recyclable waste is 78.4 % of the volume of total recyclable waste. The total volume of containers and packaging of MSW and recyclable waste accounts for approximately half of all solid waste from households. In Japan, the proportion of containers and packaging in MSW accounts for around 60 % and the proportion of containers and packaging waste in Vietnam is supposed to get larger in the near future with growth in economy and change in lifestyle.

Table 4

Types in municipal solid waste and recyclable waste from households in Cau Giay district, Hanoi (%)

|                          | Municipal solid waste |           | Recyclable waste |           | Total     |           |
|--------------------------|-----------------------|-----------|------------------|-----------|-----------|-----------|
|                          | by weight             | by volume | by weight        | by volume | by weight | by volume |
| Products                 | 64.0                  | 28.0      | 3.8              | 5.1       | 67.8      | 33.1      |
| Consumables              | 5.4                   | 3.5       | 0.0              | 0.0       | 5.4       | 3.5       |
| Containers and packaging | 9.1                   | 27.2      | 5.1              | 23.4      | 14.2      | 50.7      |
| Others                   | 11.8                  | 11.4      | 0.8              | 1.3       | 12.6      | 12.7      |

#### 4. Conclusion

According to this analysis, the average 0.551 kg (2.6 L) of MSW per capita per day is discharged from households in these areas, while the average 0.058 kg (1.3 L) of recyclable waste is discharged. More than half of MSW is food waste. The recyclable items such as paper tubs, plastic bags which are rather light by weight tend to be disposed as MSW. Products and containers and packaging are mainly discharged as recyclable waste. Cartons for beverages or EPS trays which developed countries already have the system to recycle aren't recycled in Vietnam.

The amount of recyclable waste has been unknown and the information on recycling network has not been clear because recycling network is operated in informal sectors. Recent increase of the amount and variety of MSW influences directly the systems of collecting, transporting and disposing. Ministries and municipalities in Vietnam need to figure out the entire picture of recyclable waste as well as MSW. MSW and recyclable waste must interact in diverse ways.

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