Accumulation and Reliability of Data on Municipal Solid Waste Management in Urban Areas of Vietnam

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Reliable data are necessary to evaluate the current status of municipal solid waste (MSW) management and improve current treatment systems. Many developing countries, however, lack reliable data on MSW. The objectives of this study were to accumulate data on MSW in urban areas of Vietnam in 2008 in order to confirm whether the fundamental data existed at the local level, and to evaluate the reliability of the data obtained from waste treatment facilities. Questionnaires about MSW management were distributed to 90 “urban environment companies” (waste management companies) that are in charge of managing MSW in urban areas of Vietnam. A top-down approach was used in the survey, which may have contributed to the high response rate (92%). The MSW collection amounts per person per day were compared with maximum and minimum values in published data; any values above or below these values were corrected if errors were identified in data collection or entry. The total reported population with MSW collection service was 19.1 million, which is about 22% of the total population of Vietnam. The total amount of MSW collected was about 5,335,000 t, 96% of which was transported to landfill sites and 4% to composting sites. The proportion of organic waste in terms of physical composition was 65% on average. Data on the population with MSW collection service and MSW collection amounts in Vietnam were more variable (less reliable) than those in Japan, and the results of our reliability analysis suggest that installation of weighbridges at treatment and disposal facilities would improve the reliability of MSW collection data in Vietnam.

Key Words : data reliability, municipal solid waste, collection amount, collection service, weighbridge

1. INTRODUCTION

Inappropriate management of municipal solid waste (MSW) has resulted in the emission of landfill gases caused by decomposition of organic waste and the flow of untreated leachates into ground and surface water. As a result, waste management has drawn increasing attention, most recently in developing countries.

Reliable data are necessary to evaluate the current status of MSW management; to improve current treatment systems, which often rely on open dumping of waste; as well as to establish sustainable MSW systems.1,2,3,4 Many developing countries, however, lack reliable data on MSW. The lack of data may reflect the fact that, in many developing countries, national MSW data collection systems do not exist, and data may also be inaccessible to outside agencies or researchers at the local level because local governments tend not to publicly disclose such data. Nevertheless, local governments or other organizations in charge of managing MSW most likely do possess the data necessary to manage their business activities, and these data may prove useful in improving MSW systems. The data, however, may be unreliable. Although previous surveys have not determined the reliability of existing MSW data in developing countries, lower reliability should be expected as a result of human error and a lack of standard data collection methodologies and national definitions of MSW.

Although data on solid waste management were published in a 2004 report for Vietnam as well as for other Southeast Asian countries with the support of
the World Bank\textsuperscript{5,6,7}, other data on solid waste have not been collected at the national level yet in Vietnam\textsuperscript{8}).

The objectives of this study were to accumulate MSW data in urban areas of Vietnam in 2008 to confirm whether the fundamental data existed at the local level and to evaluate the reliability of the data obtained from waste treatment facilities by calculating the MSW collection amounts per person per day and their coefficients of variation (CV). Questionnaires were distributed to 90 urban environment companies (URENCOs), which are in charge of managing MSW in urban areas of Vietnam. The data on population with MSW collection service and MSW collection amounts were examined for outliers and data were modified if necessary. The results of the survey were analyzed to determine the population with MSW collection service, MSW collection amounts, the stream of MSW collected by the URENCOs, the physical composition of MSW and the number of URENCOs using weighbridges throughout urban areas in Vietnam. The variation of the CV in the MSW collection amounts per person per day in Vietnam was compared with that in Japan to evaluate data reliability. The definitions of MSW in Japan and Vietnam are somewhat different, which could potentially impact the comparison. In Vietnam recyclable wastes are actively recovered by the informal sector (private collectors for recycling) before MSW is collected by the formal sector (municipalities), but such informal collection is rare in Japan, where the formal sector collects all types of MSW and then recovers recyclable wastes. Even with these differences, we regard the comparisons in this study as valid because we targeted the variation of the collection amounts, not the amounts themselves.

2. VIETNAM’S ADMINISTRATIVE AND WASTE MANAGEMENT STRUCTURE

As of 2008, Vietnam was divided into five cities under the direct authority of the central government (Ha Noi, Ho Chi Minh City, Hai Phong, Da Nang, and Can Tho) and 59 provinces. Ho Chi Minh City, with a population of 5.4 million, was the largest in 2007, followed by Ha Noi (2.1 million) and Hai Phong (0.7 million)\textsuperscript{9}). Cities under the direct authority of the central government generally consist of urban and rural districts. Each province generally consists of a provincial city and/or a city and several rural districts (Fig. 1). Provincial cities are generally larger than cities.

We classified all organizations in charge of MSW management in all three types of cities as URENCOs, even though their actual translated names may vary somewhat, for example, “urban works company” or “urban environment enterprise.” A large proportion of the revenues of URENCOs is still financed from local government grants. URENCOs are public companies, but they formerly belonged to local governments and have become independent only recently. Most of the URENCOs studied are engaged in the collection, transportation, treatment, and disposal of MSW. URENCOs manage MSW in cities under the direct authority of the central government, as well as in provincial cities and cities (under provinces, as shown in Fig. 1).

The Vietnam Urban Environment Association (VUREA) was established in 1995 to share information on new waste management technologies and to support local governments in developing regulations and strategies related to environmental protection. As the largest association related to waste management in Vietnam, its members consisted primarily of URENCOs. VUREA was later renamed the Vietnam Urban Environment and Industrial Zone Association (VUREIA). The objectives of VUREIA, which is under the control of the Ministry of Construction, are to maintain and improve the management ability, technical ability, and service quality.

3. MATERIALS AND METHODS

(1) Data accumulation

The questionnaires were designed in English by the authors and were translated into Vietnamese by the staffs of the Institute for Urban Environment and Industry of Vietnam (INEV). The questionnaires included questions on MSW management in 2008, as summarized in Table 1. The questionnaires were distributed in November 2009, along with a letter of
request from VUREIA, to 90 URENCOs. The purpose of the letter was to increase the number of responses to the questionnaires. The URENCOs were located in the five cities under the direct authority of the central government and 54 provinces, and all of them were members of VUREIA. The deadline for returning the questionnaire was the end of December 2009. The questionnaire defined MSW as the non-hazardous solid waste collected by URENCOs from households, institutions, and business entities, such as restaurants, hotels, markets, and offices in urban areas. Industrial waste, construction waste, and hazardous waste such as medical waste were not included as part of MSW. In addition, recyclable materials defined as salable waste, including food residues at large-scale restaurants, collected by the informal sector were not included because URENCOs are not involved with informal recycling.

The World Bank et al. reported that the MSW collection amount per person per day was 700 g for urban areas of Vietnam in 2004. The average MSW collection amount per person per day in Japan was 1,089 g, but this value includes recyclable waste that is later recovered by municipalities or private companies.

The collection amount in the question items refers to the sum of the disposal amount recorded at the landfill site and the treatment amount recorded at the composting site. The responses were translated into English and input into an Excel file by INEV staff.

(2) Verification and reliability analysis
Calculating the MSW collection amounts per person per day and comparing them with previously published data aids in identifying human errors caused by respondents or typists and contributes to the verification (and modification if necessary) of the responses on population with MSW collection service and amounts collected. Shekdar et al. reported MSW collection amounts (per person per day) of 1,100 g in Thailand, 800–1,000 g in Indonesia, 500–800 g in Malaysia, and 300–700 g in the Philippines. Troschinetz et al. reported that the MSW generation (collection) amount per person per day in developing countries ranges from 300 to 2,480 g.

Equation (1) was applied to verify the MSW collection amount per person per day:

\[ y_i = \frac{M_i}{P_i \times 365} \times 10^6 \]  

(1)

where \( y_i \) is the amount of MSW collected by URENCO \( i \) (g/person/day) in 2008, \( M_i \) is the total amount of MSW collected by URENCO \( i \) in 2008 (t/year), and \( P_i \) is the population with MSW collection service by URENCO \( i \) in 2008 (person).

Following the range reported by Troschinetz et al., if \( y_i \) was lower than 300 g/person/day or higher than 2,480 g/person/day, the population and collection data input into the system were carefully verified because of the high probability of human error. If no mistake was found in the data entry by the INEV staff, the staff contacted the URENCO to confirm the responses and modified the data if they had been reported erroneously.

After the data were verified, a CV was calculated for the MSW collection amounts per person per day for each of the URENCOs and compared with those in Japan, where the corresponding data are considered to be highly reliable, to verify the reliability of the data on the population and the collection amounts reported by the URENCOs.

4. RESULTS AND DISCUSSION

The response rate was 92%, or 83 out of 90 URENCOs. The top-down approach based on the VUREIA structure may have contributed to the high response rate.

(1) Verification of MSW collection amounts per person per day
The data on the MSW collection amounts per person per day of 82 URENCOs including 10 outliers higher than 2,480 g/person/day were verified and modified if an error was found. The collection amounts before and after the verification process are shown in Table 2. A dramatic reduction of the standard deviation was found. As the maximum and minimum MSW collection amount per person per day.

<table>
<thead>
<tr>
<th>Question items</th>
<th>Organization name</th>
<th>Number of employees</th>
<th>Year established</th>
<th>Budget</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSW collection service</td>
<td>Covered area (ha)</td>
<td>Covered population</td>
<td>Collection amount in 2008 (t/year)</td>
<td></td>
</tr>
<tr>
<td>Landfilling</td>
<td>Total area (ha)</td>
<td>Disposal area (ha)</td>
<td>Utilization of weighbridge</td>
<td>Disposal amount in 2008 (t/year)</td>
</tr>
<tr>
<td>Composting</td>
<td>Capacity (t/day)</td>
<td>Treatment amount in 2008 (t/day)</td>
<td>Production in 2008 (t/day)</td>
<td>Residues in 2008 (t/day)</td>
</tr>
</tbody>
</table>

| Physical composition | Weighbridge | Duration of operation |

Table 1 Question items on MSW management.
day (2,917 g and 92 g respectively) could be outliers, we tried to verify the corresponding data, but found no human errors. There may be other explanations for the outliers; for example, the URENCO may have made some undetected error when recording or reporting the data.

(2) Population with MSW collection service
As shown in Table 3, the total population with MSW collection service for the 82 responding URENCOs was 19.1 million, which accounted for 22.2% of the total population of Vietnam (86.2 million). In Fig. 2, ratios of greater than 100% mean that the population with URENCO MSW collection service exceeded the statistical urban population in the province, generally indicating that the MSW collection service coverage extends beyond demographic urban areas. The higher ratios in the north and central parts of Vietnam suggest that URENCOs in these areas are more active than those in the south. The ratios in Lai Chau, Quan Nam and Son La Province reached 480%, 500%, and 810%, respectively, indicating that the MSW collection service by URENCOs in these areas covered more than only cities or provincial cities. On the other hand, five provinces had no reported MSW collection service.

(3) MSW collection amounts
Eighty-two of the 83 URENCOs answered the collection amount question by weight (t), and one reported the volume (m³). The volume data were converted at a rate of 0.4 t/m³ by the authors, a conversion factor designed by Ministry of Construction of Vietnam. The total amount of MSW collected by all the URENCOs was 5.3 million t or an average of 64,000 t per URENCO.

(4) MSW stream
A total of 5.1 million t (96%) of the total amount of MSW collected by 82 URENCOs was transported to landfill sites (including open dumping sites), and 216,000 t (4%) of MSW collected by 8 URENCOs was transported to composting sites (Table 3). Four of the 8 URENCOs did not provide any information on the amount of residues from composting sites, but the other 4 did provide information on the amount of compost produced.

(5) Physical composition of MSW
Data on the physical composition of MSW were provided by 23 URENCOs. The categories of physical composition varied by URENCO, but all of them had organic waste as one of the major categories. Organic waste refers to decomposable waste, including food and plant materials. As shown in Fig. 3, the proportion of organic waste was 65% on average, the highest of all the waste categories. Some URENCOs provided the physical composition of MSW analyzed in both the rainy season and the dry season, and the proportion of organic waste was higher in the rainy season. A standard method to analyze the physical composition of MSW has not yet been developed in Vietnam, so each URENCO adopted its own method. We were unable to determine the methods of physical composition analysis used, the types of MSW sampled (from household or business entities), the location of the sampling (e.g.,

Table 2 Result of verification of MSW collection amount per person per day (g) by modifying the corresponding data on population with MSW collection service and MSW collection amount.

<table>
<thead>
<tr>
<th></th>
<th>Before verification</th>
<th>After verification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number¹</td>
<td>82</td>
<td>82</td>
</tr>
<tr>
<td>Maximum</td>
<td>346,106</td>
<td>2,917</td>
</tr>
<tr>
<td>Median</td>
<td>691</td>
<td>635</td>
</tr>
<tr>
<td>Average</td>
<td>5,520</td>
<td>724</td>
</tr>
<tr>
<td>Minimum</td>
<td>92</td>
<td>92</td>
</tr>
<tr>
<td>SD²</td>
<td>38,288</td>
<td>408</td>
</tr>
</tbody>
</table>

¹ Number of URENCOs responding. Data from one URENCO were excluded due to a lack of data on population with collection service.
² Standard deviation.

Fig. 2 Ratio of the population with MSW collection service to the total urban population in each province of Vietnam.
at sources or landfill sites), the sample amounts (kg), or when sampling was conducted (i.e., in rainy or dry seasons).

(6) Onsite weighbridges

Twenty-eight (33.7%) of the URENCOs used weighbridges at the landfill or composting sites to weigh the MSW. The URENCOs in the cities under the direct authority of the central government all had weighbridges except for Can Tho, as did all 8 composting sites. Fifty-five of the URENCOs provided data on MSW collection amounts by weight even though they had not used weighbridges. These URENCOs must have had other methods of estimating the weight, but we were unable to identify those methods.

(7) Reliability analysis of MSW collection amounts

Fig.4 and Fig.5 show the distribution of the MSW collection amounts per person per day in 982 municipalities in Japan and in 82 URENCOs in Vietnam. Data from one URENCO were excluded due to a lack of data on population with collection service (Table 3). A minimum population of 20,000 for municipalities in Japan was used because the minimum population with URENCO MSW collection service was 22,000. The CV of the MSW collection amounts per person per day in Japan was the lowest followed by that of URENCOs with weighbridges in Vietnam (Table 4). If the data on population with MSW collection service and MSW collection amounts are reliable, the MSW collection amount per person per day should converge based on the hypothesis that the pattern of MSW generation in a municipality would not differ within the same country. The reliability of the data in Japan could contribute to the lower CV.

Municipal waste treatment and disposal sites in Japan are generally equipped with weighbridges. With the exception of the amount of MSW that households dispose of by themselves, municipalities annually report the MSW collection amount to the Ministry of the Environment of Japan based on the actual measurements from the weighbridges. Therefore, the data on the MSW collection amount should be very accurate. According to the Waste Management and Public Cleansing Law in Japan, municipalities must design a plan for MSW management in their respective administrative areas. The plan should include an estimate of the amount of MSW to be generated and managed. In other words, municipalities have both the physical means and the regulatory mandate to accurately estimate the amount of MSW currently collected. The Japanese government has also developed very reliable population statistics so the daily per person MSW collection rates should be quite reliable.

Although differences in living standards and the amount of inappropriate disposal in rivers and canals may contribute to variation in the MSW collection amounts among local areas in Vietnam, the actual measurement of MSW weight with weighbridges

### Table 3 Summary of survey results.

<table>
<thead>
<tr>
<th>Collection</th>
<th>Composting</th>
<th>Landfilling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Covered area (ha)</td>
<td>Population with collection service (person)</td>
<td>Collection amount (t/year)</td>
</tr>
<tr>
<td>Number¹</td>
<td>81</td>
<td>82</td>
</tr>
<tr>
<td>Total</td>
<td>2,543,669</td>
<td>19,101,318</td>
</tr>
<tr>
<td>Maximum</td>
<td>905,940</td>
<td>1,212,668</td>
</tr>
<tr>
<td>Median</td>
<td>8,100</td>
<td>169,092</td>
</tr>
<tr>
<td>Average</td>
<td>31,403</td>
<td>232,943</td>
</tr>
<tr>
<td>Minimum</td>
<td>68</td>
<td>22,000</td>
</tr>
<tr>
<td>SD²</td>
<td>109,025</td>
<td>234,827</td>
</tr>
</tbody>
</table>

¹ Number of URENCOs responding.
² Standard deviation.
³ MSW amount directly transported from sources.

![Fig.3 Proportion of organic waste and the number of URENCOs that provided data on the physical composition of MSW.](image-url)
would contribute to a lower overall CV and make MSW collection data more reliable. However, there is little incentive for URENCOs to install weighbridges because of the cost, and most of them use open dumping, which does not require reliable data on collection amounts. In addition, most URENCOs gave the same answer for total population in the area where they provide their MSW collection service and for total population with MSW collection service. It is not likely that all URENCOs provide collection services to everybody within their collection areas. Therefore, more reliable responses in regards to the number of people being provided service would reduce the CV as would better overall population statistics in Vietnam.

6. CONCLUSION

The top-down approach used in the survey may have been effective for enhancing responses to the questionnaires. This study confirmed that the fundamental MSW data in urban areas of Vietnam existed at the local level. The MSW data would be improved by identifying human errors caused by respondents or typists, and by using weighbridges.

Based on verifying the MSW collection amounts per person per day, modification of the corresponding data on the population with MSW collection service and MSW collection amount contributed to enhancing the reliability of those data.

Increasing the use of weighbridges to provide actual measurements of MSW would no doubt contribute to developing a more reliable MSW database. However, installation of weighbridges would be expensive and URENCOs may not have the incentive to install them. In that case, it will be important to develop methods of estimating MSW collection amounts more accurately without the use of weighbridges.

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REFERENCES


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