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Research Paper

Generation and Composition of Domestic Solid Waste in Vinh Chau Town, Soc Trang Province, Vietnam

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Abstract
The study aims to assess the generation, composition and household's management of domestic solid waste in Vinh Chau town, Soc Trang province, Vietnam. The required data were collected by field survey and by interviewing 198 households in the study area. The results showed that the average generation rate of solid waste was 2.29 kg/day or 0.55 kg/person/day. The composition of domestic solid waste was organic matters accounted for 86.60%, plastics 4.30%, hazardous waste 2.11%, paper and cardboard 1.95%, textiles 1.29%, metals 0.97%, brick and porcelain 0.54%, glass 0.51% and other components 1.73%. The solid waste is currently not classified at source. About 46.46% of the surveyed households have registered for the solid waste collection service and the collection rate in the study area is only 56.5%. The result also presented that 53.53% of solid waste is collected and brought to the landfill for treatment, while the remaining is mainly burned by the households. Solid waste management in the study area has several limits and it should be soon improved to meet the current legal regulations.

Keywords
Domestic Solid Waste, Generation Rate, Solid Waste Composition, Pollution, Vinh Chau, Soc Trang

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1. INTRODUCTION

Urbanization and economic development often go along with resource consumption and emission rates, leading to increasingly complex environmental, social economic issues (Hoang et al., 2014; Gioi et al., 2020), in which domestic solid waste is one of the top concerns (Hoang et al., 2014). Domestic solid waste is all solid waste generated in human daily life, including food waste (degradable organic groups), reusable and recyclable groups, and others (Ministry of Natural Resources and Environment, 2015). According to the Ministry of Natural Resources and Environment (2019), the total volume of MSW generated nationwide in 2011 was about 44,400 tons/day and this continued to increase to 64,658 tons/day in 2019. In the Mekong Delta region, the amount of solid waste generated has almost doubled from 0.61 kg/person/day in 2007 to 1.2 kg/person/day in 2018 (Ministry of Natural Resources and Environment, 2019). However, the management of solid waste in our country currently has many shortcomings such as the low collection rate of rural solid waste, the main treatment method is unhygienic burial, and the MSW has not been classified at the source (Ministry of Natural Resources and Environment, 2019). Besides, MSW pollution leads to great environmental and human impacts if they are not managed, collected and treated with proper environmental techniques (Oanh, 2021). The indiscriminate dumping of waste pollutes surface water and groundwater; clogs drains, creating stagnant water for insects to breed (Alam and Ahmade, 2013). Greenhouse gases were generated from the decomposition of organic waste in landfills and untreated leachate contaminate soil, surface water and groundwater (Vasanthi et al., 2008; Zhao et al., 2016). Unregulated and improper burning of MSW creates challenges in terms of air pollution and ash disposal after incineration (Narayana, 2009); Disease vectors and rodents are attracted to wastes that can spread diseases such as cholera and respiratory diseases (Alam and Ahmade, 2013; Kumar et al., 2017).

Soc Trang is a province located in the marine economic zone of the Mekong Delta, with important traffic routes such as National Highway 1A, National Highway 60, National Highway 61, National Highway South Song Hau,... Urban areas have been developing strongly such as Can Tho, Bac Lieu, Ca Mau, Tra Vinh provinces. Currently, Soc Trang province is in the process of urbanization, developing constantly in terms of speed and scale, quantity and quality.

This contributes to economic growth, the cities are also expanding rapidly, but on the other hand, it generates a large amount of solid waste that affects the environment and human life. Currently, the total volume of domestic solid waste in the province is about 916.5 tons/day (Department of Natural Resources and Environment, 2021). Soc Trang province has implemented the planning and invested in a centralized solid waste treatment area with a capacity of 160 tons/day, expanding the collection network to control and thoroughly treat generated solid waste, especially in rural areas to control and treat pollution sources from solid waste. Along with that, in the area of districts, towns and communes have invested and put into operation 35 concentrated landfills, invested in pilot five incinerators at district and commune levels with a capacity of 40-50 tons/day (Department of Natural Resources and Environment, 2021). However, the situation of stagnation of waste in storage pits, overload at landfills causing environmental pollution is happening in many places in the province.

In which, Vinh Chau town in the southern coastal plain of Soc Trang province has great potential for economic development in the coastal and marine areas, is a very important strategic position in defense and security of the province, the cultural characteristic of Vinh Chau town's community is that Kinh-Khmer-Hoa people live intertwined (People's Committee of Vinh Chau Town, 2020). In parallel with the population growth rate and economic development of Vinh Chau town, the amount of domestic solid waste generated is constantly increasing in both volume and more complex in composition and nature. Moreover, at present, this amount of domestic waste is only collected at a relatively low rate, causing many environmental problems. Therefore, one of the most concerned environmental issues of the whole town is the management of domestic solid waste. The increasing volume of waste will become a big concern for the whole town in particular and for Soc Trang province in general. This study was conducted to investigate the volume, composition, and current management of MSW in Vinh Chau town, Soc Trang province. The findings could provide scientific basis for local environmental managers to come up with solid waste management solutions, contributing to the town's sustainable environmental management.

2. EXPERIMENTAL SECTION

2.1 Brief Description of The Study Sites

The research areas were selected including urban and rural areas of Vinh Chau town, Soc Trang province. Ward 1 is the central area of Vinh Chau town, with an area of 13.44 km^2, a population of 16,872 people with a density of 1,252 people/km^2. Economic activities are mainly business and services. Hoa Dong commune is the rural area, located in the northeast of Vinh Chau town, has an area of 47.96 km^2, a population of 10,783 people with 225 people/km^2. People in this area live mainly by aquaculture, for example shrimp farming.

2.2 Solid Waste Collection and Analysis

2.2.1 Household Interviewing

The study conducted an interview 198 households. The interview sample size was determined by the Equation (1).

$$n = \frac{N}{1 + n \times e^2} \tag{1}$$

Where: n is the survey sample size; N is the overall size; e is the acceptable error level (e has a value from 0.05 ÷ 0.1 (Glover, 2003), in this study, e = 0.08). With the number of households in Vinh Chau town is N = 38,574 households, the survey sample size is calculated according to the Equation (2).

$$n = \frac{38574}{1 + 38574 \times 0.08^2} \sim 156 \text{ households} \tag{2}$$

Thus, in order to limit errors in the data collection process, the study conducted a survey of 198 households.

2.2.2 Solid Waste Collection and Analysis

Domestic solid waste samples were collected at 16 fixed hours a day and continuously for 7 days (from February 1st to 7th, 2021) at the households. The solid waste was stored in specialized garbage bags, the color of the garbage bag is based on Decision 44/2018/QD-UBND of Ho Chi Minh City (People's Committee of Ho Chi Minh City , 2018). Particularly, the blue bag contains biodegradable organic waste and the black bag contains the remaining waste. Fresh garbage samples after being collected at households were weighed and classified within the day to limit the influence of external factors on the sample collection results. After collecting the garbage sample, it is classified into 9 categories: (1) organic waste; (2) paper and cardboard; (3) metals; (4) glass; (5) textiles; (6) plastic, rubber; (7) bricks, porcelain; (8) hazardous waste; (9) other. After collecting and classifying garbage samples, the percentage of each type of solid waste, the coefficient of waste generation was calculated using the following Equations (3-4).

$$\text{Waste composition}(\%) = \frac{\text{Amount of each waste type}}{\text{Total amount of waste}} \times 100 \tag{3}$$

$$\text{Generation rate (kg/person/day)} = \frac{\text{Amount of waste in each household}}{\text{Number of household members}} \tag{4}$$

3. RESULTS AND DISCUSSION

3.1 Generation Rate of the Solid Wastes in the Households

Solid waste in Vinh Chau town arises from households, offices, schools, traffic activities, construction works, agricultural production, commerce, services and markets, etc.

The results showed that the average total amount of solid waste generated per household in Vinh Chau town was 2.29 kg/household/day and the amount of waste generated per capita was 0.55 kg/person/day (Table 1). The results also showed that, in ward 1, there was a higher volume of waste generated than in Hoa Dong commune, possibly due to the concentration of many activities of people, production and business. Former study in Song Thao town, Cam Khe district, on average, each resident generates about 0.64 kg of household waste/person/day (Gioi, 2017), higher than that in the current study. In Tay Son commune, where farming activities are concentrated in home gardens, the number of by-products generated is much higher, the average amount of waste generated is 0.82±0.07 kg/person/day (Hung et al., 2020), which was higher than that in the survey area. In Cau Giay district, Hanoi capital, the MSW generation coefficient per capita reached the highest 0.54 kg/person/day (Oanh, 2021), which was similar to that found in Vinh Chau town. Compared with the study of Tran et al. (2020), in the Southern Region, the amount of waste generated was relatively low at only 0.66 tons/day with the generation coefficient per capita ranging from 0.31-0.35 kg/person/day. In addition, some countries in the world such as North America, Europe and Central Asia, Latin America, the Caribbean, the Middle East and North Africa all had higher solid waste emission coefficients per capita than that in the study area, respectively 2.21 kg/person/day, 1.18 kg/person/day, 0.99 kg/person/day and 0.81 kg/person/day (Sharma and Jain, 2020). In general, the rate of solid waste generation is depending on each locality, region, economic conditions and consumption.

Figure 1 showed that the volume of MSW generated by households in the range of 1-3 kg/day accounted for the largest proportion with 53.03%. Next, the amount of waste less than 1 kg/day accounted for 32.83%, most of the households in rural areas had smaller numbers in the family, so the amount of waste generated was also lesser. For business households, especially food and beverage businesses, a larger amount of solid waste was generated.

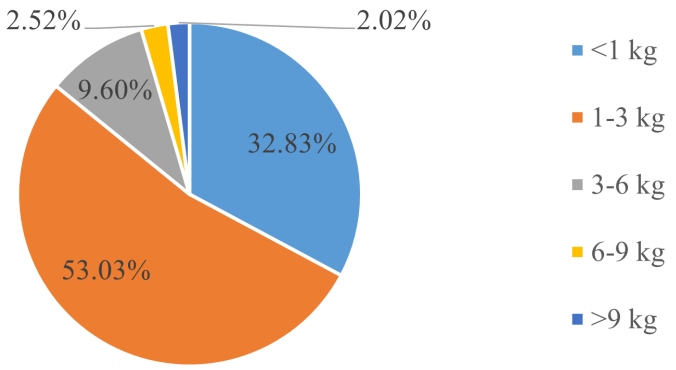

Figure 1. Ranges of Weight Mass in the Households

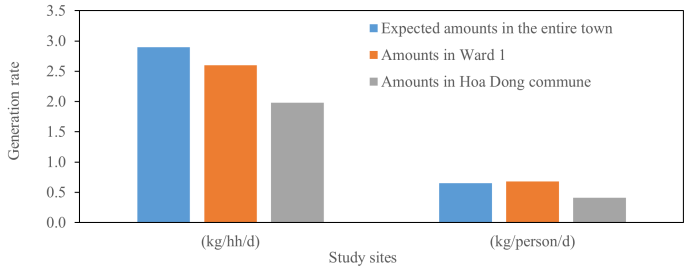

Figure 2. Expected and Measured Amounts of Domestic Solid Wastes in the Study Areas

In addition, the difference between theory and reality in the amount of waste generated in the survey area was also calculated (Figure 2). The analysis results showed that, the amount of waste generated by household in Ward 1 and Hoa Dong commune was lower, different from the theory by 0.3 kg/household/day and 0.92 kg/household/day, respectively. Compared with the theoretical amount, the rate of solid waste generation in ward 1 was higher while it was lower in Hoa Dong commune. The average generation rate of solid waste depends on the living standards including income of the households in the study areas. This explains why the ward 1 had more generation rate that that of Hoa Dong commune. In addition, the data of the survey results of 198 households in the study area showed that the majority of the household with the income less than 5 million VND/month were frequently found (64.65%) in Hoa Dong commune whereas the income of greater than 5 million VND/month were more frequently found (59.06%) in ward 1 (Figure 3). Former studies also found that solid waste generation rates heavily dependent on financial resources, urbanization, population size and living standards in each region (Sharma and Jain, 2020; Xuan et al., 2021).

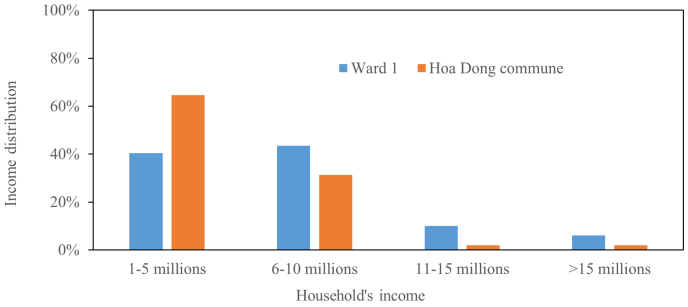

Figure 3. Income of the Households in the Study Areas (Millions per Month)

3.2 Composition of Solid Wastes in the Households

The determination of solid waste composition is very important in the selection of equipment and treatment technology, the reuse as well as the orientation of management programs for the technical system of solid waste management (Gioi

Table 1. Amounts of Solid Wastes in the Study Sites

Sites	Number of household members (person)	Amount of solid waste (kg/week)	Average amount of solid waste (kg/hh/d)	Amount of solid waste per capita (kg/person/d)
Ward 1	3.97	18.21	2.60	0.68
Hoa Dong Commune	4.87	13.89	1.98	0.41
Average	4.42	16.05	2.29	0.55

et al., 2020). The MSW survey results were divided into groups, the proportion of MSW in Vinh Chau town is shown in Table 2. Domestic solid waste in the study area had organic matters (leftover food, flowers, fruits, tubers, plants) accounted for the highest proportion (86.6%), followed by plastic, rubber (4.3%), hazardous waste (2.11%), paper of all kinds (1.95%), textiles (1.29%), metals (0.97%), brick, porcelain (0.54%), glass (0.51%) and others (1.73%). According to research by Viet et al. (2011), the composition of waste in the Mekong Delta region contains organic components accounted for 57.30-87.25%, which is consistent with the results of the current study. Previous studied by Vy and Nga (2014) in Binh Thuy district Can Tho city also have showed that the easily degradable organic content accounted for a very high rate of 88.28%. However, compared with the results of Soc Trang Natural Resources and Environment Monitoring Center in 2019 on the composition of solid waste at Vinh Chau landfill, the organic content accounted for 78.49%. Similarly, in Bac Ninh province, the organic matter composition was also lower, only fluctuating between 50.2-68.9% (Tuat, 2020). According to the World Bank's calculations, organic waste accounts for the largest proportion of all solid waste components (Van Den Berg and Duong, 2018). This is a source of biodegradable solid waste with high nutritional value, which, if used as a source of compost or as nutrition for other activities, would contribute to reducing pressure on treatment processes (Hung et al., 2020). In general, domestic solid waste from different sources has different proportions and compositions, with characteristics of each area and the nature of work and industry.

A component that needs to be considered is hazardous waste, accounting for 2.11%, through a survey of 198 households. In some other areas such as Dien Bien and Bac Ninh provinces, the proportion of hazardous waste components in the domestic solid waste was relatively low, accounting for about 0.34%, 0-1%, respectively (Gioi et al., 2020; Tuat, 2020). Hazardous wastes in the study area are mainly generated from agricultural activities such as bottles containing pesticides, insecticides and insecticides; veterinary care activities such as bottles containing veterinary drugs, tools for injection and surgery; electronic waste such as speakers, batteries, light bulbs, etc. In farming activities, the use of chemicals in agriculture such as chemical fertilizers and pesticides.

The survey results showed that there was a difference in

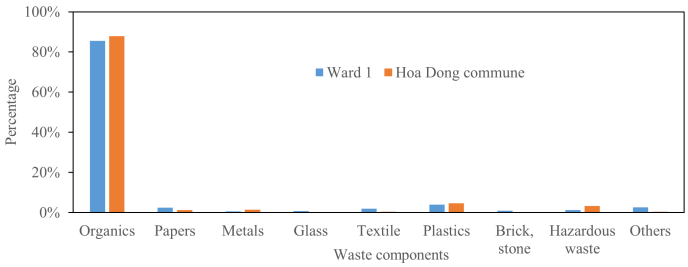

Figure 4. Comparing Solid Waste Components in the Study Sites

solid waste composition between the ward 1 area and Hoa Dong commune, which is shown in Figure 4. Domestic solid waste in Hoa Dong commune has a relatively high percentage of organic matters, mainly from food waste, garden waste accounted for 87.97% of household waste in rural areas. In contrast, plastic and rubber components were about 4.66% and hazardous waste accounted for 3.26%, which were found to be higher in urban area. The percentage of organic waste in Hoa Dong commune was 2.42% which was larger than that in Ward 1. Paper and cardboard in urban area accounted for 1.04% which was higher than that in rural areas. Similarly, textile component in the urban area (1.41%) was also higher than that in rural area (Figure 4).

3.3 Current Management of Solid Wastes in the Study Area

The survey results on solid waste classification of 198 households showed that 48% of households sort the waste at home and 52% do not classify the waste. The method of classification and arrangement of each household is not the same, there are households that divide into three categories: organic waste for chickens, fish, etc. Plastic waste for sale and other components for discard. Currently, there are very few hygienic trash cans in the locality. Most of the trash cans are now being degraded and damaged. Most households equip their own plastic containers for solid waste, for example using metal containers or bamboo baskets. Plastic bags are the most commonly used by the households to store solid waste and then the plastics and the wastes are discarded to the local waste collecting system at a fixed time. The separation of solid waste at source has not been implemented. The unclassified solid wastes are then transported to a centralized landfill for treatment. This practice

Table 2. Composition of Solid Wastes in the Surveyed Households

Solid wastes components	Amount of solid waste (kg/d)			Percentage (%)		Average
	Ward 1	Dong Hoa commune	Average	Ward 1	Dong Hoa commune	
Organics	66.78	52.69	59.74	85.55	87.97	86.60
Papers, cardboard	1.88	0.82	2.69	2.40	1.36	1.95
Metals	0.49	0.85	1.34	0.63	1.42	0.97
Glass	0.58	0.13	0.71	0.74	0.21	0.51
Textile	1.49	0.29	1.78	1.91	0.50	1.29
Plastics, rubbers	3.14	2.79	5.93	4.02	4.66	4.30
Brick, porcelain	0.68	0.07	0.75	0.87	0.11	0.54
Hazardous waste	0.95	1.95	2.91	1.22	3.26	2.11
Others	2.08	0.31	2.38	2.66	0.51	1.73

Table 3. Ways of Solid Waste Treatments of the Households

Treatment practices	Percentage (%)
Sending to collection service	46.46
Placing to waste bins	7.07
Throwing into rivers	5.56
Dumping in the bare land	3.03
Burying	3.54
Burning	34.34

is causing troubles for the processing of solid wastes at the treatment facilities (Gioi, 2017; Thang et al., 2019). In addition, solid wastes that are not segregated at the source may contain hazardous waste which can cause detrimental impact on human health and ecosystems (Xuan et al., 2021). Furthermore, biodegradable and non-biodegradable wastes are mixed together that could make waste recycling and reuse lower and challenging treatment efficiency (Tran et al., 2020). Through a survey of 198 households, the number of households registering for the garbage collection service only reached 46.46%. The average rate of waste collection in urban areas was 63.2% while it was 51.2% in rural area. The average of the collection rate for the whole town was 56.5% (Soc Trang Province People's Committee, 2019). According to Vinh Chau Urban Construction One Member Company Limited, there are currently 11 specialized garbage collection trucks for garbage collection in the area with the number of 32 employees. The environmental sanitation worker team of Vinh Chau Urban Construction One Member Company Limited collects garbage on specialized vehicles with a frequency of three times per day. Currently, the collection of household solid waste is only concentrated in urban areas, the centers of communes and wards while in alleys and small roads, the collection and treatment of garbage is very limited due to financial and accessibility. Currently, the number of households registering for the garbage collection service accounted for only 46.46%, bringing garbage to the collection place accounted for 7.07%. Thus, the remaining 46.47% of the solid waste volume is not collected and disposed of directly into the environment. In particular, the main form of waste treatment of households is burning, burying, leaving it in the open ground or throwing it into the river (Table 3). Especially, burning garbage accounted for 34.34% since most of the households believe that burning garbage is a form of environmental protection compared to disposing of it in the river or in the open field. The current practices of solid waste treatment in the study area are inappropriate. Burning garbage may generate smoke, ash, unpleasant odors and contribute to air pollution (Sivertsen, 2006; Oguntoke et al., 2019; Xuan et al., 2021). Indiscriminate throwing solid wastes into ponds, lakes, rivers, canals pollute surface water, obstructing flow and affecting decomposition rate (Hoi, 2020). Improper storage of solid waste could result in uncontrol degradation of easily-biodegradable wastes which could produce toxic gases such as H_2S and CH_4, causing odors that cause environmental pollution and respiratory diseases (Xuan et al., 2021). In addition, many insects such as flies, mosquitoes, cockroaches and other harmful bacteria form many contagious diseases that affect human health and domestic animals (Xuan et al., 2021). Without proper control measures of domestic solid wastes, it could greatly affect the socio-economic situation in Vinh Chau town.

4. CONCLUSIONS

The results showed the rate of solid waste generation in Vinh Chau town was 0.55 kg/person/day. The composition of domestic solid wastes was organic matters accounted for 86.60%, plastics 4.30%, hazardous waste 2.11%, paper and cardboard 1.95%, textiles 1.29%, metals 0.97%, brick and porcelain 0.54%, glass 0.51% and other components 1.73%. The results also showed that the management of domestic solid waste in the study area has many shortcomings such as the waste has not been sorted at source and there is no mandatory classification to reduce solid waste at source, people's awareness of solid waste management is still low, human resources and treatment technology are still limited. In addition, the rate of registration for solid waste collection service of households in the area is still low, only 46.46% and

the collection rate in the whole town is 56.5% of the total amount of waste generated. Regarding the form of treatment, the garbage collected and brought to the landfill accounts for only 53.53%, the remaining solid waste is treated in spontaneous forms such as burning (34.34%), throwing it into the river (5.56%), burying (3.54%), discarded in the bare land (3.03%). Appropriate solutions are needed for domestic solid waste management in the study area.

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