



ASSESSMENT AND IMPROVEMENT OF MUNICIPAL SOLID WASTE MANAGEMENT FOR SUSTAINABLE DEVELOPMENT IN RURAL VIETNAM: THE CASE OF CHAU THANH DISTRICT, AN GIANG

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ABSTRACT

Solid waste pollution poses a significant global challenge, requiring innovative and region-specific solutions. This study investigates municipal solid waste (MSW) generation, composition, and management in Chau Thanh District, An Giang Province, within Vietnam's Mekong Delta. Data were gathered through interviews with 270 households, tourists, waste collectors, and environmental managers, complemented by physical analysis of two MSW samples. In 2023, an estimated 96.09 tons of MSW were generated daily, with an average waste generation rate of 0.64 kg per person. Organic biodegradable waste made up 59.28%-63.00%, reusable/recyclable waste accounted for 33.83%-34.93%, hazardous waste represented 0.14%-1.63%, and other waste was 3.03%-4.15%. Collection challenges persist due to limited infrastructure and a lack of waste segregation. The study recommends improving waste collection infrastructure, expanding collection routes, and enhancing public awareness to promote proper disposal practices and sustainable waste management.

1. INTRODUCTION

The rapid urbanization and growth of urban populations have significantly contributed to detrimental effects on the environment (Cui, 2012). While urbanization and population expansion serve as primary drivers of economic advancement, particularly in metropolitan regions, they inevitably result in heightened consumption of natural resources (Song et al, 2020). The rise in solid waste generation is an unavoidable consequence of economic progress across many regions worldwide. Consequently, the need for efficient solid waste management

systems is becoming increasingly urgent. Municipalities in developing nations often face a shortage of financial resources and expertise required to address this crisis effectively. Many countries have recognized that their current solid waste management practices fall short of achieving the goals of sustainable development (Qdais, 2007). In Vietnam, the generation of municipal solid waste is estimated at 64,658 tons per day, with rural regions contributing around 28,394 tons per day (equivalent to 10,363,868 tons per year) (MONRE, 2020). Notably, the total volume of MSW generated in Vietnam in

2019 witnessed a 46% increase compared to 2010 (MONRE, 2020). The current solid waste management challenge in Vietnam is a matter of great concern.

An Giang Province, is situated in the heart of the Mekong Delta region in Vietnam. It is characterized by its fertile alluvial plains, crisscrossed by an extensive network of rivers and canals. The Mekong River flows through the province, enriching the land and supporting its vibrant agriculture. Agriculture is the backbone of An Giang's economy, with rice cultivation being the primary activity. Beyond agriculture, the province also has a growing industrial sector, with industries such as food processing, textiles, and manufacturing contributing to its economic development. However, An Giang faces various environmental challenges. Rapid urbanization and industrialization have put pressure on the province's natural resources. The amount of household solid waste generated in the province is about 1,128 tons/day, with urban areas accounting for 44.8% and rural areas accounting for 55.2% (PPC of An Giang, 2020). However, the collection, transportation, and treatment of garbage have been slow and inadequate, leading to a backlog of waste causing environmental pollution in many cities and districts of An Giang. A notable example is Chau Thanh district, one of the administrative divisions within the rural area of An Giang province. Ineffective solid waste management has led to pollution problems in rural areas. This paper aims to conduct a comprehensive review of solid waste management practices in Chau Thanh district, An Giang province, Vietnam to identify key issues and to propose appropriate measures to enhance these practices. In addition, the study determined the amount and composition of municipal solid waste in Chau Thanh district.

2. MATERIALS AND METHODS

The research team conducted direct interviews using a questionnaire with four groups of subjects: households (210 people), tourists (30 people), environmental managers (30 people), and employees of urban environmental companies (10 people). Relevant documents were also collected. Additionally, The research team conducted field surveys in seven communes and towns in Chau Thanh District to assess the current status of solid waste management.

Two sampling areas were chosen in Chau Thanh District: An Chau Town, representing urban areas, and Hoa Binh Thanh Commune, representing rural areas. Two solid waste samples, weighing approximately 100-250 kg each, were collected from these areas. The solid waste was then dumped and mixed at a separate location. The mixed waste was formed into a cone-like shape and divided into four quarters. Two opposite quarters of waste were removed, and the remaining two quarters were thoroughly mixed into a new conical pile. This process was repeated until the test sample weighed between 20-30 kg (Nguyen, 2016; Anh, 2019). After weighing, the waste samples were hand-sorted to separate the different components, which were then weighed individually. The percentage of each solid waste components was determined using the following equation :

$$\% \text{ waste type} = \frac{m_i}{m} \times 100,$$

Where: m_i is the mass of the specific waste type (kg)

$T-m$ is the total mass of the waste sample (kg).

Software SPSS (ver. 26; SPSS Inc.) was used for statistical analyses. Pearson Chi-square method was applied to test the relationship between household size and waste generation. A one sample t-test was performed to determine whether the mean rating by respondents significantly differed from a hypothetical value.

The study used a four-point scale (1 = very dissatisfied to 4 = very satisfied) to assess people’s satisfaction with garbage collection service and the impact of garbage collection points on citizens.

3. RESULTS AND DISCUSSION

3.1 Municipal solid waste generation

According to data collected from Urban Environment Company, the unit in charge of waste collection in Chau Thanh district, the total amount of urban solid waste collected in Chau Thanh district in 2023 was approximately 69.19 tons/day. According to the local environmental management agency, the district's solid waste collection rate is reported to be 72%. Thus, the estimated urban volume generated in the district in 2023 is determined to be about 96.09 tons/day. According to the statistical yearbook, the population of Chau Thanh district in 2022 was 151,006 people. From this, the average solid waste generation coefficient was determined to be 0.64 kg/person/day. This result aligns with the waste generation coefficient found in several studies in the Mekong Delta, Vietnam, where the waste generation coefficient ranges from 0.21 to 1.22 kg/person/day (Pham, 2014; Xuan et al, 2021; Viet et al, 2022).

The survey findings indicated that household size range—from 4 to 9 people.—The results

showed that the amount of garbage generated by households in a day was primarily between 0.5 and 1.0 kg, accounting for 48% of the total. Households generating between 1 and 2 kg accounted for 35%, those generating between 2 and 4 kg make up 13% and households generating 4 kg or more accounted for the lowest rate of 4%. The Chi-square method was used to test the relationship between household size and waste generation. The results indicated that waste generation was significantly correlated with household size ($\chi^2 = 75.011$, $p = 0.000 < 0.05$), implying that as the number of members in the household, increases, the amount of household solid waste generated also increases.

3.2 Municipal solid waste composition

According to the results, the composition of solid waste in urban areas shows that the composition of MSW in this area is very diverse and complex. Biodegradable organic waste accounts for the highest proportion, at 59.29%, which includes food waste, garden waste, and leaves. Reusable and recyclable waste accounts for 34.93% including paper, cardboard, plastic, nylon packaging, cans, and metal. Hazardous waste makes up a small portion at 1.63%. The remaining waste, mainly inorganic and non biodegradable materials such as fabric, leather, rubber, and other waste accounts for 4.15%.

Table 1: Compositions of MSW in Chau Thanh district

Components	Mass (%)	
	Countryside	Urban
<i>Degradable organic waste</i>	63.00	59.29
+ Food	45.06 ± 0.06	49.11 ± 4.36
+ Garden waste, leaves	17.94 ± 1.98	10.18 ± 0.52
<i>Reusable and recyclable waste</i>	33.83	34.93
+ Paper, Carton	8.93 ± 0.30	8.97 ± 1.85
+ Plastic	1.89 ± 1.40	2.80 ± 1.47

+ Nylon packaging	20.21 ± 0.32	20.59 ± 3.46
+ Cans	2.18 ± 1.02	1.54 ± 0.62
+ Metal	0.62 ± 0.42	1.03 ± 0.02
Hazardous waste	0.14	1.63
+ Batteries, accumulators, light bulbs, glass,...	0.14 ± 0.14	1.63 ± 0.40
Remaining waste	3.03	4.15
+ Fabric, leather, rubber	2.08 ± 1.52	2.98 ± 1.40
+ Other waste	0.95 ± 0.40	1.17 ± 0.11

In rural areas, the amount of MSW generated is classified into groups as follows: biodegradable organic waste accounts for 63.00% (the highest proportion), reusable and recyclable waste accounts for 33.83%, hazardous waste accounts for 0.14% and the remaining waste, mainly inorganic waste, accounts for 3.03%. Comparing the MSW composition in the two areas, we see that the proportion of biodegradable organic waste in rural areas is higher, due to the large amount of garden waste and leaves. Other components, such as, reusable and recyclable waste, hazardous waste, and residual waste have lower rates in rural areas than in urban areas. These results are also consistent with other research on solid waste management in Vietnam. The composition of municipal solid waste varies across different provinces in Vietnam. Organic components range from 46% to 71.8%, recyclable waste ranges from 7.1% to 28.4%, hazardous waste ranges from 0.1% to 1%, and the remaining waste ranges from 4.1% to 40.9%. (Loan et al, 2020; MONRE, 2020; Van and Duong, 2018). Compared to research results from other localities, there are similarities in waste composition, with organic waste always accounting for the highest proportion, hazardous waste making up a very low proportion, and the proportion of MSW components generally being low. The difference in waste composition

depends on the study area, influenced by several factors such as population, time of year (tourism development season), socio-economic conditions, local habits and customs (Lan and Thao, 2022; Vuong et al, 2020).

Utilizing organic waste for farming or composting at home can effectively reduce the volume of waste requiring collection and processing by solid waste management systems. Many developing cities exhibit a high organic fraction in their solid waste (Abu et al, 1997). The solid waste characteristics observed in Chau Thanh district are typical of these cities, with organic waste being the dominant component. With the increasing recognition of microplastics as a growing pollutant, posing threats to both ecosystems and human health. It is imperative to minimize plastic waste and promote recycling and reuse practices. The study also highlights that while the proportion of hazardous waste is relatively low, the mixing of hazardous and non-hazardous waste due to improper segregation can still pose significant environmental and health risks.

3.3 Current status of municipal solid waste management

Random interviews with 210 people in the study area revealed that 89% of households were registered for garbage collection services, while

the remaining 11% did not use these services. The reasons for this include challenging natural conditions and poor infrastructure in some remote rural areas, where motorized collection vehicles cannot access certain locations, and there are no established garbage collection routes. Additionally, low awareness of environmental protection among some residents; leads to a reluctance to participate in the collection service and pay the associated fees. Households that do not use the collection service resort to unhygienic self-treatment methods, such as burning trash, burying solid waste in their gardens, or dumping waste into rivers and canals.—These practices contribute to environmental pollution and have harmful affects on public health. Previous studies have indicated that domestic waste collection services have not been widely implemented in many areas of Vietnam (Dao et al, 2018; Giao et al, 2023, Luong et al, 2013).

To assess people's satisfaction with garbage collection service staff, the study employed a four-point scale: 1- Very dissatisfied, 2- Dissatisfied, 3- Satisfied, 4- Very Satisfied. A One-sample T-test was used to compare the average satisfaction scores of the variables. Test values of 2.0, 3.0 and 4.0 were generated at a 95% confidence level using SPSS version 26. The results indicated that the satisfaction score for *the service attitude of garbage collection staff* was 3.21, the score for *the labor protection equipment used by staff during work* was 2.67, and the score for *the garbage collector's uniform* was 2.87. The results, using test value = 3 and test value = 2 showed that all variables had a mean level greater than 2 (Dissatisfied) but less than 3 (Satisfied) (Sig. (2 –tailed) <0.05, 95% confidence level). Citizen satisfaction scores for *the enthusiasm of the collection staff when answering citizen's questions* and *the punctuality of trash pick up* were 3.02 and 2.93, respectively.

These variables had mean levels that reached level 3 (Satisfied) (Sig.(2 –tailed) >0.05, 95% confidence level), indicating that the score were greater than level 2 but lower than level 4 (Sig. (2 –tailed) <0.05, 95% confidence level). The results showed that garbage collection times are typically scheduled for early morning, from 5 to 7 a.m., or in the afternoon after 5 p.m., avoiding peak traffic hours during the day. Most respondents (91%) found these collection times convenient.

The four-point scale was applied to assess the impact of garbage collection points on citizens with the following scale: 1 – slightly influential, 2 – somewhat influential, 3 – very influential, 4 – extremely influential. A One-Sample T-test was used to compare the average score of the variables- with test values of 2.0 and 3.0 at a 95% confidence level using SPSS 26. *The distance of collection points from homes* scored-2.76, while *the lack of trash bins in public places* was rated at 2.65. *The requirement for households to provide and place trash bins in front of their homes* had a score of 2.47. *The impact of unpleasant odors from collection points and trash bins* was lower, with a score of 1.76, and *water leakage from trash bins* had the least impact, with a score of 1.51. These variables have mean levels greater than 2 (somewhat influential) but lower than 3 (very influential) (Sig. (2 –tailed) <0.05, 95% confidence level). The issue of *public trash bins being old, broken, and of low quality* scored 2.09, placing it at level 2—somewhat influential (Sig.(2 –tailed) >0.05, 95% confidence level) but still below level 3 (very influential) (Sig. (2 –tailed) <0.05, 95% confidence level).

The results of data collection and survey showed that garbage collection vehicles in Chau Thanh district include both motorized vehicles for major roads and small hand carts for alleys, narrow roads, and rural areas where motor

vehicles can not access. However, expanding waste collection and transportation routes faces many difficulties. Limited funding, has led to a shortage of collection vehicles and trash containers, which are often degraded. The survey results revealed that waste transportation difficulties, are primarily due to the landfill's distance from the collection areas and a lack of sufficient waste collection points. Consequently, most households disposed of their garbage along roadsides or in bushes, creating temporary dumps that detract from the urban landscape. The storage and collection of waste in public areas have caused various inconveniences for tourists, including unpleasant odors from public trash bins, inconvenient bin locations, and bulky bins that detract from the area's appearance. Issues such as leachate leakage from trash cans and litter scattered around further exacerbate the problem. Additionally, the design and placement of public trash bins are often unattractive. The low environmental awareness among residents contributes to careless waste disposal in public places, rivers, and canals. Due to inadequate infrastructure for waste collection, transportation, and treatment, waste classification at source has not been implemented effectively and widely. In some communes of Chau Thanh District, the local government has organized classification of MSW into 2 simple categories: recyclable waste and remaining waste. While some residents have adopted the practice of separating recyclables and reusables for sale, organic waste is largely underutilized in households. Additionally, hazardous waste is often mixed with regular waste. Currently, unclassified MSW is collected and transported to the Solid Waste Treatment Complex in Chau Thanh district, where it is treated through a hygienic burial method. However, this facility is overloaded and experiencing pollution issues.

To enhance municipal solid waste management, it is necessary to develop mechanisms and policies that attract investment, and promote community participation in the collection, transportation, and treatment of MSW. Strengthening the organization of MSW collection and transportation networks is also crucial, this includes expanding collection areas, and improving the quality of service. Local governments should provide guidance, and conduct awareness campaigns to encourage residents to classify waste into four categories. This effort can be supported by equipping communities with proper waste classification bins and ensuring that waste collection vehicles are synchronized with collection schedules.

4. CONCLUSION

Research results assessing the current state of MSW management in Chau Thanh district show that the estimated MSW generated in 2023 is approximately 96.09 tons per day, with an average generation rate of 0.64 kg per person per day. The composition of MSW reveals that, biodegradable organic waste accounted for 59.29%-63.00%, reusable and recyclable materials comprise 33.83%-34.93%, hazardous waste constitutes 0.14%-1.63% and the remaining waste is between 3.03% and 4.15%. Despite these findings, solid waste management in the district faces numerous challenges, including a lack of adequate and functioning collection, vehicles and trash bins. In some areas, household waste remains uncollected, and residents often resort to improper waste disposal methods. Public trash storage exhibits significant shortcomings with widespread indiscriminate littering and low environmental awareness among citizens. Currently, waste classification is neither effective nor widespread, with most waste being collected together and transported to the solid waste treatment

complex, where it is primarily treated through sanitary landfill methods-resulting in poor condition and overload. Therefore, implementing solutions to improve MSW management in Chau Thanh district is both necessary and urgent.

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