INTEGRATING MUNICIPAL SOLID WASTE MANAGEMENT FOR SUSTAINABLE AGRICULTURE AND CLIMATE RESILIENCE: A CASE STUDY OF CHAU THANH DISTRICT, AN GIANG

Nguyen Tran Thien Khanh[a], Pham Thi Bich Ngoc[b], Pham Van Cao[c]

[a]*An Giang University - Vietnam National University Ho Chi Minh City, 18 Ung Van Khiem, Long Xuyen, An Giang, Vietnam*

[b]University of Social Sciences and Humanities, Viet Nam National University Ho Chi Minh City, Viet Nam.

[c] An Giang Province's Department of Science and Technology

ABSTRACT

Solid waste has emerged as a significant global challenge, demanding innovative solutions. Addressing this necessitates an understanding of solid waste characteristics across various geographical regions. This study aimed to explore the generation, composition, and management of municipal solid waste (MSW) in the Mekong Delta of Vietnam, focusing specifically on Chau Thanh District, An Giang Province. Information was gathered through interviews with 270 households, waste collectors, and environmental managers. Employing methods for collecting secondary data and forecasting MSW volume, the study utilized a four-point scale and conducted statistical tests including the sample T-test and Chi-square test. The findings revealed that in 2023, approximately 96.09 tons/day of MSW were generated, with a solid waste coefficient of 0.81 kg/person/day. Projections suggest a rise to 119.84 tons/day by 2050. Notably, biodegradable organic waste comprised 59.28 to 63.00% of MSW, while reused and recycled materials constituted 33.83 to 34.93%. However, challenges persist in expanding waste collection and transport routes. Household participation in garbage collection services stands at 89%, with 11% resorting to improper waste disposal methods such as burying or burning. Shortcomings in waste collection infrastructure, including insufficient garbage bins and vehicles, exacerbate the issue. Public waste accumulation disrupts tourist experiences with unpleasant odors, inconvenient bin locations, and unsuitable designs. The study highlights the prevalence of indiscriminate waste disposal and the strain on existing treatment facilities like the Long Xuyen complex. Recommendations encompass policy, legislative, and financial reforms, alongside communication and technological enhancements, to bolster domestic waste management in Chau Thanh District.

Keywords: *Municipal solid waste, MSW management, MSW pollution, emission factor, MSW composition.*

1. INTRODUCTION

The rapid urbanization and growth of urban populations have significantly contributed to detrimental effects on the environment [3]. 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 [19]. The rise in solid waste generation is inevitable as a consequence of economic progress across numerous regions worldwide. Consequently, the need for efficient solid waste management systems is becoming increasingly pressing. Municipalities in developing nations often face a shortage of financial resources and expertise required to address this crisis adequately. Many countries have come to recognize that their current solid waste management practices fall short of meeting the goals of sustainable development [18]. The forecasting of municipal solid waste generation holds significant importance within the realm of solid waste management [5]. In

Vietnam, the generation of municipal solid waste reaches an estimated 64,658 tons per day, with rural regions contributing around 28,394 tons per day (equivalent to 10,363,868 tons per year) [13]. Notably, the total volume of MSW generated in Vietnam in 2019 witnessed a 46% surge compared to 2010 [13]. The current solid waste management issue in Vietnam is a great concern.

An Giang Province, situated in the heart of the Mekong Delta region in Vietnam. An Giang 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. 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 whole province is about 1,128 tons/day, of which urban areas account for 44.8% and rural areas account for 55.2% [17]. However, the collection, transportation, and treatment of garbage has been slow and inadequate, leading to backlog of waste causing environmental pollution in many cities and districts of An Giang. In particular, a typical case is Chau Thanh district that is one of the administrative divisions within rural area of An Giang province. Ineffective solid waste management leads 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 pinpoint key problems and to propose appropriate measures for enhancing these practices. In addition, the study determined the amount of municipal solid waste and forecast the generation of solid waste in coming years and determined the composition of municipal solid waste in Chau Thanh district.

2. MATERIALS AND METHODS

2.1. Data collection

The study conducted a survey in 7 communes and towns of Chau Thanh district. The formal questionnaires were designed. The research team conducted directly interviewed by questionnaire with four groups of subjects including households (210 people), tourists (20 people) and environmental managers (30 people) and Urban environment company employees (10 people). Relevant documents are collected. The research team also conducted field surveys.

2.2. Method of forecasting the amount of MSW generated

Method of forecasting the amount of MSW generated in Chau Thanh district by 2025:

+ The population growth rate is forecasted by the improved Euler method, calculated according to the equation [16, 6]

$$N_{i+1} = N_i + rN_i \Delta t$$

Where N_i is the initial population (people), $N_i + 1$ is the population after 1 year (people), r is the population growth rate (%) where r = 0.8% and Δt is the time period (years).

+ The amount of generated solid waste is calculated according to the equation of Oanh [16, 6]

$$\text{Amount of domestic solid waste (ton/year)} = \frac{N_{i+1} \, x \, g \, x \, 365}{1000}$$

Where $N_i + 1$ is the population in the period under consideration (person) and g is the waste generation coefficient (kg/person/day)

2.3. Determination of the composition of MSW

Choose two sampling areas in Chau Thanh District: An Chau Town, representing urban areas, and Hoa Binh Thanh commune, representing rural areas.

The two solid waste samples taken from the research areas had a mass of about 100 - 250 kg, then the solid waste was dumped and mixed in a separate place. The mixed waste components were heaped

into a cone-like shape. The cone of waste was divied into four quarters. The two opposite quarters of waste were removed and the remaining two quarters were mixed thoroughly into a new conical pile. Continue performing the above operations until the test sample had a mass of 20 - 30 kg [14, 2].

After weighting, the waste sample was hand sorted to separate the different components. The separated components were weighted and the results of different components of waste were expressed in percent of the total solid waste. Determining the percentage of composition of all types of waste according to the equation [6].

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

Where: m_i is the volume of waste to be calculated (kg) and m is the total volume of waste collected (kg).

2.4. Analytical procedure

Software SPSS (ver. 26; SPSS Inc.) was applied for statistical analyses. Pearson Chi-square method was used to test the relation between household size and waste generation. One sample t-test was performed to determine whether the mean rated by respondents significantly differs from a hypothetical value. The study used the four-point scale.

3. RESULTS AND DISCUSSION

3.1. Composition of MSW

The results of determining MSW composition are presented in table 1 below

Table 1: Compositions of MSW in Chau Thanh district

Components	Mass (%)	
	Countryside	**Urban**
Degradable organic waste	***63.00***	***59.29***
+ Food	45.06 ± 0.06	49.11 ± 4.36
+ Garden waste, leaves	17.94 ± 1.98	10.18 ± 0.52
Reusable and recyclable waste	***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

According to the Table 1, 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, 59.29%, including food, garden waste, and leaves. Reusable and recyclable waste accounts for 34.93% including paper, cardboard, plastic, nylon packaging, cans, and metal. Hazardous waste components account for a low proportion, 1.63%. The remaining waste is mainly inorganic and difficult to decompose waste such as fabric, leather, rubber, and other waste accounts for

a low percentage, 4.15%. In rural areas, the amount of MSW generated is classified into groups such as: biodegradable organic waste accounts for 63.00% (accounting for the highest proportion), waste that can be reused - recycled 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 biodegradable organic waste composition in rural areas accounts for a higher proportion, due to the large amount of garden waste and leaves. Other components such as waste that can be reused, recycled, hazardous waste, and residual waste have lower rates in rural areas than in urban areas.

The results are also consistent with researches on solid waste management in Vietnam with the main components in MSW being organic components (55 - 65%), inorganic components accounting for about 12 - 15.5% [12]. This result is consistent with the general waste situation in our country, with the biodegradable organic matter component in MSW accounting for a higher proportion than other components and this component is changing in a decreasing trend due to lifestyle of residents in the era of industrialization and urbanization [12].

Compared to research results in some other localities, there are similarities in waste composition with organic waste always accounting for the highest proportion, hazardous waste accounting for a very low proportion, and the proportion of MSW components being low. The difference depends on the study area. The cause is due to the influence of many factors such as population, time of year (time for tourism development), socio-economic conditions, habits and customs in each locality [10, 20].

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 [1]. The solid waste characteristics observed in Chau Thanh district are typical of developing cities, with organic waste being the dominant component. In terms of waste suitable for reuse and recycling, nylon bags and plastic waste are the most prevalent. With the recognition of microplastics as a burgeoning pollutant, posing threats to both ecosystems and human health [8]. It is imperative to minimize plastic waste and promote recycling and reuse practices. The study also highlights that the proportion of hazardous waste is relatively low. However, the mixing of hazardous and non-hazardous waste due to the failure to segregate waste can pose significant risks.

3.2. Generation of MSW

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 is 69.19 tons/day. According to the local environmental management agency, the district's solid waste collection rate is 72%. Thus, the estimated urban volume generated in the district in 2023 is determined about 96.09 tons/day. From there, the average solid waste generation coefficient is determined to be 0.81 kg/person/day.

Table 2: Amount of MSW generated in 2023 in Chau Thanh district

Town	Population (people)	Generated MSW (tons/day)	Collected MSW (tons/day)	Waste generation coefficient (kg/person/day)
An Chau town	22,918	12.58	9.06	0.55
Vinh Binh town	8,892	9,11	6.56	1.02
An Hoa commune	14,374	2.20	1.59	0.15
Can Dang Commune	17,509	7.92	5.71	0.45
Vinh Hanh commune	12,965	9,10	6.55	0.70
Binh Thanh commune	6,242	2.01	1.45	0.32
Binh Hoa commune	20,265	8.99	6.47	0.44
Vinh An commune	9,001	6.47	4.65	0.72

Hoa Binh Thanh commune	10,752	4.94	3.56	0.46
Vinh Loi commune	5,189	6.59	4.75	1.27
Vinh Nhuan commune	6,409	9.88	7,12	1.54
Tan Phu commune	3,634	8.06	5.81	2.22
Vinh Thanh commune	12,856	8.22	5.92	0.64
Total	**151,006**	**96.09**	**69.19**	
Mean				**0.81**

In this study, a survey was conducted on the amount of MSW generated by interviewing households in the study area. The survey findings indicate that, on average, households comprise 4 individuals, with 32% of households falling into this category. Additionally, 22% of households have 5 members, 19% have 3 members, 17% have 6 members, 5% have 2 members, 3% have 7 members, while 1% each have 8 and 9 members among those interviewed. Demographic differences lead to fluctuations in the amount of MSW generated by households. Survey results showed that the amount of garbage generated by households in a day was mainly from 0.5 - 1.0 kg, accounting for 48%, the amount generated from 1 - 2 kg accounted for 35%, the amount from 2 - 4 kg accounted for 13% and from 4 kg or more accounted for the lowest rate of 4%. Thus, the amount of household waste in households ranges mainly from 0.5 - 2.0 kg/household/day (83%) (Firgure 1).

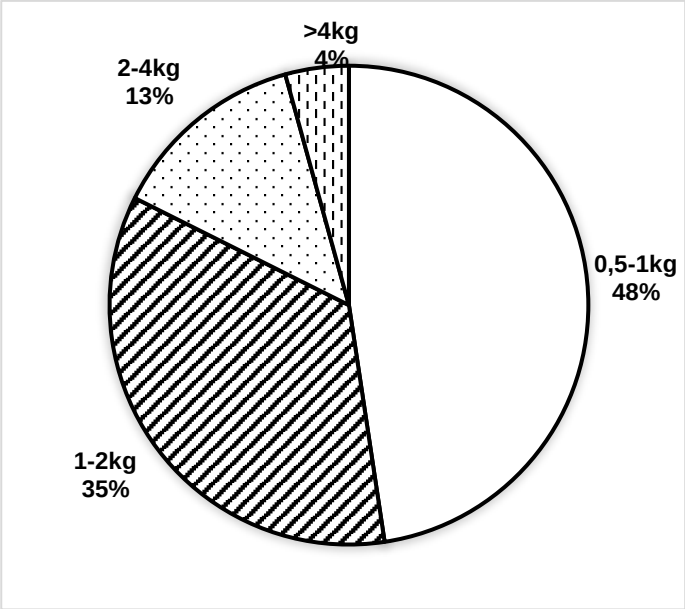

Figure 1: Interview results on the amount of waste generated per household per day

Chi-square method was used to test the relation between household size and waste generation. Results indicated that waste generation was correlated with household size ($\chi 2 = 75.011$, $p = 0.000 < 0.05$). This implied that more members in household, more household solid waste generation. For instant, out of 100 households with a waste amount of 0.5 - 1kg, households with a number of members from 3-4 people account for the highest proportion (61/100 households). Among 73 households with a waste amount of 1-2 kg, households with a number of members of 4-5 people account for the highest proportion (46/73 households). Among the 28 households with 2 - 4 kg of waste, households with 5-6 members account for the highest proportion (22/28 households). Among the 9 households with a large amount of trash of 4 kg, households with a number of members from 5-9 people account for the highest proportion (4/9 households).

3.3. Forecasting of MSW for the period 2023 – 2050

Table 3: Population forecast results for the period 2023 - 2050 (unit: people)

Town/Commune	2022	2025	2030	2035	2040	2045	2050
An Chau town	22,918	23,472	24,426	25,419	26,452	27,528	28,647
Vinh Binh town	8,892	9.107	9,477	9,862	10,263	10,681	11,115
An Hoa commune	14,374	14,722	15,320	15,943	16,591	17,265	17,967
Can Dang Commune	17,509	17,933	18,661	19,420	20,209	21,031	21,885
Vinh Hanh commune	12,965	13,279	13,818	14,380	14,964	15,573	16,206
Binh Thanh commune	6,242	6,393	6,653	6,923	7.205	7,497	7,802
Binh Hoa commune	20,265	20,755	21,599	22,477	23,390	24,341	25,330
Vinh An commune	9,001	9,219	9,593	9,983	10,389	10,811	11,251
Hoa Binh Thanh commune	10,752	11,012	11,460	11,925	12,410	12,915	13,440
Vinh Loi commune	5,189	5,315	5,531	5,755	5,989	6,233	6,486
Vinh Nhuan commune	6,409	6,564	6,831	7.108	7,397	7,698	8,011
Tan Phu commune	3,634	3,722	3,873	4,031	4.194	4,365	4,542
Vinh Thanh commune	12,856	13,167	13,702	14,259	14,839	15,442	16,069
Total	**151,006**	**154,659**	**160,945**	**167,487**	**174,295**	**181,379**	**188,751**

According to the Vietnam Statistical Yearbook and report on socio-economic development in 2022 of Chau Thanh district, the population and population growth rate in 2022 of Chau Thanh district are 151,006 people and 0.8%, respectively. The population forecast results for the period 2023 - 2050 showed that the population in communes and towns from 2023 - 2050 tended to increase, the population of the entire district was forecast to increase by 37,745 people. The An Giang provincial authorities has oriented socio-economic development, creating jobs to attract local labors, creating more effective jobs, aiming to improve local people's lives, and strengthen security policies, social life. Therefore, the population growth forecast in the coming time is consistent with the general development trends and goals of the district and province. The population forecast results in this study are similar to the population forecast results in studies in other localities in Vietnam, the forecast population tended to increase [7, 9, 15].

Table 4: Results of forecasting the amount of MSW generated in Chau Thanh district 2023 - 2050

Town/Communes	Amount of MSW generated (tons/day)					
	2025	2030	2035	2040	2045	2050
An Chau	12.86	13.38	13.93	14.49	15.08	15.69
Vinh Binh	9.31	9.69	10.08	10.49	10.92	11.36
An Hoa	2.25	2.34	2.44	2.54	2.64	2.75
Can Dang	8,10	8.43	8.77	9,13	9.50	9.88
Vinh Hanh	9.30	9.68	10.07	10.48	10.91	11.35
Binh Thanh	2.06	2.14	2.23	2.32	2.41	2.51
Binh Hoa	9.18	9.56	9.94	10.35	10.77	11.21

Vinh An	6.61	6.87	7.15	7.44	7.75	8.06
Hoa Binh Thanh	5.05	5.26	5.47	5.69	5.92	6.16
Vinh Loi	6.74	7.01	7.29	7.59	7.90	8.22
Vinh Nhuan	10,10	10.51	10.94	11.38	11.84	12.33
Tan Phu	8.24	8.58	8.92	9.29	9.66	10.06
Vinh Thanh	8.40	8.74	9,10	9.47	9.86	10.26
Total	**98.19**	**102.18**	**106.34**	**110.66**	**115.16**	**119.84**

The results of forecasting the amount of MSW generated are presented in Table 4. The amount of MSW generated was determined depending on the total population of the locality and the MSW generation coefficient. The population in wards from 2023 - 2050 tends to increase, so the amount of MSW also increases. It is forecast that by 2035 the amount of MSW generated per day will be 106.34 tons/day, an increase of 1.11 times compared to 2023. It is forecast that by 2050 the amount of MSW generated per day will be 119.84 tons/day, an increase of 1.25 times compared to 2023.

In studies on forecasting the amount of MSW generated in other districts and cities in Vietnam, it has been shown that the amount of MSW tends to increase over time. In Dien Bien district, Dien Bien province, the amount of MSW in 2018 was 56.15 tons/day and is forecast to increase to 61.39 tons/day by 2030, an increase of 1.09 times [7]. The amount of MSW generated in Dong Anh town, Hanoi is forecast to increase 1.14 times, from 20,314 tons/person day in 2020 to 34,608 people in 2025 [9]. It is forecast that the amount of MSW generated in 5 communes in Dong Hung district, Thai Binh city will increase 1.18 times, from 31,849 tons/day in 2021 to 37,663 tons/day in 2025 [15]. Thus, the forecast results of the increase in MSW generated in this study are consistent when compared with related studies.

3.4. Solid waste collection at households

The resullts of data collection showed that garbage collection vehicles in Chau Thanh district has included motorized vehicles that collect garbage on major roads and small hand carts that collect garbage in alleys, narrow roads and rural roads where motor vehicles can not enter. Expanding waste collection and transportation routes still has faced many difficulties. Due to limited funding, the number of collection vehicles and trash containers is still lacking and degraded.

The garbage collection time of the collection unit is avoided peak hours of the day, will focus on collecting mainly in the early morning from 5 - 7 a.m or in the afternoon, after 5 p.m. The collection time is appropriate according to the assessment of the majority of interviewed people, with 91% of respondents finding this collection time convenient for them.

Results of random interviews with 210 people in the study area showed that 89% of households registered for garbage collection services, the remaining 11% did not use garbage collection services. The reason is that in some remote rural areas, natural conditions are difficult, infrastructure is poor, motorized collection vehicles cannot enter, and there are no garbage collection routes. Another reason is that people's awareness of environmental protection is still low, so they do not want to participate in the collection service and pay fees according to regulations. Households that do not use collection service have applied unhygienic self-treatment methods at households such as burning trash, burying solod waste in the garden or poured waste into rivers and canals, causing environmental pollution and affecting public health. The previous studies indicated that domestic waste collection services have not been widely implemented in various areas of Vietnam [4, 6, 11].

Regarding the fee for garbage collection services, in general this fee is relatively low. The current fee collection does not meet the needs of garbage collection and treatment and cannot compensate for operating costs. The solid waste management system almost depends entirely on the provincial budget. People's awareness in some rural areas is still poor and they do not actively participate in paying garbage

collection fees.

Survey results on people's satisfaction with garbage collectors and collection fee collectors are presented in Table 5 below

Table 5: Satisfation of households on garbage collection service

Rank	Code	Variables	Mean	SD	T-Test (Test value =2)	T-Test (Test value =3)	T-Test (Test value =4)
1	CS1	Service attitude of garbage collection staff	3.21	0.82	0.000*	0.001*	0.000*
2	CS2	The enthusiasm of the collection staff when answering citizen's questions	3.02	0.70	0.000*	0.754	0.000*
3	CS3	Punctuality when coming to pick up trash	2.93	0.76	0.000*	0.210	0.000*
4	CS4	Garbage collector's uniform	2.87	0.77	0.000*	0.018*	0.000*
5	CS5	Labor protection equipment of garbage collectors during work for	2.67	0.81	0.000*	0.000*	0.000*

*Note: * denoted that it was significant at 95% level of confidence*

To assess the sattisfation of people on garbage collection servive staff, the study used the four-point scale: 1- Very dissatisfied, 2- Dissatisfied, 3- Sattisfied, 4- Very Sattisfied. Table 5 presents the results of one-sample t-test with the aim of comparing the average score of variables. The test value 2.0, 3.0 and 4.0 with a 95% confidence level were generated using SPSS 26.

Results with test value = 4 and test value = 2 showed that all variables had mean level greater than level 2 and lower than level 4. For test value = 3.0, the level of test significance of 2 variables> 0.05 (CS2, CS3) should not reject the hypothesis H_0 (mean = 3). The mean of CS2 and CS3 are 3.02 and 2.93, meaning that the these variables reach level 3 - Sattisfied. The remaining variables (CS1, CS4, CS5) are worth Sig. (2 –tailed) <0.05 so the hypothesis H_1 is approved, meaning these variables have a mean level lower than level 3—Sattisfied.

The investigation showed that the places where household waste is gathered as follows: families arrange their own trash bins in front of the house (accounting for 67.4%), trash is gathered in public trash bins along the road (accounting for 23.5%), putting trash in bags in front of the houses for collecting by collection vehicles (accounts for 17.60%). In addition, some households generate little solid waste and will take the trash out of their house when the garbage collection truck arrives (accounting for 1.6%).

The results of the survey on the impact of garbage collection points on households are presented in Table 6

Table 6: The impact of garbage collection points on households

Rank	Code	Variables	Mean	SD	T-Test (Test value =2)	T-Test (Test value =3)
1	CP1	Collection points are too far from home	2.76	1.20	0.000*	0.007*
2	CP2	Lack of trash bins in public places	2.65	1.11	0.000*	0.000*
3	CP3	Households must prepair trash bins by themselves and put in front of there houses	2.47	1.08	0.000*	0.000*
4	CP4	Trash bins in public places are too old, broken, low quality	2.09	0.97	0.229	0.000*
5	CP5	Bad odor from collection points, trash bins	1.76	0.94	0.001*	0.000*
6	CP6	Water leaking from trash bins	1.51	1.13	0.000*	0.000*

*Note: * denoted that it was significant at 95% level of confidence*

The four-point scale was applied to assess the impact of garbage collection points on people: 1 – slightly influential, 2 – somewhat influential, 3 – very influential, 4 – extremely influential. Table 6 presents the results of one-sample t-test. The test value 2.0 and 3.0 with a 95% confidence level were generated using SPSS 26.

Results with test value = 3.0 showed that all variables had mean level lower than level 3 - very influential. For test value = 2.0, the level of test significance of variable CP4> 0.05 should not reject the hypothesis H0 (mean = 2.0). The mean of CP4 is 2.09, meaning that the variable reach level 2 - somewhat influential. The remaining variables (CP1, CP2, CP3, CP5, CP6) are worth Sig. (2 –tailed) <0.05 so the hypothesis H1 is approved, meaning these variables have mean levels greater than level 2 - somewhat influential and lower than level 3 - very influential.

3.5. Storage and collection of trash in public places

Results of interviews with tourists about their feelings when coming to Chau Thanh about the inconvenience of garbage storage and collection in public places are as follows: 60% of tourists surveyed feel trash bins in public places stinks and causes discomfort, 55% of tourists fell that the location of public trash bins is not convenient for them to put away their trash. There are also some other inconveniences such as bulky trash bins that ruin the beauty of the area, water leaking from trash bins, trash bins are too small (opinion of 30% of interviewed tourists). In addition, uncovered garbage causes discomfort (opinion of 20% of interviewed tourists). This wil reduce tourist satisfaction, reduce attraction and affect local tourism development.

To assess the satisfaction of tourists on garbage storage and collection in public places, the study used the four-point scale: 1- Very dissatisfied, 2- Dissatisfied, 3- Sattisfied, 4- Very Sattisfied. The results showed that the level of satisfaction of tourists with the arrangement of trash cans in public places was not high, at a dissatisfied level, with an average score of 2.42. The lowest level of satisfaction is with aesthetic issues, specifically the beautiful design and arrangement of public trash bins, only reaching 1.95/4 points. Next, the arrangement of trash bins in public places was rated at dissatisfied level in terms of suitability of trash bins for children and people with disable people with 2.30/4 points. Satisfaction with the arrangement of trash bins on roads reached 2.45/4 points, and at parks and tourist areas reached 2.60/4 points. The satisfaction with the issue that trash can having a lid or not is 2.80/4 points.

To evaluate littering in public places, the study used the four-point scale: 1- Very little, 2-Little, 3- Much, 4- Very Much. The results show that tourists rate that waste is thrown indiscriminately in public places such as markets (average 3.25/4 points), bus stations, and wharves (average 3.10/4 points). points) and tourist areas and parks (average 3.05/4 points). In other places such as historical relics and religious spiritual areas, the level of littering is lower (2.00-2.35 points). The reason is that in public places with high density of people, a large number of visitors, a large amount of trash is generated, while the current number of trash bins is lacking and the collection frequency is not guaranteed. Waste control faces many difficulties.

3.6. Classification and treatment of MSW

Due to inadequate collection, transportation, and treatment infrastructure, 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. Some local people have the habit of separating waste that can be recycled and reused for sale. Organic waste is not utilized much in households. Hazardous waste is not separated from normal waste. Unclassified MSW is currently collected and transported to the Solid Waste Treatment Complex in Chau Thanh district and treated by hygienic burial method, which is in an overloaded and polluted state.

3.7. Proposed solution

The study offers some solutions to improve MSW management in Chau Thanh district, An Giang province, Vietnam. It is necessary to develop mechanisms and policies to attract, call for investment, and socialize the collection, transportation, treatment of MSW, and community-based management. It is importnt to speed up investment in construction of waste treatment plants in the district to deal with the increasing amount of landfilled waste. In addition, it is necessary to strengthen the organization of the network of MSW collection and transportation units, expand collection areas, increase the quality of collection service. The authorities should apply principle: "Polluters pay and beneficiaries pay". Local government need to organize guidance, communication and mobilization of people to classify waste into 4 types, equip waste classification bins, and synchronize waste collection vehicles. It is necessary to increase recycling, reuse of MSW. Environment manager need to guide households on how to compost at home using organic waste, and develop composting models. It is possible to apply waste incineration technology to generate electricity combied with the model of classifying waste into two types: burnable waste and non-burnable waste.

4. CONCLUSION

Research results assessing the current situation of MSW management in Chau Thanh district show that the estimated amount of MSW generated in the district in 2023 is about 96.09 tons/day, the average MSW generation coefficient is 0.81 kg/person/day. It is forecasted that the volume of MSW generated in Chau Thanh district in the period 2023-2050 will tend to increase, by 2050 it will reach 119.84 tons/day, an increase of 1.25 times compared to 2023. The results showed that in the MSW composition, biodegradable organic waste accounted for 59.29%-63.00%, waste that can be reused - recycled accounted for 33.83%-34.93%, and hazardous waste accounted for 0.14%-1.63% and the rate of the remaining waste is 3.03%-4.15%. In general, solid waste management in the district has many limitations such as: collection vehicles and trash bins are lacking and degraded, household waste in some areas has not been collected, people treat solid waste by themselves. The storage of trash in public places still has many shortcomings, a lot of trash is thrown indiscriminately, and people's awareness is still poor. Currently, waste is not classified effectively and widely, mainly collected together, brought to solid waste treatment complex, treated mainly by hygienic burial method and is in poor condition, overloaded. Applying solutions to improve MSW management in Chau Thanh district is very necessary and urgent

5. REFERENCES

[1] Abu, Q.H. A., Hamoda, M. F., Newham, J. (1997). Analysis of residential solid waste at generation sites. *Waste Management and Research,15,* 395–406.

[2] Anh, V. T. L., Le, T. T. T., Linh, N., D., &Thuy, Đ. T. N. (2019). Study on solid waste collection work at Dich Vong Hau ward, Cau Giay district, Hanoi. Conference Proceedings: Basic Research in "Earth and Environmental Sciences". http://dx.doi.org/10.15625/vap.2019.000224

[3] Cui, L.S. (2012). Urbanization and its environmental effects in Shanghai, China, *Urban Climate, 2,* 1-15.

[4] Dao, T. A., Nguyen, T. N. A., Nguyen, T., K., Bui, T., A., & Dinh, T. H. V. (2018). Optimizing vehicle routing with path and carbon dioxide emission for municipal solid waste collection in Ha Giang, Vietnam. *In Industrial Networks and Intelligent Systems: 3rd International Conference, INISCOM 2017, Ho Chi Minh City, Vietnam*, September 4, 2017, Proceedings 3, 212-227. Springer International Publishing

[5] Dyson, B., Chang, N.(2005). Forecasting municipal solid waste generation in a fast- growing urban region with system dynamics modeling. Waste Manage, 25, 669-679.

[6] Giao, N. T., Thao, B. T., Truc, T. H., & Mi, L. T. D. (2023). Current Generation and Management of Domestic Solid Waste at Nhon Nghia Village, Phong Dien District, Can Tho City, Vietnam. *Journal of Applied Sciences and Environmental Management, 27*(7), 1459-1469.

[7] Gioi, N. V., Chinh, C. M., & Tuat, N. T. N. (2020). The current situation and solutions to improve the efficiency of domestic solid waste management in Dien Bien District, Dien Bien province. *TNU Journal of Science and Technology,* 225(06), 396-404. http://jst.tnu.edu.vn/jst/article/view/2994/pdf

[8] Kurniawan, S. B., Said, N. S. M., Imron, M. F., Abdullah, S. R. S. (2021). Microplastic pollution in the environment: Insights into emerging sources and potential threats. Environ. Technol. Innov., 23: 101790.

[9] Lan, N. M. & Thao, M. H. (2022). Assessment of household solid waste management in Dong Anh town and Tien Duong, Uy No communes in Dong Anh district, Hanoi. Vietnam Environment Journal, 4, 65 – 71. https://sti.vista.gov.vn/tw/Pages/tai-lieu-khcn.aspx?ItemID=352007

[10] Le, D. K., & Pham, Q. N. (2023). The current status of household solid waste management in Tan Thuan Dong commune, Cao Lanh city, Dong Thap province. Dong Thap University Journal of Science, 12(8), 52-59. https://doi.org/10.52714/dthu.12.8.2023.1151

[11] Luong, N. D., Giang, H. M., & Thanh, B. X. (2013). Challenges for municipal solid waste management practices in Vietnam. Waste Technology, 1(1), 17-21.

[12] Ministry of Natural Resources and Environment. (2011). National environmental status report 2011: Solid waste. Hanoi: Ministry of Natural Resources and Environment.

[13] Ministry of Natural Resources and Environment. (2020). National Environment Report 2019: Domestic solid waste management. Hanoi: Ministry of Natural Resources and Environment.

[14] Nguyen, M. K., Đo, M. P., Le, H., C., & Pham, T. T. (2016). Study on the Possibility of Transforming household waste to biogas. *VNU Journal of Science: Earth and Environmental Sciences*, *32*(1S).

[15] Oanh, P. T. T. (2020). Assessment on management of domestic solid wastes and solutions in Dong Hung district, Thai Binh. *TNU Journal of Science and Technology*, *225*(06), 528-535.http://jst.tnu.edu.vn/jst/article/view/3162

[16] Oanh, PTT (2021). Status assessment and solutions of management to domestic solid waste in Ha Noi. *TNU J. Sci. Technol, 226*(7): 190-198.

[17] People's Committee of An Giang province. (2020). *Report on the current statas quo of the environment in An Giang province 2016 -2020.* An Giang: People's Committee of An Giang province.

[18] Qdais, H. A. (2007). Techno-economic assessment of municipal solid waste management in Jordan. *Waste management*, *27*(11), 1666-1672.

[19] Song, T. P. P., Fujiwara, T., Hoang, M. G., Pham, V. D., Kieu, T. H., Tran, T. Y. A., Le, D. C. (2020). Enhancing Waste Management Practice The Appropriate Strategy for Improving Solid Waste Management System in Vietnam Towards Sustainability, *Chemical Engineering Transactions, 78,* 319–324.

[20] Vuong, T. P., Nguyen, T. T., Nguyen, V. N., & Nguyen, P. T. (2020). Assessing the current status of household soud waste of Phu Tan district, Ca Mau province. *Vietnam Industry and Trade Magazine, 10,* 356-359. http://113.165.166.110:81/bitstream/DL_134679/22716/1/CVv146S102020356.pdf