



## STATUS OF RESIDENTIAL SOLID WASTE MANAGEMENT. A CASE STUDY IN DONG ANH DISTRICT, HANOI, VIETNAM

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### Abstract

*Residential solid wastes have been becoming an environmental threat for every city, especially crown and high population. The status of Residential Solid Waste (RSW) in a large city, such as Hanoi in general and Dong Anh district in particular, can bring a better vision for management activities. In this study, RSW will be carried out to assess the sources and component contribution being inputs for further forecasting of generated RSW until 2025 in study areas, Dong Anh district, the Tien Duong, and Uy No communes. This study applies the separation of the waste in sites and surveys to calculate the Generated Residential Solid Waste Rate (GRSWR) and in combination with the increased population rate from the famous Euler's model to predict and forecast the Generated Residential Solid Waste (GRSW) in Dong Anh in the 5 years (2020 - 2025). The results show that the increase in population for every study region will lead to an increase in RSW. In particular, the total GRSW will increase by more than 1,000 tons/year with only 1,000 raised citizens in 5 years. The overall trash collection rate reaches 86.5 % of the total waste generated in the area. The residential waste composition of the Dong Anh district is extremely diverse, with organic matter accounting for nearly 75 %, higher than the average of Hanoi. The important thing is to rigorously and thoroughly implement waste classification at the source according to the regulations of the Law on Environmental Protection (2020) to reduce the amount of waste generated that needs to be collected.*

**Keywords:** Residential Solid Waste; Hanoi; Environmental sanitation.

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### 1. Introduction

Environmental pollution has recently been the cause of many global issues, including a decrease in human health, diseases, animal mutation, and a reduction

in life expectancy. These problems have become worse in the past decade among developing countries, in which industrial activities and the increase of household waste are booming. The total amount of waste rapidly increased in all European

countries to over 235 million tons per year in 2020 [1]. Vietnam is one of the fastest countries in the world in both economy and population. Following this trend, the increase in residential waste, both solid and recycled, creates so many problematic environmental and health issues. In the national environmental report in 2019 [2], the total waste from households in all cities was estimated to be up to 36 thousand tons per day, rating about 55 % of all solid wastes in the nation. However, the figures could become even worse in that 92 % of solid waste could be collected in cities and 66 % in the countryside.

Residential solid wastes can be dumped into the environment from different sources. Households, shopping malls, offices, and institutions are the typical sources due to the great use of the household, such as plastic bags, broken electricity pieces of equipment, food, and many others. Additionally, construction waste with a high quantity of steel, broken concrete, bricks, and PVS piles became the secondary sources. The components of wastes can have some threatening potentials, including (1) Ignitable components from papers, clothes, food disposal, wooden pieces of equipment, plastic, and leather, and (2) Non-flammable materials, e.g., steels, concretes, bricks, or glasses. Whereas wastes in type (1) can be found in households, shopping malls, or offices due to their common use, the most typical wastes in type (2) are dumped from construction and industrial sites. Furthermore, due to the lack of technique for dividing components, solid or residential wastes can be more

complicated to manage. As a result, negative effects on the environment and residents' health become the main problems for every large city, leading to great pressure on waste management.

Solid waste management in Asian countries can be recycling processes, flame disposal, bio- and chemical disposal, open-dump sites, and sanitary landfills, which are the most used due to lower capital, maintenance cost, and operational. Becoming common, the use of open dump sites for household wastes leads to an overwhelming amount of air, groundwater, and water pollution [3]. In Vietnam, a total of 1322 solid waste disposal sites, 381 flame disposal stations, 37 compost processes, and 904 open-dump sites resulted in 13, 16 and 71 % of waste disposal, respectively [2]. As a result, the effects of ineffective management on human health, including physical, biological, non-communicable diseases, psychological and ergonomics, health risks [2 - 5].

In the past decade, the living standards have been improved significantly, leading to an accompanied rise in a deterioration in the quality of the environment. Residential wastes, mostly from offices, enterprises, and households, are now becoming a serious threat. Moreover, it is recognized that the management of the mobile trash locations is under control due to the lack of quantity and quality. Additionally, the mindset for reusing plastic products, such as plastic cans and pesticides/medicine bottles, is faulty since those products are still widespread among the residents of the municipality. The indiscriminate dumping of waste and untreated domestic

wastewater has caused most of the drainage canals to be black in color and smell of rotteness, which has a great impact on the surrounding environment. Nevertheless, the timely intervention of the functional agencies in the area is still weak and not synchronized between the various sectors. The management of the environment by the specialized agencies in the ward still reveals many limitations. At present, in these areas, the rate of new garbage collection is only 85.6 % of the amount of waste generated at the current time, and the waste treatment technology does not meet environmental hygiene requirements. [2].

Several studies have been conducted on household solid waste management, which aims to assess the current state of waste management practices, including collection, disposal, and recycling [6 - 8]. According to Van den Berg (2018) [9], the collection of solid waste in Hanoi currently has two forms, consisting of (i) Garbage trolley system, (ii) Direct trucks, and (iii) Container systems. Garbage trolleys are mostly used in crowded areas where garbage trucks are difficult to pass through. Small and medium-sized garbage trucks (e.g., total volume from 5 to 15 m<sup>3</sup>) are typically used to directly collect wastes and transport them to disposal or treatment sites without the secondary transmitter station. However, this process is commonly expensive and inconvenient to collect in narrow roads and crowded areas. Unlike hazardous waste, there are no specific licensing requirements for collecting municipal solid waste. Many outdated waste collection trucks need replacement or supplementation with

newer compactor trucks. The report also outlines various scenarios for improving waste management in Hanoi, including the forecasted waste quantities for the period from 2018 to 2030 in Vietnam, infrastructure requirements for waste handling under different scenarios and impacts on investment costs and operations, and the associated effects on fee increases and remaining financial deficits, which can, directly and indirectly, influence individual spending, business investment, and budget deficits.

In the need to understand solid waste status for forecasting, this study will carry out an analysis of solid waste in Dong Anh district, Hanoi, Vietnam. Firstly, a brief description of study areas and interpretation of waste separation will be presented in the Methodology section. Next, this study will carry out an analysis of waste components and a forecast for 2025 of waste in the study areas. Finally, discussions and conclusions will be due.

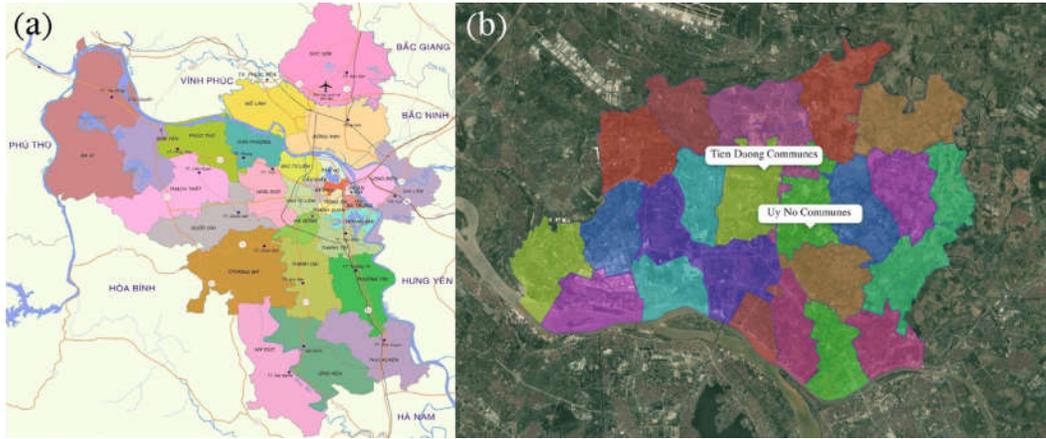
## **2. Methodology**

### **2.1. Study areas**

Dong Anh, North of Hanoi, is a suburban district that covers an area of 4.45 km<sup>2</sup> and is home to around 32,766 people. Dong Anh is also an economic and political center and has a concentrated population with relatively high living standards. Additionally, the neighboring communes, Tien Duong in the East and Uy No commune in the West (Figure 2b) are the focused areas in this study. Tien Duong and Uy No communes are covered by areas of 10.09 km<sup>2</sup> and 7.72 km<sup>2</sup>, respectively, with corresponding populations of around 19,118 and 18,501

citizens. Accordingly, Tien Duong is the second largest area in the district; however, it has a low population density. The majority of the population follows agriculture, providing mainly fresh vegetables to the other neighboring regions. There is also the Medical Center of Dong Anh district with the commune medical station, and together with 3 levels of kindergartens, primary schools,

and secondary schools. As located close to Dong Anh district, Uy No is also quite bustling with business activities, including trade, transportation, and markets, and one known as the famous To market. Interestingly, as known as a home of a high population and economic center, Dong Anh and the two studied areas are presented as a good example to assess residential solid waste.



**Figure 1: (a) The overview of Dong Anh district and (b) Tien Duong and Uy No communes and Dong Anh district center**

**2.2. Waste separation**

To estimate the rate and volume of residential solid wastes in the study area, this study conducts a determined calculation for the Generated Residential Solid Waste Rate (GRSWR) based on the weight of solid waste per household, which is yielded:

$$GRSWR = \frac{W_{RSW}}{N_P} \quad (1)$$

where, GRSWR (kg/person/day) is the resident solid waste rate of a person created in a day,  $W_{RSW}$  (kg) is the total weight of solid waste per household, and NP is the number of people in a household.

Next, the residential solid waste type is manually separated into several

types, including decomposed solid wastes (organic type), recycled and reused solid wastes (paper and plastic products), and other types (ceramics, glass, and other components), calculated as their percentage rate, following equation:

$$RSW_{type} = \frac{W_{N\_RSW}}{SW_{RSW}} \quad (2)$$

where,  $RSW_{type}$  (%) is the percentage of a type of waste,  $W_{N\_RSW}$  and  $SW_{RSW}$  (kg) are the weight of the sample wastes and the standard weight (10 kg), respectively.

In this study, the GRSWR and  $RSW_{type}$  can only be done manually with 10 random households in the study area. For each household, the total weight is measured within a full day (24 hours) with an advanced

notification. Data collection is repeated three times per week and lasts for one week. The  $GRSWR$  will be calculated following the Eq.(1). Simultaneously, the component rate ( $RSW_{type}$ ) is determined based on standard weight (10 kg) and separated into different types, such as organic, recycled, reused and other components. Afterward, it will be estimated by Eq.(2).

Additionally, this study introduces forecasting of the total volume of residential solid waste generated until 2025 based on the famous advanced Euler model using the population forecasting input in Dong Anh district. The prediction values in this study will be determined by the increased population rate from the Euler model (Eq. 3) multiplied by the  $GRWR$  (Eq. 1) and the total population in the study area, which can be yielded as follows:

$$N_{i+1}^* = N_i + rN_i\Delta t \quad (3)$$

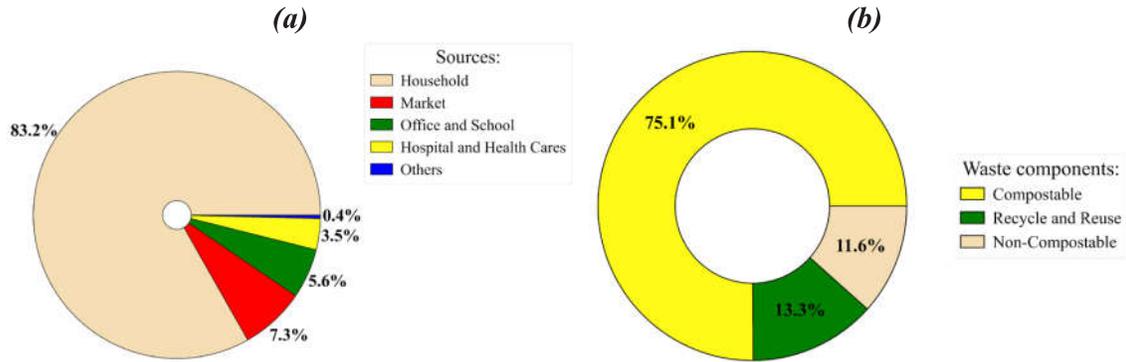
$$Total_{RSW}^{i+1} = GRSWR \times N_{i+1}^* \quad (4)$$

where,  $N_{i+1}^*$  and  $N_i$  are the total population in year  $i$  and  $i + 1$  (after a year),  $r$  is the natural population increasing rate, and  $\Delta t$  is the time resolution. In Eq.(4),  $Total_{RSW}^{i+1}$  is the total generated residential solid waste in a full day (24 hours) in the year  $i + 1$  in the study area, considering the prediction of residential solid waste per day.

### 3. Results

#### 3.1. Residential solid waste components

In this study, the sources of RSW are relatively determined from different sources (Figure 2), which are from residential areas, markets, hospitals, health care, schools, and government offices. As can be seen in Figure 2a, the majority of waste is from the household at about 83 %, while markets, offices, and schools are only under 8 %.



**Figure 2: (a) Sources of Residential solid waste and (b) Residential solid waste components**

Furthermore, a report by Dong Anh Urban Environment Joint Stock Company in 2020 [10] accordingly stated that the rate of waste found to be the highest from the household at 83.2 %, corresponding to about 210.56 tons/day. In the market, waste is mainly composed of biodegradable organic waste with many

different items such as food, vegetables, fruits, and damaged fruits rounding at 18.47 tons/day, whereas a large number of plastic products (packaging and nylon bags) was dominated at 7.3 %. Moreover, waste from offices and schools is relatively simple in composition found at 5.6 %, roundly equal to 14.17 tons/day.

In Dong Anh district, four large hospitals, 23 health cares, and more than 200 private clinics are currently active, leading to enormous waste at 8.86 tons/day (3.5 %, see Figure 2a). Specifically, various components, including newspapers, documents, and plastic gloves from patient and doctor activities) and hazardous waste (used syringes, bandages, or scalpels are the original. Only 0.4 % of sources (Figure 2a) are wastes generated by pedestrians or randomly dumped. However, this source contributes quite less as an important role which can be neglected in calculation.

In Figure 2b, the average composition waste per household in a standard weight consists of the largest proportion, 74.35 %, while the non-compostable and recycle and reuse are quite similar at 13.3 % and 11.97 %, respectively. The recycle and reuse components tend to increase over time because of the awareness improvement mindset in waste sorting. However, the improvement progress is quite slow due to the lack of understanding about reasonable waste sorting by regulations.

**Table 1. Residential solid waste weight by households**

No.	Location	GRSWR (kg/person/day)	WRSWR (tons/day)	Total WRSWR (tons/year)
1	Dong Anh district	0.62	20.315	7,414.97
2	Tien Duong	0.58	11.088	4,047.12
3	Uy No	0.56	10.36	3,781.4

Table 1 shows the Generated Residential Solid Waste Rate (GRSWR, see Eq. 1), the weight of Residential Solid Waste per day (WRSWR), and the total Weight of Solid Waste per year (Total WRSWR), which is calculated through residential waste collection and survey collecting activities. It can be seen that Dong Anh district, with a larger population and larger area, produces more waste than both Tien Duong and Uy No communes, even though the GRSWR is quite similar. Moreover, the composition of generated residential solid waste generated in three types of waste in all study areas. It is recognized that the weight of types 2 and 3 has similar numbers. The number in two communes (Tien Duong and Uy

No) is relatively lower than it is in Dong Anh district. However, it is interesting that the non-compostable waste of Tien Duong is nearly double that of Uy No communes. This can be explained by the consumption habits of residents in Uy No are quite different from the Tien Duong community.

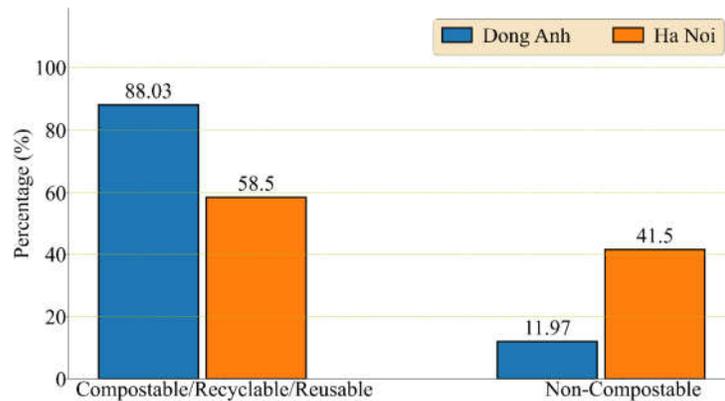
Additional information from Table 1 shows that the average residential waste generation rate was 0.59 kg/day (Table 1). At the end of 2020, the population of Dong Anh district was calculated at 399,162 by the Euler method. Therefore, the amount of residential waste generated in Dong Anh district is 85,959 tons/year.

**Table 2. Composition of generated residential solid waste**

Type	RWS type		Weight (kg)		
			Dong Anh district	Tien Duong	Uy No
1	Compostable waste		62.3	55.9	30.1
2	Recyclable/ reusable waste	Paper	6.1	2.16	1.7
		Plastic	4.4	3.47	2.3
		Plastic bag	3.1	2.2	1.8
3	Non - compostable waste	Ceramic	4.8	3.02	1.9
		Other	6.3	5.22	2.7
<b>Total</b>			<b>87.1</b>	<b>72</b>	<b>40.4</b>

The composition and the weight of solid waste depends on some factors, such as food habits, cultural traditions, and socio-economic status (time at home, living needs, and jobs). The waste generation was found to increase gradually with the increase of income per month. The daily waste volume of households depends on their occupation.

The officers or agricultural employees have less weight on solid waste than commercial employees and service households. In Tien Duong and Uy No communes, agricultural, livestock, and poultry activities are popular, so a part of the household waste was mainly kitchen waste (excess food or damaged) that is reused.



**Figure 3: Percentage of RSW composition in the research area and Hanoi city**

In Figure 3, the average generation index of RSW in the study area (0.59) is low compared to the general generation index of Hanoi city (0.81) [2]. The reason is that this is a suburban area with low population density, and agricultural activities are still relatively popular in people’s daily lives. Compostable, recyclable, and reusable waste in the study area accounted for 88.03 %, higher than the average level of these wastes in Hanoi city (58.5 %). Non-compostable

waste is only 1/3 of the average level of the whole city of Hanoi.

### **3.2. Forecast of residential solid waste volume generated by 2025**

The calculation of the population forecast for Residential solid wastes of Dong Anh district until 2025 is presented in Table 3, showing that the number of RSWs tends to increase. As can be seen, the total GRSW increases along with the increase of population by more than 12,000 units per year with 20,000 citizens.

**Table 3. Forecast of RSW generated in Dong Anh district to 2025**

Year	Population	Coefficient of GRSW (kg/people/day.night)	Amount of GRSW (tons/day.night)	Total of GRSW (tons/year)
2020	399,162	0.59	235.51	85,959
2021	403,552	0.60	242.13	88,378
2022	407,991	0.61	248.88	90,839
2023	412,479	0.62	255.74	93,344
2024	417,017	0.63	262.72	95,893
2025	421,604	0.64	269.83	98,486

While the amount of daily-life solid waste increased gradually over the years from 85,959 tons/year to 98,486 tons/year in the period of 2020 - 2025, that is an increase of 12,527 tons/year. At the same time, in 5 years, the population of Dong

Anh district increased by 22,442 people. With the increasing consumption demand of households, the amount of waste generated will also increase, requiring more specific management and treatment solutions.

**Table 4. Forecast of GRSW until 2025**

Year	Population			Coefficient of GRSW (kg/people/day.night)			Amount of GRSW (tons/day.night)			Total of GRSW (tons/year)		
	Dong Anh	Tien Duong	Uy No	Dong Anh	Tien Duong	Uy No	Dong Anh	Tien Duong	Uy No	Dong Anh	Tien Duong	Uy No
2020	32,766	19,118	18,501	0.62	0.58	0.56	20.31	11.09	10.36	7414.9	4047.2	3781.6
2021	33,126	19,328	18,704	0.63	0.59	0.57	20.87	11.41	10.66	7617.4	4162.3	3891.4
2022	33,490	19,540	18,910	0.64	0.60	0.58	21.43	11.72	10.97	7823.4	4279.4	4003.3
2023	33,859	19,755	19,118	0.65	0.61	0.59	22.01	12.05	11.28	8033.1	4398.6	4117.1
2024	34,231	19,973	19,328	0.66	0.62	0.60	22.59	12.38	11.59	8246.4	4519.9	4232.9
2025	34,608	20,192	19,541	0.67	0.63	0.61	23.18	12.72	11.92	8463.4	4643.3	4350.8

Last but not least, Table 4 presents the forecast of GRSW until 2025 for all three study areas, Dong Anh, Tien Duong, and Uy No. The total GRSW has appeared to be enormous, corresponding to the large population, even though the increase rate is similar to each neighboring region. Interestingly, the increase in population of all study areas is relatively low while a quick rise of GRSW is recognised to be greater every year. For example, there is about a 1,000 residents gap in 5 years in either Tien Duong or Uy No, but the total of GRSW increased by over 1,000 units. This is due to either the life standards being considered to level up or the development of industry and economic needs, therefore becoming greater.

## 4. Discussion

### 4.1. Residential waste management

The results above show how great GRSW could be in a short period and it will increase even faster in the next decade due to urban development. However, those numbers only present the total generated wastes since the separated calculation of each component (see Figure 2b) is nearly impossible.

In Dong Anh, all municipal solid waste collection and transportation areas are taken care of by Dong Anh Urban Environment Corporation. Three main collection and transportation routes are currently active, including [Route 1]

Along National Highway No. 3 through Dong Anh district, Uy No commune, [Route 2] Along National Highway 23, Tien Duong, Uy No communes, Dong Anh district, and [Route 3] Along Uy No, Dan Di road toward Dong Anh district. Moreover, the distribution of trolleys and human resources for those routes is relatively limited, which is corresponding to 60 wheelbarrows and 20 employees, once a day for Route 1, 50 wheelbarrows and 18 employees, twice a day for Route 2, and finally 35 wheelbarrows and 12 employees, 2 - 3 times a day for Route 3.

In villages and surrounding areas, the collected garbage is taken to collection points on the highway for easy collection by compactors. The waste collection process involves gathering mixed waste without sorting it at the source. The garbage from markets and other locations is manually collected using handcarts and transported to designated collection points. In addition to street, office, and residential waste, we also collect from municipal garbage bins. Collection frequency and timing are customized to meet people's needs. Route 1, located in the urban center with high waste volume, is collected once daily. Routes 2 and 3 are serviced two to three times daily. Despite limited human resources, the overall trash collection rate reaches 86.5 % of the total waste generated in the area. Collection fees are 3,000 VND per person per month for households and 30,000 - 50,000 VND per household per month for restaurants and eateries.

At present, the waste of Dong Anh district is transported to Nam Son Waste Treatment Complex for disposal. However,

in the last 2000s, the Nam Son landfill had closed due to overflow. This has caused many problems, such as illegal dumping, lack of transportation, lack of sanitation facilities, and loss of urban aesthetics. Consequently, the People's Committee of Dong Anh district is directing the acceleration of the completion of a Waste Treatment and Recycling Plant in Duy Tu, Dong Anh, with an area of 71,739 m<sup>2</sup> and an investment of nearly VND 20 trillion (20 trillion Vietnam dong). However, the project still faces many problems due to the request for additional licenses to process hazardous industrial and medical waste.

With the understanding of the limitation of human resources in collecting wastes, a collection, classification, and treatment program at source has been initiated in Dong Anh in 2021 [11], which is now expanded with many positive results. The program included sorting activities at the source household for solid waste and regularly collected by self-managed volunteer teams. The teams are then transported to central points for processing following standard procedures.

According to a Ministry of Natural Resources and Environment report in 2022 [11], a total of 23 communes and a town in Dong Anh District participated in the program nationwide until the end of March 2022, and it continued to implement others with three communes, Lien Ha, Duc Tu, and Viet Hung, and villages. Moreover, more than 20 communes have implemented this program in at least one hamlet or multi-housing block. With more activities and practices, the program still tends to set a new mindset on residents, managers, and agencies.

However, it recognized that the difficulty for social impacts on what has been set deeply into resident's minds. Whereas those programs need to be kept for the longer term, improvements also need to consider, for example, the impact of social networks (Facebook, YouTube, or Google) [12]. Later programs should focus on more communication methods to make a successful way for a better living environment.

#### ***4.2. Improvement of current residential solid waste management***

##### *a) Advantages of the current management system*

The effective enforcement of environmental protection laws and regulations has led to positive changes in environmental activities. Local governments now prioritize environmental protection, utilizing communication tools. Each commune has an environment manager, ensuring rigorous and effective handling of environmental issues. Awareness of environmental protection has increased across all levels and sectors, resulting in environmental campaigns. Government environmental management has also improved. At the local level, teams handle residential solid waste collection and disposal. People are now conscious of waste classification and proper disposal. Additionally, many organizations, such as the People's Committee, Women's Union, and Youth Union, collaborate effectively in environmental protection efforts. Besides, there are still large natural areas in Dong Anh suitable for landfill construction.

##### *b) Limitations of the current management system*

Several segments of the community still lack awareness, leading to the persistence of uncontrolled landfills. Long-term investment in waste management projects and local programs remains insufficient. Coordination among environmental protection departments is poor. The existing system of environmental management agencies does not adequately address the needs of environmental protection activities and lacks clear division. Additionally, many activities remain informal.

##### *c) Solutions to improve the management of residential solid waste*

In Dong Anh district, strengthening enforcement of penalties for administrative violations in the field of environment according to Decree 45/2022/ND-CP of the Government on sanctioning of administrative violations in the field of environmental protection.

Increasing allowances for environmental sanitation workers to create the best conditions for them to do the collection and transportation of waste. It is recognized that the current income for waste collecting workers is seriously under-rated by their contribution. It is necessary to have solutions to propagate and raise public awareness continuously and extensively. Mobilize all the organizations of Youth Unions, Women's Union, Farmers' Union, Veteran's Association, and Elderly Association to actively participate in the declaration, collection, and management of domestic waste more effectively.

Moreover, integrating environmental protection criteria into the assessment

of cultural families. Re-implement the “Program on collection, classification, and treatment of waste at source” built-in 2021 with the people of the whole district. Also, strengthening training and fostering knowledge of domestic solid waste management for district-level grassroots staff in general and full-time agents in particular. Improving the knowledge and training of environmental sanitation workers, improving the quantity and quality of the waste collection team.

Last but not least, the implementation of waste classification at the source is being promoted. By no later than December 31, 2024, all households are required to carry out waste classification according to regulations according to the Law on Environmental Protection (2020) [13], with the result that compostable waste requiring collection accounts for 74.35 % of the waste generated in the research areas, The number of vehicles and personnel for waste collection can be reduced in the future to align with the actual needs and bring economic efficiency to the local area.

## 5. Conclusion

Based on the investigation and survey of domestic waste in Dong Anh district, Tien Duong, and Uy No communes, it has been found that 235,505 tons of residential solid waste per day in the whole Dong Anh district, with an average coefficient of 0.59 kg of waste per person each day. It was discovered that the majority of localities did not have enough collection capacity, sufficient handcarts, specialized trucks, or enough collection points. This makes the collection of waste difficult.

The residential waste composition of the Dong Anh district is extremely diverse, with organic matter accounting for nearly 75 %, higher than the average of Hanoi. The important thing is to rigorously and thoroughly implement waste classification at the source according to the regulations of the Law on Environmental Protection (2020) to reduce the amount of waste generated that needs to be collected.

Despite the presence of protective equipment, there is still a need for more gear, and interest in the work remains low. Additionally, the frequency of waste collection is not consistent, as it should be performed once every day. Furthermore, there has been positive progress in terms of raising awareness and interest in environmental protection waste management. However, the environment is still not adequately protected, and the waste has not been properly sorted at the source. It is therefore important to take further steps to promote environmental protection and efficient waste management in the Dong Anh district.

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