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Composting Activities in Vietnam – The Situation, Problems, and Challenges

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In Vietnam, biodegradable waste is a primary component of urban municipal solid waste, accounting for 54 - 65 % of the total waste. Aerobic composting is one of the most effective methods for reducing this waste as well as decarbonization, but with poor management, it is the greatest source of greenhouse gas emissions. According to the Ministry of Environment and Natural Resource, there are 37 composting facilities in Vietnam, treating 16 % of the total municipal solid waste. However, the number of well-maintained facilities is decreasing over time, due to difficulties and challenges in operating and maintaining highly efficient composting. This study aimed at evaluating the current situation of composting facilities in Vietnam, evaluating the efficiency and problems in the composting facility in Hoi An City (HAC). Social and technical surveys were conducted to identify the social consensus on waste separation and to measure the performance of the Cam Ha composting facility. The results indicated that 91.95 % of HAC's households were aware of the separation of waste since the waste segregation policy was implemented in 2012. In the composting facilities, raw materials for composting contained 40.44 % inorganic matter, showing the low efficiency in waste separation at source. 1.27 % glass and plastic debris in the composting product lowering the compost quality, raising the concern on human health and safety. This study gives an overview of Vietnam's composting situation and contributes to local decision-making related to the municipal solid waste management system toward sustainability and lowering global warming.
Keywords: biodegradable waste, composting, global warming, sustainable development, solid waste management.

1. Introduction

Biodegradable solid waste, including food waste and leftovers, is the primary component of municipal solid waste, accounting for 50-70 % of the total waste. The proportion of food-original waste in high-income countries is lower, but the amount per capita is much higher, due to the increase in living standards and human demand. In Vietnam, urban areas were the main source of MSW, contributing 70 % of the total 27.8 Mt of waste generated annually (Schneider et al., 2017). In which, biodegradable waste is the dominant type of municipal solid waste, accounting for 54 % of the total waste. Due to the fast and convenient lifestyle shifting, the proportion of biodegradable components in the total waste is decreasing, from 80-90 % in 1995 to 50-70 % in 2017 (MONRE, 2020). The amount of organic waste is on the trend of increasing due to the increase in total waste, especially in cities that promote tourism and service industries. In Danang City, the amount of food waste per capita increased from 0.39-0.41 kg/cap/d in 2016 to 0.52 kg/cap/d in 2018 (Pham et al., 2021). In the tourist destination of Hoi An City, the food waste generation rate increased from 0.116 kg/cap/d (Giang et al., 2017) to 0.127 kg/cap/d. Biodegradable waste is often contained in plastic packaging, Styrofoam boxes, etc., leading to difficulties in waste segregation at source as well as recycling.

In developing countries, the most common treatment for biodegradable waste are landfilling and illegal dumping, composting, anaerobic digestion, and animal feeding. According to China's annual statistics, urban areas generated up to 60 Mt of food waste and 13 Mt of waste including vegetables and fruits, and over 80 % are not

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treated properly (Wang et al., 2018). In Vietnam, with only 20 % of the landfill is salinity, this method is causing severe environmental issues for the surrounding area.
Aerobic composting proved to be effective, and suitable for countries with high population density, limited land funds, and relatively low investment capital. It also has positive impacts on pollution control and reducing the emission of greenhouse gas. Several composting scales had been applied for organic waste treatment in the World and Vietnam (Song Toan et al., 2021). In 2022, the Vietnamese government delivered the “National Strategy for Environment Protection to 2025, vision to 2050”, which enhances municipal solid waste management, reduce the amount of waste-to-landfill, and increase the recycling of food waste. To achieve these targets, the application of composting is indispensable. To maintains high efficiency in waste treatment as well as reduce pollution, composting facilities need to be strictly managed.
Several studies had been conducted to determine the waste-treating performance of composting facilities in the World, including the environmental impact (Douglas et al., 2017), microorganisms (Grisoli et al., 2009), and composting characteristics (Panaretou et al., 2019) that giving a brief review on the waste-treating performance. In Vietnam, besides studies related to GHG emissions from waste-treating plants (Verma and Borongan, 2022), research on composting facilities is limited even though the Government had promoted composting since 2010s. Therefore, decision-makers could not provide suitable strategies for the development of composting facilities, leading to the decrease in composting effectiveness. This study aims at determining the current composting activities in Viet Nam on the situation, problems, and challenges, evaluating the waste treatment in the Cam Ha composting facility in Hoi An City, Vietnam.

2. Methodology

2.1 Study site

Hoi An is a small coastal city located in Central Vietnam and was recognized as a World Heritage Site by UNESCO. According to the province statistical yearbook, Hoi An City (HAC) has a natural area of 6.355 ha with a population of 100.53 thousand people, of which 75 % are living in the urban area. Even though being a small city, Hoi An is the center of culture, tourism, and service industries. In 2018, HAC welcomed 2,517,217 visitors, the number of arrivals decreased during the pandemic but still more than 1.5 M tourists visited HAC in 2022. With the rapid development of tourism and service, especially in accommodation, food, and shopping business, the amount of waste also increased significantly. This put high pressure on the municipal solid waste management system for the city.
With the increase in population and tourism services, the amount of waste generated from restaurants and stores in the center of HAC is very high. The total waste generated in the tourism destination is 15.08 t/km^2, with 49 % being food waste, it is 5, 16, and 56 times higher compared to suburban and rural areas. This waste will be collected and transported to the Cam Ha composting facility for composting treatment. Despite applying advanced technology, the facilities had shown weaknesses in management, GHG emission, and environmental problems for the surrounding area.

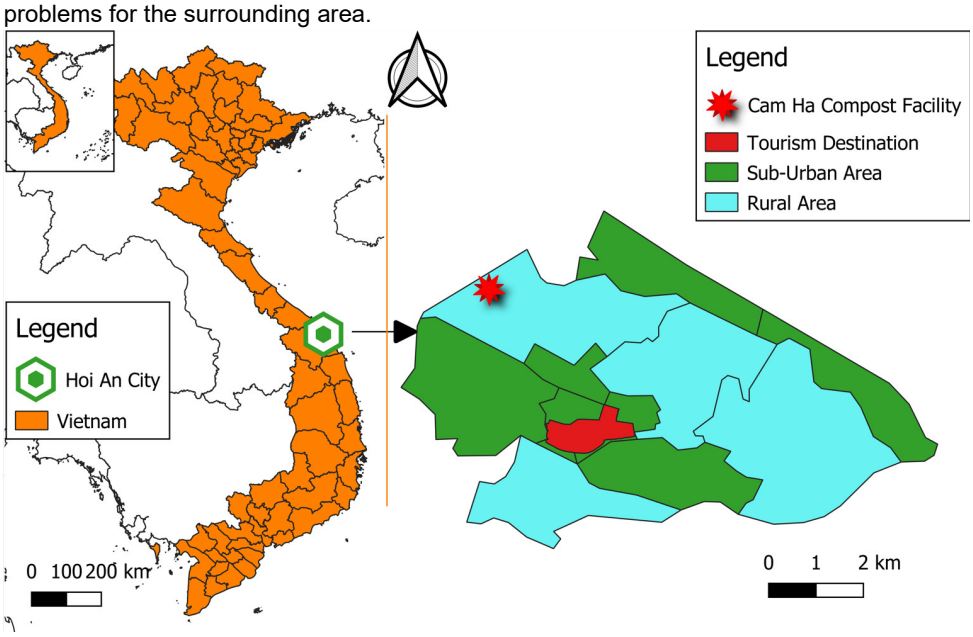

Figure1: Hoi An city

2.2 Social survey

Stratified Random Sampling was conducted in the study site of Hoi An City. Eq(1) had been applied for determining the number of samples needed for the survey. Where, n is the number of samples, N is the population of Hoian City, and e is tolerance.

$$n = \frac{N}{1 + N \times e^2} \quad (1)$$

Three states were identified due to the characteristics of Hoi An City, namely tourism destination, sub-urban area, and rural area (Giang et al., 2017). To be specific, the survey collected a total of 560 samples, with 200 in the tourist destination, 200 in the sub-urban area, and 160 in the rural area. From 13th to 16th February, a questionnaire survey within two weeks had been carried out to evaluate the social consensus and participation of locals in waste management.

2.3 Technical assessment

The composting process of the Cam Ha facility is following the two-stage composting method. Figure 2 showed the operation procedure of the factory. Collected organic waste (Q1) will be gathered at storage site, non-biodegradable matters are discarded manually, the raw material (Q2) after separation will go into the composting process. The composting procedure is divided into two step, Stage 1 (7 - 9 weeks) with force aeration and water supply to increase bacteria activation, Stage 2 (10 – 12 weeks) is the maturity period of the compost. The composting will be sifted at the product collection for impurities removal.

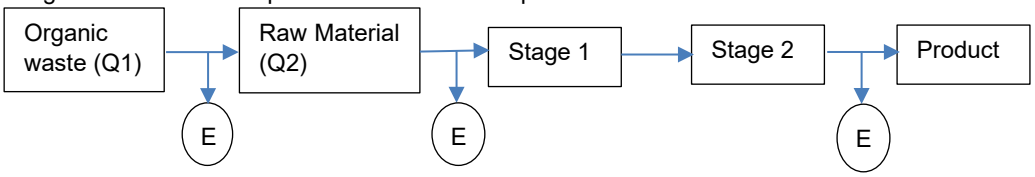

Figure 2: The waste treatment procedure of Cam Ha composting facilities.

From 24th to 26th March, technical survey to evaluate the performance of waste treatment was conducted. Three samples of each phase of the composting process of the Cam Ha composting facility and of the Hoi An incineration plant collection site had been taken for determining the waste component. In each sample point, 50 kg of waste was collected, mixed, separated, and weighed. Nine types of waste had been sorted, including organic, branches, plastic, metal, paper, combustible, incombustible, hazardous, and glass.

3. Results and discussion

3.1 Current Situation of Vietnam's composting facilities

According to the Ministry of Environment and Nature Recourse, there are 37 composting facilities in 2019, treating 16 % of the total waste, this number increased to 41 in 2021 (MONRE, 2020). Even though the number of composting facilities is increasing, the efficiency of waste treatment by this method is still low. Out of 41 facilities, 28 are operating with a lower capacity than designed, 10 are being constructed (Khoi and Quang, 2019), and 3 are shutting down. Overall, the actual number of operating facilities is 28. Most of the facilities are located in the South and North of Vietnam, as the two are the main region of the agriculture and service industry, generating a mass amount of waste, including a high percentage of biodegradable waste. In the Central and Highlands of Vietnam, with a lower amount of waste, less available construction area, as well a low budget from the local government, investigation for composting is still limited. In HAC, a composting facility had been built since 2012 with a capacity of 55 t/d. In Hue City, Thuy Phuong waste treatment company had applied composting methods to treat organic waste since 2007. After years of ineffective operation, leading to environmental issues in the surrounding area, the Hue facility had been closed since 2017. Apart from facilities having good composting quality, the rest are facing ineffectiveness in maintenance due to problems related to input material, management, and low composting product quality.

Vietnam currently applying the bed composting with force aeration technique with two phases including (1) raw composting with moisture and air supply, and (2) fine composting with a mixing rate of once every week. The total processing time of this technology is 3 to 6 months, with 10 – 12 weeks for each phase (MONRE, 2020). The advantage of this technique is that it provides air to aerobic decomposition, with the application of an air supply system at the bottom of each bed, together with a leachate collection system to prevent odor. The disadvantage of this technique is that it needs proper management and well-maintaining to keep high efficiency. The air supply and leachate collection need to be cleaned regularly to prevent clogging by waste, leading to bad

odor and increasing anaerobic digestion. Waste classification is being done by the worker of the Cam Ha composting facility with a manual method. Thus, the input materials for composting process contain a large amount of non-biodegradable materials such as nylon bags, plastic, and especially glass fragments.
To enhance the composting system, Vietnam had to bypass the challenges that are limiting the effectiveness of composting facilities, which are:

- The “great” diversity of urban waste characteristic, with high moisture, and low heat capacity. A study on municipal waste from 110 households in Hanoi City determined 13 categories and 25 sub-categories of waste, with 79 % being food and garden waste (Phuong et al., 2021). Even though the components of urban waste are suitable for composting technology application, it is a great barrier to waste segregation, collection, recycling, and reuse.
- Inappropriate waste segregation and collecting model. The segregation of waste is depending on the waste treatment system. In Hoi An, waste is separated into organic and inorganic to meet the requirement of biodegradable waste treatment. The lack of guidance in waste classification also led to the confusion of residents in distinguishing the type of waste. Leather, wood, and paper are normally mistaken as biodegradable waste. While in Da Nang City, waste is classified into 4 categories according to the decision 1577/2022, and there is no organic waste in the category. Inefficient waste collection, especially in suburban and rural areas also causes issues with waste management.
- The limited composting markets. The consumption of composting products is highly dependent on the quality of the compost. For farmers, the mixing of compost and glass, and ceramic debris is unacceptable. In the process of composting, nutrients are not added to the product, making the compost not meet the standard on nutritional compared to the Vietnamese standard on organic fertilizer TCVN7158:2002, reducing the competence with other products.

3.2 Cam Ha composting facility

3.2.1 Difficulties and Challenges

Since its operation, Cam Ha composting facility has treated the city’s biodegradable waste, producing composting fertilizer for local farmers. The facility has a capacity of 55 t/d, suitable for the amount of organic waste in Hoi An City, 57 % of the total 100 tons of waste generated per day (Giang et al., 2017). Only receiving waste on the day of organic waste collection (Monday, Wednesday, and Friday) indicated that the facility is operating at 50 % designed capacity. Even though composting is an effective waste to reduce global warming with the least amount of GHG emission per ton of waste (Song Toan et al., 2022), Cam Ha composting facility shows the opposite as it is the greatest source with an estimated 5,016 t-$CO_{2\text{-eq}}$ emitted in 2015. The waste treating efficient and the quality of the composting product are showing problems and challenges in maintaining the high efficiency of the facility.
The low quality of raw materials is one of the biggest challenges. Since 2012, the policy on waste separation at source has been delivered by the HAC government, but the efficiency is still low. On organic collection days, the amount of biodegradable waste accounted for 55 - 65 % of the total waste, the rest is inorganic waste. Mixed waste is usually contained in plastic bags, tightly tied to reduce emitting and odor. This put high pressure on the waste management as waste segregation for the raw material is required before entering the composting process.
The result of the social survey on residents’ participation in waste segregation at source indicated that people have a high knowledge of waste segregation, but the efficiency is still low. Accordingly, 91.95 % of HAC households know or have an awareness regarding the waste separation at source, with two (organic, inorganic) or more categories (recyclable, hazardous). In rural areas, organic waste is used as cattle and animal feed, waste collection is mainly carried out by the local people according to the cooperative model. The collection rate is two to three times per week depending on the area, together with the non-separation waste collection. Therefore, in rural areas, people dump organic and inorganic waste together instead of separating them.
In the urban area of HAC, waste separation at source, especially in business households, is very limited due to the concerns about waste storage and bad odor that may impact the surrounding area. Many households tend to dump waste on the day of inorganic waste collection (Tuesday, Thursday, Saturday), this leads to the workload of the collection team is much higher than the rest of the week (Cuong et al., 2021)

3.2.2 Waste treating performance

Figure 3 illustrated the waste component at two waste collection sites of HAC, the incineration plant – inorganic waste treatment, and the Cam Ha composting facility – organic waste treatment. There is a remarkable similarity in waste characteristics at both waste storage places. In general, biodegradable components accounted for the highest proportion with 53 – 60 % of the total waste. The following are combustible and plastic with very small differences, accounting for 13 – 14 % of organic waste and 17 – 20 % of inorganic waste. Branches can only find in the composting facility storage and glass can only be found at the incineration collection site. The waste

component at the Hoi An waste incineration plant and Cam Ha composting facility demonstrated that the inefficient waste segregation in source in HAC, resulting in low-quality inputs for the composting process.

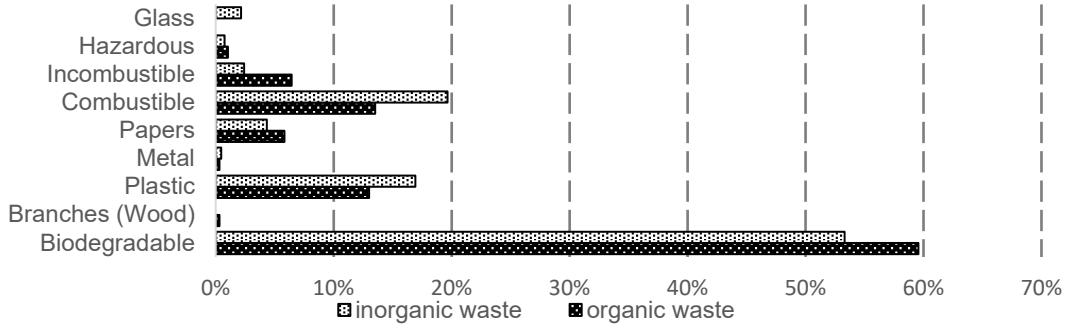

Figure 3: The waste component at Hoi An waste treatment facility.

Table 1 shows the results of the waste characteristic analysis through each phase of the composting process, from the waste collection to the separation of raw material, composting stages 1 and 2, and composting products before being used as soil improvement products. Before entering the composting process, biodegradable waste accounted for only 59.56 % of the total waste collected, and other are non-biodegradable waste, due to the low efficiency of waste segregation at source. These ingredients can lower the composting quality, causing contamination of heavy metals, and reducing the self-heating of the composting process (Rodrigues et al., 2018). Plastic, combustible, and paper accounted for a large amount of the material during the process of composting. Plastic accounted for 13 % of the input and 8.31 % at the end of the composting process. The main components are low-value plastic with nylon, single-use plastic cups, bowls, food wrap, etc. used as food waste and leftover containers. High-value plastic is rarely seen in the composting process. With 0.17 % of the composting product, this is one of the microplastic littering sources to the environment. Paper and combustible waste (leather, fabric) are mistaken as organic waste during the waste separation at source, with 3.83 % and 13.51 % in the organic waste collection site. In which, napkins from restaurants, and fabric from local clothes stores took up the highest amount. During the composting process, paper is decreased gradually due to the degradation, mixing, and transporting that tear them apart. Combustible waste also decreases throughout the composting process but still took up a high amount at the end with 5.09 %.

Table 1: Waste components through each phase of the Cam Ha composting facility (Unit: %)

Types of waste	Samples				
	Q1	Q2	Stage 1	Stage 2	Product
Organic	59.56	71.47	52.73	81.97	98.73
Branches	0.31	-	-	0.38	-
Plastic	13.00	7.94	17.96	8.31	0.17
Metal	0.31	0.27	0.44	0.29	0.07
Paper	5.82	3.59	3.20	-	-
Combustible	13.51	9.69	19.23	5.09	-
Incombustible	6.43	1.66	4.47	3.51	0.22
Hazardous	1.04	0.72	0.44	0.16	-
Glass	-	4.67	1.53	0.29	0.81

Incombustible waste are shells, ceramics, etc. accounting for 6.43 % of the input organic waste and 0.22 % of the composting product. On the other hand, glass accounted for a small amount during the composting process, but is the primary unwanted ingredient with 0.81 % in the composting product. These components are hard to be separated from the product due to they exist in the form of tiny debris after going through the process of transportation, classification by rotating drum, mixing, and environmental impacts. The mix of composting products and glass, and ceramic is the main reason local farmers refuse to use the composting from Cam Ha composting facility as fertilizer due to concerns on health and safety. Hazardous waste (battery, e-waste, and medical waste) accounted for a small amount of 1.04 % in the raw material and 0.16 % at the end process but can cause negative impacts on the composting quality due to the littering of chemicals.

4. Conclusions

The research determined the current situation and challenges of Vietnamese composting, as well as evaluated facilities that are being constructed, is increasing but the number of underperforming facilities also raising, 28 out of 41 composting facilities in Vietnam are operating with a capacity lower than designed. Three main challenges in the composting situation of Vietnam are (1) high diversity in the waste components, (2) inappropriate waste separation and collection model, and (3) low composting markets.

91.95 % of the residents in HAC indicated that they have knowledge or awareness of waste segregation since it had been promoted in 2012. The technical assessment at the organic waste collection site and inorganic waste collection site shows the opposite result, with a remarkable similarity in the waste characteristic in both places, indicating low waste segregation at source. This led to low effectiveness during the following composting procedure. The presence of 1.27 % glass, ceramic, and plastic in the composting product raises the concern about human health and safety, causing local farmers to refuse the product.

This study provides decision makers with the current status and difficulties that composting facilities are facing, contributing to the decision-making process that minimizes the risks and maximizes the opportunity of composting in the future. The study shows the potential for future research on optimizing waste management system and enhancing composting for urban areas of Vietnam's city, in the context of maximizing the waste recycling process.

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