CHEMICAL ENGINEERING TRANSACTIONS
VOL. 89, 2021
A publication of AIDIC
The Italian Association of Chemical Engineering
Online at www.cetjournal.it
Guest Editors: Jeng Shiun Lim, Nor Alafiza Yunus, Jiří Jaromír Klemeš

ISBN 978-88-95608-87-7; **ISSN** 2283-9216
DOI: 10.3303/CET2189084

Waste Segregation at Source and Separately Collection – The Inadequacy in Implementation in Vietnam

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Hoi An city is a dynamic tourism city in Vietnam which had received the certificate of World Heritage Site by UNESCO. The boom in tourism activities led to problems for the solid waste management system. Solid waste collection activities account for the largest proportion of expenses on solid waste management. Optimization of the present solid waste collection system of Hoi An city is an urgent mission. This research is an effort to describe the current solid waste collection system of Hoi An city with the support of GIS and GPS. The results denoted Thursday, Friday, and Saturday accounted for the most enormous workload with 36, 34, and 40 trips. The total working time for these days were 103.86, 96.12, and 109.6 h while the total traveled distances were 733.76, 719.21, and 848.12 km. The complexity of solid waste collection routes, frequencies of solid waste collection, and coverage of solid waste collection activities decreased from urban areas to rural areas. Collection of waste accounted for the largest amount of time in solid waste collection activities. The low rate of waste separation at source, illegal solid waste collection, extreme weather, misbehaviours of drivers and workers, as well as the limitation in waste treatment facilities were the problems and challenges of the solid waste collection system in Hoi An city.

1. Introduction

Hoi An city (HAC) is a tourism destination of many tourists in the world as a World Heritage Site (Hoang Minh et al., 2017). This led to the sky-rocketing in solid waste generation and the burden of the existing solid waste management system for the last decade (Pham Phu et al., 2019a). Enhancements in the solid waste management system is a mission in the research area. Solid waste collection system (SWCS), understood as all activities, facilities, and resources that are related to solid waste collection, is an important part of the solid waste management system which accounts between 50 % and 90 % of cost for solid waste management (Hoornweg and Bhada-Tata, 2012). Optimization of the present SWCS in HAC is an urge for making enhancements of the solid waste management system.

Geographic Information System (GIS) and Global Positioning System (GPS) are the popular tools in environment management with a variety of applications. GIS is a powerful tool with the ability to organize and integrate disparate data as well as illustrate the output through mapping (Maguire, 1991). GPS can be described as a satellite-based navigation and time transfer system. GPS was applied in tracking the route and collecting spatial-related data of vehicles in studies of SWCS (Nguyen Hong et al., 2018).

Understanding the current solid waste collection is the first step in optimizing the solid waste collection. A paper provided understandings on the current SWCS of tourism destination in HAC by using GPS logger and QGIS 3.4 (Le Dinh et al., 2021). Despite the power of GIS and GPS, the application of these tools in getting insights of the SWCS of HAC is still limited. There was no research offered an overall picture on the current solid waste collection of the HAC. The aim of this study is to (i) examine the existing solid waste collection activities of in HAC – the status, problems and challenges; (ii) create the scientific base for the enhancements of the SWCS towards sustainability.

Paper Received: 24 June 2021; Revised: 5 September 2021; Accepted: 23 November 2021
Please cite this article as: Dinh C.L., Fujiwara T., Pham Phu S.T., 2021, Waste Segregation at Source and Separately Collection – The Inadequacy in Implementation in Vietnam, Chemical Engineering Transactions, 89, 499-504 DOI:10.3303/CET2189084

2. Methodology

Figure 1 shows the process of research that was used. The survey was conducted from December 2019 to December 2020 in HAC. GPS loggers were used to collect GIS-related data including collection routes, distance, and time of collection activities by routes (Nguyen Hong et al., 2018). GPS logger was mounted on the trucks. The GPS logger collected spatial, distance, and time data by second. Locations of facilities supported for solid waste collection were also collected by GPS logger.

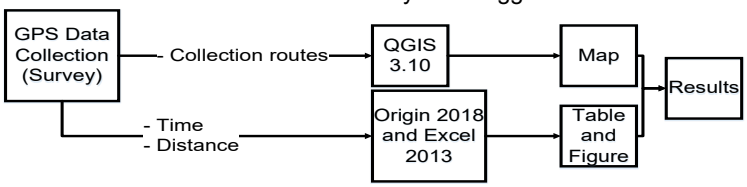

Figure 1: The process applied of the study

All data was imported and analyzed by specific software (Figure 1). Spatial data namely collection routes of trucks and coordinates of facilities were imported to QGIS. QGIS is an open-source GIS software becoming popular for multipurpose applications. It has capability of creating, editing, analyzing, and mapping spatial data (Graser and Olaya, 2015). Distance and time data were imported to Origin software and Excel. Origin created by OriginLab Corporation is a powerful and full-featured data analysis software (Moberly et al., 2018). Maps of facilities and collection routes were exported by QGIS while other figures were outputs of Origin and Excel. This research focused on the mainland solid waste collection activities with exception of Cu Lao Cham island of HAC.

3. Results and discussion

3.1 The existing solid waste collection system in Hoi An city

Figure 2 showed six main locations of the SWCS in HAC. The parking for trucks was a place for truck parking and midday break of drivers and workers. Regarding the two parking areas, Parking 1 (Figure 2) was the main parking area for the solid waste collection activities by carts in the morning and afternoon while the Parking 2 was the main parking area for the carts working in evening and early morning (Le Dinh et al., 2021). Non-biodegradable waste was collected by forklift truck and disposed at landfill site on Tuesday, Thursday, and Saturday. Biodegradable waste was discharged at waste treatment factory on Monday, Wednesday, Friday, and Sunday. Before and after discharging the waste into the landfill or waste treatment factory, forklift trucks must go to the scale bridge for measuring the amount of solid waste collected. This was the base for the payment from the government for the service company.

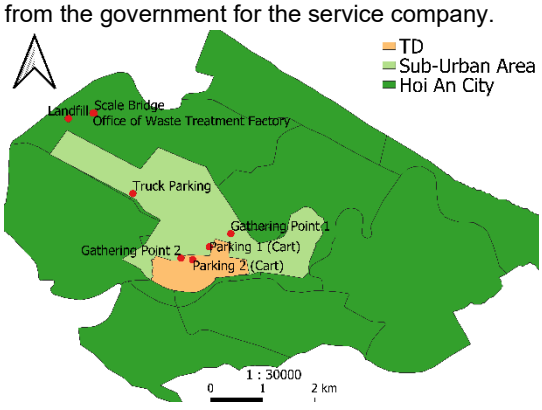

Figure 2: The current locations of facilities for solid waste collection in Hoi An city

Figure 3 shows the spatial information on the solid waste collection routes on a daily basis in HAC. HAC was divided into three areas with different characteristics of solid waste generation (Hoang Minh et al., 2017). Solid waste collection activities were conducted on a daily basis in the urban area and some parts on the sub-urban area (Figure 3). These areas, especially the area of ancient town in HAC, was the most crowded area of tourism activities. This led to the largest amount of solid waste generation in this area of HAC. That amount of waste was out of storage capacity of households in these areas if solid waste collection was not conducted daily (Pham Phu et al., 2019c). Regarding the rural area, the frequency of solid waste collection was lower in comparison to other areas (Figure 3). There were three main causes for this. Firstly, the amount of solid waste generated in

rural areas was half of that in urban areas due to the tourism activities (Hoang Minh et al., 2017). Secondly, the behavior of dwellers in the rural areas was an important factor. The people in the rural areas have been familiar with the current frequency of waste collection for many years. Thirdly, the drivers and workers themselves would change the schedule of solid waste collection frequency according to their personal views and experiences.

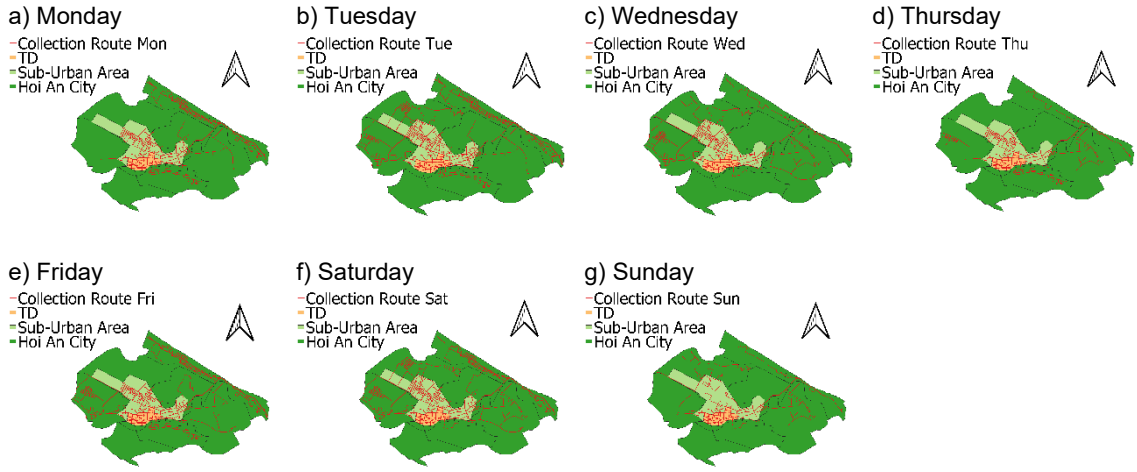

Figure 3: The solid waste collection routes by days in Hoi An city

Sunday and Thursday accounted for the simplest collection routes (Figure 3). These were the day-off for the majority of drivers and workers, which was set by the managers of the truck fleet. The solid waste collection routes appeared to be the most complex on Tuesday, Wednesday, Friday, and Saturday. The current schedule for the solid waste collection resulted in complexity in solid waste collection on those day.

The complexity of solid waste collection routes, frequencies of solid waste collection, and coverage of solid waste collection activities decreased from urban areas to rural areas. The solid waste collection routes of urban areas, namely Minh An ward, parts of Son Phong ward, and parts of Cam Pho ward, conducted once a day on a daily basis (Figure 3). These were the increased tourism areas with the highest requirements on urban aesthetics. In other communes namely Cam Thanh, Cam Ha, and Cam Kim, the solid waste collection frequencies ranged from two times to five times on a weekly basis (Figure 3).

The coverage of solid waste collection in communes was also lower in comparison to urban and suburban areas (Figure 3). The transportation conditions and schedule of solid waste collection, as well as the modification of drivers in collecting solid waste would be the main factors of differences in current collection routes of solid waste collection in HAC, ward by ward or commune by commune.

Cam Kim Ward was a special case of the SWCS in HAC. The isolated geographic conditions of Cam Kim Ward resulted in the individual waste collection routes (Figure 3). All solid waste generated in this ward was collected and transported to a transfer station by the local government. The three smallest trucks of the truck fleet collected waste at the transfer station in Cam Kim on Wednesday and Saturday on a weekly basis.

The details of the solid waste collection routes are shown in Table 1. Thursday, Friday, and Saturday accounted for the most enormous workload with 36, 34, and 40 trips. The total working time for these days were 103.86, 96.12, and 109.6 h while the total travel distances were 733.76, 719.21, and 848.12 km (Table 1). The workloads in these days were significantly larger compared to other days in a week. The smallest figures belonged to Thursday and Sunday with 23 and 21 trips a day. The figures of working time and total distance traveled for Thursday were 464.76 km and 65 h while these figures for Sunday were 400.92 km and 52.31 h (Table 1). The significant differences in the workloads were mainly from the schedule of solid waste collection activities decided by the managers. The managers proposed the schedule for the solid waste collection based on their experiences. The illegal solid waste discharge was also the reason for considerable workloads on Tuesday and Saturday. In HAC, the biodegradable waste was collected on Monday, Wednesday, Friday, and Sunday. Storage of biodegradable waste had negative impacts on the tourism activities due to leachate and odors (Pham Phu et al., 2019c). The owners and managers of the business showed no enthusiasm on storage of biodegradable waste. This was the precursor for the illegal solid waste discharge in HAC which led to the problem in the existing solid waste collection activities in HAC.

Table 1: Details of solid waste collection by days

		Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Number of trips		27	36	29	23	34	40	21
Number of driver		11	11	11	7	11	11	7
Number of worker		26	30	27	16	29	30	16
Distance (km)	Moving without waste	191.65	219.35	215.01	145.54	231.80	290.62	117.10
	Collection	210.91	297.42	226.74	169.20	265.30	281.24	152.37
	Moving with waste	187.89	217.00	199.37	150.02	222.12	276.26	131.45
	Total	590.46	733.76	641.12	464.76	719.21	848.12	400.92
Time (h)	Moving without waste	9.00	10.38	9.38	7.06	10.51	12.74	5.35
	Collection	48.24	66.73	49.60	40.55	60.13	64.73	33.84
	Moving with waste	8.74	10.01	9.15	7.48	10.12	12.52	5.87
	Break(Breakfast)	3.67	3.50	4.03	2.68	4.22	3.58	3.03
	Break(Middday)	4.39	13.24	8.82	7.23	11.14	16.03	4.22
	Total	74.04	103.86	80.99	65.00	96.12	109.60	52.31

Figure 4 and Figure 5 illustrated the travel distance and time of activities in solid waste collection. Regarding the distance, similarities among three main stages (moving with waste, moving without waste, and collection were revealed. Each stage accounted for approximately 33 % of total travel distances (Figure 4). The time allocated for these stages were quite different (Figure 5). Collection time was dramatically larger (approximately six times larger) than time spent on stages (Table 1). Hoi An was crowded with tourism activities. The number and space of temporary transfer stations must be limited. The main type of solid waste collection in HAC was door-to-door waste collection by forklift trucks. This required more time compared to the waste collection only at transfer stations by forklift trucks. Reduction in collection would be a topic in optimization of the SWCS in HAC.

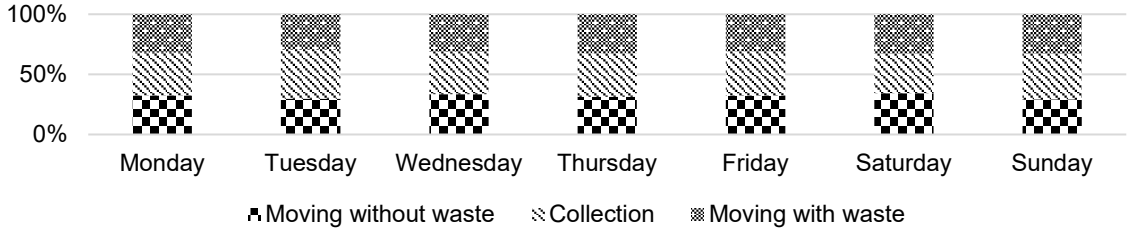

Figure 4: Distance travelled by truck on a daily basis

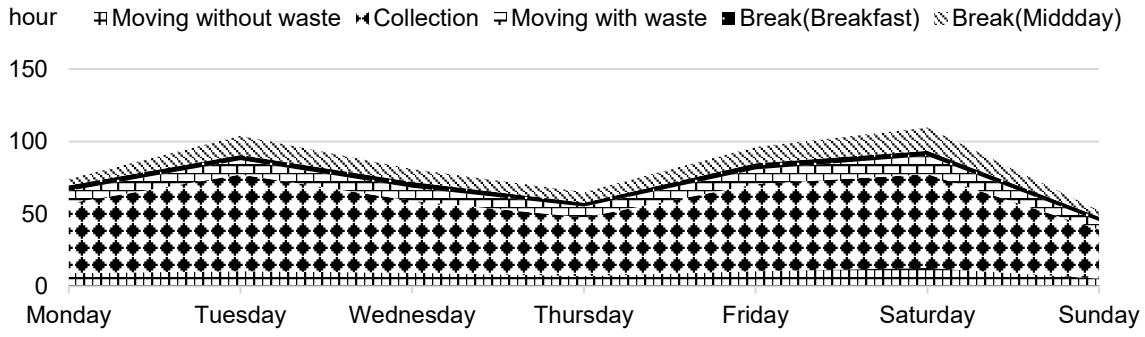

Figure 5: The amount of time for activities in solid waste collection

The total time for breakfast in the morning of drivers and workers ranged from 2.68 h to 4.33 h (Table 1). Despite the short time for eating breakfast, taking enough time for breakfast was the problem of solid waste collection. There was no scheduled time for breakfast while the demand for breakfast of the workers and drivers was

inevitable. The breakfast time in the morning for drivers and workers was illegal. Figure 5 and Table 1 showed the total amount of time for midday break in solid waste collection. The total time for midday break varied between 4.22 h and 16.03 h which accounted for an insignificant amount of time compared to collection time. The climate of HAC was uncomfortable for solid waste collection in the midday. The weather was too hot, especially in summer, to work. The drivers and workers took midday break before continuing the solid waste collection activities.

3.2 The existing problems and challenges of solid waste collection system in Hoi An city

The inefficiency of waste separation at source program and the illegal solid waste collection were observed in HAC. This led to a challenge of increasing the efficiency of separating waste at source in HAC. The increase in the amount of waste separated at source can contribute directly to the reduction of waste discharged to landfill as well as increase the profits of the business units in HAC (Pham Phu et al., 2020). The minimalism in waste management practice in accordance with improvement in recycling activities can be achieved for combating the existing problems in the solid waste management system of HAC (Pham Phu et al., 2020). The education to understand and practice solid waste separation at source was also essential in achieving the success in waste separation at source program due to lack of solid waste management knowledge and skills (Pham Phu et al., 2018). The inefficiency of waste separation at source program and illegal solid waste discharge also spread distrust among the people as well as the tourists on the waste separation at source program in HAC (Pham Phu et al., 2019a).

The waste treatment facilities were limited. The improvement of solid waste treatment facilities is an important mission that should be focused on in the near future. Existing incineration and composting facilities should be enhanced. Improvement in waste treatment facilities combined with waste minimization and increase in waste quality was highly recommended to ensure the sustainable solid waste management in HAC (Pham Phu et al., 2019b). The improper solid waste collection routes for separated waste and improper waste treatment showed inadequacy in implementation of solid waste separation at source.

These issues denoted that the waste separation at source program needs meticulous preparation for implementation. Propaganda for conducting waste separation, guiding for waste separation, schedule for separated waste collection, and treatment for separated waste are stages which must be properly considered as an integrated system to ensure the success of the waste separation program.

The misbehaviors of drivers and workers towards the solid waste collection as a service provider. Drivers and workers themselves showed an attitude towards completing the workload rather than acting as a service provider. This would be a challenge in enhancing the SWCS towards sustainability.

The climate of HAC was also a difficulty factor for solid waste collection activities. Extreme weather in the sunny season caused difficulties in collecting solid waste, especially in midday. The cost-benefit calculation would be conducted to modify the schedule of solid waste collection activities to mitigate the negative impact of the working environment.

The tourism activities on weekends were normally crowded. This would result in the solid waste generation increasing on weekends. There were not many trips of trucks as well as the less numbers of workers and drivers working for solid waste collection in comparison to weekdays (Table 1). This was the improper point in the schedule of solid waste collection in HAC. The scheduling of solid waste collection activities in HAC was mainly based on the experiences and the regulations of the government. Schedule of solid waste collection in HAC would be paid attention to optimizing the SWCS.

The improper time frame and frequency of the solid waste collection were the problems in the SWCS. In the morning, the regulation required the citizens to gather waste between 5:00 AM to 6:00 AM. The tourism activities normally lasted until midnight so citizens, especially in the tourism area, discharged and gathered waste right after finishing the tourism activities at night. This caused two main problems. Firstly, the regulations of the company and Hoi An government were violated. Secondly, the nuisance from waste and unhygienic storage of solid waste along the pavement led to the damage to aesthetic conditions.

This combined with dissatisfied demand from business units could lead to the un-success in implementing solid waste separation at source program. The optimization of the SWCS is also an urge to deal with these problems. This also illustrated that the opinions and demand must be thoroughly examined in conducting solid waste separation at source. Citizens are the service users and directly conduct waste separation. If citizens have a sense of dissatisfaction, they may take countermeasures and refuse to participate in waste separation at source. This will inevitably lead to un-success in waste separation at source program.

The geographic conditions of rural areas of HAC were the factors needed to be considered in optimization of solid waste collection in HAC. Rural areas, with the low population density (Pham Phu et al., 2019a), had a large distance between households as well as other business units. The door-to-door collection should be examined and compared to the type of waste collection by transfer stations in these rural areas. The low population density

and the available area of unused land can be the proper conditions for the foundation of a transfer station instead of door-to-door waste collection.

4. Conclusion

This study examined the existing solid waste collection of the Hoi An City by using GIS and GPS to create the scientific base for the enhancements of the SWCS towards sustainability, and the results are summarized as below. The solid waste collection activities were the most complex with the highest workload on Tuesday, Friday, and Saturday. Thursday and Sunday accounted for the lighter workload due to the schedule of solid waste collection activities. The complexity of solid waste collection routes, frequencies of solid waste collection, and coverage of solid waste collection activities decreased from urban areas to rural areas. Thursday, Friday, and Saturday accounted for the most enormous workload with 36, 34, and 40 trips. The total working time for these days were 103.86, 96.12, and 109.6 h while the total travelled distances were 733.76, 719.21, and 848.12 km. The smallest figures belonged to Thursday and Sunday with 23 and 21 trips a day. The figures of working time and total distance travelled for Thursday were 464.76 km and 65 h while these figures for Sunday were 400.92 km and 52.31 h. The vast majority of time in solid waste collection by forklift truck was spent on collection which was around six times larger in comparison to moving stages.
The conducting waste separation at source, illegal solid waste collection, improbability in solid waste collection activities, extreme weather, misbehaviors of drivers and workers, as well as the limitation in waste treatment facilities were the problems and challenges regarding the SWCS in HAC. The optimization of the existing SWCS in HAC is urgent towards sustainability.

Acknowledgments

The authors are thankful to Hoi An Public Work Company for supporting the survey as well as Graduate School of Environmental and Life Science, Okayama University for financial support.

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