CHEMICAL ENGINEERING TRANSACTIONS
VOL. 83, 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 978-88-95608-81-5; **ISSN** 2283-9216

DOI: 10.3303/CET2183008

Solid Waste Collection System in Tourism Destination – The Status, Problems and Challenges

Cuong Le Dinh[a], Takeshi Fujiwara[a], Misuzu Asari[b], Song Toan Pham Phu[c,*]

[a]Graduate School of Environmental and Life Science, Okayama University, 700-8530, Japan
[b]Graduate School of Global Environmental Studies, Kyoto University, Yoshida-Honmachi, Sakyo-ku, Kyoto, 606-8501, Japan
[c]The University of Danang – University of Technology and Education, 48 Cao Thang Road, Hai Chau District, Danang City, 550000, Vietnam.
ppstoan@gmail.com

Solid waste collection system (SWCS) plays an extremely important role in solid waste management system (SWMS). Optimization on SWCS have always been a primary mission of SWM towards sustainability. Hoi An city (HAC) is a tourist attraction in the central of Vietnam with omnipresence of tourism activities especially in tourism destination (TD). As a result, optimization of SWCS towards sustainability is crucial for TD of HAC. This study aimed to offer understandings on the current SWCS. This study was conducted with GPS (Global Positioning System) logger and QGIS 3.4 to collect and analyze data of existing SWCS. Results showed that, four modes of transportation were used for solid waste collection activities (SWCA) with almost all of sources of WG in the morning. Largest figures for total number of route (29) and amount of waste collected by carts (19.6m^3) were illustrated in the morning shift (MS). Illegal solid waste collection (SWC) accounted for about 10 % of total amount of waste collected by carts. Forklift trucks were the final disposal of all SWCA in TD. Current waste gathering (WG) practices indirectly damaged the tourism activities while the improper implementation of selective waste collection at source hindered the efficiency of SWCS in TD. This study made a contribution as a scientific base for optimization and administration of SWCS.

1. Introduction

Hoi An is a tourism city in the central of Vietnam with beautiful sceneries and ancient town designated as World Heritage Site by UNESCO. These days, the population of HAC has been stable at approximately 94,300 people while there was a boom in tourism enterprise, with an exponential increase in arrivals of more than 200 % in the last decennium (Pham Phu et al., 2019a). Tourism development led to the considerable increase in the generation of solid waste in HAC (Pham Phu et al., 2018). This inevitably imposed onerous burden on the SWMS in HAC. Regarding SWMS, SWC is an important component, which accounts from 50 % to 90 % of total cost for municipal SWM in low-income and middle-income countries (Hoornweg and Perinaz, 2012). As a result, it is vital to deeply understand the existing status of SWCS with to make enhancements on the SWMS in HAC. HAC was partitioned into three areas (urban area, suburban area, and rural area) basing on the characteristics of tourism industry (Hoang et al., 2017). TD in urban area, accounted for 1.05 km2, is overwhelmingly concentrated with commercial activities. Notably, 60 % of SW came from commercial activities related to tourism in HAC (Hoang et al., 2017). This results in the need of research on SWCS in TD of HAC. The urge in understanding the collection demand of stakeholders in TD was also mentioned (Pham Phu et al., 2019b). GIS (Geographic Information System) is a valuable tool for environmental management (Sumathi et al., 2008). As a result, GIS-based research on SWCS have recently been omnipresent. In Bolivia, GIS was applied to assess the impact of inclusion of waste pickers into SWMS. This study illustrated that the inclusion of informal sector lead to the decreasing cost of 10 % and distances, travelled by trucks, of 7 % while increasing recovery rate for recycling of 3.5 % (Ferronato et al., 2020). In Vietnam, there were also GIS-based research on SWCS. Notably, there were research mentioned about the SWC in HAC, Vietnam. The illegal solid collection was illustrated as a serious problems of existing SWCS in TD, which was the reason of financial loss of

Paper Received: 30/06/2020; Revised: 30/08/2020; Accepted: 01/09/2020
Please cite this article as: Le C.D., Fujiwara T., Asari M., Pham Phu S.T., 2021, Solid Waste Collection System in Tourism Destination – The Status, Problems and Challenges, Chemical Engineering Transactions, 83, 43-48 DOI:10.3303/CET2183008

SWMS and restaurants (Pham Phu et al., 2019b). The proper models of waste management practice towards sustainability were constructed with positive results in reduction of WG and increase in recovery performance of recyclable waste (Pham Phu et al., 2020). Assessment on cost-effective solutions for reducing waste-to-landfill amount denoted that there was a proportional relationship between landfill target and cost while separation ratio was in inverse proportion the system cost (Hoang et al., 2020).

Although the above research mentioned about the SWCS in TD, the deep insights of SWCS were not fully showed. There was no GIS-based research on the existing SWCS in HAC. Unlike other studies on the SWCS, this study focuses strongly on the status, problems and challenges of existing SWCS in Tourism Area – HAC. The aims of this research is to: (i) offer the deep understandings on the present SWCS, (ii) offer the scientific base for optimization of SWCS and efficient administration of SWMS.

2. Materials and methods

2.1 Studied area

TD was the main studied area in this research. This area had the highest population density in HAC as well as has been becoming densely crowded with ubiquitous business activities and welcoming approximately 9,000 arrivals a day (Pham Phu et al., 2019b).

2.2 Survey

2.2.1 GIS data collection

The Figure 1 showed the analytical procedure of data in this research. The survey was conducted from December 14, 2019 to March 7, 2020. The survey was daily conducted for all components of SWCS in TD including forklift trucks, cart, electric carts, and boats. A GPS data loggers, Transystem 747A+ GPS Trip Recorders, was used to collect GIS data by the second (Nguyen et al., 2018). The collected GIS data was analysed by QGIS 3.4. To be specific, the kinds of GIS data collected were routes of door-to-door SWC by forklift trucks and electric carts in TD; routes of road sweeping (RW) in TD; routes of SWC on the rivers. The data namely distance travelled and time worked by routes were managed by Excel 2013 software and then imported to Origin 2018 for analysing and creating graphs.

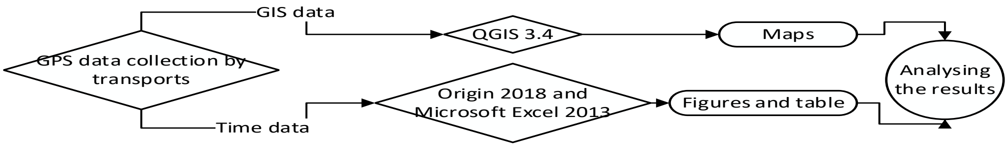

Figure 1: Analytical procedure of data

2.2.2 Documents review

The SWC-related documents were reviewed. To be specific, they were schedule for sweeping roads, door-to-door SWC in TD, technical specifications of trucks and carts, and regulation of Hoi An public works joint stock company (HAPWJSC) on SWC.

3. Result and discussion

3.1 Waste gathering practice

3.1.1 Present Waste gathering practice

The flow of solid was in TD was illustrated by the Figure 2. SW generated from households, which accounted for around 1,937 kg/d (Figure 2), was disposed by plastic bags and left on the pavement in TD. Besides, SW was also gathered in alleys in TDs. Regarding the shops and production in TDs, SW from this source was gathered on the pavement nearby. These sources of WG were lower (a total of approximately 1,200 kg/d) compared to other sources of waste in TD (Figure 2). The SW from hotel and restaurants accounting for the largest amount (more than 7,000 kg/d) was discharged in the plastic bins. The capacity of these bins can vary from 60 L to 240 L (Figure 2). The SW of Hoi An market (HAM) was about 1,100 kg/d. This amount was then collected and gathered in the parking area of HAM (Figure 2). SW must be gathered approximately 30 min before the waste collection activities start (6:30 PM) due to the regulations. The garbage was gathered last night, and as a result, the waste collection activities started earlier, at around 5:00 AM. Notably, there were some exceptions with hotels and restaurants. The municipal solid waste (MSW) from these business units were gathered and collected later, between 8:00 AM and 9:00 AM.

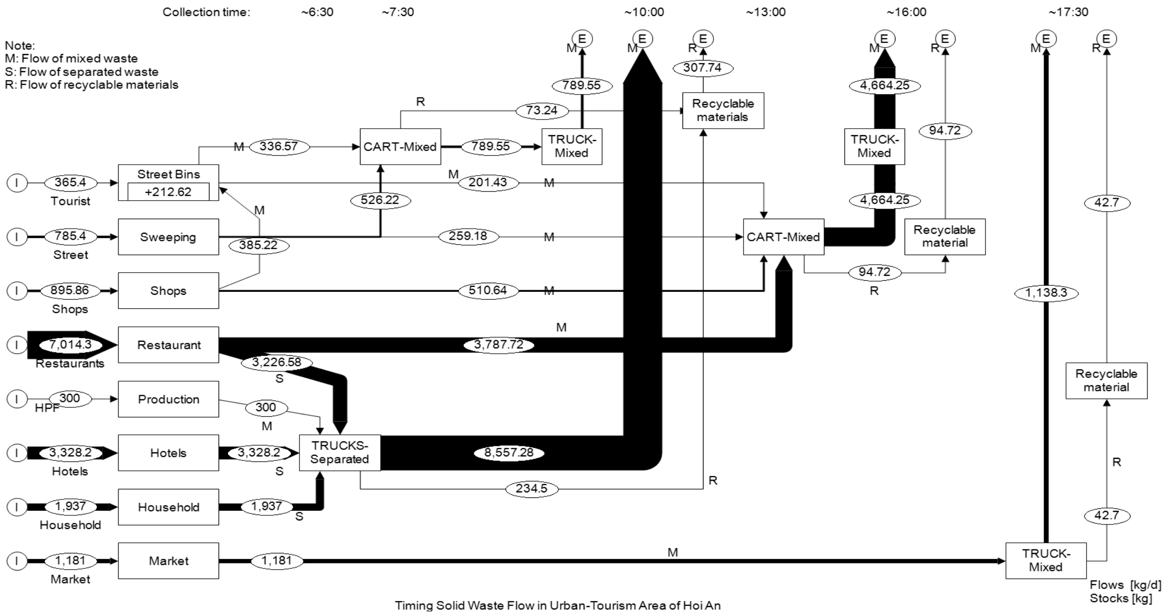

Figure 2: The flow of solid waste in TD of HAC (Pham Phu et al., 2019b)

3.1.2 Problems and challenges

Gathering SW on the pavement in the evening had a negative impact on the urban aesthetics, especially TD, where tourism activities are held until early morning. This was detrimental to the commercial tourism activities. There were many reasons for this. Firstly, the shops and restaurants normally open between 8:00AM and 10:00 AM in the morning. WG cannot be conducted as regulations. Secondly, WG in the early morning is not convenient for the citizens in the TDs. The tourism activities last until early morning. Owners of household business and other staffs could not gather SW as time frame complied with regulations. The temporary garbage dumps also resulted in the improper environmental sanitation because of leachate, odour, rodent damage, and flies. This inevitably caused discomfort among the nearby citizens and the tourism activities.

3.2 Working shifts of solid waste collection in TDs

The Table 1 showed general information on the current solid waste collection system in TD. The Figure 3 illustrated routes of waste collection activities by trucks, carts, and electric carts in early morning, morning, afternoon, and evening. The Figure 4 denoted the description of total time operated and distance travelled regarding kinds of transportation by routes.

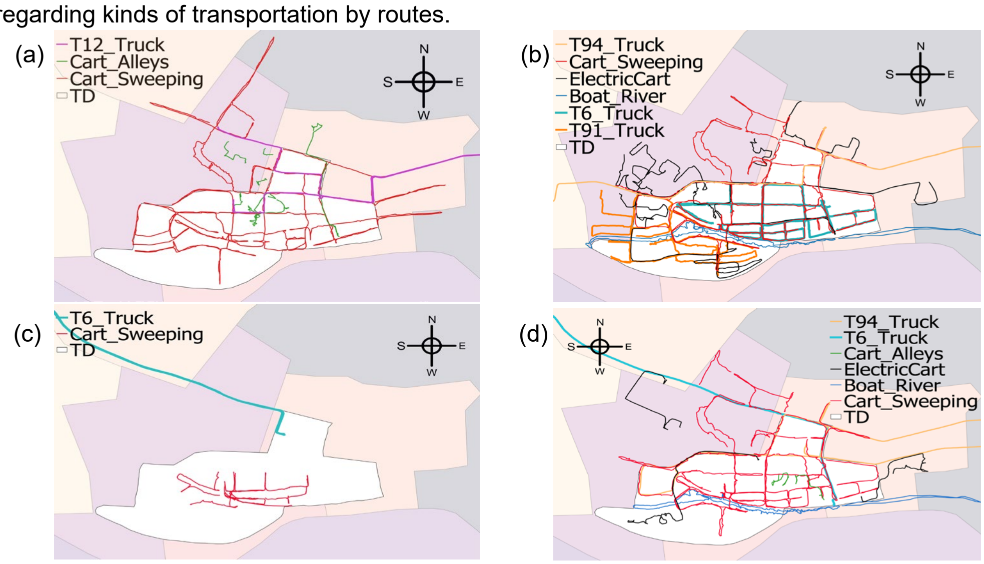

Figure 3: Waste collection routes in (a) Early morning, (b) Morning, Afternoon and (d) Evening in TDs

Morning was the main shift for SWC with 29 routes operated. There were a variety in WG sources (Figure 3) and transportation modes (Figure 4). The figure for amount of SW collected was also largest among four shift with 19.6 m^3 of SW handled (except trucks) (Table. 1). The reason for this was MS was major waste collection services under regulation of HAPWJSC. By contrast, lowest figures for number of routes, amount of waste collected, and the variety in modes of transportation used, was illustrated in evening shift (ES). There were six routes of RW with an amount of 3.5 m^3 of SW collected (Table 1). The operated routes of forklift truck and handy carts were simple (Figure 4). The workload of early morning shift (EMS) and afternoon shift (AS) were medium, mainly RW and SWC in residential alleys (Figure 3). The number of routes and amount of waste collected in the AS were slight larger compared to EMS. To be specific, SWC was operated in 26 routes while only 21 of that in EMS. The total amount of SW collected in the afternoon was around 4 m^3 larger compared to the EMS (Table 1). The explanation was the diversity in the modes of transportation and the complexity of route that was depicted in Figure 3. The SWC of HAM was conducted by truck once a day in the AS. The amount of SW collected was approximately 1,800 kg/d (Pham Phu et al., 2019b).

3.3 Modes of solid waste transportation on TDs

3.3.1 Forklift trucks

Morning was the most significant workload of trucks. A total of four routes were conducted in TDs with a mean of 15.727 km travelled and 2.396 h worked (Figure 4). These figures were much larger than other working shifts. Giving a look at the Figure 3, trucks in the morning covered large area of TDs. In the morning, the duty of forklift trucks were mainly door-to-door waste collection of households, production, restaurants, hotels according to the regulation of HAPWJSC. This resulted in the extreme workload compared to others working shifts. The operation of truck in TDs was mainly for waste collection of RW among remaining three working shifts with an exception in the afternoon (Table 1). The figure for distance travelled forklift trucks in the afternoon varied wider compared to MS despite the similar in mean value at approximately 6.2 km. In the afternoon, SW of HAM was collected by 6m^3 truck at the parking area next to the Thu Bon river comforted to the regulation of HAPWJSC. There was a group of people who were in charge of gathering all SW generated at HAM to the parking area in the afternoon.

Table 1: General information on the solid waste collection in TDs by shift

	Early morning (0:15 -5:15 AM)	Morning (5:15-10:30 AM)	Afternoon (1:00 -4:30PM)	Evening (4:30-9:00PM)	Total (daily)
Number of routes	21	29	26	7	83
Handy Cart	20	15	18	6	59
Electric car	0	7	3	0	10
Truck	1	4	2	1	8
Boat (waste from river)	0	3	3	0	6
Amount of waste collected (m^3)	12.65	19.60	16.48	3.50	52.23
Handy Cart	12.65	8.30	10.28	3.50	34.73
Electric car		10.70	5.60		16.30
Boat (waste from river)		0.60	0.60		1.20
Proportion of illegal waste collection (%)	0.00	2.01	6.89	0.96	9.86
Handy cart		2.01	6.89	0.96	9.86

3.3.2 Handy carts

The workload of ES was significantly low compared to other shifts. The amount of waste and numbers of route in the evening was nearly a third of other shift (Table 1). This was shown in the Figure 4 that, the mean of working time were just 2.277 h and mean distance travelled was shortest among four working shift, 2.38 km. The collection route in the evening of handy cart was simplest (Figure 3). In the evening, RW was only operated in the areas of ancient town and part of Minh An ward from 4:00 PM to 9:00 PM. This working shift was based on the contract between the HAG and HAPWJSC. Workloads of handy carts were similar among three remaining working shifts with the mean working time of three shifts was nearly 3 h. The range of working time per route of EMS were larger than that of MS and AS (Figure 4). In the early morning, handy carts had two crucial functions which were household waste collection in alleys and RW. The total distances of routes in alleys were shorter than RW (Figure 4). Despite the long routes of RW in the early morning, the mean working time per route in the early morning was corresponding to other working shifts with an exception of evening.

3.3.3 Electric carts

Figure 4 showed that shorter mean time (1.222 h) was showed in the afternoon compared to MS (1.462 h) despite similarities in mean distances (6.6 km) travelled. Despite the corresponding in data of mean distances travelled, the distances that electric carts took were shorter than that of morning (Figure 3). In terms of household waste collection in alleys, electric carts were in charge of longer route compared to the handy carts.

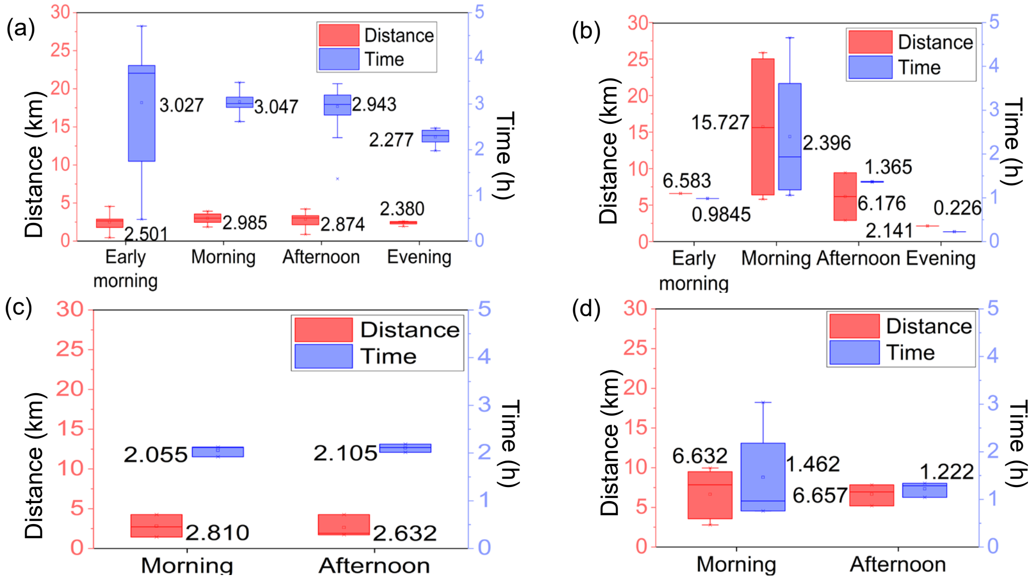

Figure 4: The operated time and distance of (a) Trucks, (b) Carts, (c) Electric carts, and (d) Boats

3.3.4 Boats

The similar characteristics between two working shifts were denoted in Figure 3. Analogous working time were shown in Figure 4 with, 2.055 and 2.105 h. Figure for distances plied were slight different with 2 km shorter of AS. This was the shorter route of boats of AS compared to MS (Figure 3).

4. Problems and challenges

There was illegal solid waste collection. The degradable waste of BU is collected in Monday, Wednesday, Friday, and Sunday while the non-degradable is collected on the remaining days of a week by forklift trucks with frequency of SWC of once a day. The degradable waste was collected in all days of a week by handy carts (only for RW and street bins) and forklift trucks in TD. The SW was illegally discharged into street bins which were only for tourists (Pham Phu et al., 2019b). These activities were breaches of the regulation of HAPWJSC regarding SWC. Illegal waste collection among handy carts accounted for nearly 10 % of total amount of waste collected by electric carts, boats, and handy carts (Table 1). Notably, the illegal collection by handy carts also resulted in financial loss of 17,007 $/y and 75.08 $/restaurant/y for SWMS and restaurants. The illegal SWC of handy carts led to garbage overload, which in turn had adverse impact on urban aesthetics (Pham Phu et al., 2019b). Consequently, tourists and business activities would be in unfavourable conditions in TD.

The improper implementation of selective waste collection at source in TDs was also a problem. There were no distinct selective SWC routes for street bins, rivers, and HAM. The SWC of HAM was conducted as mixed waste. Despite two compartments for degradable and non-degradable waste of street bins, the existing of mixed waste was illustrated in both compartments. This amount of waste were then mixed together by workers before being transported to the landfill by trucks. The SWC on rivers was also conducted with similar patterns. The mixing of solid waste, after being separated, had spread erroneous beliefs in SSWSASP among people in TD. This limitation was also denoted by Song Toan et al. (2019a). As a result, the changes in SW should be proposed to satisfy the demands and requirements of all stakeholders towards sustainability in TD.

The administration of solid waste collection system was inefficient. The Figure 5 showed the percentages of time for waiting forklift trucks of handy carts. There was no efficient and flexible management of SWCS in TD. After completing their workload, workers had to wait for forklift trucks. The Figure 5 highlighted that the percentages of waiting time of carts of EMS and ES were approximately a quarter of total time. This was extremely detrimental to the efficiency of working shift and a waste of time for workers.

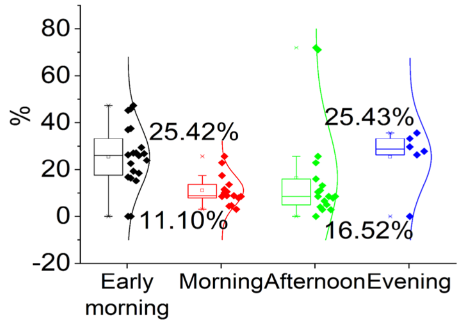

Figure 5: The percentages of time for waiting forklift trucks of handy carts

5. Conclusion and recommendation

This research aimed to deeply understand SWC system in TD of HAC. SWC was organized strongly in MS with complexity in routes (alleys, streets, and rivers), the largest number of routes (29), variety in modes of transportation (all modes used), sources of WG (exception of HAM) and amount of waste collected by carts (19.6 m^3). Forklift trucks conducted four routes with a mean of 15.727 km travelled and 2.396 h worked, which were extremely higher than other working shifts of trucks. The workloads of handy carts were similar among four working shifts with an exception of EMS due to SWC in alleys. The workload of electric carts and boats were corresponding among two working shifts. Forklift trucks were the final disposal of all sources of WG. There was a percentage of 10 % of total amount of waste, which was illegally collected by carts. The improper SWC for SSWSASP and inflexibility administration of SWCS were significant problems. These problems must be handled to optimize the SWCS towards sustainability. This research contributed as scientific base on optimizing SWCS as well as the administration of SWMS.

Acknowledgements

The authors are thankful to Hoi An Public Work Company for supporting the survey and Graduate School of Global Environmental Studies, Kyoto University for financial support.

References

Ferronato N., Preziosi G., Gorritty Portillo M. A., Guisbert Lizarazu E.G., Torretta V., 2020, Assessment of municipal solid waste selective collection scenarios with geographic information systems in Bolivia, Waste Management, 102, 919-931.

Hoang M. G., Fujiwara T., Pham Phu S. T., 2017, Municipal Waste Generation And Composition In A Tourist City — Hoi An, Vietnam, Journal of Japan Society of Civil Engineers, 5(1), 123-132.

Hoang M. G., Pham Phu S. T., Fujiwara T., Pham V. D., 2020, Waste-to-Landfill Reduction: Assessment of Cost-Effective Solutions using an Optimisation Model, Chemical Engineering Transactions, 78, 511-516.

Hoornweg D., Perinaz B. T., 2012, What a waste: a global review of solid waste management, Urban Dev Ser Knowl Pap, 15, 87-88.

Nguyen H. D., Le Thi T. V., Tran Vu C. M., Yasuhiro M., 2018, Scenario Analysis on Operation Efficiency for Waste Collection and Transport: A Case Study in Da Nang City, Vietnam, Journal of Environmental and Social Sciences, 5(1).

Pham Phu S. T., Fujiwara T., Hoang M. G., Pham V. D., Kieu Thi H., Tran Thi 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.

Pham Phu S. T., Fujiwara T., Hoang M. G., Pham V. D., Tran M. T., 2019a, Waste separation at source and recycling potential of the hotel industry in Hoi An city, Vietnam, Journal of Material Cycles and Waste Management, 21(1), 23-34.

Pham Phu S. T., Fujiwara T., Hoang M. G., Pham V. D., 2019b, Solid waste management practice in a tourism destination – The status and challenges: A case study in Hoi An City, Vietnam, Waste Management And Research, 37(11), 1077-1088.

Pham Phu S. T., Hoang M. G., Fujiwara T., 2018, Analyzing solid waste management practices for the hotel industry, Global Journal of Environmental Science and Management, 4(1), 19-30.

Sumathi V. R., Natesan U., Sarkar C., 2008, GIS-based approach for optimized siting of municipal solid waste landfill, Waste Management, 28(11), 2146-2160.