Construction and demolition waste illegal dumping: Environmental, social and economic impacts assessment for a growing city

Luu Ngoc Cham\(^{i}\), Nguyen Lan Huong\(^{ii}\), Tran Thi Viet Nga\(^{ii}\), Yugo Isobe\(^{iii}\), Mikio Kawasaki\(^{iii}\) and Ken Kawamoto\(^{iv}\)

\(^{i}\) Master Student, Department of Environmental Engineering, NUCE University, 55, Giai Phong, Hanoi 100000, Vietnam
\(^{ii}\) Department of Environmental Engineering, NUCE University, 55, Giai Phong, Hanoi 10000, Vietnam
\(^{iii}\) Center for Environmental Science in Saitama, Kasushi Kamitanadare 914, Saitama 347-0115, Japan
\(^{iv}\) Professor, Graduate School of Science and Engineering, Saitama University, 255-Shimo-Okubo, Saitama 338-8570, Japan

ABSTRACT

Solid waste management causes a significant challenge for the developing countries, especially in Vietnam. With the rapid development of Vietnam’s economic and urbanization, the construction industry has enjoyed continuous development and has gradually become one of the pillar industries of the national economy in general and particularly Hanoi capital. While the construction industry has enjoyed continuous development, huge amounts of construction and demolition waste (CDW) being generated and dumped illegally on the vacant areas including roadsides, streets, and canals occur frequently. The consequences of improper waste management are potential alarming. With the rising concerns of waste management and global carbon concentrations, this research aims to evaluate the potential environmental impacts associated with CDW and to identify the best alternative in managing the CDW. Generally, the data are not homogeneous around the research area as the number of inhabitants is not constant nor it is the economic activity. Therefore, if all the information is showed in thematic maps, the final waste management decisions can be made more efficiently. This study is performed with the aims of analysis on the current situation of CDW management in order to identify the environmental impacts related to CDW. Thereby, this research intended to be assessing CDW recycling potential and evaluating on the economic feasibility of the utilizing of recycled materials in the future. This paper combines the planning methodology to present the final results in thematic maps that make easier to interpret them. The results of the study would play the major role in developing a sustainable system such as assessing recycling potential, choosing appropriate treatment options, or operating solid waste management system.

Keywords: construction and demolition waste, illegal dumping, waste composition, stratified sampling, Hanoi city, Vietnam.

1 INTRODUCTION

With the rapid development of Vietnam’s economy and urbanization, the construction industry has enjoyed continuous development and has gradually become one of the pillar industries of the national economy. While the construction industry has made tremendous contributions to the development of the entire society, the amount of construction and demolition waste (CDW) has also grown rapidly, accounting for 10-12% of total solid waste in Vietnam (Vietnam MONRE, 2011). Huge amounts of CDW are being generated in Hanoi city due to active construction activities including new constructions, renovations, and demolition of buildings, exceeds 3000 tons/day. Except for collected CDW sent to controlled CDW landfills and marketable materials, other generated CDW is liable to be dumped illegally. It is reported that the total illegal CDW dumping collected was about 69,891.65 tons in 2017 and approximately 72,219.25 tons in 2018 (Hanoi DOC, 2019). The illegal dumping of CDW can cause risks to the human health and to the environment, including transportation obstacles leading to accidents, impact on the urban landscape, air pollution, soil and ground water contamination, degraded infrastructure, and waste of land. In order to reduce the environmental impact and develop a waste management system in Hanoi, accurate and reliable data on the CDW illegal dumping are needed.

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Results of the study would play a major role in developing a sustainable system such as assessing recycling potential, choosing appropriate treatment options, or proposing suitable CDW management and recycling strategies suited to these conditions to all stakeholders. This paper addresses the current status of illegal dumping in the capital city of Vietnam and the composition of the CDW illegally dumped. The authors also provided an advantageous framework including sampling procedures and appropriate statistical analysis, as a reference that is readily applicable to small-scale wards in Hanoi.

2 MATERIALS AND METHODS

2.1 Research target area

Hanoi is the capital of the Socialist Republic of Vietnam, which is the largest city in the country, and also the second largest province with a population of over 8 million people (in 2019). However, if unregistered residents are counted, the actual population of this city in 2019 is nearly 10 million people. The population density of Hanoi is 2398 people km$^{-2}$, the traffic density is 105.2 vehicles km$^{-2}$ of road surface.

Hanoi capital comprises 30 district-level administrative units; we focus on two typical district in Hanoi, one is a major district, and another one is suburban district in this study.

Hai Ba Trung district located in the Southeast of Hanoi capital, Vietnam and it is recognized as one of the major district of Hanoi city. The district has a natural land area of 10.26 km$^2$ with a total population, in 2017, of around 318,000 and population density of 30,994 people km$^2$, making Hai Ba Trung the 3rd most densely inhabited district in Hanoi. On the other hand, most of the infrastructure and residential areas in Hai Ba Trung district are now seriously degraded. The CDW illegal dumping in this district was about 6,897.48 tons in 2018.

Dong Anh district is located in the North of Hanoi city, and it is known as one of the suburban district of the capital. Dong Anh district has a natural land area of 185.62 km$^2$ with a total population, in 2017. Of around 381,500 and population density of 2055 people km$^2$, making Dong Anh belong to the lowest densely inhabited areas in Hanoi. In addition, the high percentage of agricultural land and specially use land, accounted for 53.2% and 19%, respectively, also are specialty of this district (Hanoi Statistics Office, 2017).

2.2 Field survey

2.2.1 Mapping of CDW illegal dumping hotspots

Limited research target scope at some typical district in Hanoi, one is a major district, and another is suburban district includes:

- Establish a map of CDW illegal dumping hotspots at Hai Ba Trung district in 2018 based on preliminary research data and on-site inspection records.
- Mapping a map of current situation of CDW illegal dumping hotspots at a suburban district - Dong Anh district using field survey actual data.

We divided the illegal CDW dumping hotspots into two types by waste amount > 100 m$^3$, which is a permanent hotspots, and another one is temporary hotspots. All the information is showed in thematic map.

2.2.2 CDW composition survey

The sampling strategy adopted in this study is stratified random sampling to reduce variations in illegal CDW dumping. CDW is dumped illegally at vacant sites in two types including waste in bags, waste in piles or both, as show in Figure 2.
a. Case study for of urban district
Hai Ba Trung district comprises 20 administrative wards; we focus on Bach Dang ward, which consist of many types of CDW illegal dumping points including temporary hotspots and permanent hotspots in this study. Bach Dang ward located in the Northeast of Hai Ba Trung district with a natural land area of 0.98 km².

To determine the illegal CDW dumping characterization from various forms, not only CDW dumped illegally in trash bin mix with municipal solid waste (MSW), but also illegal CDW dumping at vacant sites including streets, pavements, and roadsides was chosen as targets of the study. The period of the survey was five days from May 7 to May 11, 2019. On the first day, we focused on training students joined in the sampling program. We conducted the survey at ten trash bin points (including purple, brown, and orange points) and six illegal dumping sites (green points) in total from May 8 to May 10, 2019, as shown in Figure 3. We divided the Bach Dang ward into three strata (ST). ST11 and ST12 are the center urban areas located inside the Red river dike, and ST13 is the urban areas that located outside the dike (Nordtest, 1995). Figure 3 also describes the three strata in this study; the ST11, ST12 and ST13 areas are represented by purple, orange and brown, respectively.

b. Case study of suburban district
Dong Anh district comprises 23 communes and 01 downtown area according to administrative boundaries in this study. We divided this district into three strata (ST). ST1 and ST2 are the center area, and ST3 is the suburban areas. Figure 5 also describes the three strata in this study; the ST21, ST22 and ST23 areas are represented by gray, blue and yellow, respectively.

2.2.3 Waste analysis composition method
In order to ensure that the analyzed waste had been generated in the last 24 hours, the collecting team members made the identification codes for each sample and transported samples to the laboratory to measure and record the weight every morning.

Samples were separated few hours after being transported to minimize the variations. Sieving with the size of 20mm to segregate small materials (under 20mm), sorting by hand for designed categories and scaling each one, waste samples were separated into ten primary components presented in Table 2.

| ID | Primary components | Material |
|----|--------------------|----------|
| W1 | ABC waste          | Asphalt, brick, concrete. |
| W2 | Wood               | Wood scrap, wood panel, etc. |
| W3 | Metal 1            | Aluminum, iron, ferrous metals, etc. |
| W4 | Metal 2            | Non-ferrous metals, etc. |
| W5 | Ceramic            | Tile, ceramic debris. |
| W6 | Paper              | Paper, corrugated paperboard. |
| W7 | Gypsum             | Gypsum board, rock wool sound absorption panel, ALC. |
| W8 | Others             | Glass, textile, rubber, paper, household waste, etc. |
| W9 | Stone              | Plastic bag, plastic bottles, |
2.2.4 **Statistical analysis**

The amount of CDW is identified by the total amount of each waste type \( W \) in sample by the equation (1) below:

\[
M = \sum_{w} m_w
\]

After sampling, waste weight would be reduced by an amount of \( \Delta \). Thus, the equation (1) becomes:

\[
M = \sum_{w} m_w + \Delta
\]

Percentage of each waste type due to difference of \( M \) and total amount of \( m_w \) is described by the equation (2), as below:

\[
a_{adj}^w = \frac{(m_w + \Delta \times m_w)}{M} \times 100\%
\]

### 3 RESULTS AND DISCUSSIONS

#### 3.1 CDW illegal dumping map

Figure 4 shows the CDW illegal dumping hotspots at Hai Ba Trung district (a major district) in 2018. Illegal CDW dumping management is now a serious challenge to Hanoi capital. There are over 110 illegal CDW dumping points appeared in Hai Ba Trung district in 2018. Therefore, we divided the illegal CDW dumping point into two types by waste amount. Type 1 comprises 106 points with waste amount < 100m³; type 2 consists of 9 points with waste amount > 100m³. Figure 4 also describes the two types in this study; the group 1, and 2 are represented by blue, and red, respectively.

There are also over 100 illegal hotspots have marked during the survey period. Figure 5 describes the current status of CDW dumped illegally hotspots at Dong Anh district (a suburban district), in which the temporary hotspots and the permanent hotspots are represented by blue and red, respectively.

The waste generation rate was calculated by dividing the amount of illegal CDW dumping produced in three days with the number of days. Figure 6 shows the results of statistical estimation of waste generation rate (WGR) at Bach Dang ward in May, 2019. These results indicated that WGR of illegal CDW dumping approximately 836.33 kg per day at sites (CDW_AS) accounts for 4% of total MSW and about 208 kg per day in trash bin points (CDW_TB), only accounting for 1% of total MSW produced. Thus, the total amounts of CDW is dumped illegally adopted is 1,044.33 kg per day.

Figure 7 shows the total amount and frequency of CDW generation at each trash bin point. It can be seen that during the three-day survey, illegal CDW dumping was collected from 5 trash bin points; particularly, illegally dumped CDW can be found in about 2 or 3 trash bins points among the total 10 points. The results indicated that the frequency of illegal CDW dumping at
the outside areas of the dike (ST13) is higher than that of the center urban areas (ST11 and ST12), because of few inhabitants and low vehicle density.

Fig. 7. The total CDW generation amount is dumped illegally in trash bin points at Bach Dang ward, May 8 - 10, 2019.

The results of this study indicated the differences characteristic of CDW dumped illegally activities between center districts with suburban districts. It is important to obtain information about the type of CDW illegal dumping sites at center districts and suburban districts. At most major district, CDW are packed in bags, a small part was dumped in piles. Different from the situation in suburban districts, almost CDW are dumped into large piles, used intentionally to landing, and to fill up the lake bed. Another characteristic that needs attention is the location of the CDW illegal dumping sites, its dumped at roadsides, scattered on the streets become transportation obstacles, blocking sewers and canals at major districts. On the other hand, the dumped CDW in the large vacant areas including rice fields, and ponds at the suburban districts can cause risks to human health and environment, including air pollution (due to dust), soil and groundwater contamination.

3.2 Illegal CDW dumping composition

Illegally dumped composition at a major district was indicated in Figure 8, in which the largest proportion was ABC waste (47.35%) and the smallest proportion was metal (0.26%). Mixed material (<20mm) accounts for 27.86%. Wood and ceramic were significant contributors, from about 8% to 9%. Other components were less than 8% of total waste.

Fig. 8. CDW illegal dumping composition at Bach Dang ward, from May 8 - 10, 2019.

Figure 9 presents the illegal CDW dumping at a suburban district, in which the largest proportion was mixed material (<20mm) accounts for 41.32% and the smallest proportion also was metal (0.11%). ABC waste accounts for 38.69%, which is the 2nd most contributor in this composition. Stone was significant contributor, over 11% making a difference between the CDW dumped illegally composition at a major district and suburban district. Other components were less than 4% of total waste.

Currently as the remaining capacity of landfills is constrained, reduction of the amount of construction waste being landfilled is an urgent issue. Figure 8 and figure 9 also shows that of the materials composing mixed CDW, accounted from 27% to 40% of total CDW truly cannot be recycled. If the remaining from 60% to 73% could be recycled, the amount being landfilled can be minimized. The significant quantities of asphalt, concrete, and brick proved that we might consider introducing crushing technology as a potential recycling treatment option for construction and demolition waste. However, a priority policy or investment policy for research, manufacture, and business investment in the recycling and management of CDW has not been promulgated in Vietnam (The Prime Minister of Vietnam, 2014).
Centralized recycling plant with high capacity might be improper for the Hanoi city condition due to the lack of management skills, operating funds, transporting fees, low technology application, especially narrow working space. Thus, decentralized recycling treatment (small-scale stations, district model) seem advisable to apply in these conditions, especially with urban areas.

3.3 Environmental impact of CDW illegal dumping

There are several problems caused by CDW dumped illegally in Hanoi. Major problems are hazardous waste, and dusting.

Figure 8 and Figure 9 indicated that hazardous waste such as gypsum board, rock wool sound absorption panel, ALC (accounted from 0.94 to 1.42%), asphalt and metal are not separated at sources and dumped illegally together with other CDW. It is also indicated that the significance amount of CDW fall in the mixed material category with less than 20mm. This would also cause impact to the environment. For future perspectives, it is important to examine the suitable treatment method and possible reuse of fines with a careful characterization of environmental safety of the fines.

Four building-related CDW materials (wood, asphalt shingle, carpet, and gypsum drywall) have been targeted by the Commonwealth of Massachusetts as items of high priority. These building-related waste materials, on a volume basis, constitute a large share of CDW debris generated in residential construction. Other materials generated from both road and bridge projects as well as building construction/demolition activities, such as asphalt pavement, brick and concrete (ABC), and metals have been routinely diverted from CDW streams. It has been reported that ABC accounts for 96% by weight of all CDW recycled in Massachusetts in 1999 (Executive Office, 2000).

The high concentration of hazardous materials like asbestos, wastes containing coal tar, and heavy metal, mercury increases the potential risk to human health. The issue of illegal dumping of hazardous waste is mainly due to the cost and lack of the treatment facilities. On the other hand, the large proportion of mixed materials (<20 mm) is one of the main causes of dust dispersion in urban environment, potentially causing air pollution.

CDW are adding to the phenomenon of global warming. Hotter temperatures due to Global Warming Potential (GWP) lead to increased weather extremes including heat waves and worsening of air quality. Epidemiological studies of deaths during the heat waves refer to the fact that a substantial portion of the mortality might be attributed to elevated ozone and particulate levels that occurred during the heat waves (American lung Association, 2004). The California Air Resources Board indicated that the health effects of increasing concentrations of particulate matter and ozone are: 6500 premature deaths, 4000 hospital admissions for respiratory disease, 3000 hospital admissions for cardiovascular disease, 350,000 asthma attacks, 2000 asthma-related emergency room visits, elevated school absences due to respiratory conditions, including asthma, and reducing lung function growth rate in children. Sensitive groups, including seniors, people with heart or lung disease, children and infants are the most vulnerable to the harmful effects of air pollution (Marzouk M., Azab S., 2014).

3.4 Socio-economic impact of CDW illegal dumping

Illegal dumping of CDW poses socio-economic implications associated with waste cleaning and landscape restoration. The dumped CDW illegally not only impact on the urban landscape, degraded infrastructure, damages the urban drainage system, but also costs around VND 1.2 billion of Hanoi city’s government budget on cleaning open areas from illegal dumped waste including collection, transportation and tipping fee (Hanoi DOC, August 20, 2019).
The majority of illegally dumped CDW components, for example, soil, brick and concrete can be recycled and reused after a proper treatment; therefore, other construction sites can utilize those materials. Using recycled materials can be a great direct contribution in order to reuse the need of natural resources, e.g., metal, natural/virgin soil for producing clay bricks, and natural/virgin gravels and aggregates for roadbed materials and concrete manufacturing. Additionally, the overload situation and reduction of landfill area at authorized CDW landfill sites are caused by illegally dumped.

This study found urban citizen are not likely to be against CDW illegal dumping activities but also coordinate with local authorities to investigate offended people. In contrast, the inhabitants at suburban area are unknowledgeable about the harm of environmental directly dumped CDW. Moreover, a part of locals accepted and cooperated with guilty organizations namely transport companies, individual contractors to conduct the illegal activities.

4 CONCLUSIONS

The study presents the current state of illegal construction and demolition waste dumping in Hanoi. Detailed survey and analysis of waste generation and composition in a major district, Hai Ba Trung district, were conducted to identify the generation rate and composition of illegal CDW dumping. Another survey in order to identify waste characteristics and the factor associated with illegal dumping activities were conducted at a suburban district, Dong Anh district. The findings are as follows:

Daily waste generation rate of illegal CDW dumping was 1,044.33 kg per day which accounted for about 5% of total municipal solid waste generation, including 4% of CDW dumped at illegal sites and 1% at trash bins.

The illegal construction and demolition waste dumping composition at major districts had asphalt, concrete and brick waste as the largest proportion and metal waste as the smallest contribution. Wood waste was the second significant component, of about 8%, while “other” component contributed less than 8% of the total CDW dumped illegally.

Results from this study suggested a methodology of waste characterization survey based on the characteristics of center urban areas. The results and methodology are proposing suitable CDW management and recycling strategies suited to the country’s conditions and to all authorities, stakeholders, and planners. We suggested that crushing treatment technology should be considered as a highly potential option for construction and demolition waste to reduce the amount that is dumped illegally.

The results of this study also indicated the differences characteristic of CDW dumped illegally activities, and locations of sites between center districts with suburban districts. At most major district, CDW are packed in bags, a small part was dumped in piles at roadsides, scattered on the streets become transportation obstacles, blocking sewers and canals at major districts. Different from the situation in suburban districts, almost CDW are dumped into large piles, used intentionally to landing, and to fill up the lake bed. It dumped in the large vacant areas including rice fields, and ponds at the suburban districts can cause risks to human health and environment. Urban citizen is likely to be with CDW legal dumping activities. The awareness of people from suburban districts should be raised so that reduces the negative impact to environment, and socio-economy.

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