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Research Article

ASSESSMENT OF GENERATION AND MANAGEMENT OF HOUSEHOLD HAZARDOUS WASTE IN LONG XUYEN CITY, AN GIANG PROVINCE

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ABSTRACT

Household hazardous waste is an important part of the domestic solid waste stream, which can cause significant harm to the health of families, communities, and the environment if not managed properly. The research was conducted to assess the current status of household hazardous waste generation and management in Long Xuyen City, An Giang Province. The study interviewed 100 households and collected hazardous waste over three months. The results showed that household hazardous waste reached 0.8395 kg/person/year, equivalent to about 228.97 tons of household hazardous waste each year, of which, 62.59% of them are bottles and jars with dangerous chemicals. The waste sorted by households was found to be inadequate, with 98% of households not separating hazardous waste from other regular waste. Only 68% of households have registered services for hazardous waste at the Long Xuyen City Hazardous Waste Treatment Plant. The other predominant waste disposal methods included improper burning and burial (accounting for 8%) and selling scrap materials (accounting for 24%). Although the residents in the research area exhibited good knowledge and positive attitudes toward household hazardous waste management, their practices regarding the management of such waste were found to be inadequate.

Keywords: An Giang Province; household hazardous waste; management; waste

1. Introduction

The term "Household Hazardous Waste (HHW)" was coined in 1981 when there was an increase in concerns about hazardous waste generated by households (Manggalit & Susanna, 2019). HHW is a heterogeneous waste that contains toxic, flammable, explosive, reactive and corrosive chemicals (Diankha et al., 2020). Although HHW only accounts for about 1-4% of municipal solid waste (Letcher & Slack, 2019), it is an important part of the domestic solid waste stream and is associated with the daily life of households (Gu et al., 2014). In particular, with the increasing population, the amount of waste generated from

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households also increase (Fikri et al., 2017). HHW is mainly generated from waste products such as automobile products (engine oil, antifreeze, oil filters), household cleaning products (bleach), health care products (shampoos, nail polish, deodorants), pesticides, pharmaceuticals, and products containing heavy metals (fluorescent bulbs, batteries, mercury thermometers) (Letcher & Slack, 2019; Diankha et al., 2020; Lin et al., 2023).

HHW impacts can cause significant harm to the health of families, communities, and the environment if not managed properly. According to Mudiyanselage and Herat (2022), only a small percentage of HHW is sorted and recycled, while the majority of HHW is disposed of together with other municipal waste. At landfills, nearly 70% of municipal solid waste is disposed of and contains hazardous substances in the form of paints, vehicle maintenance products, mercury-containing waste, pharmaceuticals, batteries, and many other products (Adamcová et al., 2015). The general disposal of HW can lead to an increase in hazardous conditions, which are not only potentially hazardous to the environment and health but can also cause changes in other waste streams by reacting directly with the waste or by changing the redox environment (Letcher & Slack, 2019). In addition, HHW can contaminate wastewater treatment systems if discharged directly into sewers, or enter groundwater and surface water causing quality deterioration (Diankha et al., 2020). Toxins can enter the food chain and accumulate in the human body causing genetic mutations, cancer, and birth defects (Fikria et al., 2015).

Long Xuyen City is a grade I urban area directly under An Giang Province, with an inner city area of about 24.4 km^2 and a population of 272,750 people, is a densely populated area with many activities. At the same time, this is one of the major urban centers of the Mekong Delta. Currently, in the city, there is only one hazardous waste treatment plant, Long Xuyen City Hazardous Waste Treatment Plant – An Giang Urban Environment Joint Stock Company. This is considered the first factory in the Mekong River Delta licensed by the Vietnam Environment Administration to treat hazardous wastes. However, the management of hazardous wastes in households in the city is still inadequate. To avoid potential risks associated with HHW, people must always supervise the use, storage, and disposal of such products. Therefore, the assessment of the current status of HHW generation and management in Long Xuyen City, An Giang Province is extremely necessary. The objectives of this study are to (1) determine the level of the HHW generation, (2) the level of HHW management, and (3) assess the knowledge, attitudes, and behaviors of people in Long Xuyen City towards HHW.

2. Materials and methods

2.1. Scope of the study

The study was carried out from June 2022 to June 2023 with HHW in Long Xuyen City, An Giang Province.

2.2. Interviews and samples

To collect information on the level of generation, management, knowledge, attitude, and behavior of people about hazardous waste, the study conducted random direct interviews with households in Long Xuyen City. The sample size was determined according to Slovin's formula (1) (Fikri et al., 2017; Kyere et al., 2019):

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

Where: n is the number of households to be interviewed, and N is the total number of households in Long Xuyen City. At the end of 2022, the whole city of Long Xuyen had 73,146 households. With a 10% allowable error, (Farizal et al., 2019), the total number of households that need to be interviewed to ensure sample size and represent the population in this study is 100 samples. The detailed questionnaire includes contents related to the level of HHW generation and hazardous waste management including classification, collection and treatment, knowledge, attitude, and behavior of households for hazardous waste management.

2.3. Data collection

The study collected hazardous waste samples from 100 households selected throughout Long Xuyen City. Time for collecting waste samples continuously for three months, from December 15, 2022 to March 15, 2023. During the sample collection process, the study equipped each household with garbage bags and labels all types of hazardous wastes on the bags so that people can easily classify them. The list of HHW in this study includes (1) broken fluorescent lamps; (2) waste batteries and accumulators; (3) brushes and rags contaminated with hazardous chemicals; (4) bottles and jars containing hazardous chemicals; (5) damaged electronic equipment and components; (6) broken thermometer, syringe, needle, razor; (7) sharp objects; and (8) packaging, medicine packaging, expired drugs according to regulations of the Ministry of Natural Resources and Environment (2022).

2.4. Measures of knowledge, attitudes, and behavior

For the questions related to the knowledge and behavior of HHW management, each correct answer is counted as 1 and the wrong answer is counted as 0. According to the knowledge classification of Ahamad et al. (2018), a person with a score of 80-100% is assessed as "high knowledge," between 60% and 80% is assessed as "average knowledge," and less than 60% is "low knowledge." While a 5-point Likert scale is applied to questions related to hazardous waste management attitudes, from 1 "strongly disagree" to 5 "strongly agree."

2.5. Data analysis

Determine the percentage composition of various types of hazardous waste according to the Eq (2):

$$\%\, waste\ type\ = \frac{m_i}{m} \times 100 \quad (2)$$

Where: m_i is the volume of the hazardous waste to be calculated (kg) and m is the total volume of waste collected (kg).

The coefficient of waste generation is calculated according to the following Eq (3):

$$Waste\ generation\ coefficient\ (kg/person/day) = \frac{Mass\ of\ solid\ waste}{Number\ of\ household\ members} \quad (3)$$

For qualitative data, the study coded data for themes and patterns together with descriptive statistics showing the mean and percentage (%) using Microsoft Excel software.

3. Results and discussion

3.1. Level of HHW generation

After three months of sampling, the total volume of HHW generated was 78.27 kg with diverse hazardous waste components (Table 1). The average volume of hazardous waste generated by households every day is about 0.87 kg. Besides, the results show that the HHW generation volume is 0.0023 kg/person/day, equivalent to about 0.8395 kg/person/year. Currently, Long Xuyen City has 272,750 people, equivalent to about 228.97 tons of HHW each year. The rate of HHW generation in this area is underestimated compared to some other areas, such as Suzhou City, China (0.0062 kg/person/day) (Gu et al., 2014), Amirkola, Iran (0.0026 kg/person/day) (Amouei et al., 2014), Semarang City, Indonesia (0.01 kg/person/day) (Fikri et al., 2017), and Sleman District, Indonesia (0.0024 kg/person/day) (Iswanto et al., 2019). This difference may be due to usage needs, lifestyles, and economic conditions in each country and locality.

Table 1. *The volume of HHW generated*

No	Type of HHW	Weight (kg)	Ratio (%)
1	Broken light bulb	9.27	11.84
2	Used batteries and accumulators	2.43	3.10
3	Brushes and rags contaminated with hazardous chemicals	7.35	9.39
4	Bottles and jars containing hazardous chemicals	48.99	62.59
5	Damaged electronic equipment and components	2.32	2.96
6	Broken thermometer, syringe, needle	0.69	0.88
7	Sharp objects (glass, broken glass)	7.12	9.10
8	Packaging, pill packaging, expired medicine	0.1	0.13
	Total	**78.27**	**100**

Regarding HHW composition, bottles and jars containing hazardous chemicals account for the highest proportion (accounting for 62.59%). These types of wastes arise from products that meet basic human needs such as fragrance oils, shampoos, dishwashing liquid, clothes softeners, insect spray, paint containers, and pesticides. Next were broken light bulbs (accounting for 11.84%), sharp objects (accounting for 9.10%), and brushes and rags with hazardous chemicals (accounting for 9.39%). The remaining hazardous waste such as used batteries and accumulators; damaged electronic equipment and components; broken thermometers, syringes, needles, razors; and packaging, drug packaging, and expired drugs ranges from 0.13-3.10%. In particular, batteries are used in many devices such as watches, radios, phones, control devices, computers, and MP3 players. The research in Dong Anh

District, Hanoi, identified six groups of HHW including plastic bags containing cleaning products (accounting for 30.2%), bottles containing detergents (accounting for 22.8%), batteries and accumulators (accounting for 18.7%), paint cans (accounting for 15.4%), light bulbs (accounting for 8.4%) and waste electronic equipment (accounting for 4.5%). Among them, waste components "packaging, bottles containing hazardous chemicals" accounts for the largest proportion. This is similar to the results reported by Bui et al. (2022). However, in the Slemen District, Indonesia, electronic equipment, light bulbs and batteries are the largest sources of HHW (Iswanto et al., 2019). Similarly, in Thailand, three groups of HHW account for the majority of paint products (accounting for 20.11%), household batteries (accounting for 17.39%), medicines and packaging (accounting for 14.13%) (Chaiyarit & Intarasaksit, 2021). HHW generation is influenced by many factors, including income level, local customs and culture, consumption patterns, household structure, and lifestyle of the population (Gu et al., 2014; Mudiyanselage & Herat, 2022).

3.2. The level of HHW management

3.2.1. Waste segregation at households

The study found that up to 98% of households in Long Xuyen City do not perform waste separation, which means that hazardous waste is collected and mixed with ordinary domestic solid waste. Only 2% of households sort garbage, but this activity only focuses on batteries. This result is similar to the study of Nguyen et al. (2022) in Hue City, which found that about 97% of people do not separate hazardous wastes from other types of waste. Circular No. 36/2015/TT-BTNMT on hazardous waste management does not specifically mention HHW as well as the obligation to classify hazardous wastes for households. However, this rate in Long Xuyen City tends to be higher than in Mandera, Kenya, with about 87.8% of surveyed households not separating HHW from household waste (Sheikh, 2018). HHW usually accounts for only 1-4% of municipal solid waste, but the potential risks to the environment and health are disproportionate to its size (Letcher & Slack, 2019). Most HW mixed with conventional solid waste are improperly disposed of in landfills which can pose a threat to groundwater and create harmful pollutants in the soil (Xhou et al., 2022). Besides, HHW often contains many different heavy metals such as Pb, Hg, Ni, Cd, and Cr (Chakraborty et al., 2022). Typically, mercury arises mainly from fluorescent lamps and waste batteries (Bui et al., 2022). Mercury exposure can cause various health problems in humans such as neurological disorders, damage to siRNA and DNA, disruption of thyroid function, and even death (Liu et al., 2023). Thereby, it is found that the garbage classification in households in Long Xuyen City has many shortcomings, not meeting the requirements for garbage classification according to the provisions of the Law on Environmental Protection Viet Nam 2020. This can cause many potential risks to the environment and public health.

3.2.2. The level of HHW collection

The collection and transportation of hazardous waste generated in Long Xuyen City is carried out by An Giang Urban Environment Joint Stock Company. Figure 1 shows the HW collection process in the study area. HHW will be transported by specialized means.

Currently, the factory has two specialized vehicles with a tonnage of 1.65 tons/vehicle used to transport all kinds of hazardous wastes. However, the result recorded that only 68% of total households have registered for collection services with the frequency of collection mainly one time/day. For garbage collection services, the household fee is 20,000 VND/month. This fee is consistent with the fee specified in Decision No. 19/2021/QD-UBND of An Giang Province on amending and supplementing several articles of the decisions regulating service prices in An Giang Province (An Giang Province People's Committee, 2021). In some neighboring provinces, such as Dong Thap, for households not doing business, the price for collection and transportation is 24,000 VND/month, while households with production and business have a higher fee depending on the amount of m^3 of waste generated (Dong Thap People's Committee, 2018). In Kien Giang, for households in wards - townships and communes, the service fee is 20,000 VND/month and 10,000 VND/month, respectively, while business households have fees from 40,000-60,000 VND/month (Kien Giang People's Committee, 2017). It can be seen that the fee for collection and transportation of waste does not have a big difference between areas. Therefore, garbage collection is now highly appreciated by the majority of people.

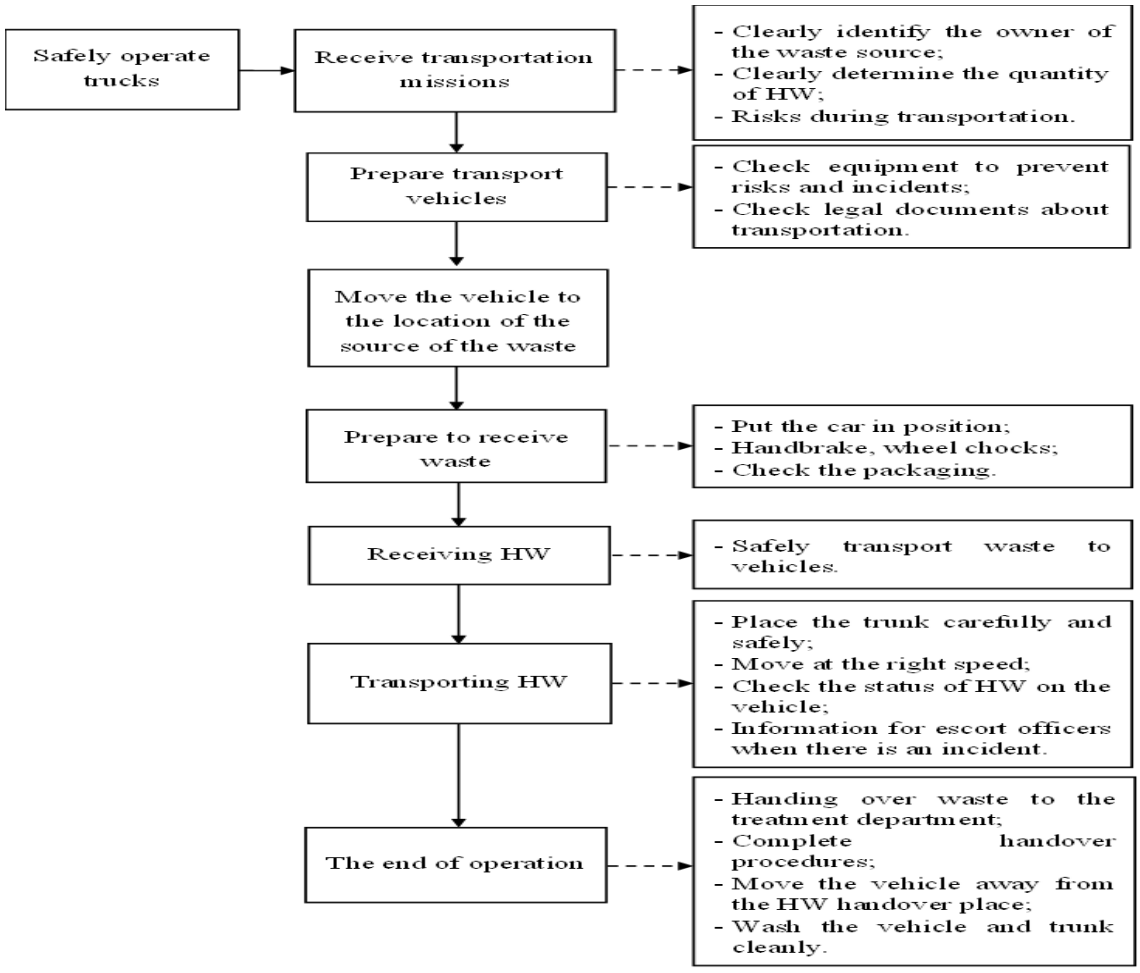

Figure 1. *The HHW collection process in the study area*

3.2.3. The level of HHW treatment

HHW disposal is considered a difficult problem for solid waste managers and policymakers (Wagner et al., 2013). Improper disposal of hazardous wastes can generate toxic substances that cause cancer in humans, hinder the growth of plants and animals, and increase environmental pollution problems, which in turn have the potential to destroy the ecosystem (Elbeshbishy & Okoye, 2019). Figure 2 shows that there are four forms of hazardous waste treatment applied by households in Long Xuyen City. Among them, gathering waste in front of the house without sorting accounts for the highest percentage (66%). Households said that they would bring their waste to the front of the house, not separate hazardous wastes from ordinary garbage, and wait for specialized vehicles to collect and treat them at the Long Xuyen City's hazardous waste treatment plant. Self-transporting unclassified HHW to the collection and treatment site accounts for 2%. This action is considered to cause difficulties in the treatment of hazardous wastes at the factory. Therefore, the separation of waste at the source should be paid special attention by the government, thereby propagating and raising awareness of households about the benefits that garbage classification brings as well as the harmful effects of not segregating waste at the source. Currently, the Long Xuyen City hazardous waste treatment plant is equipped with many modern equipment and technologies, meeting environmental standards according to QCVN 30:2012/BTNMT on hazardous waste treatment, including (1) solid-liquid hazardous waste incinerators and the exhaust gas treatment system operating synchronously with the incinerator, (2) the wastewater treatment system, (3) the waste lamp treatment system of all kinds, and (4) the ash solidification stabilization system of the incinerators for hazardous wastes, broken glass.

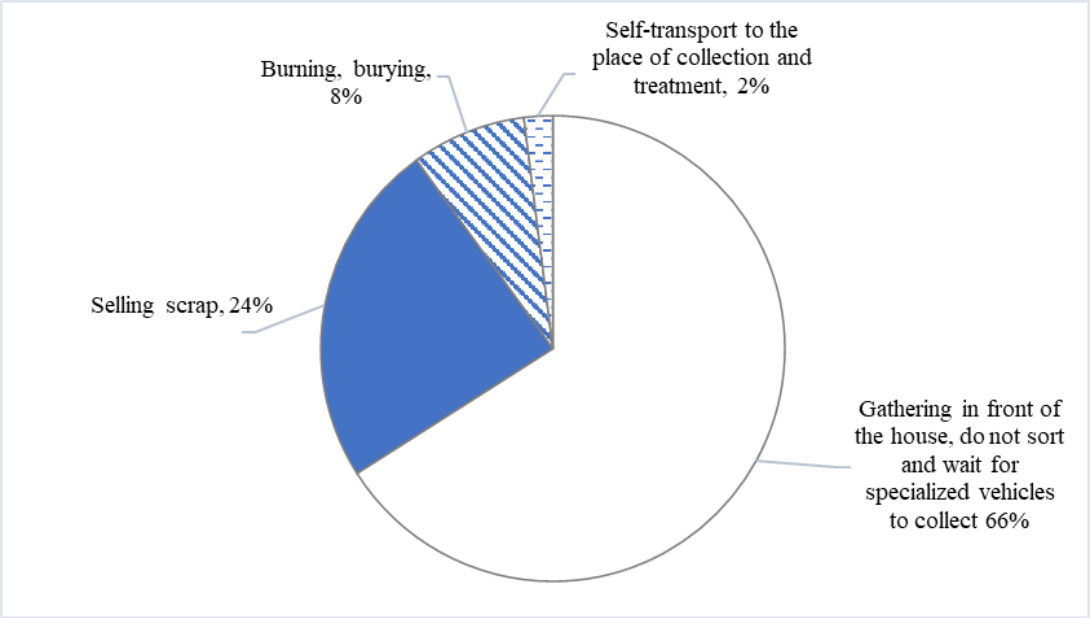

Figure 2. *Ways of treatment of HHW in the study area*

Besides, selling scrap is also applied by the majority of households (accounting for 24%). Selling scrap brings income to people, but this action leads to people storing more and more hazardous wastes in their homes as well as making it more difficult to control the waste stream, and this will affect the health of waste collectors and recyclers (Bui & Pham, 2017; Diankha et al., 2020). The form of burning or burying hazardous wastes accounts for about 8%. Open-air incineration, one of the waste management practices by many people around the world, is an inefficient combustion process, due to lack of oxygen supply and temperature control. The open burning of waste can produce hazardous compounds such as polycyclic aromatic hydrocarbons (PAHs), polychlorinated dibenzo-p-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs) and polychlorinated biphenyls (PCBs), and heavy metals (Ramadan et al., 2022; Okafor et al., 2022). These are substances that have the potential to cause cancer in humans (Okafor et al., 2022). At the same time, greenhouse gases such as carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (NO_x) are also formed from open burning (Okafor et al., 2022). While improperly burying HHW, the potential risks of leachate discharged into water bodies increase significantly, threatening public health (especially children), ecosystems, and the environment (Arbastan & Gitipour, 2022). From the research results, it is found that there are still the majority of households that arbitrarily dispose of hazardous wastes without complying with regulations. Similarly, improper HHW disposal has been reported in many areas. Typically, in Sleman District, Indonesia, HHW is treated by burning open-air or dumping into rivers, landfills, or open ground (Iswanto et al., 2019). Up to 68.6% of households in Hue City have inadequate practice in hazardous waste disposal (Nguyen et al., 2022).

3.3. Knowledge, attitude, and behavior of people towards HHW

3.3.1. People's knowledge about HHW

The study assessed people's knowledge about HHW through seven questions (Figure 3). The results show that people have moderate to high knowledge about HHW, the percentage of households that correctly answer the observed knowledge ranges from 67-98%. According to a report by Manggali and Susanna (2019), people's education level positively affects environmental knowledge and information. In this study, people with a high school education or higher accounted for the largest proportion with 43%.

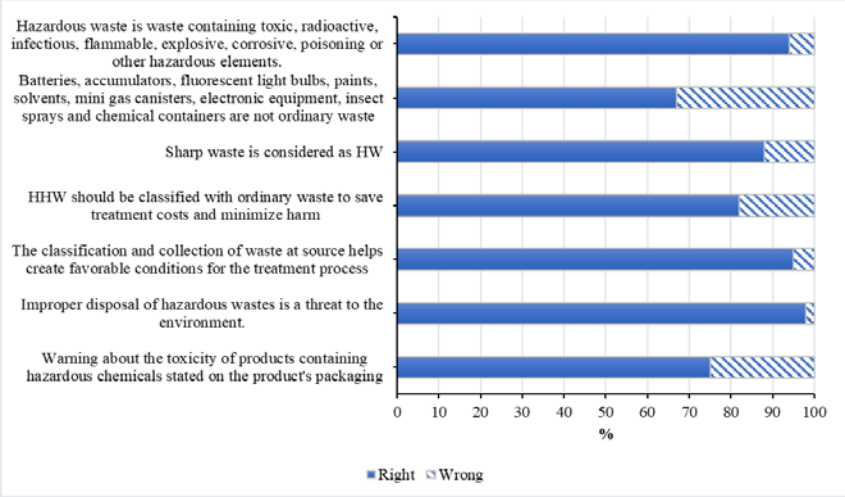

Figure 3. *People's knowledge about HHW*

Households with average knowledge focus on two observed variables: “warning about the toxicity of products containing hazardous chemicals stated on the product's packaging” (accounting for 75%) and “batteries, accumulators, fluorescent light bulbs, paints, solvents, mini gas canisters, electronic equipment, insect sprays, and chemical containers are not ordinary waste” (accounting for 67%). People have good knowledge about the benefits of classification, the consequences of improper disposal of hazardous wastes, and the concept of hazardous waste (ranging from 82-98%). Waste segregation saves valuable resources, typically saving the time needed to dispose of waste, saving money on collection and treatment, and reducing the amount of waste sent to landfills (Otitoju & Seng, 2014; Cheng et al., 2021). While waste management is improper, the unpredictable negative consequences of HHW not only threaten the quality of the environment but also affect public health (Gu et al., 2014; Diankha. et al., 2020). According to the Law on Environmental Protection Viet Nam 2020, hazardous waste is waste containing elements that are toxic, radioactive, infectious, flammable, explosive, corrosive, toxic, or having other hazardous properties. Up to 94% of households have full knowledge of this concept. Having good knowledge helps people to limit the risks and potential hazards caused by HHW. On the contrary, inadequate knowledge is a factor that increases the rate of poor HHW management practices.

3.3.2. People's attitude toward HHW

The study assesses people's attitudes toward HHW management through eight questions (Figure 4). The results show that the percentage of people with attitudes agreeing to strongly agree with the observed variables of attitudes is quite high. This reflects that people in the study area have a positive attitude toward HHW management.

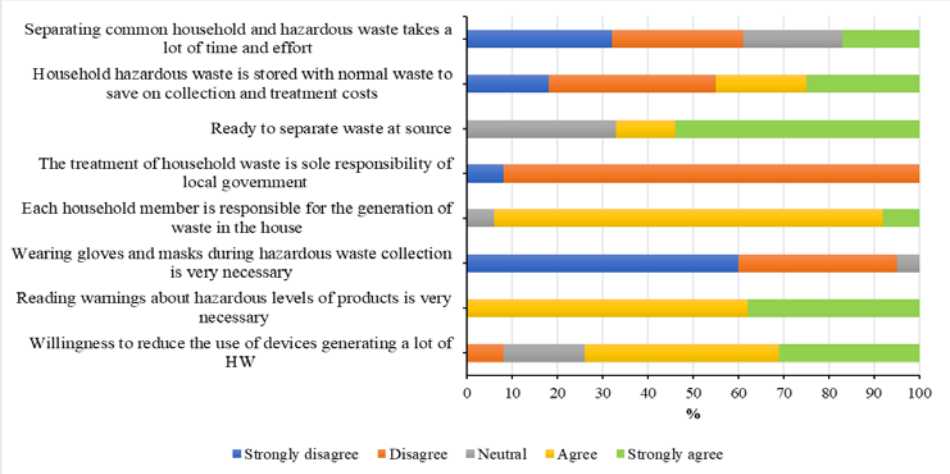

Figure 4. *People's attitude toward HHW management*

Up to 74% of households have a positive attitude toward "willingness to reduce the use of devices generating a lot of HHW." Besides, people said they would choose to buy and use safer and less harmful alternatives. Notably, 100% of households have an attitude of agreeing to strongly agree with the observed variable "reading warnings about hazardous levels of products is very necessary." According to research by Intaraksit and Pitaksanurat (2018), households are paying attention to warning labels on household hazardous products such as chemical names, dangerous poisons, warnings, warning signs, and proper use and storage. This action helps consumers identify the nature and extent of the risks posed by the product, thereby taking measures to prevent and reduce risks. In particular, alarm data printed in red have a higher rate of alert compliance behavior than in green and black (Braun & Silver, 1995). Similarly, most of the households said that "wearing gloves and masks during hazardous waste collection is very necessary" while 95% of households with a positive attitude agreed. This will help limit and prevent harmful chemicals from entering the body. For the observed variable "each household member is responsible for the generation of waste in the house," 94% of households have a positive attitude, and for "the treatment of household waste is the sole responsibility of local government," 100% of households disagreed with this idea. People believe that the government as well as each individual in society share responsibility to properly manage waste. Among them, community participation has a direct influence on effective solid waste management (Mukama et al., 2016). Besides, people have a positive attitude towards waste separation at source, ready-to-sort household hazardous waste and ordinary domestic solid waste (accounting for 67%). Human waste segregation behavior is an important step to control the hazards posed by HHW (Gu et al., 2014).

3.3.3. People's behavior toward HHW

The study assesses households' behavior toward hazardous wastes through 10 questions (Figure 5). The results show that the percentage of households that correctly

answer questions related to behavior is quite low, only ranging from 2% to 44%, except for two behaviors "always keep the label intact on the packaging containing hazardous wastes during use" and "always use up the entire product before disposal" accounts for 90%. This reflects that people in the study area have many problems with HHW management practices that need to be overcome and improved.

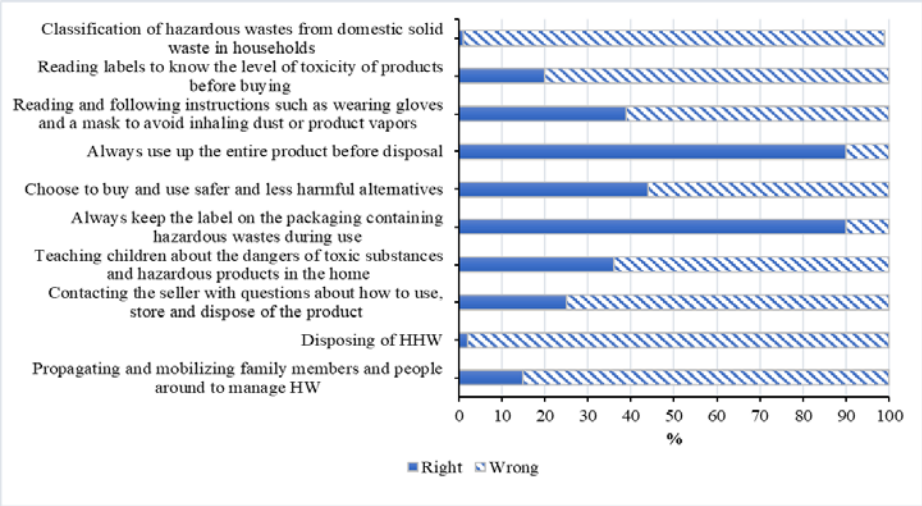

Figure 5. *People's behavior toward HHW management*

Specifically, for the action of "propagandizing and mobilizing family members and people around to manage hazardous wastes such as sorting garbage, minimizing hazardous waste generation,",15% of total households have done it, while 85% of the total households do not. This behavior meant to motivate people around to do well in hazardous waste management, households that have good knowledge and practices need to actively propagate and mobilize people to do so. Notably, up to 98% of households have the behavior of "not classifying HHW" and "disposing of HHW" improperly. It can be seen that households have good knowledge and positive attitudes towards this issue, but the practice is very limited, mainly because people have not had a legal obligation to separate waste at source, the locality has not issued guidelines on waste separation for the people nor propagated the benefits of waste separation at source. This poses many potential risks to the environment and public health. For the act of "contacting the seller with questions about how to use, store and dispose of the product," 25% of households do it, mainly asking how to use the product, while storage issues storage and disposal have not been considered. Up to 64% of households do not "teach children about the dangers of toxic substances and hazardous products in the home." This is considered a potential danger of chemical poisoning in children because young children are inherently hyperactive and are not aware of toxic chemicals (Electronic Newspaper of Health and Life, 2023). For the behavior of "always keep the labels intact on the packaging containing hazardous wastes during use" and "always use up the entire product before disposing of it," up to 90% of households do well. In addition, 56% of households are willing to "choose to buy and use safer and less harmful alternatives." For the behavior

of "reading and following instructions such as wearing gloves and a mask to avoid inhaling dust or product vapors" and "reading labels to know the level of toxicity of products before buying," respectively only 39% and 20% of households do, while 61% and 80% of households do not, respectively. Although the survey results of households' attitudes toward these two behaviors are very good, this will create favorable conditions for harmful chemicals to easily enter the body, leading to health risks.

4. Conclusion

The average volume of HHW generated per day in Long Xuyen City, An Giang is 0.87 kg, with the HHW generation reaching 0.8395 kg/person/year. Among them, bottles and jars containing hazardous chemicals account for the highest proportion of all waste components. Most households do not separate waste at source (accounting for 98%), leading to the situation that HHW are collected and treated together with ordinary domestic solid waste. Besides, only 68% of households have registered for hazardous waste collection services with the frequency of collection once a day. Other common forms of self-treatment are burning and burying (accounting for 8%) and selling for scrap (accounting for 24%). The results showed that people in the study area have good knowledge and positive attitudes toward HHW management, but people's behavior toward HHW management is not satisfactory. This result will help local authorities come up with specific measures to promote proper HHW management behavior in the future, thereby limiting potential risks to the environment and public health.

- ***Conflict of Interest:*** *Authors have no conflict of interest to declare.*
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ĐÁNH GIÁ HIỆN TRẠNG PHÁT SINH VÀ QUẢN LÍ CHẤT THẢI NGUY HẠI HỘ GIA ĐÌNH TẠI THÀNH PHỐ LONG XUYÊN, TỈNH AN GIANG

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TÓM TẮT

Chất thải nguy hại hộ gia đình là một phần quan trọng trong dòng chất thải rắn sinh hoạt, có thể gây tổn hại đáng kể đến sức khoẻ của gia đình, cộng đồng và môi trường nếu không được quản lí đúng cách. Nghiên cứu được thực hiện nhằm đánh giá hiện trạng phát sinh, công tác quản lí chất thải nguy hại hộ gia đình tại thành phố Long Xuyên, An Giang. Nghiên cứu phỏng vấn 100 hộ gia đình và tiến hành thu mẫu chất thải nguy hại trong vòng ba tháng. Kết quả cho thấy, tỉ lệ phát sinh chất thải nguy hại hộ gia đình đạt 0,8395 kg/người/năm. Trong đó, có 62,59% chất thải độc hại là vỏ bình và chai lọ đựng hoá chất nguy hại. Công tác phân loại rác tại nguồn của các hộ gia đình rất kém thông qua 98% hộ dân không phân loại rác thải nguy hại với các chất thải thông thường khác. Chỉ có 68% hộ gia đình có đăng kí dịch vụ thu gom chất thải nguy hại để xử lí tại Nhà máy xử lí chất thải nguy hại thành phố Long Xuyên. Các hình thức xử lí khác chủ yếu là đốt, chôn lấp không hợp vệ sinh (chiếm 8%) và đem bán phế liệu (chiếm 24%). Mặc dù người dân khu vực nghiên cứu có kiến thức tốt, thái độ tích cực đối với công tác quản lí chất thải nguy hại hộ gia đình, tuy nhiên thực hành của người dân đối với quản lí chất thải nguy hại hộ gia đình còn rất kém.

Từ khoá: tỉnh An Giang; chất thải nguy hại hộ gia đình; quản lí; hiện trạng phát sinh