



Knowledge, Behavior, and Household Hazardous Waste Composition: Implications for Environmental Health in Nakhon Nayok Province, Thailand

Jitjira Chaiyarit¹, Kanittha Saengpae², Koranitch Jomkathok², Piyawan Roshom²,
Thananya Seehatab² and Prat Intarasaksit^{2*}

¹Department of Statistics, Faculty of Science, Khon Kaen University, Khon Kaen 40002, Thailand,

²Department of Public Health, Faculty of Physical Education, Sport and Health, Srinakharinwirot University, Bangkok 10110, Thailand

*E-mail : prat@g.swu.ac.th

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Abstract

Improper management of household hazardous waste (HHW) poses serious risks to environmental and public health, particularly in low-resource communities. This study examined the relationship between residents' knowledge and behavior regarding HHW management and assessed the composition of HHW generated at the household level in a community in Nakhon Nayok Province, Thailand. A cross-sectional study was conducted with 41 households using structured interviews and a seven-day HHW collection protocol. Descriptive statistics, Pearson correlation analysis, and physical waste composition assessment were applied. Findings revealed that 87.8% of respondents demonstrated high levels of knowledge, and 68.3% reported good HHW management practices. A statistically significant positive correlation was observed between knowledge and behavior ($r = 0.382$, $p = 0.014$), indicating that increased awareness modestly influenced safer practices. The HHW stream was primarily composed of pesticide containers (31.5%) and fluorescent bulbs (26.02%), reflecting potential environmental hazards in domestic waste streams. These results underscore the need for community-based interventions that combine public education with improved waste segregation systems. Targeted efforts to enhance awareness, infrastructure, and policy enforcement are essential to minimizing the environmental impact of HHW and protecting community health.

Keywords : Household hazardous waste; Waste management behavior; Environmental health; Waste composition analysis

Introduction

Municipal solid waste (MSW) presents a growing challenge for both urban and rural communities worldwide due to its escalating volume and increasingly complex composition [1]. Factors such as rapid urbanization, population growth, and evolving consumption patterns have significantly increased waste generation rates, placing immense strain on existing waste management infrastructure, particularly in developing countries [2]. Inefficiencies in collection, inadequate disposal systems, and limited public

awareness continue to exacerbate both environmental degradation and public health threats [3, 4].

Among the various waste fractions, household hazardous waste (HHW) remains a less visible but highly consequential component of MSW. Although it constitutes a relatively small proportion of the total waste stream, HHW poses a disproportionately high risk to environmental and human health due to its toxic, corrosive, flammable, and reactive properties [5]. Common HHW sources include cleaning agents, disinfectants, pesticides, lubricants, batteries, and fluorescent lamps—many of which are

found in ordinary households and often disposed of improperly [5-7]. The residual contents of these products are hazardous and, when mixed with general waste, can contaminate landfills, leach into groundwater, or cause injuries to waste handlers [8].

HHW is particularly concerning in developing nations where segregation at source is rare and centralized treatment infrastructure is limited. In Thailand, HHW is routinely mixed with general household waste and collected without special handling by local authorities [9]. This practice increases the likelihood of environmental contamination and human exposure, especially among vulnerable populations such as children. Reported health risks include respiratory irritation, chemical burns, and accidental poisonings due to unsafe storage and disposal of hazardous household substances [10]. Inadequate public knowledge and behavioral practices further compound the risks, highlighting the need for targeted education and improved local waste governance [11].

While international studies have addressed HHW generation and its environmental impacts [12, 13], limited empirical research exists in the Thai context—particularly on the interplay between public knowledge, behavioral practices, and the physical composition of HHW at the household level. Understanding this relationship is essential for designing community-specific interventions, improving waste segregation systems, and informing local policy. Most existing studies have relied solely on self-reported knowledge or behavior data without validating those responses through actual waste audits. This approach limits the ability to assess whether awareness truly translates into safer HHW practices. Moreover, empirical data on HHW composition in semi-rural Thai households remain scarce. By integrating survey-based assessments with physical HHW collection and categorization, this study addresses a critical gap in evidence needed to support community-level interventions and policy design.

Therefore, this study aims to address this gap by (a) examining the relationship between knowledge and behavior in managing household hazardous waste, and (b) characterizing and quantifying HHW generated at the source in communities of Nakhon Nayok Province, Thailand.

Materials and Methods

Study Site and Population

This study was conducted in Tha Sai Subdistrict, Mueang District, Nakhon Nayok Province, Thailand. The target population comprised residents from seven villages within the subdistrict. A simple random sampling technique was used to select the study site. All seven villages were listed, and Village No. 5 (Ban Tha Sala) was randomly selected as the sampling location.

Sample Size Calculation

The sample size was calculated using the formula for estimating the population mean with known population size [14]. The population consisted of 155 households in Ban Tha Sala. The calculation was based on a 95% confidence level (CI) ($Z = 1.96$), a standard deviation (σ) of 1.5 derived from a previous study on knowledge of household hazardous waste management in That Subdistrict, Warin Chamrap District, Ubon Ratchathani Province [15], and a margin of error (d) of 0.4.

The sample size (n) was calculated as follows:

$$n = \frac{NZ_{\alpha/2}^2 \times \sigma^2}{d^2(N-1) + Z_{\alpha/2}^2 \sigma^2}$$

Where:

n = required sample size

N = total population = 155 households

$Z_{\alpha/2}$ = standard normal critical value for 95%CI = 1.96

σ = standard deviation = 1.5 (from previous study [15])

d = acceptable margin of error = 0.4

Instrument Design

Data was collected using a structured questionnaire developed specifically for this study, comprising three main sections.

Section 1: General Information

This section included four closed-ended items capturing demographic information: gender, age, household size, and monthly household income.

Section 2: Knowledge of Household Hazardous Waste (HHW)

This section consisted of 15 closed-ended questions assessing participants' knowledge of HHW. Each correct response received one point; incorrect responses were scored zero. Total scores ranged from 0 to 15. Knowledge levels were classified into three categories using equal intervals: 0–5: Low, 6–10: Moderate; 11–15: High.

Section 3: Behavior in HHW Management

Fifteen items assessed HHW management behavior using a five-point Likert scale: “Always,” “Often,” “Sometimes,” “Rarely,” and “Never.” The items included nine positive and six negative statements. Responses were scored such that higher values reflected more desirable behaviors, resulting in total scores ranging from 15 to 75. Behavior levels were classified as: 15–34: Low (needs improvement), 35–55: Moderate, 56–75: High (good behavior). The full questionnaire used to assess knowledge and behavior, the corresponding scoring rules, and the household hazardous waste (HHW) sorting taxonomy applied in this study are provided in the Supplementary Material (Appendices A–C).

Reliability Testing

The questionnaire was pilot tested with 30 individuals from a population similar to the study sample. Internal consistency for the knowledge section was measured using the Kuder-Richardson Formula 20 (KR-20), yielding a coefficient of 0.66, indicating moderate reliability. For the behavior section, Cronbach's alpha was 0.84.

HHW Composition Data Collection

To assess household HHW composition, a structured seven-day waste collection protocol was employed. Data collection was conducted over a continuous seven-day period in May 2025, following ethics approval. The selected timeframe avoided public holidays to better reflect typical household waste generation patterns. Each participating household received a dedicated container for separating HHW from general waste. Prior to the collection period, participants were trained using educational materials—such as posters and leaflets—that clearly explained the definition, types, and examples of HHW. Households were instructed to place items such as expired medications, used batteries, pesticide containers, and fluorescent

bulbs into the provided containers. At the end of the seven-day collection period, the HHW from each household was retrieved, sorted, and categorized by type. Each category was weighed using a calibrated digital scale, and both the total weight and percentage composition of each HHW type were recorded and analyzed accordingly.

Statistical analysis

Data were analyzed using both descriptive and inferential statistics. For categorical (count) data, descriptive statistics included frequency and percentage. For continuous data, mean, standard deviation, median, minimum, and maximum values were calculated to describe central tendency and dispersion. To test the study hypothesis, Pearson's correlation coefficient was employed to examine the relationship between knowledge of household hazardous waste (HHW) and behavior in HHW management. The null hypothesis (H_0) posits that there is no correlation between knowledge and behavior in HHW management, while the alternative hypothesis (H_1) states that a correlation exists. The strength of the correlation was interpreted as follows: a correlation coefficient between 0.00 and 0.30 was considered negligible, 0.31 to 0.50 indicated a low correlation, 0.51 to 0.70 represented a moderate correlation, 0.71 to 0.90 was interpreted as a high correlation, and 0.91 to 1.00 indicated a very high correlation. All analyses were performed using IBM SPSS Statistics version 28.

Research ethics

The study was reviewed and approved by the Human Research Ethics Committee of Srinakharinwirot University, Thailand (reference no. SWUEC-681028)

Results and Discussion

This section presents the demographic and socioeconomic characteristics of the 41 households participating. The majority of respondents were female ($n = 30$, 73.2%), while male respondents accounted for 26.8% ($n = 11$). The mean age was 63.2 years ($SD = 14.02$), with a range of 33 to 91 years and a median age of 62 years. Regarding household size, most participants lived in households comprising three members. The average household size was 3.37 persons ($SD = 1.99$), with household sizes ranging from one to nine members. Concerning

household income, 87.8% of respondents ($n = 36$) provided income information. The mean monthly household income was 9,897.56 Thai Baht ($SD = 14,076.31$), while the median income was 5,000 Baht. Reported income ranged from a minimum of 600 Baht to a maximum of 80,000 Baht per month.

These findings indicate a predominance of older, female respondents with modest household sizes and relatively low-income levels, which may influence their capacity to manage household hazardous waste effectively.

The analysis revealed that most respondents ($n = 36$, 87.8%) demonstrated a high level of knowledge concerning household hazardous waste (HHW). A smaller proportion ($n = 5$, 12.2%) exhibited a moderate level of knowledge. Notably, none of the participants were classified as having low knowledge or falling into the “needs improvement” category.

These findings suggest that the study population possesses a relatively strong awareness of HHW issues, which may be attributed to previous exposure to local public health campaigns, educational materials, or environmental initiatives. However, the absence of respondents in the low-knowledge category warrants further investigation to determine whether this reflects actual awareness or potential response bias.

The results indicated that most respondents ($n = 28$, 68.3%) exhibited good behavior in managing household hazardous waste (HHW), while the remaining 13 participants (31.7%) demonstrated moderate behavior. No respondents fell into the category requiring improvement. This behavioral profile reflects a generally high level of engagement with proper HHW management practices among participants.

Table 1 Socioeconomic of respondents

Characteristics	Number (Percentage)
Sex	
Male	11 (26.8)
Female	30 (73.2)
Age (years)	
Mean $\pm$ SD	63.2 $\pm$ 14.02
Median (Min – Max)	62 (33 – 91)
Household size	
Mean $\pm$ SD	3.37 $\pm$ 1.99
Median (Min – Max)	3 (1 – 9)
Monthly Household Income (THB)	
Mean $\pm$ SD	9,897.56 $\pm$ 14,076.31
Median (Min – Max)	5,000 (600 – 80,000)

Table 2 Knowledge Level of Respondents on Household Hazardous Waste ($n = 41$)

Knowledge Level	Frequency (n)	Percentage (%)
High knowledge	36	87.8
Moderate knowledge	5	12.2
Needs improvement	0	0.0
Total	41	100.0

Table 3 Behavior Level of Respondents in Managing Household Hazardous Waste ($n = 41$)

Behavior Level	Frequency (n)	Percentage (%)
Good behavior	28	68.3
Moderate behavior	13	31.7
Needs improvement	0	0.0
Total	41	100.0

The relationship between respondents’ knowledge of household hazardous waste (HHW) and their behavior in HHW management was analyzed using Pearson’s correlation coefficient. The analysis revealed a statistically significant positive correlation ($r = 0.382$, $p = 0.014$), indicating a low but meaningful association between the two variables. Given that the p -value was less than the threshold of 0.05, the null hypothesis (H_0)—which posits no relationship between knowledge and behavior—was rejected. These findings suggest that individuals with higher levels of HHW-related knowledge were more likely to engage in appropriate and safer waste management practices. Although the correlation strength was modest, the result aligns with previous research highlighting the influence of knowledge on environmentally responsible behavior. This underscores the potential value of targeted educational interventions to promote better household practices in managing hazardous waste.

Knowledge and Behavior in Managing Household Hazardous Waste

The findings revealed that most respondents demonstrated a high level of knowledge regarding household hazardous waste (HHW), with a mean score of 12.07 out of 15. This indicates a strong general understanding of HHW, including its definition, associated health and environmental hazards, and appropriate disposal practices [16, 17]. High accuracy in items related to chemical packaging, fluorescent bulbs, and awareness of community risks suggests that recent public health campaigns or environmental education efforts may have played a role in raising awareness [18, 19]. In terms of behavior, 68.3% of households demonstrated good HHW management practices. These included proper

segregation of waste, use of sealed containers, and disposal via designated hazardous waste collection systems. Such behavior may reflect the influence of Thailand’s national policies and local infrastructure supporting community-level HHW management [5].

However, some unsafe practices persist. These include the reuse of hazardous containers—such as paint cans—and improper disposal of expired medications. This finding aligns with prior studies showing that high knowledge does not always translate into safe behavioral practices due to low-risk perception, convenience barriers, or habitual routines [20].

The Pearson correlation analysis identified a statistically significant but low positive relationship between knowledge and behavior ($r = 0.382$, $p = 0.014$). This suggests that while knowledge is a contributing factor to improved HHW practices, it may not be sufficient alone. Behavioral outcomes are likely influenced by a combination of factors including infrastructure access, convenience, perceived risk, and social norms [21, 22]. These findings reinforce the need for interventions that combine educational outreach with improvements in local waste handling systems and behavioral nudges. While this study provides important insights into HHW management at the household level, it is important to acknowledge that the findings are based on a relatively small sample size ($n = 41$) drawn from a single semi-rural village. This limitation may restrict the generalizability of the results to broader populations. Nevertheless, the observed HHW composition patterns and the knowledge–behavior relationship are broadly consistent with previous community-based studies in similar contexts. Future research involving larger and more diverse populations across different geographic regions is warranted to validate and expand on these findings.

Table 4 Correlation Between Knowledge and Behavior in Household Hazardous Waste Management ($n = 41$)

Variables	Pearson Correlation (r)	p -value
Knowledge of HHW	1	
Behavior in HHW Management	0.382	0.014

Although 87.8% of participants demonstrated high knowledge regarding HHW, this did not fully eliminate unsafe disposal practices. Several underlying factors may explain this gap. First, perceived risk plays a significant role; individuals may underestimate the hazards of certain actions (e.g., reusing pesticide containers or discarding expired medicine into household trash) [20, 21]. Second, convenience and habit influence decision-making—many respondents lack access to specialized disposal infrastructure or have long-standing routines that are difficult to change [22]. Third, social norms and cultural practices can reinforce unsafe methods, particularly in semi-rural contexts [18, 19]. Finally, limited local enforcement and inadequate collection systems may reduce motivation to act on knowledge [5, 6]. These findings underscore the need for interventions that combine awareness with practical systems and community engagement.

Composition of Household Hazardous Waste

A total of 7.3 kilograms of household hazardous waste (HHW) was collected during the 7-day study period from 41 participating households, which collectively comprised 138 individuals. This corresponds to an average generation rate of approximately 0.178 kilograms per household and 0.053 kilograms per capita. These figures provide additional context for the percentage-based composition data shown in Figure 1. The HHW composition analysis showed that pesticide containers were the most common waste type, accounting for 31.5% of the total volume collected. This was followed by fluorescent bulbs (26.02%), paint containers and household cleaning products (each 9.58%), electronic waste (8.21%), engine oil containers (5.47%), and thinner bottles (5.47%). Less common items included laundry cleaning products (2.73%) and electrical wires (1.36%). These findings reveal that chemical- and lighting-related materials dominate the HHW stream, reflecting household practices typical of semi-rural or agricultural communities, where pesticide use is common and fluorescent lighting remains prevalent [23, 24]. The presence of items such as electronic components, engine oil containers, and solvent bottles suggests increased access to commercial and industrial-grade household products, which may not be disposed of safely without adequate public guidance.

Even less frequently occurring HHW items, such as laundry cleaners and electrical wires, represent potential health and environmental hazards if improperly managed. These materials can leach toxic substances into the environment or pose fire and injury risks if not segregated and processed appropriately [25-27].

The diversity of HHW types identified in this study highlights the urgent need for community-level interventions that promote safer handling, facilitate waste separation at source, and expand accessible collection infrastructure—particularly in semi-rural settings where mixed waste collection remains the norm.

As shown in Figure 1, pesticide containers accounted for the largest share of household hazardous waste (31.5%), followed by fluorescent bulbs (26.02%). Paint containers, household cleaning products, and electronic waste each comprised around 9-10% of the total. Less prevalent items included engine oil containers, thinner bottles, laundry cleaning products, and electrical wires.

These findings highlight the predominance of chemical-based and lighting-related waste in semi-rural households, likely reflecting common domestic and agricultural practices. The data underscore the need for improved community-level HHW collection infrastructure and targeted public education to address the safe disposal of hazardous materials.

The predominance of pesticide containers (31.5%) and fluorescent bulbs (26.02%) among the HHW stream poses significant environmental and health concerns. Pesticide containers often retain hazardous residues, and improper disposal (e.g., burning, reuse, or disposal of general waste) can lead to soil and water contamination or accidental poisoning. Fluorescent bulbs contain mercury vapor, which is highly toxic if released through breakage during storage or collection. These findings suggest an urgent need for safe storage guidelines at the household level and accessible drop-off systems for such high-risk items. Local governments should consider policy interventions to promote safe handling, including public education, enforcement of proper disposal standards, and investment in HHW-specific infrastructure. Risk-based prioritization of HHW categories—such as chemical and mercury-containing items—could help optimize limited resources and reduce community-level exposure risks.

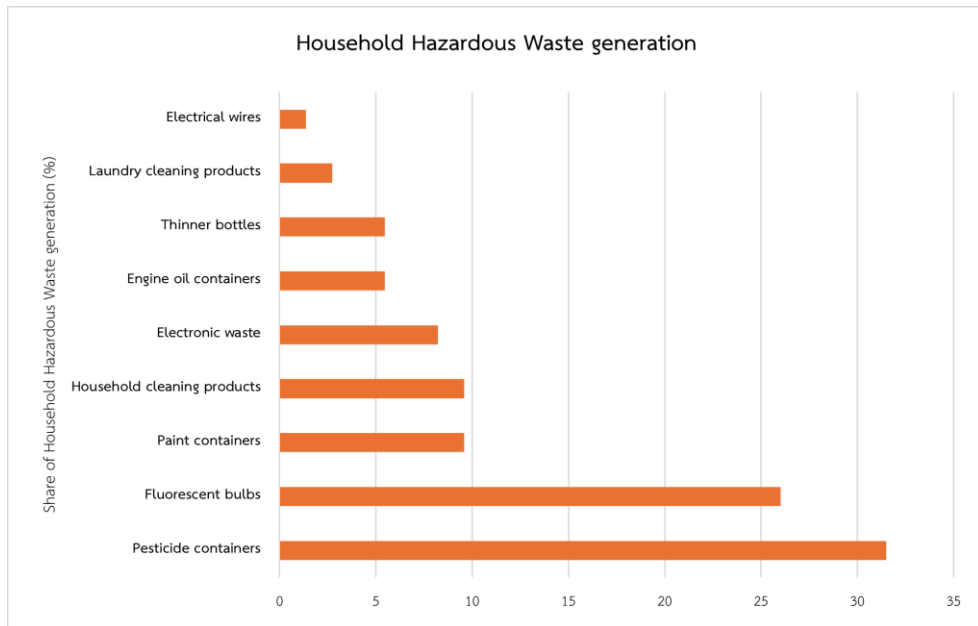


Figure 1 Percentage Composition of Household Hazardous Waste by Type (n = 41 households)

The use of pre-distribution educational materials (e.g., posters, brochures) in this study proved effective in improving source separation and HHW tracking. This aligns with prior studies demonstrating that providing households with knowledge *before* the act of disposal can significantly influence behavioral outcomes [28, 29]. Integrating public awareness campaigns with practical tools—such as clearly labeled containers and visual guides—can strengthen safe HHW practices in resource-limited settings.

Despite its contributions, this study has several limitations. First, the sample size was relatively small (41 households) and drawn from a single village, limiting generalizability. Second, self-reported knowledge and behavior data may be subject to social desirability bias. Although training and anonymity were used, some bias may persist. Third, the HHW audit was conducted over a single week in May, and seasonal variation could not be assessed. Finally, while regression analysis was considered, insufficient power (post hoc power = 0.481) limited its feasibility. Future research should involve larger, more diverse samples, cover multiple time points, and apply multivariate methods to better understand the knowledge–behavior gap and inform targeted interventions.

Conclusions

This study found that households in Ban Tha Sala, a semi-rural community in Nakhon Nayok Province, generally exhibited high levels of knowledge and good behavior regarding the management of household hazardous waste (HHW). However, the modest positive correlation between knowledge and behavior suggests that awareness alone does not guarantee safe disposal practices. The predominance of pesticide packaging and fluorescent bulbs in the HHW stream points to context-specific risks linked to agricultural and domestic lighting practices.

While these results are rooted in the conditions of Ban Tha Sala, they also mirror challenges faced by other semi-rural areas across Thailand, where HHW is often mixed with general waste due to infrastructural limitations and the absence of targeted local waste policies. Addressing these issues requires more than education alone. Community interventions should combine awareness campaigns that address behavioral norms and perceived risks with practical solutions, such as designated HHW drop-off points and integration of HHW management into school curricula and local health promotion activities.

At the policy level, local administrative organizations (LAOs) can utilize the study findings to inform planning and budgeting for HHW-specific services. For example, evidence from this study supports the establishment of household-level HHW collection points, community-based educational initiatives, and integration of HHW management into existing health promotion campaigns. In addition, collaboration between LAOs and national agencies could help standardize HHW protocols and secure sustainable funding mechanisms. These steps would help bridge the current implementation gap between knowledge and behavior while building long-term community resilience in waste governance. Further studies with expanded sampling frames are recommended to enhance the external validity of findings and support the development of scalable HHW management strategies at regional and national levels.

Supplementary Material

Supplementary data associated with this article, including the full questionnaire (Appendix A), scoring rules (Appendix B), and the HHW sorting taxonomy (Appendix C), are available in the online version of the paper.

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