Identification of hazardous solid waste (HSW) at Universitas Andalas, Limau Manis campus, Padang City

Yenni Ruslinda[1, 2*] and *Atika* Aisyah Honesty[1]

[1]Departement of Environmental Engineering, Faculty of Engineering, Universitas Andalas, Padang, 25163, Indonesia
[2]Doctoral Programme in Environmental Engineering, Faculty of Engineering, Universitas Andalas, Padang, 25163, Indonesia

Abstract. In its operations, the Universitas Andalas Limau Manis Campus generates hazardous solid waste (HSW); however, no specific management is in place. This study aims to identify the HSW generated at Universitas Andalas Limau Manis Campus, including analyzing the waste generation rate, composition, and characteristics. Measurements were conducted at 36 sampling points representing office, academic, student, and other campus activities, with a confidence level of 99.92%. The analysis revealed that the specific HSW waste generation rate was 0.56 ± 0.28 g/person/day (0.10 ± 0.03 g/m²/day) by weight or 2.89 ± 1.19 mL/person/day (0.56 ± 0.16 mL/m²/day) by volume. The total HSW generation was 37.59 kg/day (169.68 L/day), accounting for 1.6% of the campus's total waste. The composition of HSW includes HSW products 0.58%, HSW packaging 23.43%, electronic waste 46.35%, and expired or off-specification HSW products 29.65%. The HSW characteristics identified were toxic 76.70%, corrosive 13.19% and flammable 10.11%. Currently, HSW is mixed with non-HSW and ends up in landfills, except for electronic waste, which is stored in warehouses. This situation poses risks to health and the environment, thus highlighting the need for a specific HSW management plan.

1 Introduction

Solid waste management is a critical issue on university campuses due to the diverse range of activities that contribute to solid waste generation. One particular type of solid waste that requires special attention is hazardous solid waste (HSW), given its potential to harm human health and pollute the environment if not properly managed [1].

Improper management of HSW can cause more serious environmental impacts compared to regular waste, as it can contaminate soil, water, and air, and even enter the food chain. Though not always immediately evident, certains types of HSW can cause injury, burns, and poisoning, and can trigger health problems such as respiratory difficulties, dizziness, eye and skin irritation, and even cancer. HSW is also linked to environmental issues, including ozone layer depletion. This is because HSW shares similar characteristics with hazardous waste—namely, flammability, explosiveness, corrosiveness, toxicity, and infectiousness [2].

According to the Ministry of Environment and Forestry Regulation No. 9 of 2024 concerning the Management of Hazardous and Toxic Waste and Residues, HSW includes household products containing hazardous substances, used HSW packaging, broken electronic items, and expired or off-specification hazardous products. HSW products include used batteries, mothballs, rat poison, nail polish, mercury thermometers, and contaminated textiles. Used HSW packaging includes containers for aerosol cleaners, cosmetics, insecticides, fungicides, disinfectants, wood cleaners, bleach, hair dye, medications, paint, thinner, and shoe polish. Electronic waste includes computers, lamps, batteries, and other electronic devices. Expired or off-specification HSW includes expired medicines or damaged packaging of hazardous products [3]. The characteristics of hazardous waste can be grouped into explosive, flammable, reactive, infectious, corrosive and toxic [4].

Located in Limau Manis, Pauh District, Padang City, Universitas Andalas had a population of 35,202 students, 1,565 faculty members, and 1,401 administrative staff in 2025. The campus generates both organic and inorganic waste, including HSW. Organic waste such as yard waste is currently processed at the university's Integrated Waste Processing Center (PPST) using rotary kiln composting and biodrying technologies through the Waste Processing at Source (TOSS) system. According to a study by Ruslinda (2024), the solid waste generation at Universitas Andalas, Limau Manis Campus was 0.592 kg/person/day (0.00163 kg/m²/day) by weight and 0.5245 L/person/day (0.02945 L/m²/day) by volume, with biodegradable waste being the dominant type at 49.61%. HSW comprised 1% of the total solid waste generated [5]. However, that study did not identify HSW waste composition, characteristics, or management. Therefore, this study aims to identify the generation, composition, characteristics, and management practices of HSW. The resulting data can be used to plan HSW management on campus.

* Corresponding author: yenni@eng.unand.ac.id

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2 Research methodology

The stages of this research consisted of secondary data collection, primary data collection, and data processing and analysis. The required secondary data included the number of facilities, area, and number of occupants in each facility, as well as previous research on waste at Universitas Andalas. The primary data included the amount, composition, characteristics, and current management of HSW from each facility. The amount and composition of HSW were obtained through direct field measurements, while information on existing HSW management was gathered through site observations and interviews with facility managers.

The first step in measuring HSW generation and composition involved determining the number of HSW samples and preparing the necessary tools for the research. Sample determination was based on SNI 19-3964-1994 regarding the Method for Sampling and Measuring Urban Waste Generation and Composition, which recommends sampling 10% of the total number of facilities [6]. As a result, 36 sampling points were selected with a confidence level of 99.92%. These sampling points represented office, academic, student, and other campus activities. The number of samples per activity is shown in Table 1, and the sampling location map is shown in Fig. 1.

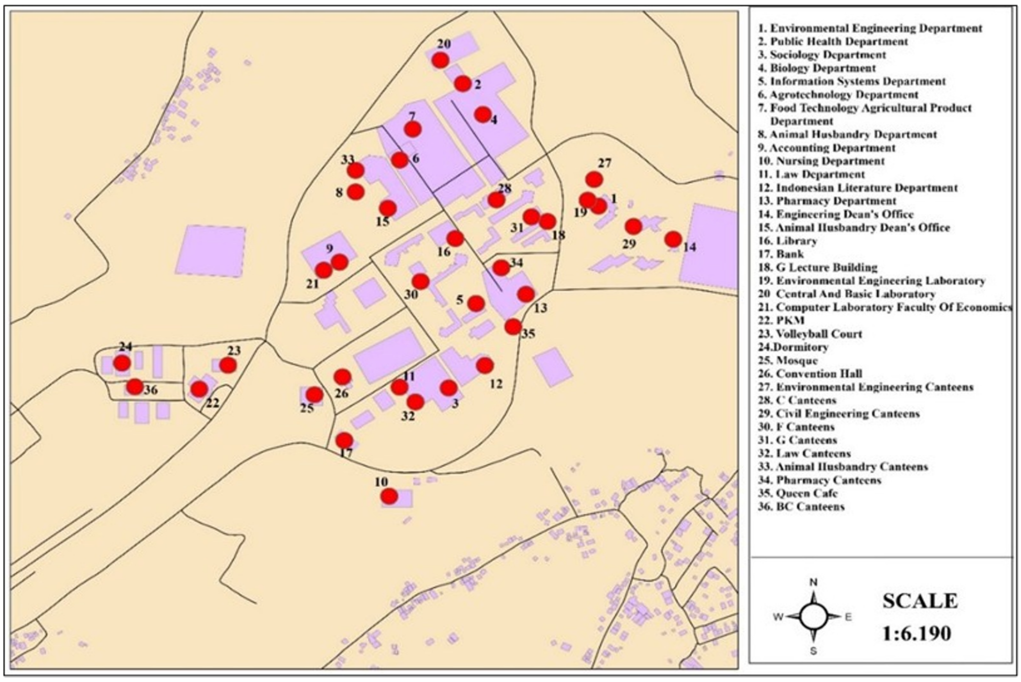

Fig. 1. Sampling point map

Table 1. Number of waste samples per activity

No	Facility Type	Total Facilities	Sample
	Campus Activities		
1	**Office Activities**		
	Study Program/Department	128	13
	Dean's Office	16	2
	UPT	6	1
	Bank	4	1
2	**Academic Activities**		
	Lecture Buildings	10	1
	Laboratories	23	3
3	**Student Activities**		
	Student Facilities	7	1
	Sports Facilities	7	1
	Dormitories	9	1
4	**Other Activities**		
	Worship Facilities	7	1
	Convention Hall	1	1
	Canteens/cafes	95	10
	Total	313	36

Sampling was conducted weekly for two months because HSW is not generated daily; sometimes, it is produced weekly or monthly. Before sampling, the respondents in each facility were briefed on the types of HSW and the potential risks if not properly managed. HSW was collected using plastic bags distributed to each sampling point, and respondents were instructed to collect HSW in the bag for one week. Electronic waste was documented by recording the number and brand of damaged or unused electronics, assuming they would eventually become e-waste.

Collected HSW was retrieved weekly. The total generation was then calculated both by weight and by volume. Weight measurements were made using scales, while volume measurements involved placing the waste in a compactor, pressing it three times, and recording the volume. Waste composition was determined by sorting HSW by type, based on Ministry Regulation No. 9 of 2024, and weighing each category. Waste characteristics were identified based on Government Regulation No. 22 of 2021 and weighed by characteristic type. Table 2 shows the types and characteristics of HSW identified.

Table 2. Types and characteristics of HSW

Type of HSW			HSW Characteristics
Household products containing hazardous substances	a.	Used batteries	a. corrosive [7]
	b.	Mothballs	b. toxic [8]
	c.	Rat poison	c. toxic [8]
	d.	Nail polish	d. toxic [7,8]
	e.	Mercury thermometer	e. toxic [8]
	f.	Fabrics contaminated with hazardous and toxic	f. toxic [8]
Used packaging of products containing hazardous substances	a.	Used aerosol containers (e.g., hairspray)	a. flammable [7]
	b.	Used floor/ceramic cleaner containers	b. corrosive [7]
	c.	Used cosmetic containers	c. toxic [8]
	d.	Used insecticide containers	d. toxic [8]
	e.	Used pesticide containers	e. toxic [7]
	f.	Used fungicide containers	f. toxic [7,8]
	g.	Used disinfectant containers	g. corrosive [8]
	h.	Used wood cleaner containers	h. corrosive [7]
	i.	Used fabric bleach containers	i. corrosive [7]
	j.	Used hair dye containers	j. toxic [7]
	k.	Used medicine containers	k. toxic [8]
	l.	Used ink containers	l. flammable [7]
	m.	Used thinner containers	m. flammable [7]
	n.	Used shoe polish containers	n. flammable [7]
Damaged or unused electronic devices	a.	Lithium dry cell batteries	a. corrosive [7]
	b.	Non-lithium dry cell batteries	b. corrosive [7]
	c.	Wet cell batteries	c. corrosive [7]
	d.	Video cassette recorders	d. toxic [7]
	e.	Antennas	e. toxic [8]
	f.	DVD players	f. toxic [8]
	g.	Communication devices	g. toxic [8]
	h.	Personal computers	h. toxic [8]
	i.	Laptops	i. toxic [8]
	j.	Connector cables	j. toxic [8]
	k.	Stereo systems	k. toxic [8]
	l.	Fax machines	l. toxic [8]
	m.	Printers	m. toxic [8]
	n.	Electric fans	n. toxic [8]
	o.	Air purifiers	o. toxic [8]
	p.	Mixers	p. toxic [8]
	q.	Bread makers	q. toxic [8]
	r.	Toasters	r. toxic [8]
	s.	Washing machines	s. toxic [8]
	t.	Air conditioners	t. toxic [8]
	u.	Televisions	u. toxic [8]
	v.	Lamps	v. toxic [8]
	w.	Irons	w. toxic [8]
	x.	Power banks	x. toxic [8]
	y.	Battery- or electricity-powered toys	y. toxic [8]
	z.	Electric stoves	z. toxic [8]
	aa.	Shavers	aa. toxic [8]
	bb.	Other household electric appliances	bb. toxic [8]
Expired or off-specification hazardous products	a.	Expired medicines and products	a. toxic [7]
	b.	Hazardous and toxic-containing products with damaged packaging	b. toxic [8]

The data on existing HSW management were obtained through direct observation at each facility and interviews with facility managers responsible for waste handling.

The interview questions covered aspects of HSW reduction strategies that had been implemented including limitation, reuse, and recycling efforts, as well as the handling of HSW, encompassing segregation, collection, transportation, treatment, and final disposal.

The analysis of HSW generation involved calculating the specific waste generation rate and the total HSW generated, both by weight and by volume, using the following equations:

Weight-based generation rate:

$$q=\frac{W}{P} \quad \text{or} \quad q=\frac{W}{A} \tag{1}$$

Volume-based generation rate:

$$q=\frac{V}{P} \quad \text{or} \quad q=\frac{V}{A} \tag{2}$$

Where:

q = specific waste generation rate (g/person/day, g/m^2/day or mL/person/day, mL/m^2/day)

W = weight of HSW (g)

P = number of people at the sampling point

A = area of the sampling point (m^2)
V = volume of HSW (ml)

Subsequently, the total amount of HSW was calculated by multiplying the specific waste generation rate by each facility's population or area. For electronic waste, the estimation of waste generation also took into account the service life of each electronic item, using the following equation [9]:

$$E=\frac{W\times N}{L} \quad (3)$$

Where:
E = estimated quantity of electronic waste
W = weight of the electronic item
N = number of elcetronic units
L = average service life (years).

The percentage of HSW within the total campus waste was obtained by dividing the total HSW by the overall campus waste generation. The total campus waste was projected by extrapolating the specific waste generation rate at Universitas Andalas Limau Manis Campus from 2024 to 2025, according to this HSW study. The equations used for the projection of future waste generation are as follows:

$$q_n= q_o(1+C_s)^n \quad (4)$$

$$C_s= \frac{[1+(Ci+Cp+Cqn)/3]}{[1+p]} \quad (5)$$

Where :
q_n = specific waste generation rate in year *n*
q_o = specific waste generation rate in the base year
C_s = city growth factor
C_i = industrial growth rate
C_p = agricultural growth rate
C_{qn} = income per capita growth rate
p = population growth rate.

The analysis of the composition and characteristics of HSW was conducted using the following equation :

$$C=\frac{W_{HSW}}{WT}\times 100\% \quad (6)$$

Where:
C = Composition (%)
W_{HSW} = Weight of the HSW waste component (kg)
W_T = Total measured waste weight (kg)

The analysis of existing HSW management was carried out by processing interview data with facility managers, field observations, and comparison with relevant regulations, particularly the Ministry of Environment and Forestry Regulation No. 9 of 2024 concerning HSW management. The analysis focused on both waste reduction and treatment measures. This analysis formulated recommendations for the HSW management system at Universitas Andalas Limau Manis Campus, integrated into the existing waste management framework.

3 Results and discussion

3.1 HSW waste generation

HSW generation at Universitas Andalas exhibited variation across locations with different activity types, as presented in Table 1. The average specific generation rate of HSW at Universitas Andalas Limau Manis Campus was 0.56 ± 0.28 g/person/day or 0.10 ± 0.03 g/m²/day by weight, and 2.89 ± 1.19 mL/person/day or 0.56 ± 0.16 mL/m²/day by volume. This value is significantly higher than the specific HSW generation rates previously recorded at higher education institutions in Padang City. A 2014 study reported a HSW generation rate of 0.0006 g/m²/day by weight or 0.0008 mL/m²/day by volume [10]. The increased value observed in this study is attributed to including electronic waste measurements.

Based on the calculations, the total HSW generation at Universitas Andalas Limau Manis Campus in 2025 was 37.59 kg/day or 169.68 L/day. The primary sources of HSW were activities conducted by academic departments, laboratories, and canteens. The types of HSW generated by academic departments included electronic waste and sanitary pads. At the same time, laboratories produced electronic waste and expired chemical packaging resulting from practical sessions and research activities. In canteens, HSW primarily consisted of cigarette butts.

For comparison, the HSW generation from four faculties and one facility at Indonesia University was recorded at 0.078 kg/day, with the most common waste types being sanitary pads, expired medications, and air freshener packaging. In this study, the dean's office at Universitas Andalas generated 0.86 kg/day of HSW. The difference in figures is partially due to including electronic waste measurements in the present study. At the Institut Teknologi Sepuluh Nopember (ITS), laboratory-generated HSW was recorded at 0.9 kg/day, consisting of contaminated gloves, masks, and tissues. In contrast, laboratories at Universitas Andalas produced 4.90 kg/day of HSW, with the main types including batteries, lamps, medications, and floor cleaning agents [11].

The proportion of HSW at Universitas Andalas Limau Manis Campus in 2025 reached 1.6% of the total campus solid waste, higher than the 1% recorded in 2023. Similarly, Nahdlatul Ulama University, reported a HSW proportion of 1%, while Jahangirnagar University reported 0.5%, CCSHAU and LUVAS campuses recorded 0.34% [12], and Ifugao State University Potia Campus reported 0.84% [13]. These differences in HSW proportions can be attributed to variations in campus activities, academic community size, campus area, research periods, and the type of HSW measured. The relatively high percentage at Universitas Andalas is primarily due to the inclusion of electronic waste in the measurement scope, as detailed in Table 3.

Table 3. HSW generation at Universitas Andalas

Facility	Specific Generation Rate (by Weight)		Specific Generation Rate (by Volume)		Total HSW Generation (by Weight)	Total HSW Generation (by Volume)
	g/person/day	g/m²/day	mL/person/day	mL/m²/day	Kg/day	L/day
Office Activities						
Study Program/Department	0.38±0.12	0.02±0.01	1.56±1.08	0.09±0.06	18.47	76.51
Dean's Office	1.14±0.88	0.04±0.03	4.61±3.19	0.15±0.10	0.86	3.48
UPT	0.38±0.25	0.02±0.01	1.51±0.74	0.07±0.03	0.76	3.03
Bank	0.78±0.32	0.05±0.02	4.47±1.62	0.29±0.10	0.16	0.89
Academic Activities						
Lecture Buildings	0.14±0.05	0.03±0.01	0.31±0.28	0.063±0.06	3.93	9.04
Laboratories	1.23±0.59	0.14±0.07	6.04±1.49	1.07±0.20	4.90	24.06
Student Activities						
Student Facilities	0.45±0.28	0.01±0.004	2.47±1.01	0.04±0.02	0.47	2.59
Sports Facilities	0.98±0.37	0.10±0.04	5.20±1.97	0.52±0.20	0.18	0.73
Dormitories	0.26±0.05	0.07±0.01	0.60±0.19	0.16±0.05	0.69	1.63
Other Activities						
Worship Facilities	0.32±0.18	0.03±0.02	4.30±1.89	0.46±0.20	1.108	15.04
Convention Hall	0.20±0.17	0.018±0.016	0.84±0.76	0.08±0.07	0.08	0.34
Canteens/cafes	0.49±0.12	0.60±0.14	2.62±081	3.35±0.82	6.02	32.34
Average	**0.56±0.28**	**0.10±0.03**	**2.89±1.19**	**0.56±0.16**	**37.59**	**169.68**

3.2 Composition of HSW

The composition of HSW at Universitas Andalas Limau Manis Campus is predominantly made up of electronic waste, which accounts for 46.35% of the total HSW generated. This is followed by expired or off-specification hazardous and toxic products, comprising 29.65%, including items such as sanitary pads and cigarette butts. Meanwhile, used packaging waste from hazardous and toxic products - such as packaging for floor cleaners, toilet disinfectants, and chemical substances - accounts for 23.43%. Lastly, household products containing hazardous and toxic substances contribute 0.58% of the total HSW, represented by contaminated cloth materials. Figure 2 illustrates the average composition of HSW at Universitas Andalas Limau Manis Campus.

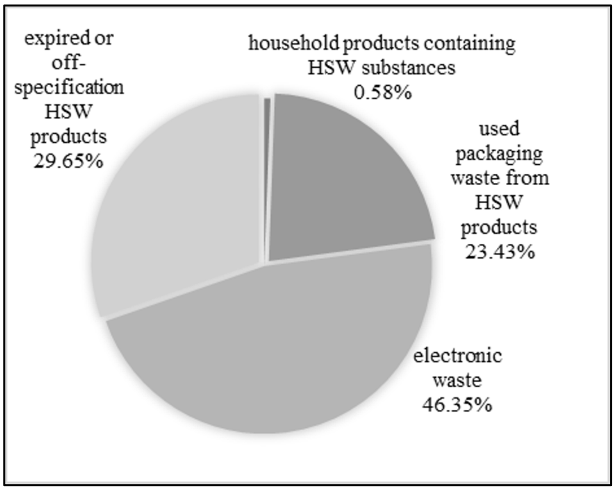

Fig. 2. Composition of HSW at Universitas Andalas

Floor and glass cleaner packaging represents one of the most frequently encountered types of HSW waste, accounting for 17.88%, or nearly one-fifth of the total HSW waste. Additionally, a significant portion of the HSW waste comprises products containing hazardous substances in damaged packaging, such as sanitary pads and cigarette butts. Electronic waste commonly includes air conditioners, personal computers, electric fans, printers, and damaged electrical cables

3.3 Characteristics of HSW

Regarding hazardous properties, most HSW at Universitas Andalas Limau Manis Campus are classified as toxic, comprising 76.70% of the total. This indicates a potential threat to human health and the environment if improperly managed. Toxic HSW includes mothballs, nail polish, used cosmetic containers, bleach containers, personal computers, laptops, and expired medications. Corrosive HSW accounts for 13.19%, including items such as used packaging of floor and glass cleaners and batteries. Meanwhile, flammable HSW represents 10.11% of the total and consists of used ink containers and thinner packaging. Figure 3 illustrates the characteristics of HSW at Universitas Andalas Limau Manis Campus.

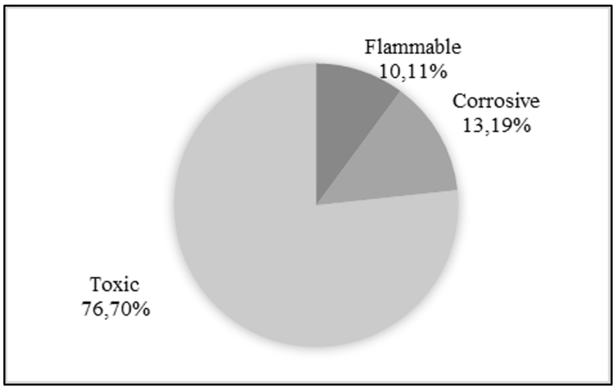

Fig. 3. Characteristics of HSW at Universitas Andalas

3.4 Existing HSW management

Based on interviews with facility managers and direct observations across various facilities, it was found that HSW reduction efforts at Universitas Andalas have been implemented through several campus activities, primarily by selecting environmentally friendly products with longer service lives. One concrete step taken is using more durable and recyclable items, such as LED lamps. These lamps save energy and reduce the frequency of waste generation due to their extended lifespan. A study by Fabanyo (2023) showed that LED lamps have a service life of 9 to 10 years—significantly longer than conventional fluorescent (TL) and essential lamps, which typically last around 3 years [14]. In addition, procuring products in large-sized packaging also serves as an effective strategy to minimize the volume of packaging-related HSW.

HSW segregation at Universitas Andalas is currently only practiced in laboratories, while in non-laboratory activities such as offices, student areas, and public facilities, HSW segregation systems have not yet been implemented. Typically, HSW is mixed with general waste and disposed of in the available waste bins. This mixed waste is then transported to the Air Dingin landfill for burial. The availability of designated HSW containers remains limited, and not all facilities are equipped with proper HSW bins.

Science and technology laboratories have demonstrated better practices in HSW management. These include collaborations with licensed third-party service providers responsible for transporting HSW to processing, recovery, and final disposal facilities. The types of HSW managed include expired chemical packaging. For instance, a laboratory in the Department of Environmental Engineering has established a Temporary Storage Facility (TPS) for HSW, enabling the safe storage of hazardous waste before collection by licensed transporters. Similarly, the Universitas Andalas Hospital has also established a TPS for storing medical and non-medical HSW. HSW that is transported by licensed parties is weighed and documented using a standardized HSW manifest system.

The management of non-functional electronic equipment has not yet received specific attention. Electronic waste is typically stored in storage rooms across several buildings. These items must undergo an asset devaluation (write-off) process as an administrative requirement before being destroyed. This process often takes a significant amount of time, leading to the accumulation of electronic waste. Such accumulation poses a risk if the equipment becomes damaged, cracked, or broken, potentially releasing hazardous substances into the surrounding environment. Exposure to toxic materials from electronic waste can endanger human health and ecological systems. Therefore, there is an urgent need to improve the overall HSW management system, including raising campus-wide awareness, providing adequate waste storage facilities, and developing internal policies to ensure safe, systematic, and sustainable HSW handling practices.

3.5 Recommendations for HSW management

3.4.1 Recommendations for HSW reduction

Efforts to reduce HSW at Universitas Andalas should be aligned with the Ministry of Environment and Forestry Regulation No. 9 of 2024, which outlines three main approaches : source reduction, recycling, and reuse. Source reduction can be implemented by gradually replacing conventional light bulbs with longer-lasting alternatives such as LED lamps, which do not contain mercury and offer high energy efficiency. LED lamps directly reduce the frequency of replacements and minimize the amount of used lamps, which are classified as HSW. Additionally, selecting products with clear instructions for use, storage, and post-use management is important to minimize the potential generation of hazardous waste. The procurement of electronic devices should consider sustainability factors, including durability, repairability, and recyclability. Recycling can be applied to waste materials that retain utility value after processing. For instance, electronic waste containing precious metals can be reprocessed into industrial raw materials by companies licensed to recycle HSW. This approach not only reduces HSW but also supports the circular economy.

Reuse refers to the repeated use of HSW, partially or wholly, by licensed HSW utilization companies. An example is the collection of used packaging for floor cleaners or chemicals through drop boxes provided by partner companies in collaboration with Universitas Andalas. These packages can be washed and refilled with HSW products using environmentally friendly materials. Furthermore, certains types of HSW also have the potential to be utilized as alternative energy sources through Refuse Derived Fuel (RDF) technology, which has been widely applied in modern waste management systems. These approaches offer strategic directions for comprehensive HSW reduction efforts within the campus environment.

3.4.2 Recommendations for HSW handling

The initial step in HSW handling is implementing a segregation system directly at the source. As the primary waste generator, the academic community plays a vital role in this process, and the campus supports it through ongoing outreach and education programs regarding the types, hazards, and proper handling of HSW. Segregation efforts must also be supported by the provision of specialized waste containers designed in accordance with technical standards. Referring to Public Works Regulation No. 3 of 2013, HSW bins should be red in color, clearly labeled, and strategically located to ensure accessibility and effective usage, as shown in Figure 4 [15].

The next step involves the collection of HSW from various points across campus to the designated temporary storage location, namely the Non-Medical HSW Temporary Storage Facility (TPS-HSW) located within the Andalas University Hospital area.

Fig. 4 Recommendations for waste containers

Collection should be carried out by a dedicated unit appointed by the campus administration and supervised by the Facilities and Maintenance Division, in accordance with the Ministry of Environment and Forestry Regulation No. 9 of 2024, which states that waste managers must conduct HSW management within their respective jurisdictions.

The site manager must provide a Temporary Storage Facility for Specific HSW (TPSSS-HSW) that meets safety standards. This facility must be enclosed, adequately ventilated, and equipped with a recording and security system. Waste containers within the TPSSS-HSW should be customized according to the type of HSW and clearly color-coded: red for household HSW products, orange for HSW product packaging, black for damaged electronic waste, and brown for expired or off-specification HSW. Figure 5 illustrates the HSW containers used in the TPSSS-HSW facility.

Fig. 5 Recommended HSW containers at TPSSS-HSW

The transportation of HSW must be carried out by licensed parties using specially designated vehicles. All transported waste must be securely packaged, labeled according to its hazardous characteristics, and accompanied by a transport document or manifest as proof of documentation. Subsequently, HSW treatment is to be conducted by licensed companies utilizing technology that meets regulatory standards, such as incineration, stabilization, or solidification. Electronic manifest systems and periodic reporting to the Ministry of Environment and Forestry must also support this process.

The final stage of HSW management involves ultimate disposal in a landfill designated for HSW. Such landfills must comply with technical and environmental standards, including using impermeable liners to prevent soil contamination, leachate management systems, and regularly monitoring groundwater quality. The disposal site must be officially licensed and monitored by authorized regulatory agencies.

The recommendations for HSW management at Universitas Andalas have been formulated by considering the roles and responsibilities of various stakeholders. For campus administrators, essential steps include conducting regular education and awareness programs for the entire academic community on the importance of proper HSW management. Additionally, the university should implement waste generation limitation strategies through the control of hazardous material usage. Collaborations with third-party service providers officially licensed for HSW transportation, recycling, utilization, treatment, and disposal are also crucial to ensure all management stages comply with regulations. Infrastructure support is equally vital, such as providing HSW containers at primary waste generation sources and other strategic campus locations. Coordination between the Integrated Waste Management Center (PPST) and the Universitas Andalas Hospital must be strengthened, particularly regarding HSW collection and storage. Furthermore, the existing non-medical HSW temporary storage facility at the hospital may serve as the TPSSS-HSW, equipped with four separate containers in accordance with HSW categories.

On the other hand, active participation from the campus community is essential. Students, faculty members, administrative staff, and cleaning personnel must clearly understand the various types of HSW generated, such as used batteries, lamps, cleaning product packaging, and electronic waste. Their involvement in outreach and educational programs organized by the university serves as a tangible contribution toward fostering an environmentally conscious culture. All campus stakeholders are expected to increase their awareness and engage actively in consistent efforts to reduce and manage HSW. Implementing an integrated and sustainable HSW management system will create a clean and safe campus environment and instill a collective awareness toward building an environmentally responsible university.

4 Conclusion

The findings of this study indicate that the generation of HSW at Universitas Andalas Limau Manis Campus, Padang City, amounts to 37.59 kg/day or 169.68 L/day, with an average generation rate of 0.56 ± 0.28 g/person/day (or 0.10 ± 0.03 g/m²/day) in weight units, and 2.89 ± 1.19 mL/person/day (or 0.56 ± 0.16 mL/m²/day) in volume units. HSW constitutes 1.6% of the total campus waste. The composition of HSW includes electronic waste 46.35%, expired or off-specification HSW materials 29.65%, used HSW product packaging 23.43%, and household products containing HSW substances 0.58%. Regarding hazardous characteristics, 76.70% of the HSW is classified as toxic, 13.19% as corrosive, and 10.11% as flammable. Current efforts to reduce HSW include limiting hazardous materials, such as adopting long-lasting LED lighting to replace conventional lamps. However, overall HSW management remains largely unsegregated and mixed with general waste, except for waste generated by science and technology laboratories, which licensed third-party service providers manage. The study recommends an integrated approach to HSW management, including waste reduction, segregation, and the provision of specialized containers, as well as collection and storage in the TPSSS-HSW facility at Universitas Andalas Hospital. Further, treatment, recycling, reuse, and final disposal should be conducted by authorized third-party entities under the Padang City Environmental Agency supervision. These recommendations will serve as a reference for further research, namely the planning of hazardous waste management at the Universitas Andalas Campus.

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