Factors Influencing Household Hazardous Waste Management Practices in Kramatwatu District, Serang, Indonesia

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Abstract. Hazardous and Toxic Materials Waste (B3) encompasses waste derived from daily household activities containing substances that threaten environmental integrity and human health. In Kramatwatu Subdistrict, Serang Regency, Indonesia—a region ranked second in local waste generation—Harjatani Village alone produced approximately 0.1335 m³/day of B3 waste in 2023, including discarded batteries, pesticide containers, expired medications, and electronic waste. This cross-sectional study analyzed household B3 waste management practices in Kramatwatu Subdistrict, Banten Province, Indonesia, utilizing questionnaires and observational data from 196 randomly selected female heads of households. Chi-Square analysis identified statistically significant associations between B3 waste management compliance and two factors: education level (p-value = 0.031) and availability of waste management facilities/infrastructure (p-value < 0.001). The results highlight the imperative for targeted public education initiatives to improve B3 waste handling literacy and community engagement. Concurrently, local governments must prioritize the provision of dedicated infrastructure, such as accessible disposal drop boxes and trained waste management personnel, to establish sustainable and systematic B3 waste mitigation systems.

Keywords: Education, Facilities and Infrastructure, Role of Officers, Waste B3 Household.

1 Introduction

Indonesia, ranked as the world's fourth most populous nation, had a population exceeding 276 million in 2022, projected to rise to 281 million by 2023 and 284.5 million by 2025 [1]. Assuming an average daily domestic waste generation of 2.25 liters per capita, national waste production reaches approximately 640 million liters (640,000 tons)

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daily, accumulating to an estimated 66.5 million tons annually. In 2021, Banten Province contributed 115.3 tons to Indonesia's waste burden, as reported by the Ministry of Environment and Forestry. Concurrently, the Ministry of Health identified persistent waste management challenges across 240 Indonesian cities [2] [3].

The escalating volume of waste poses multifaceted challenges, including public health hazards, environmental degradation, diminished community aesthetics, and methane emissions—a potent greenhouse gas linked to climate change. A distinct concern within broader waste management systems is the improper disposal of Hazardous and Toxic Materials (B3) waste, which contains environmentally persistent and biologically harmful substances requiring specialized handling. Despite typically low generation volumes, B3 waste's inherent toxicity elevates its environmental and public health risks [4]. Households constitute a notable source of B3 waste generation, producing items such as used batteries, fluorescent bulbs, paint residues, cosmetic products, and automotive lubricants, many of which contain hazardous constituents such as mercury[5].

Household B3 waste enters environmental compartments such as water, soil, air, and biota, exerting immediate and long-term impacts on human health and ecosystem integrity. Such contamination jeopardizes groundwater resources, disrupts biodiversity, and threatens human health through direct contact or bioaccumulation in food chains. Despite accounting for a minor proportion (<2%) of total domestic waste volumes, improper household B3 waste disposal in landfills or general waste disposal sites creates disproportionate environmental hazards.

Serang Regency, with a population of 1,622,630 residents in 2021, faces intensifying waste management pressures. The region generates approximately 3,650.92 m^3 of waste daily, of which Hazardous and Toxic Materials (B3) waste constitutes a notable subset. Alarmingly, only 8.2% of this waste is systematically managed [6]. Kramatwatu Subdistrict exemplifies these challenges, ranking as Serang's second-largest waste producer with a daily output of 248.78 m^3 in 2021—a 19.7% increase from 207.91 m^3/day in 2017. This upward trajectory underscores escalating regional waste management demands.

Harjatani Village, situated in Kramatwatu Subdistrict, Serang District, Banten Province, Indonesia, hosts the subdistrict's largest population at 11,600 residents (2021). With per capita waste generation estimated at 2.25 liters/day, the village produces 26.1 m^3 of daily waste, including 0.1335 m^3 (1,148.4 kg) of B3 waste [6]. Population growth trajectories suggest a proportional escalation in B3 waste volumes, heightening risks to environmental sustainability and public health.

In response to these pressures, this study aims to systematically analyze determinants influencing household B3 waste management efficacy in Harjatani Village,

Kramatwatu Subdistrict, and develop evidence-based strategies to optimize waste handling protocols.

2 Methods

This research was conducted in Harjatani Village, Kramatwatu Subdistrict, Serang Regency, Banten Province—a demographically significant area within the subdistrict. Employing a quantitative cross-sectional design, the study investigated associations between independent variables (education level, infrastructure availability, and healthcare worker engagement) and the dependent variable (household Hazardous and Toxic Materials [B3] waste management practices). Data were collected through single time-point assessments between April and June 2023 to evaluate variable interactions within the study population.

This study utilized probability-based simple random sampling to select 198 female heads of households in Harjatani Village for structured interviews. The minimum sample size was calculated using a two-proportion hypothesis test to ensure statistical validity [7]. Primary data were gathered through face-to-face interviews, while secondary data were sourced from administrative records at the Kramatwatu Subdistrict Office and the Serang Regency Environmental Agency. The research instrument comprised four domains: (1) respondent sociodemographic characteristics, (2) B3 waste management practices, (3) educational attainment, (4) waste infrastructure accessibility, and (5) healthcare worker involvement in waste governance.

Data analysis proceeded in two sequential stages. Stage 1 employed univariate analysis to characterize frequency distributions of all variables, including household B3 waste management practices and independent predictors (education level, infrastructure availability, and healthcare worker roles). Stage 2 implemented chi-square analysis to evaluate associations between dependent and independent variables, with statistical significance defined at $\alpha=0.05$ (95% confidence level). The study protocol received formal ethical clearance from the Research Ethics Committee of Faletehan University (Approval No. 319/KEPK.UF/EN/2023).

3 Result

Table 1 summarizes the sociodemographic characteristics of 196 participating housewives in Harjatani Village. Respondents were primarily non-working housewives (77.6%) within the productive age range (39–49 years: 42.3%). The predominant educational attainment was senior high school completion (51.5%), with a majority (59.7%) reporting household incomes below Serang Regency's regional minimum wage (IDR 4.5 million).

Table 1. Sociodemographic characteristics of participants (n = 196)

Variable	n	%
Age (years)		
19-28	24	12.2%
29-38	45	22.9%
39-49	83	42.3%
50-69	41	20.9
≥ 70	3	1.7%
Mother's Occupation		
Housewife	152	77.6%
Civil Servant	2	1%
Trader	9	4.6%
Entrepreneur	14	7%
Laborer	7	3.6%
Private Employee	6	3.1%
Kindergarten Teacher	6	3.1%
Familly Income		
< Regional minimum wage	117	59.7%
≥ Regional minimum wage	79	40.3%
Mother's Education		
Unfinished Elementary School	5	2.6%
Elementary School	13	6.6%
Middle High School	30	15.3%
Senior High School	101	51.5%
Undergraduate	6	3.1%
Bachelor's Degree	40	20.4%
Postgraduate Degree	1	0.5%

Table 2. Household B3 waste management practices and associated factors (n = 196)

Variable	n	%
Household B3 Waste Management		
Poor	108	55.1%
Good	88	44.9%
Education		
Low	149	76%
High	47	24%
Availability of infrastructure facilities		
Not available	142	72.4%
Available	54	276%
Role of Officers		
Inadequate Engagement	173	88.3%
Adequate Engagement	23	11.7%
Total	**196**	**100%**

Table 2 reveals that 55.1% of households in Harjatani Village demonstrated inadequate management of B3 waste, defined as failure to implement basic mitigation practices such as waste sorting, secure storage, or proper disposal. Conversely, 44.9% exhibited compliant practices. Key determinants associated with poor B3 waste management include low educational attainment (76% of respondents), limited infrastructure accessibility (72.4%), and perceived inadequacy in waste management personnel engagement (88.3%) .

Table 3. Household B3 Waste types generated by respondents

The Types of Households B3	%
Perfume Bottles	61.7%,
Batteries	55.6%
Electronic Waste	54.6%
Fluorescent Lights and Neon Bulbs	53.1%
Used Comestics Packaging	50.5%

Findings indicate that perfume bottles constitute the most prevalent type of household B3 waste in Harjatani Village, Kramatwatu Subdistrict.

Table 4. Determinants of Household B3 Waste Management

Variable	Household B3 Waste Management				Total		P *Value*	OR
	Poor		Good					
	N	%	N	%	N	%		
Education								
Low	89	59,7%	60	40,3%	149	100%		
High	19	40,4%	28	59,6%	47	100%	0,031	2,189
Total	108	55,1%	88	44,9%	196	100%		
Infrastructure Availability								
Not Available	103	72,5%	39	27,5%	142	100%	0,000	17,733
Available	7	13%	47	87%	54	100%		
Total	108	55,1%	88	44,9%	196	100%		
Waste Management Personnel Engagement							0,004	4,271
Less Responsible	104	60,1%	69	39,9%	173	100%		
Responsible	6	26,1%	17	73,9%	23	100%		
Total	108	56,1%	88	43,9%	196	100%		

The results of research data analysis in table 4 shows that all variables are significantly related to household hazardous (B3) waste management.

4 Discussion

4.1 Household Hazardous and Toxic Materials (B3) Waste Management

Research on household B3 waste management remains limited, with prior studies predominantly focusing on industrial B3 waste and general domestic waste systems. Current attention has prioritized electronic waste, despite households generating B3 waste through daily activities such as the disposal of batteries, cosmetics, and chemical containers. Though household B3 waste volumes are relatively small, improper disposal practices, including mixing these materials with organic waste, plastics, and other domestic refuse in communal landfills, pose persistent risks of environmental contamination and public health hazards. Household B3 waste is frequently discarded indiscriminately alongside general waste due to limited public awareness and infrastructure. This study underscores the critical oversight of household B3 waste in existing waste governance frameworks and advocates for stakeholder recognition of its ecological and health implications.

Hazardous and Toxic Substances (B3) originate from daily human activities and, if mismanaged, threaten immediate and prolonged harm to human populations, ecosystems, and environmental systems. Defined as solid waste capable of endangering public health or ecological integrity [8]. Household B3 waste encompasses materials such as used motor oils, batteries, pesticide containers, expired medications, and electronic waste. These items contain hazardous constituents that can induce systemic contamination, biological harm, and environmental degradation through improper handling[9].

Improper management of household B3 waste poses substantial risks to environmental and public health. Despite constituting a minor proportion of total domestic waste (approximately 2.44 g per capita daily or 0.488% by mass), household B3 waste presents disproportionate hazards due to its explosive, flammable, toxic, and corrosive properties, which can contaminate water systems, soil matrices, and air quality [10]. In Harjatani Village, discarded perfume bottles emerge as a prevalent B3 waste category. While these glass or acrylic containers are frequently disposed of post-use, many respondents reported reusing them for refilling purposes, thereby mitigating waste generation. Additionally, discarded perfume bottles—particularly plastic or glass variants—are creatively repurposed into economically valuable items such as stationery holders, decorative vases, and household ornaments, demonstrating community-driven waste reduction strategies [11], [12].

In addition to perfume containers, electronic waste and spent batteries constitute prevalent forms of household B3 waste in Harjatani Village. While respondents frequently attempt to repair malfunctioning electronic devices for continued use, irreparable items are typically sold to informal waste collectors or disposed of within general domestic waste streams. The absence of designated disposal infrastructure for B3 materials in the village results in commingling of hazardous and nonhazardous waste, exacerbating systemic waste management challenges.

Household B3 waste management in Indonesia remains critically underdeveloped due to inadequate infrastructure and fragmented waste management systems. While industrial B3 waste is regulated through comparatively advanced protocols, household-generated B3 waste persists as a largely unaddressed challenge despite formal regulatory frameworks. This gap is further amplified by the proliferation of informal e-waste recycling sectors in developing nations, where non-compliant processing methods frequently violate environmental safety standards. Such practices contribute to cross-media contamination, polluting terrestrial, aquatic, and atmospheric systems through improper handling of hazardous components [13].

The 2020 Global E-Waste Monitor report documented 53.6 million metric tons of global electronic waste generated in 2019, with projections indicating a rise to 74.7 million metric tons by 2030 and 120 million metric tons by 2050. Only 17.4% of this waste underwent formal recycling processes globally. In Indonesia, 2021 estimates indicated approximately 2 million metric tons of electronic waste generation, yet national B3 waste management frameworks predominantly prioritize formal industrial sectors.

Household-derived B3 waste streams remain systematically overlooked despite their cumulative environmental risks [14].

Findings indicate that 56.1% of households in Harjatani Village inadequately managed household B3 waste, primarily treating it as equivalent to non-hazardous domestic waste. Most respondents commingled B3 materials with general refuse, depositing mixed waste in temporary disposal sites (TPS) prior to final landfill transport. This practice reflects systemic deficiencies in waste segregation protocols, compounded by insufficient public awareness of B3 risks and a critical absence of designated disposal infrastructure. The lack of specialized collection mechanisms, such as B3-specific drop boxes, further compounds systemic challenges in mitigating hazardous waste contamination.

The study identified predominantly conventional waste management practices in Harjatani Village, with minimal differentiation between waste types. While 25.5% of respondents reported efforts to reduce B3 waste generation through reuse or recycling, 75.5% did not utilize environmentally friendly products, and 87.8% refrained from reusing household B3 items [15]. Critical gaps were observed in segregation practices: 58.2% of households failed to properly sort or collect B3 waste, and 92.3% disposed of it indiscriminately with general domestic waste. Alarmingly, 33.2% of respondents resorted to open burning of B3 waste alongside other refuse, exacerbating air pollution risks. These findings underscore systemic shortcomings in sustainable B3 waste mitigation strategies within the community.

Three factors significantly influenced household B3 waste management practices: education level, infrastructure accessibility, and healthcare worker engagement. Education emerged as the primary determinant, with 76% of respondents possessing a high school diploma or lower educational attainment. Lower educational levels correlated strongly with suboptimal waste management practices, while higher educational attainment demonstrated a positive association with improved compliance ($p = 0.031$). These findings align with prior studies establishing education as a critical driver of waste management literacy and pro-environmental behaviors [16], [17].

Infrastructure availability significantly influenced household B3 waste management outcomes, with 72.4% of Harjatani Village respondents citing insufficient access to dedicated B3 waste management infrastructure. The absence of specialized facilities, such as designated drop boxes for hazardous materials, hindered effective waste segregation and amplified contamination risks. Implementation of standardized infrastructure could enhance segregation compliance and mitigate cross-contamination of waste streams. Prior studies corroborate that accessible, standardized infrastructure forms the foundation of systematic B3 waste mitigation [18], [19].

The study identified health workers as pivotal actors in household B3 waste management, with 60.1% of respondents perceiving their current engagement as minimal. Health workers hold critical responsibilities in raising community awareness, disseminating safety protocols, and providing logistical support for hazardous waste mitigation. Their capacity to serve as communicators, motivators, and facilitators directly strengthens community participation in compliant B3 waste handling. Empirical evidence confirms that proactive health worker involvement in public education correlates with measurable improvements in household waste management efficacy [18], [19].

Household B3 waste management in Harjatani Village is constrained by interrelated systemic deficits: limited educational attainment among residents, inadequate infrastructure for hazardous waste segregation and disposal, and insufficient engagement from healthcare personnel. Addressing these challenges necessitates coordinated interventions, including community-tailored educational programs to enhance waste literacy, investment in dedicated B3 waste infrastructure (e.g., drop boxes, collection systems), and proactive mobilization of health workers as educators and facilitators of safe disposal practices. This study highlights the necessity for subsequent research to examine additional determinants, such as intrahousehold dynamics, governmental policy frameworks, and the direct health impacts of household B3 exposure. Further investigation into sociocultural, institutional, and regulatory dimensions will strengthen the evidence base for holistic B3 waste governance strategies.

5 Conclusion & Suggestion

This study concludes that household B3 waste management practices in Harjatani Village remain suboptimal. Key determinants influencing effective management include educational attainment, availability of dedicated waste infrastructure, and the proactive engagement of health workers in community education initiatives. These factors collectively enhance awareness and foster sustainable waste handling behaviors, underscoring their critical role in mitigating environmental and public health risks associated with improper B3 waste disposal.

Author's Contribution

WEP contributed to study design, conducted data analysis, and performed critical manuscript revisions. OJ, ML, TN, and DN participated in data collection and literature searches. TN and OJ synthesized research findings into preliminary reports, while ML and DN drafted the manuscript for publication.

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