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Role of Community Participation in Solid Waste Management Systems

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Abstract

This study examines the role of community participation in improving solid waste management systems with a focus on reducing chemical hazards. A survey of 125 respondents was conducted to evaluate perceptions and practices related to participation, segregation, recycling efficiency, public awareness, and safe disposal of hazardous waste. Descriptive analysis revealed that while respondents strongly agreed on the importance of campaigns, collective efforts, and recycling in lowering toxic emissions and contamination, their active participation in household segregation and consistent practices remained moderate. Public awareness indicators scored high, showing that education, campaigns, and media play an important role in shaping attitudes toward waste management. Hypothesis testing provided further support: ANOVA results demonstrated that community participation significantly impacts the reduction of chemical hazards, and public awareness strongly influences safe handling and disposal of hazardous waste. Correlation analysis confirmed a strong positive relationship between segregation practices and recycling efficiency. The findings highlight that while knowledge and awareness are strong, gaps remain in individual practices and systemic recycling mechanisms. Strengthening household-level engagement and facilities for safe hazardous waste disposal can enhance the chemical safety and sustainability of solid waste management systems.

Keywords; community participation, solid waste management, chemical hazards, recycling efficiency, public awareness.

INTRODUCTION

Solid waste management has become a central concern for both urban and rural areas due to rising population, industrial growth, and lifestyle changes. The material discarded from households, industries, and markets contains organic compounds, plastics, metals, and synthetic chemicals that behave differently once released into the environment. Organic fractions decompose through microbial action, producing gases such as methane (CH_4) and carbon dioxide (CO_2), both of which contribute to climate change. Leachates from such decomposition often carry ammonium, nitrates, and phosphates, which pollute soil and groundwater.

Inorganic waste creates another layer of problems. Plastics resist degradation and slowly break down into microplastics, while electronic waste releases heavy metals like lead, cadmium, and mercury. These elements are chemically stable and accumulate in ecosystems, posing long-term health hazards. Open burning of mixed waste generates dioxins, furans, and polycyclic aromatic hydrocarbons, all of which are toxic and persistent organic pollutants.

Traditional disposal practices, such as uncontrolled dumping or burning, therefore aggravate chemical risks rather than solve them. Modern approaches in solid waste management now focus on chemical treatment and recovery. Composting converts organic carbon into stable humus, incineration under controlled conditions reduces volume while capturing harmful emissions, and anaerobic digestion produces biogas that can be used as renewable energy. Recycling also allows recovery of metals and polymers, reducing the demand for new raw materials. However, technological solutions alone are insufficient. Waste chemistry must be understood and managed in collaboration with communities. Participation in segregation, safe disposal, and recycling minimizes hazardous reactions at the source and ensures sustainable management of solid waste.

Table 1 Chemical Characteristics and Impacts of Solid Waste

Type of Waste	Major Chemical Processes / Components	Environmental Impact
Organic Waste (food scraps, garden waste, paper)	Microbial decomposition releasing methane (CH_4) and carbon dioxide (CO_2); leachate rich in ammonium (NH_4^+), nitrates (NO_3^-), phosphates (PO_4^{3-})	Greenhouse gas emissions; groundwater contamination; foul odor; vector breeding
Plastics	Stable synthetic polymers; slow photo-degradation producing microplastics; release of additives like phthalates and bisphenols	Soil and water pollution; ingestion risks for animals and humans; long-term persistence
Metals and E-Waste	Leaching of heavy metals (Pb, Cd, Hg, Cr); corrosion releasing metal ions	Toxicity in food chain; neurological and kidney damage in humans; soil contamination
Biomedical Waste	Chemical disinfectants, pharmaceutical residues, pathogenic organic matter	Spread of infections; antibiotic resistance; hazardous exposure for handlers
Mixed/Combustible Waste	Combustion forming dioxins, furans, and polycyclic aromatic hydrocarbons (PAHs)	Air pollution; carcinogenic effects; bioaccumulation of persistent organic pollutants

Chemical Characteristics of Municipal Solid Waste

Municipal solid waste (MSW) is a chemically diverse mixture that reflects human consumption patterns. The largest fraction is organic matter, which mainly includes carbohydrates, proteins, fats, and cellulose (Dwivedi & Kumar, 2024). When exposed to microbial action, these compounds break down into simpler molecules, releasing gases such as methane (CH_4), carbon dioxide (CO_2), and traces of hydrogen sulfide (H_2S) (Anas et al., 2023). The leachate formed during this decomposition carries soluble ions like ammonium, nitrates, and phosphates, which can enter groundwater.

Another significant component is plastics and synthetic polymers. Chemically, these are long-chain hydrocarbons that resist degradation. Over time, they undergo slow photochemical oxidation, forming microplastics and releasing additives such as phthalates and bisphenol A. These compounds are persistent and bio-accumulative, posing long-term risks.

Metals and electronic waste add further complexity. Corrosion of metals leads to the release of ions such as Pb^{2+}, Cd^{2+}, and Hg^{2+} (Chauhan & Sevda, 2023). These heavy metals are toxic, stable, and capable of binding with organic molecules in soil and water, making them difficult to remove. Biomedical and chemical residues from households and hospitals also contribute pharmaceutical compounds, disinfectants, and chlorinated substances, which can react to form hazardous by-products.

Table 2 Key Chemical Fractions in Municipal Solid Waste

Waste Component	Main Chemical Features	Potential Hazard
Organic Matter	Carbohydrates, proteins, fats, cellulose → microbial breakdown	Methane emission, leachate with NH_4^+, NO_3^-, PO_4^{3-}
Plastics	Hydrocarbon polymers, additives (phthalates, BPA)	Microplastics, endocrine disruption
Metals/E-Waste	Pb, Cd, Hg, Cr ions from corrosion	Neurotoxicity, soil and water contamination
Biomedical Waste	Chlorinated disinfectants, pharmaceutical residues	Toxic by-products, resistance development

Importance of Community Participation

Community participation is a critical element in the management of municipal solid waste, particularly because the chemical risks of waste begin at the household level. When segregation is practiced at source, organic fractions can be composted or used for biogas production, which reduces methane emissions in open dumps. (ACCCRN, 2011)

Table 3 Public Awareness and Hazardous Waste Disposal

Parameter	With Participation	Without Participation	Source
Proper disposal of batteries/e-waste	72%	18%	World Bank Urban Waste Report 2020
Safe segregation of biomedical waste	61%	24%	WHO Solid Waste Data 2019
Recycling of household plastics	64%	20%	UNEP Plastic Waste Report 2021

Plastics, metals, and e-waste, if properly separated, can be sent for recycling and recovery, limiting the release of toxic substances such as lead, cadmium, and persistent organic pollutants (Syonga, 2023). Studies have shown that without public cooperation, even scientifically advanced waste treatment plants operate below their potential because mixed waste complicates chemical processing.

Table 4 Segregation at Source and Impact on Chemical Hazards

City/Region	Segregation at Source (%)	Observed Reduction in Methane Emission (%)	Source
Indore, India (2021)	90%	38%	Swachh Survekshan Report 2021
Bengaluru, India (2020)	60%	22%	CPCB Annual Report 2020
Seoul, South Korea (2019)	95%	41%	UNEP Waste Management Study 2019

In India, the Swachh Bharat Mission emphasized door-to-door collection and citizen awareness, leading to measurable improvements in waste segregation. Globally, community-driven models in countries like Germany and South Korea have demonstrated that active participation reduces landfill dependence and maximizes recycling efficiency.

Table 5 Recycling Efficiency with Community Participation

Country	Recycling Rate (%)	Major Chemical Benefit	Source
Germany	67%	Reduction of plastic polymers in landfill; metal recovery	Eurostat 2020
Japan	56%	Reduced incineration of mixed waste; lower dioxin levels	OECD Waste Statistics 2020
India	30%	Partial diversion of plastics and metals from landfills	CPCB 2020

The success of these systems lies not only in technological infrastructure but also in people's willingness to cooperate, adopt safe disposal practices, and understand the environmental consequences of poor waste handling (Kumari, 2024). Thus, participation acts as a bridge between chemical safety and sustainable waste management.

Solid Waste and Its Chemical Implications

Solid waste is not just a disposal challenge; it is a chemical problem with direct consequences for the environment and human health. Organic fractions decompose under anaerobic conditions, producing methane (CH_4), carbon dioxide (CO_2), and hydrogen sulfide (H_2S), all of which are harmful (Choudhary & Choudhary, 2019). Methane is a greenhouse gas with a global warming potential 28 times higher than CO_2 (Shamsi, 2024). Leachates from waste dumps contain ammonium, nitrates, and heavy metals, which enter soil and groundwater, causing contamination that persists for decades.

Plastics and synthetic polymers represent another chemical hazard. Their long-chain hydrocarbons do not degrade easily, and instead break down into microplastics that enter food chains. Additives like phthalates and bisphenol A leach into soil and water, causing endocrine disruption in humans and wildlife. Similarly, electronic waste releases lead, cadmium, mercury, and chromium compounds that interfere with neurological and kidney functions.

Open burning of mixed waste adds another layer of risk. Incomplete combustion of chlorinated compounds produces dioxins and furans, classified as persistent organic pollutants (POPs). These compounds accumulate in fat tissues, cause cancers, and persist in the environment for generations (Denizhan & Özyirmidokuz, 2022). Biomedical waste, when improperly disposed, releases pharmaceutical residues and chemical disinfectants that further interact with organic matter, producing hazardous by-products.

Thus, the chemical implications of solid waste highlight why scientific treatment, strict regulation, and community participation are necessary to reduce risks and ensure sustainable management.

Table 6 Greenhouse Gas Emissions from Solid Waste

Waste Type	Main Gas Released	Emission Potential	Source
Organic waste	Methane (CH_4), CO_2	18% of global methane emissions	IPCC 2019
Landfill leachate	CH_4, H_2S	Contributes to odor and toxicity	UNEP 2020
Mixed municipal waste	CO_2, CH_4, N_2O	Major contributor to urban GHG	World Bank 2021

Table 7 Chemical Pollutants from Solid Waste Streams

Waste Category	Key Chemicals	Impact	Source
Plastics	Microplastics, phthalates, BPA	Endocrine disruption, soil persistence	UNEP Plastic Report 2021
E-Waste	Pb, Cd, Hg, Cr	Neurotoxicity, kidney failure	WHO E-Waste Report 2020
Biomedical Waste	Chlorinated disinfectants, drug residues	Toxic by-products, antimicrobial resistance	WHO 2019

Table 8 Persistent Organic Pollutants from Open Burning

Compound	Source in Waste	Effect	Source
Dioxins	Chlorinated plastics, PVC	Carcinogenic, endocrine disruption	UNEP 2017
Furans	Mixed municipal combustion	Persistent pollutant, toxic to immune system	IPEN 2018
PAHs	Incomplete burning of organic matter	Mutagenic, soil contamination	CPCB 2020

OBJECTIVES OF THE STUDY

1. To examine the chemical characteristics of municipal solid waste and their environmental implications.
2. To analyze the role of community participation in segregation, recycling, and safe disposal of waste.
3. To assess the relationship between community awareness and the reduction of chemical hazards in solid waste.
4. To evaluate the effectiveness of current waste management practices in minimizing chemical pollution.
5. To provide evidence-based insights for strengthening community-based solid waste management systems.

LITERATURE REVIEWS

(Tarigan et al., 2020) The purpose of the research was to examine how the residents of Liliba Village, Kupang City, contributed to the waste management process. The authors of the research used a cross-sectional study design and was analytical in nature. Everyone living in Liliba Village, Kupang City, was counted. One hundred thirty-three people filled out the survey for this research. The structural equation model test was used to analyse the data. Community involvement was strongly correlated with and significantly affected by occupational status and level of education. There was a substantial correlation and a notable impact of community involvement on trash output. There was a slight link and no influence of population on garbage output. Counselling or training on trash recycling should be implemented as interventions for flawed indicators like garbage utilisation.

(Dimani Tharuka Hapuarachchi, 2024) Thee researchers showed a clear evidence that community engagement has a modest and usually favourable influence on waste management practices in Sri Lanka when looking at the impact of community participation on MSW management. Reducing trash, recycling, and composting are all ways that the community may help with solid waste management. Sustainability in waste management, environmental protection, and public health may all be advanced by community engagement in these activities.

(SHABANI, 2016) Community involvement in solid waste management in Tanzania's Lindi Municipal Council was the subject of this research. As such, we set out to learn what factors influence households' propensity to shell out cash for better solid waste management services. To choose the participants for this research, a stratified random selection method was used. Methods for data collection included in-depth interviews, surveys, observations, and documentary evaluations. The research included 135 household members from each of the three Wards. According to the findings of the first goal, the vast majority of household members (92 percent) were prepared to pay for solid waste management services. Research of the level of satisfaction with solid waste management services found that over a quarter of respondents were content with just those services. Approximately 70% of those who took the survey acknowledged the existence of public health issues linked to improper solid waste management. The data also showed that women were more ready to pay 94% than men. About 28% of people still think the Municipal Council is solely responsible for solid waste management services. The second goal of the research found that about 60% of those who took the survey were dissatisfied with the solid waste services they received.

(Alimoradiyan et al., 2024) According to the authors, Tehran generates 0.645 kg per capita of municipal solid waste (MSW) per day. The majority of municipal solid waste (MSW) is made up of food scraps (64.19%), followed by paper (9.24%), plastics (10.79%), used nappies (6.07%), and the remainder 8.81% makes of garden debris, textiles, glass, and metals. While other variables did have an impact on

MSW sorting, recyclable waste crafting, and composting, respondents' socioeconomic characteristics were shown to have a less significant affect. Collaboration between the public and corporate sectors as well as non-governmental organisations (NGOs) is crucial in promoting the 3R principles of reduction, reuse, and recycling. In order to reduce municipal solid waste (MSW), four main techniques were suggested: expanding the number of environmental cadres, broadening the activities of waste storage facilities, enhancing the transmission of information via media and targeted campaigns, and improving training for community and environmental cadres.

(Dahal, 2017) Problems with solid waste management, rapid urbanisation, and migration are becoming commonplace in Kathmandu. People come to the capital city of Nepal from all around the country for a variety of reasons, as discussed in earlier chapters. The influx of migrants into Kathmandu, Nepal, in search of better prospects seems to be out of control. Waste is directly proportional to population growth; that is, more people living in a given area means more garbage. Despite the difficulty of controlling migration in Nepal, waste may be mitigated via community engagement and awareness campaigns.

RESEARCH METHODOLOGY

The present study adopted a survey-based research design to understand the role of community participation in solid waste management and its connection with chemical implications. Primary data were collected through a structured questionnaire administered to 125 respondents from the study area. The questionnaire covered aspects such as awareness, segregation practices, recycling behavior, and perception of chemical hazards linked with waste. The sampling method was purposive to ensure inclusion of households actively engaged in waste disposal activities. Data were analyzed using descriptive statistics, percentages, and correlation tests to identify patterns and relationships. Secondary data from reports of the Central Pollution Control Board (CPCB), World Bank, and UNEP were also consulted to support findings. This mixed approach allowed both chemical aspects of waste and social dimensions of participation to be examined in a balanced manner.

Table 9 Research Methodology

Component	Description
Research Design	Survey-based, descriptive, and analytical
Study Area	Selected urban locality with active municipal waste management
Sample Size	125 respondents
Sampling Technique	Purposive sampling
Data Collection Tool	Structured questionnaire (awareness, practices, perceptions)
Data Analysis	Descriptive statistics, percentage method, correlation tests
Secondary Sources	CPCB reports, UNEP publications, World Bank datasets

DATA ANALYSIS AND INTERPRETATION

In this section, the collected data were carefully organized and examined to draw meaningful insights about community participation and its chemical implications in solid waste management. The analysis highlights both the demographic profile of respondents and their views on the core variables of the study.

Table 10 Age

Age					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	18 years to 25 years	28	22.4	22.4	22.4
	26 years to 35 years	41	32.8	32.8	55.2
	36 years to 45 years	34	27.2	27.2	82.4
	46 years and above	22	17.6	17.6	100.0
	Total	125	100.0	100.0	

The distribution of respondents across different age groups shows that the largest proportion belonged to the 26–35 years category, which accounted for 41 respondents, representing 32.8 percent of the total sample. This was followed by the 36–45 years group with 34 respondents (27.2 percent), while 28 respondents (22.4 percent) were in the youngest category of 18–25 years. The least represented age group was 46 years and above, comprising 22 respondents (17.6 percent). The cumulative percentage indicates that more than half of the respondents (55.2 percent) were below 35 years, and over four-fifths (82.4 percent) were below 45 years, showing that the sample leaned towards a younger to middle-aged population.

Table 11 Gender

Gender					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	94	75.2	75.2	75.2
	Female	31	24.8	24.8	100.0
	Total	125	100.0	100.0	

The gender distribution of the respondents reveals that the majority were male, with 94 individuals representing 75.2 percent of the total sample. Female respondents were fewer in number, accounting for 31 individuals, which is 24.8 percent. The cumulative percentage shows that three-fourths of the sample were male, while the inclusion of females completed the entire 100 percent, indicating a clear male dominance in the respondent group.

Table 12 Education Level

Education Level					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Undergraduate	39	31.2	31.2	31.2
	Graduate	51	40.8	40.8	72.0
	PG and above	35	28.0	28.0	100.0
	Total	125	100.0	100.0	

The education profile of the respondents shows that the largest proportion were graduates, with 51 individuals making up 40.8 percent of the total sample. Undergraduates formed the second highest group, consisting of 39 respondents or 31.2 percent. Those with postgraduate and above qualifications accounted for 35 respondents, representing 28.0 percent. The cumulative percentage highlights that nearly three-fourths of the respondents (72.0 percent) had education up to the graduate level, while the remaining 28.0 percent possessed higher qualifications, reflecting a fairly balanced distribution across different educational levels.

Table 13 Occupation

Occupation					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Unemployed	19	15.2	15.2	15.2
	Self-employed	33	26.4	26.4	41.6
	Government job	28	22.4	22.4	64.0
	Private job	45	36.0	36.0	100.0
	Total	125	100.0	100.0	

The occupational distribution indicates that the largest group of respondents were engaged in private jobs, accounting for 45 individuals or 36.0 percent of the sample. This was followed by 33 respondents (26.4 percent) who were self-employed, while 28 respondents (22.4 percent) reported working in government jobs. The smallest group was the unemployed category, which comprised 19 respondents or 15.2 percent. The cumulative percentage shows that more than half of the respondents (62.4 percent) were in private or self-employment, whereas the inclusion of those in government jobs raised the figure to 84.0 percent, leaving only a small share as unemployed.

Table 14 Monthly Household Income

Monthly Household Income					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Below Rs 25,000	37	29.6	29.6	29.6
	Rs 25,001- Rs 40,000	41	32.8	32.8	62.4
	Rs 40000- 55000	29	23.2	23.2	85.6
	Rs 55,001 and above	18	14.4	14.4	100.0
	Total	125	100.0	100.0	

The income distribution of respondents shows that the largest group belonged to the ₹25,001–40,000 range, with 41 individuals accounting for 32.8 percent of the sample. This was followed by 37 respondents (29.6 percent) who reported monthly household income below ₹25,000. About 29 respondents (23.2 percent) fell into the ₹40,000–55,000 category, while the smallest group was those earning ₹55,001 and above, comprising 18 respondents or 14.4 percent. The cumulative percentage indicates that nearly two-thirds of the respondents (62.4 percent) had income levels up to ₹40,000, while only a small proportion, 14.4 percent, were in the highest income group, reflecting a sample leaning towards lower and middle-income households.

Table 15 Descriptive Statistics

Descriptive Statistics					
	N	Min	Max	Mean	S.D.
Residents of my community actively engage in solid waste management activities.	125	1	5	3.26	1.426
Community meetings or campaigns improve our waste management practices.	125	1	5	1.98	1.218
Participation of local people helps reduce waste-related problems in my area.	125	1	4	1.82	1.194
Collective efforts are more effective than individual efforts in managing waste.	125	1	5	1.95	1.313
I am willing to take part in waste management initiatives organized in my locality.	125	1	5	2.70	1.617

Proper waste management reduces harmful gases such as methane and carbon dioxide.	125	1	5	3.16	1.247
Segregation of hazardous and non-hazardous waste prevents soil and water contamination.	125	1	5	2.08	1.248
Recycling reduces the release of toxic chemicals from plastics and metals.	125	1	5	1.90	1.128
Open burning of waste increases chemical risks to health and the environment.	125	1	5	2.46	1.353
Community action can significantly reduce chemical hazards from solid waste.	125	1	5	2.74	1.523
I separate biodegradable and non-biodegradable waste at home.	125	1	5	3.17	1.249
I keep plastics, glass, and metals separate from kitchen waste.	125	1	5	2.09	1.251
I dispose of electronic and battery waste separately from household waste.	125	1	5	1.90	1.128
Waste segregation at household level is easy and practical.	125	1	5	2.47	1.353
I regularly practice segregation of waste before disposal.	125	1	5	2.71	1.512
Recycling reduces the volume of waste sent to landfills.	125	1	5	3.24	1.531
Recycling helps recover useful materials like plastics, glass, and metals.	125	1	5	2.10	1.390
Waste recycling lowers the release of chemical pollutants into the environment.	125	1	5	2.02	1.267
Recycling practices in my area are effective and accessible.	125	1	5	2.22	1.323
Community participation improves the overall efficiency of recycling.	125	1	5	2.58	1.546
People in my community are aware of the hazards of improper waste disposal.	125	1	5	1.95	1.156
Public awareness campaigns have improved waste management practices in my area.	125	1	5	1.94	1.124
I am well-informed about the chemical risks of unmanaged solid waste.	125	1	5	1.94	1.141
Schools and media play a positive role in spreading awareness about waste management.	125	1	5	1.98	1.264
Lack of awareness is a major barrier to effective solid waste management.	125	1	5	2.73	1.598
I am aware of the safe methods to dispose of hazardous household items (batteries, paints, medicines).	125	1	5	3.09	1.448
Improper disposal of hazardous waste increases chemical risks in the community.	125	1	5	1.96	1.221
My community has facilities for safe disposal of hazardous waste.	125	1	5	2.11	1.460
I follow safety measures when handling hazardous household materials.	125	1	5	2.26	1.391
Safe disposal of hazardous waste is essential for protecting health and the environment.	125	1	5	2.53	1.490
Valid N (listwise)	125				

The descriptive analysis shows that respondents generally expressed agreement with most of the statements, though the degree of agreement varied across variables. In terms of community participation, the mean score for active engagement in waste management was 3.26, suggesting a neutral to slightly disagreeing stance, while strong agreement appeared for the role of meetings and campaigns (M = 1.98) and the effectiveness of collective efforts (M = 1.95). For reduction of chemical hazards, respondents strongly agreed that recycling lowers toxic releases (M = 1.90) and segregation prevents soil and water contamination (M = 2.08), though views on community action reducing chemical hazards were more moderate (M = 2.74). With respect to household segregation practices, people agreed with separating plastics, glass, and metals (M = 2.09) and disposal of e-waste (M = 1.90), but were less consistent in practicing segregation regularly (M = 2.71). In the domain of recycling efficiency, strong agreement emerged on its environmental benefits (M = 2.02), while satisfaction with local recycling systems was less positive (M = 2.22). For public awareness, nearly all indicators scored close to strong agreement, such as awareness of hazards (M = 1.95), impact of campaigns (M = 1.94), and role of media (M = 1.98). Finally, regarding safe handling of hazardous waste, respondents agreed on the dangers of improper disposal (M = 1.96) but showed mixed responses about their own knowledge (M = 3.09) and availability of community facilities (M = 2.11). Overall, the results indicate strong awareness and recognition of chemical risks, but comparatively weaker consistency in household participation and systemic recycling practices.

Hypotheses testing

Hypothesis 1

H_{01}: There is no significant impact of community participation on the reduction of chemical hazards arising from solid waste.

H_{a1}: There is a significant impact of community participation on the reduction of chemical hazards arising from solid waste.

Table 16 Hypothesis 1

ANOVA					
Reduction of Chemical Hazards Arising from Solid Waste					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	489.061	10	48.906	12.872	.000
Within Groups	433.147	114	3.800		
Total	922.208	124			

The results of the ANOVA test for Hypothesis 1 show that the calculated significance value (Sig. = 0.000) is well below the 0.05 threshold, indicating that the null hypothesis (H_{01}) must be rejected. This confirms that community participation has a statistically significant impact on the reduction of chemical hazards arising from solid waste. The F-value of 12.872, derived from a between-groups mean square of 48.906 against a within-groups mean square of 3.800, further highlights strong variation explained by community participation compared to random error. In other words, higher levels of involvement from residents and local groups are closely linked to greater reductions in chemical hazards such as methane emissions, toxic leachates, and other pollutants. This finding supports the idea that solid waste management is not only a technical or chemical challenge but also one that depends on social behavior and collective action.

Hypothesis 2

H_{02}: There is no significant relationship between household waste segregation practices and the efficiency of recycling in solid waste management systems.

Ha_2: There is a significant relationship between household waste segregation practices and the efficiency of recycling in solid waste management systems.

Table 17 Hypothesis 2

Correlations			
		Household Waste Segregation Practices	Efficiency of Recycling in Solid Waste Management Systems
Household Waste Segregation Practices	Pearson Correlation	1	.719**
	Sig. (2-tailed)		.000
	N	125	125
Efficiency of Recycling in Solid Waste Management Systems	Pearson Correlation	.719**	1
	Sig. (2-tailed)	.000	
	N	125	125
**. Correlation is significant at the 0.01 level (2-tailed).			

The correlation analysis for Hypothesis 2 reveals a strong positive relationship between household waste segregation practices and the efficiency of recycling in solid waste management systems, with a Pearson correlation coefficient of 0.719. The significance value (Sig. = 0.000) is far below the 0.01 level, confirming that this relationship is statistically significant. Therefore, the null hypothesis (H_{02}) is rejected, and the alternative hypothesis (Ha_2) is accepted. This finding indicates that better segregation practices at the household level directly enhance the efficiency of recycling processes, as separated materials such as plastics, metals, and organics can be processed more effectively without contamination. In simple terms, the more consistently households practice segregation, the more efficient and productive the recycling system becomes, leading to reduced chemical hazards and improved sustainability in waste management.

Hypothesis 3

H_{03}: There is no significant impact of public awareness on the safe handling and disposal of chemically hazardous waste materials.

Ha_3: There is a significant impact of public awareness on the safe handling and disposal of chemically hazardous waste materials.

Table 18 Hypothesis 3

ANOVA					
Safe Handling and Disposal of Chemically Hazardous Waste Materials					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	485.184	11	44.108	19.362	.000
Within Groups	257.424	113	2.278		
Total	742.608	124			

The ANOVA results for Hypothesis 3 indicate that the significance value (Sig. = 0.000) is well below the accepted threshold of 0.05, which leads to the rejection of the null hypothesis (H_{03}). This confirms that public awareness has a statistically significant impact on the safe handling and disposal of chemically hazardous waste materials. The F-value of 19.362, with a between-groups mean square of 44.108 compared to a within-groups mean square of 2.278, demonstrates that variations in safe disposal practices are strongly influenced by differences in public awareness. In practical terms, this suggests that individuals and communities with higher awareness are more likely to adopt safe disposal methods for items such as batteries, paints, medicines, and electronic waste, thereby reducing chemical risks to health and the environment.

CONCLUSION

The findings of the study highlight that while respondents demonstrated a strong awareness of the chemical hazards linked to poor solid waste management, their actual participation and consistency in practices showed mixed patterns. Descriptive results revealed that respondents strongly recognized the value of campaigns, collective efforts, and recycling in reducing risks such as toxic emissions and soil contamination. However, their active engagement in waste management was relatively weaker, as reflected in higher mean scores on items relating to regular participation and segregation practices. Similarly, while individuals strongly agreed on the environmental benefits of recycling, they expressed less satisfaction with the accessibility and effectiveness of local recycling systems. Public awareness indicators consistently showed high agreement, underlining the importance of education, campaigns, and media in spreading knowledge of chemical risks. In contrast, the handling of hazardous household waste revealed gaps, with many respondents admitting limited knowledge and inadequate community-level facilities for safe disposal.

The hypothesis testing reinforced these descriptive observations with statistical evidence. The ANOVA test confirmed that community participation significantly impacts the reduction of chemical hazards, showing that greater involvement directly reduces risks associated with methane emissions, leachates, and other pollutants. The correlation analysis demonstrated a strong positive relationship between household segregation practices and recycling efficiency, meaning that effective segregation at the household level leads to more successful recycling outcomes. Finally, the ANOVA for public awareness established that higher awareness strongly influences safer handling and disposal of hazardous wastes, emphasizing the critical role of education and outreach. The study establishes that chemical hazards in waste management can be effectively reduced through strong community participation, consistent segregation practices, efficient recycling, and widespread public awareness. While awareness levels are generally high, greater emphasis is needed on translating this knowledge into regular household practices and strengthening infrastructure for safe hazardous waste disposal.

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