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Research Article

Knowledge, Attitude and Practices on Solid Waste Management among Households in Biratnagar Metropolitan City, Nepal

Rajesh Gautam[1], Rubina Karki[2], Sweta Dixit[3], Barsha Khadka[3], Satyam Kumar Chaudhari[4,5,*]
[1]College of Applied Science, Tribhuvan University, Kathmandu, Nepal
[2]BRAC University, Dhaka, Bangladesh
[3]GoldenGate International College, Tribhuvan University , Kathmandu Nepal
[4]State Key Laboratory of Tibetan Plateau Earth System, Resources and Environment (TPESRE), Institute of Tibetan Plateau Research, Chinese Academy of Sciences, Beijing, China
[5]Environment Conservation Forum Nepal, Jhapa, Nepal
[*]Corresponding author: satyamchaudhari65@gmail.com

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Abstract

Solid waste management (SWM) remains a critical environmental challenge in rapidly urbanizing cities of developing countries, including Nepal. This study aimed to assess the knowledge, attitudes, and practices (KAP) toward SWM among households (HHs) in Wards 5 and 7 of Biratnagar Metropolitan City (BMC). A stratified random sampling approach was used to survey 186 HHs in November 2017. Semi structured questionnaires, key informant interviews (KIIs), and observational waste audits were used for data collection. Waste composition was analyzed following United Nations Environment Programme (UNEP) guidelines, revealing over 70% organic waste, with recyclables like plastics, paper, glass, and metals comprising the remainder. Household waste generation averaged 0.167 kg/person/day in BMC. Knowledge of waste segregation was high, attitudes were acceptable, but practices were moderate, one third segregating waste due to space constraints. Most of composting was organic waste, while inorganic waste was sold to vendors. Despite high KAP scores, systemic failures in collection infrastructure and policy enforcement undermine SWM efficacy. The study highlights SWM practices in these industrial wards, indicating that although residents possess good knowledge and attitudes regarding solid waste management, practical implementation is hindered by infrastructural and policy gaps.

Introduction

Municipal solid waste management (MSWM) is a major issue worldwide, exacerbated by urbanization and population growth (Maalouf & Mavropoulos, 2023; Zohoori & Ghani, 2017). The Industrial Revolution marked a surge in waste generation, with developing countries facing acute challenges due to inadequate infrastructure (Mishra, 2013). Globally, solid waste include organics, recyclables, hazardous materials, and construction debris, with improper management leading to environmental and health risks (Kaza *et al.,* 2018). Modern approaches emphasize the 3R concept (reduce, reuse, recycle) and technologies like composting and energy recovery (Abdel-Shafy & Mansour, 2018; Genon *et al.,* 2022; Ragazou *et al.,* 2024).

In South Asia, rapid urbanization has increased SWM problems, with low collection rates and open dumping prevalent (Dixit *et al.,* 2014; Ferronato & Torretta, 2019). Nepal also face these issues, with MSWM complicated by population growth and migration (Singh *et al.,* 2015). The Solid Waste Management Act of 2011 promotes segregation and composting, but implementation lags (Pathak, 2017). National surveys report average waste generation at 0.317 kg/capita/day, with 68% organic content (Asian Development Bank, 2013; SWMTSC, 2017). Recent data suggest increases, with collection efficiency varying (Rai *et al.,* 2019). Community participation is key, yet awareness and infrastructure deficits hinder progress (Gurung & Dhakal, 2016; Gutberlet, 2017).

Developing countries like Nepal changes have taken place rapidly over the past few decades, while the

government and the people have failed to comprehend the serious implications of improper SWM and its impacts. As a result, many cities in developing countries like Nepal are now suffering from the adverse impacts of unmanaged waste (Rai *et al.,* 2019). The problem is critical, particularly in large cities like Biratnagar, Kathmandu, Lalitpur, and Pokhara, where improper management of waste has led to environmental pollution, public health hazards, and adverse effects on an urban economy (Gurung & Dhakal, 2016). IUCN (1992) has started a review work on the environmental pollution of Nepal, especially focusing on SWM. Community wise involvment has a direct bearing on efficient SWM (Singh *et al.,* 2015). Local level authorities are failed to organize the community and educate citizens for handling waste and proper practices of storing it (Asnani, 2006; Duwal, 2015). With the absence of a basic facility for the collection of waste from source, citizens are prone to dumping waste on the streets, open spaces, drains, and water bodies, creating unhygienic conditions (Ferronato & Torreta, 2019).

Biratnagar, Nepal's largest and fast growing city , serves as an industrial hub in Koshi Province, experiencing escalating waste from urbanization (CBS, 2021). Prior studies note poor disposal and health risks (IUCN, 1992; Rai *et al.,* 2019). This cross-sectional study aimed to assess HH KAP toward SWM and associated factors. Findings may inform local government actions, provide baseline data, and offer insights into challenges and solutions.

Methods and Materials

Study Area

Biratnagar Metropolitan City (26°28'N, 87°16'E, 72 m elevation) extends Morang District, with Wards 5 (Kanchanbari) and 7 (Sarochaiya) as key industrial zones located between Singia and Keshaliya Rivers (Figure 1). These wards are embanked by the Singia River in the east and Keshaliya in the west. The city's population grew to 242,548 by 2021, driving waste increases (CBS, 2021), it is largest and capital of koshi province. It is located 399 km east of the capital, Kathmandu, and 6 km north of the bordering town of Jogbani in the Indian state of Bihar.

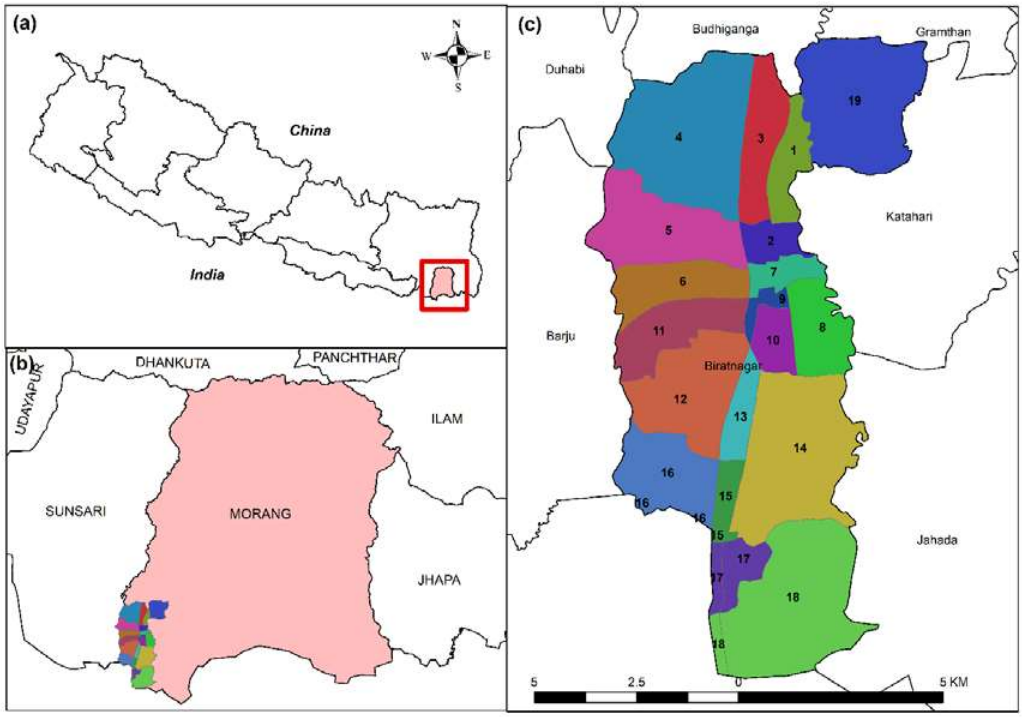

Figure 1: Location map of the study area showing (a) Nepal wish showing Morang district (b) Morang District highlighting BMC, and (c) BMC with ward wise boundaries.

Data Collection

A stratified random sampling method was employed in November 2017, coinciding with BMC's metropolitan designation, to capture baseline SWM practices. Socio-economic and HH characteristics were obtained via direct interviews using structured questionnaires. HH heads or spouses provided responses after instructions for sincerity. KAP on HH waste management was recorded. The 186 HHs were selected from Wards 5 and 7 for their socio-economic diversity and high waste generation. Allocation was proportional across strata. Ethical verbal informed consent ensured anonymity and voluntariness. Sample size was calculated using the finite population formula in eq (i) (Arkin & Colton, 1963):

$$n = \frac{\mathrm{N} \times Z^2 \mathrm{p}\,(1-\mathrm{p})}{\mathrm{N} \times d^2 + Z^2 \mathrm{p}\,(1-\mathrm{p})} \quad (i)$$

Where,

n =Sample size,

N = total number of households in the selected wards (based on 2011 census data adjusted for population growth),

Z= Value of variance at 95 % confidence interval (1.96),

d= Acceptable error (10%), and

p = Estimated population proportion (0.5, this maximizes the sample size)

Data Analysis

The waste characteristics were designed as per the United Nations Environment Programme (2005) solid waste classification. Quantitative data were analyzed using descriptive statistics, including frequencies, percentages, means, and standard deviations, computed with SPSS version 25. Waste quantification was expressed as kg/capita/day and extrapolated to tonnes/year using population estimates from the 2011 Nepal census (Central Bureau of Statistics, 2012). The descriptive statistics of the variables were calculated. The quantification of solid waste was expressed in kg/person/day and ton/year; here, the load was expressed in kg/person/day. The conceptual diagram on waste management was drawn. Besides, the degree of knowledge, attitudes, and practices was also assessed in terms of agreement and disagreement scales. The respondent ranking for knowledge, attitude, and practices was done based on KAP scored on Likert scales (Knowledge: 1=Low–3=High; Attitude: 1=Less favorable,3=Most favorable; Practices: 1=Poor–3=Good). Thematic analysis for qualitative data (Braun & Clarke, 2006). To explore socio-economic influences, data were analyzed waste generation rates, segregation practices, and perceptions with variables such as education level, occupation, income, and gender using chi-square (χ^2) tests for associations ($p < 0.05$) indicating the significance.

Results

Demographic Profile of Respondent

Out of the total 186 respondents were mostly female (56.45%, n=105), reflecting the main role of female in household waste management with average household size was (4.2 ±1.8). Education levels varied: 33.8% had secondary education, 28.5% primary education, 22.5% high education and 15.05% no education. Occupations included private employed were 36.5%, farming 23.6%, Government employed 17.2%, housewife 16.6%, and others 5.9%. Similarly, monthly household income distribution was: low 29.03%, medium 47.8%, and high 23.11% (Table 1).

Table 1: Socio-demographic characteristic of the respondents and associations with knowledge, attitude, and practices (KAP) on solid waste management (N=186)

Variable	Category	Frequency (%)	High Knowledge (%)	Favorable Attitude (%)	Good Practices (%)	Chi-square (df, p-value)		
						Knowledge	Attitude	Practices
Gender	Male	81 (43.5)	68	75	28	2.14 (1,0.014)	1.56 (1,0.21)	3.45 (1,0.06)
	Female	105 (56.45)	76	82	35			
Education level	No education	28 (15.05)	53	68	73	12.45 (2,<0.01)	9.87 (2,<0.05)	11.23 (2,<0.01)
	Primary education	53 (28.5)	62	70	25			
	Secondary education	63 (33.8)	75	80	32			
	Higher education	42 (22.5)	85	90	42			
Occupation	Private employed	68 (36.5)	65	72	24	7.89 (4, <0.05)	6.45 (4,0.09)	8.32 (4,<0.05)
	Farming	44 (23.6)	78	85	38			
	Government employed	32 (17.2)	74	80	35			
	Housewife	31 (16.6)	80	88	40			
	Others	11 (5.9)	70	75	30			
Income level	Low (< NPR 15,000)	54 (29.03)	60	68	22	10.56 (2,<0.01)	8.76 (2,0.05)	9.45 (2,<0.01)
	Medium (NPR 15,000-35,000)	89 (47.8)	72	80	32			
	High (> NPR 35,000)	43 (23.11)	85	90	40			

Higher education levels were linked to better knowledge of segregation (χ^2 = 12.45, df=2, p < 0.01) and positive attitudes (χ^2 = 9.87, df=2, p < 0.05). Female headed households showed higher attitudes toward organic composting (χ^2 = 8.32, df=4, p < 0.05), likely due to their role in daily waste handling. Income levels influenced practices: higher income HHs were more likely to sell recyclables (χ^2 = 10.56, df=2, p < 0.01) but generated more waste (average 0.19 kg/person/day vs. 0.14 kg/person/day in lower income groups). Occupation (e.g., industrial workers) correlated with lower segregation rates due to time constraints (χ^2 = 7.89, p < 0.05). These patterns indicate that waste generation and perceptions are modulated by socio-economic factors, with education and gender emerging as key drivers.

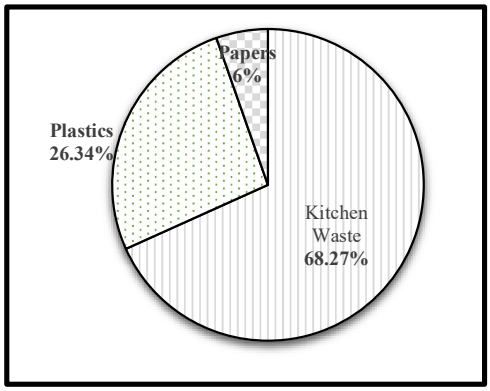

Figure 2: Household responses identifying major types of household waste in BMC

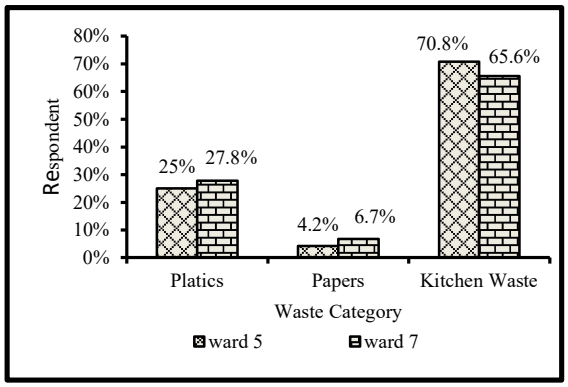

Figure 3: Ward wise household responses identifying major types of household waste in BMC.

Among the 186 surveyed households (HHs), 68.27% (n=127) identified kitchen waste as the primary HH waste, followed by plastics (26.34%, n=49) and paper (5.37%, n=10) (Figure 2). Ward level variations were minimal, with organic waste (kitchen) ranging from 66-71%, plastics 25-28%, and paper 4-7% across studied wards (Figure 3). Households contribute 50-75% of total MSW in Nepal.

Households' Knowledge and Attitudes towards SWM

A large number of respondents73.11% (n=136) have high knowledge of waste segregation, encompassing benefits such as improved disposal efficiency, manure production, and income generation from recyclables (Figure 4). Ward-specific analysis showed 76% and 70% awareness in Wards 5 and 7, respectively, yet actual segregation practices lagged at 24% and 40% (Figure 5). Only 5.2% and 3.3% reported earning from segregation, highlighting a knowledge-practice gap. Reasons for segregation included disposal efficiency (70.8% in Ward 5, 63.3% in Ward 7) and manure preparation (>20% in both) (Figure 6), while reluctance stemmed from space constraints (15.6% and 22.2%) (Figure 7).

Waste Quantification and Characterization in BMC

Our results show that organic materials are major, accounting for over 72% of the total municipal solid waste (MSW), with plastics and paper contributing 9% and 11%, respectively. Glass comprised approximately 4%, metals (primarily iron) about 1%, and mixed waste nearly 4%. The total MSW generation rate in BMC was estimated at approximately 0.167 kg/person/day.

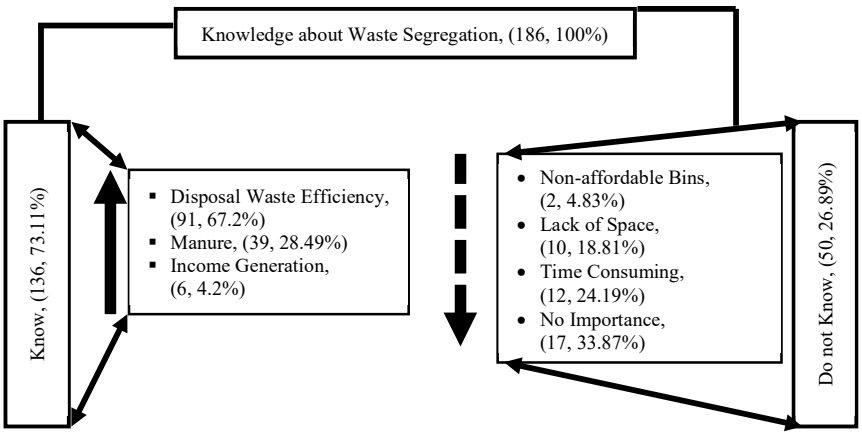

Figure 4: Distribution of household knowledge levels on waste segregation in BMC.

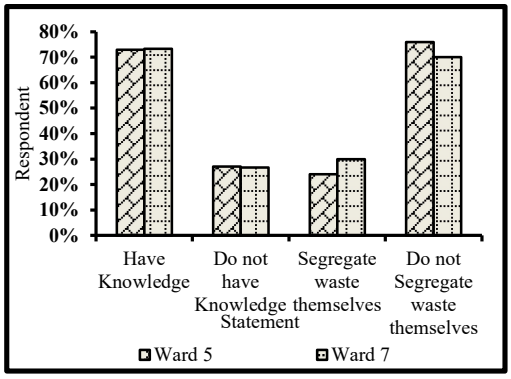

Figure 5: Ward wise knowledge levels on waste segregation in BMC.

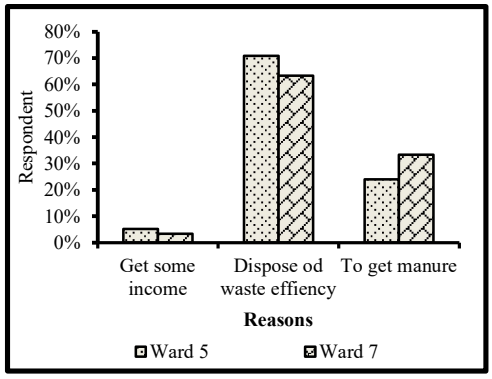

Figure 6: Ward wise reasons provided by households for practicing waste segregation in BMC.

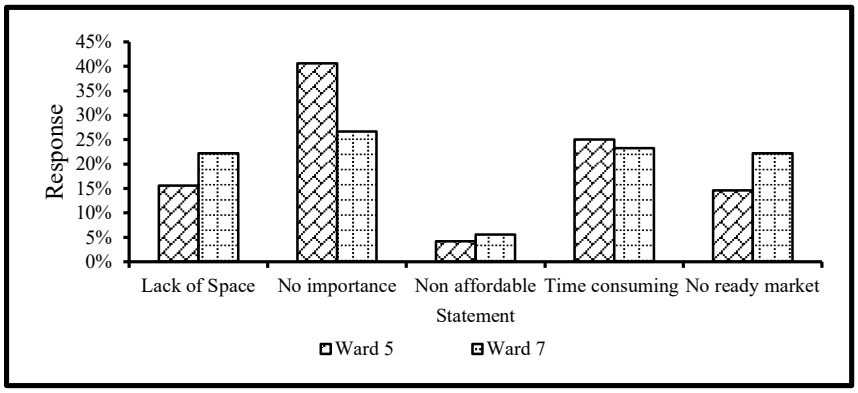

Figure 7: Ward Wise Reluctances Responses for Waste Segregation

Perceptions and Practices of Waste Management in BMC

Perceptions of the 3R (reduce, reuse, recycle) principles were mixed, with 51.07% familiar with recycling, 35.48% with reuse, and 13.45% with reduction. Ward 5 showed higher recycling awareness, while Ward 7 favored reduce/reuse. Practices included composting (primary for organics), vendor delivery for fertilizers, and reuse of items like bottles (33.33%). However, 3-6% resorted to roadside dumping, and >45% sold inorganics to scrap dealers. The existing SWM system in BMC focuses on collection and disposal, with public private partnerships (PPPs) managing operations since 2003, including NGO led fee based services.

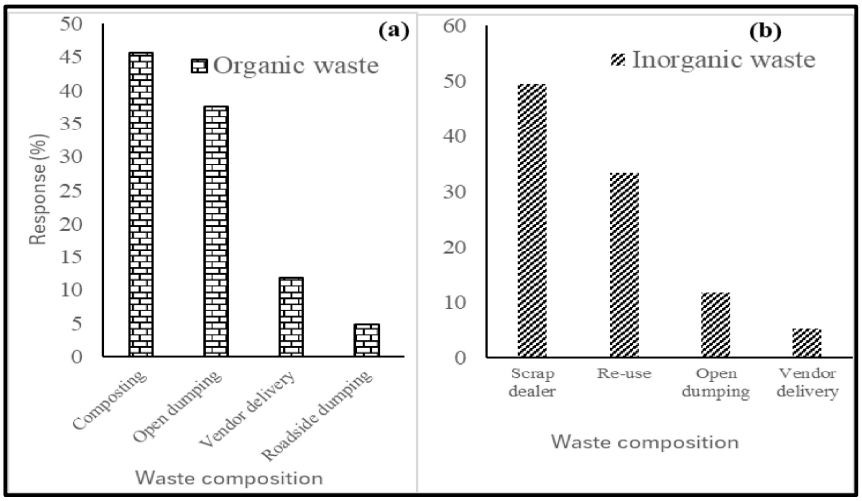

Figure 8: Bar diagrams showing waste composition of households in BMC: (a) disposal practices for organic waste and (b) disposal practices for inorganic waste

Discussions

Waste Quantification and Characterization in BMC

This distribution of waste aligns with national trends in Nepal, where organic waste typically dominates MSW, often exceeding 60-65% due to high reliance on agricultural and food-related activities (Maharjan *et al.,* 2019). For example, the Asian Development Bank's (ADB) comprehensive survey across 58 Nepalese municipalities reported an average organic fraction of 56%, with plastics at 12% and paper at 9%, underscoring the consistency of BMC's waste profile with broader patterns in low to middle income urban settings (Asian Development Bank, 2013).

The waste generation rate in BMC is notably higher than the national average of 0.317 kg/capita/day reported by the ADB in 2013. Comparative studies in other Nepalese cities, such as Kathmandu (0.66 kg/capita/day) and Ghorahi (with a 10-year increase from 0.25 to 0.35 kg/capita/day), highlight how population growth and economic development drive elevated generation rates (Dangi *et al.,* 2011). In BMC, with an annual population growth rate of 1.29% exacerbated by rural to urban migration, waste production is projected to escalate further, necessitating proactive interventions (Chauhan *et al.,* 2025). These findings corroborate earlier reports on Biratnagar, where household waste generation was estimated at 46.7 tonnes/day in 2010, with biodegradables comprising 72%. Seasonal and temporal variances in waste composition, as noted in global literature, could influence these figures, though studies in Nepal suggest such fluctuations are often insignificant in tropical climates (Gurung & Oh 2012). The high organic content underscores the urgency for frequent collection to prevent public health risks, aligning with recommendations for daily removal in organic heavy MSW systems (Asian Development Bank, 2013).

Households' Knowledge and Attitudes towards SWM

This KAP (knowledge, attitudes, practices) disparity is prevalent in developing countries, where high awareness (e.g., 70-80% in Ethiopia and Uganda) contrasts with low implementation due to infrastructural barriers (Eshete *et al.,* 2023). In Nepal, similar gaps are evident in cities like Besisahar, where 197 g/capita/day generation coexists with suboptimal practices influenced by demographics (Aryal & Adhikari, 2025). Demographic factors in BMC, including female-dominated HHs (60%), education levels, and occupation, significantly shaped attitudes, with women playing pivotal roles in SWM perceptions (Apio *et al.,* 2024). Age and education positively correlated with pro environmental attitudes, consistent with studies showing maturity and literacy enhance sanitation awareness (Rahman & Bohara, 2023). These insights reveal opportunities for targeted education to bridge the gap, as seen in successful interventions in Malaysia and Iran, where attitude-focused campaigns improved segregation rates by 20-30% (Fadhullah *et al.,* 2022; Zand *et al.,* 2022).

Perceptions and Practices of Waste Management in BMC

One of the challenges in developing nations, where 3R adoption is difficult due to policy gaps and financial constraints, despite potential for resource recovery (e.g., organic composting yielding 30-50% reduction in landfill needs) (Subedi *et al.,* 2023). In Nepal, the Solid Waste Management Act (2011) mandates 3R promotion, yet implementation lags, as evidenced by national efficiency rates of 92-98% in collection but persistent open dumping (Goyal *et al.,* 2020). Recent initiatives in BMC, such as a 13.1-ha landfill and PPPs, but align with global critiques of Nepal's SWM lagging behind standards in 3R integration (Melles *et al.,* 2025). Opportunities for circular economy approaches, like waste-to-energy or enhanced recycling, could recover value from BMC's organic-rich waste, reducing environmental impacts as seen in impacts on local rivers from improper disposal (Amin *et al.,* 2023). Addressing these through community engagement and policy enforcement could elevate BMC's SWM to sustainable levels, mitigating risks from monsoon-exacerbated waste issues.

Education and income facilitate better practices, while gender influences attitudes, aligning with broader literature on demographic drivers in developing contexts (Rahman & Bohara, 2023; Apio *et al.,* 2024). These findings suggest tailored interventions, such as education programs for low-income groups and time-efficient solutions for workers, to enhance equity in SWM.

The sample of 186 households from only two industrial wards may not represent the wider socio-economic and geographic diversity of the BMC. As data were collected in November 2017, subsequent changes in urbanization, policies, or awareness campaigns may have influenced KAP, limiting the present relevance of findings. Future research should cover the entire geography with larger, more representative samples.

Conclusions

This case study reveals high knowledge and favorable attitudes toward SWM in BMC Wards 5 and 7, but moderate practices due to infrastructure deficits. Organic waste dominates, with composting prevalent, yet collection inefficiencies persist. Key takeaways include the need for space efficient segregation, education, and 3R adoption. By highlighting socio-economic influences on KAP, this research contributes to broader SWM strategies in urban cities, informing policies for equitable, sustainable and environment friendly systems. It demonstrates how bridging KAP gaps through targeted awareness, improved infrastructure, and PPPs can reduce environmental and health risks, promote circular economies, and support national goals like Nepal's Solid Waste Management Act. Strict regulation on mandatory segregation, female-

targeted education campaigns, enhanced collection schedules, and landfill site development are some suggestion on urban cities. These insights provide a model for other developing cities, emphasizing community driven approaches to mitigate urbanization's waste challenges and foster resilient urban environments.

Disclosure statement

The authors declare there is no conflict of interest.

Informed Consent

Verbal informed consent was obtained from head of the house prior to the data Collection.

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CRediT Author Statement

RG: Conceptualization, Methodology, Writing – Review & Editing; **RK:** Writing – Original Draft, Visualization, Supervision, Writing – Review & Editing**; SD:** Data analysis, Investigation, Data curation, Writing – Review & Editing; **BK:** Methodology, Data Curation, Methodology, Writing – Review & Editing; **SKC:** Writing – Original Draft, Writing – Review & Editing.

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