ORIGINAL RESEARCH ARTICLE

Practices and Determinants of Household Solid Waste Management: A Cross-Sectional Study in Urban Karnataka, South India

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ABSTRACT

Introduction: Scientific and sustainable household solid waste management is crucial in achieving SDG 12 (responsible consumption) and SDG 3 (good health). Poor waste practices can harm both the environment and people's health. **Objective:** To assess the solid waste management practices and its association with socio-demographic profile of households in a selected urban locality of Kolar, in South India.

Methods: A cross-sectional study was conducted from April to June 2023, covering 318 consecutively sampled urban households, using a validated semi-structured questionnaire to collect data.

Results: The majority (28.6%) of households were from the lower middle socioeconomic class. Food and kitchen waste, plastics, and paper waste were the most common types of waste generated. Sanitary napkins/pads were disposed of with plastic waste without segregation. Closed containers were used for wet waste storage in 64.8% of households. Households with children under 5 years were more likely to use closed containers (OR: 2.04, 95% CI: 1.18-3.50). Sanitary disposal of waste was practiced by 64.4% of households, with higher odds in households located along main roads.

Conclusion: This study found high waste segregation rates but poor sanitary waste management so this recommends a multi-faceted approach to improve waste management. Urban governance should adopt a circular waste management approach to improve accountability and resource efficiency.

Keywords: Solid waste management, Urban households, Socio-demographic factors, Sanitary disposal, Waste segregation, Circular economy, Public health

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Introduction

Household solid waste management is a multi-pronged issue encompassing various practices aimed at reducing, recycling, and properly disposing of the waste generated in houses. Waste management is directly linked to several Sustainable Development Goals (SDGs), including SDG 3 (Good Health and Well-being), SDG 11 (Sustainable Cities and Communities), and SDG 12 (Responsible Consumption and Production). For instance, SDG 3 is impacted by poor waste handling, which can lead to disease outbreaks such as diarrhoea and vector-borne illnesses. SDG 12 emphasizes reducing waste generation through prevention, reduction, recycling, and reuse. In particular, Indicator 11.6.1 of SDG 11, "Municipal Solid Waste Management" aims to quantify the solid waste generated by cities and monitor the progress in solid waste management.[1] Further, all 17 SDGs are linked directly or indirectly to waste management. For instance, indiscriminate household waste disposal has an impact on environmental health, resulting in unhygienic circumstances that can lead to disease outbreaks and epidemics (SDG 3) of several illnesses, infections, and infestations, such as dysentery, helminthiasis, diarrhoea, typhoid, and vector-borne diseases.[2] Improper management of household waste damages the landscape, creates fire threats, foul odours, and unpleasantness, increases the expense of dredging streams, clogs reservoirs, reduces plant productivity, deteriorates buildings and their foundations, and decreases the property's value.[3]

Waste management has grown more difficult in the last 20 years for both developing and less developed nations.[4] The rapid population growth and urbanisation have also resulted in massive trash production. Over the next 50 years, the amount of solid waste produced is anticipated to rise by 70% yearly from the 2.01 billion tonnes produced globally in 2016.[5] In India, it is estimated that the total quantity of solid waste generated in the country is 1,70,339 TPD (tonnes per day) and the total waste collected is 1,56,449 TPD (92% coverage). The South Indian state of Karnataka produces about 200g of solid waste per capita per day, above the national average of 123.45g/per capita/day. In Karnataka, about 13,034 TPD of solid waste is generated, out of which approximately 11,655 TPD is collected, 5,440 TPD of waste is treated and 4,198 TPD is landfilled. Thus, there is a gap of 11% in solid waste collection and 26% in solid waste management.[6]

In India, waste management in the backdrop of urban space expansion is a significant concern. Further, municipal garbage management is a challenging urban function that necessitates community involvement.[7] In most parts of the country, the local authority (Municipal Corporation in urban/ Panchayat in rural areas) is responsible for solid waste management, as mandated by the Solid Waste Management Rules, 2016.[8,9] In Kolar, despite existing municipal systems, significant gaps remain in solid waste segregation and sanitary disposal, particularly in crossroad areas. Challenges include irregular waste collection, poor segregation awareness, and limited access to municipal services in interior areas. These local challenges justify the need for an in-depth household-level analysis of waste practices. These rules further detail the responsibilities of the producer of waste. However, sustainable waste management requires a shift from linear economy, which follows "Take-Make-Waste" model to a circular economy, which focuses on "Reduce-Reuse- Recycle" model.[10] The circular economy, in turn relies on manufacturing methods, consumer behaviour and collaboration between the suppliers, local authority and consumers. Thus, consumer awareness, practices and determinants form the basis of establishing a circular economy. This study was designed to explore the perceptions and practices of household waste management among residents (consumers) of an urban locality of Kolar, with a special focus on social and health determinants.[11]

Methodology

Kolar is a south eastern District in the South Indian state of Karnataka. The district headquarters, also named as Kolar (city), is located at 13.13º N, 78.13ºE. Kolar City Municipal Council has a population of about 138,462 (2011 census), and 35 wards.[12] The current study was carried out in the urban field practice area of the affiliated medical college from November 2022 to January 2023. This locality was selected purposively in order to plan for future interventions in the locality. This locality has 350 houses, located along the two main roads and 16 cross roads. Residents of all the 350 houses were approached to participate in the study. The head of the family was interviewed using a structured questionnaire. In households where the head of the family was not available, then the available resident, aged above 18 years was requested to participate. Households which were locked in two consecutive visits were excluded from the study. Similarly, persons who were not residents of the locality, but merely visited the locality for business or other reasons were not included. The study finally covered 318 of the 350 houses (91%), representing a population of 1514 residents.

Institutional Ethics Committee clearance was taken before the start of the study (No DMC/KLR/IEC/177/2023-24. Date: 26.05.2023). Informed written consent was obtained from participants.

Questionnaire Development: A semi-structured questionnaire was developed after an extensive literature review and consideration of the Solid Waste Management Rules (2016) and Kolar municipal waste handling guidelines. The tool was pre-tested on 20 randomly selected households from a neighbouring locality and revised accordingly. Reliability was assessed using Cronbach's alpha, with all scales demonstrating acceptable internal consistency ($\alpha > 0.7$).

The participants were interviewed for 10-15 minutes to capture the sociodemographic characteristics, health profile and household waste management practices.

The data was entered in a Microsoft Excel sheet and analysed using SPSS v 22(IBM Corp).[13] The independent variables were sociodemographic variables (Age, Gender, Occupation, Number of members currently living in the house, Family with child less than 5 years of age, Family with persons above 60 years of age, socioeconomic status and number of family members, Duration of stay in this place) and occurrence of Food/vector borne disease in the past 1 year. Three household waste management practices – segregation of waste into wet and dry waste, storage of waste in closed containers and sanitary disposal of waste through municipality vans/recycling, were examined in the light of the sociodemographic and health profile of the family. Logistic regression analysis was performed to evaluate the associations between household waste management practices (segregation, closed container use, and sanitary disposal) and sociodemographic variables (age, gender, socioeconomic status, presence of children under 5, elderly members, and disease history). The association was further examined using multivariable analysis. A p-value <0.05 was considered statistically significant.

RESULTS

Among 318 participants, the majority (28.6%) represented families from the lower middle socioeconomic class, according to Modified BG Prasad Classification (2023).[14] The sociodemographic profile of the participants is given in Table 1.

The predominant types of wastes generated in the household were food and kitchen waste (wet waste), plastics and paper waste, regardless of the socioeconomic status (Table 3). Sanitary napkins were disposed of by 32% (102 households), but were named as plastic waste by the respondents.

Segregation of wet and dry waste was practised in 299 (94%) households. However, none of the houses segregated used sanitary napkins or diapers separately and were disposed of with dry waste. Three methods of waste storage exist. Makeshift cans or buckets were old, used paint buckets or broken plastic buckets, which were repurposed as wastebaskets. Whenever kept closed, these cans or buckets had ill-fitting lids. The second method was to use plastic bags to temporarily store waste till final disposal. In some households, these plastic bags were filled with waste and kept tied at the neck, to be disposed of in bulk. In other households, these plastic bags were kept open (untied). The third method was to use dedicated waste baskets. In some households, the lids of these waste baskets were broken or missing and hence were kept open. In others, closed waste baskets, provided by the Municipality were used. Further, multiple waste storage methods (before disposal) existed within the same household.

Table 1: Sociodemographic profile of the participants from households included in the study in an urban locality of Karnataka (n=318)

Sociodemographic variable	Participants(%)
Age of the participants (mean ± SD)	
18-35 years	150 (47.1)
36-64 years	144 (45.25)
Above 65 years	24 (7.5)
Gender of the participants	
Male	112 (35.2)
Female	206 (64.8)
Socioeconomic Status (according to Modified BG Prasad classification)	
Upper class	44 (13.8)
Upper middle class	87 (27.4)
Middle class	77 (24.2)
Lower middle class	91 (28.6)
Lower class	19 (6.0)
<5 year child in the family	94 (29.6)
> 60 years Family member	143 (45.0)
At least one family member affected by food/vector borne disease in last one year*	227 (71.4)

*Food borne disease included common diseases transmitted by houseflies (acute diarrheal disease, Typhoid and Cholera); Vector borne diseases included Aedes mosquito transmitted diseases (Dengue and Chikungunya)

Table 2: Types of waste generated in past 2 weeks, from households of different socioeconomic classes (n=318) in an urban locality of Karnataka

Type of waste	Socioeconomic class					
	Upper N (%)	Upper Middle N (%)	Middle N (%)	Lower Middle N (%)	Lower N (%)	Total N (%)
Food and kitchen waste (wet waste)	40 (90.9)	80 (92)	73 (94.8)	81 (89)	19 (100)	293 (92.1)
Plastics (bags/bottles/Sanitary napkins)	40 (90.9)	77 (88.5)	70 (90.9)	83 (91.2)	19 (100)	289 (90.9)
Paper and carton	41 (93.2)	75 (86.2)	72 (93.5)	77 (84.6)	16 (84.2)	281 (88.4)
Medicines and medical waste	22 (50)	40 (46)	22 (28.6)	31 (34.1)	7 (36.8)	122 (38.4)
E waste	21 (47.7)	30 (34.5)	22 (28.6)	25 (27.5)	2 (10.5)	100 (31.4)
Tins/cans	15 (34.1)	31 (35.6)	22 (28.6)	20 (22)	5 (26.3)	93 (29.2)
Fiber bags	13 (29.5)	20 (23)	22 (28.6)	23 (25.3)	6 (31.6)	84 (26.4)
Glass	17 (38.6)	24 (27.6)	14 (18.2)	16 (17.6)	1 (5.3)	72 (22.6)
Animal waste	0 (0)	0 (0)	0 (0)	0 (0)	1 (5.3)	1 (0.3)
Total	44 (100)	87 (100)	77 (100)	91 (100)	19 (100)	318 (100)

Table 3: Use of closed containers for storage of wet waste and its association with sociodemographic profile of households from an urban locality of Karnataka

Sociodemographic Variable	Use of closed container for storage of wet waste					
	Yes (n=206)	No (n=112)	cOR (95% CI)	P value	aOR (95% CI)	P value
Family with child < 5 years of age						
Yes	71(75.5)	23(24.5)	2.04 (1.18-3.50)*	0.01	2.43 (1.36-4.34)*	0.002
No	135(60.3)	89(39.7)	Ref		Ref	
Family with persons > 60 years of age						
Yes	91(63.6)	52(36.4)	0.91 (0.58-1.45)	0.70	0.85 (0.52-1.38)	0.50
No	115(65.7)	60(34.3)	Ref		Ref	
Socioeconomic status						
Upper class	34(77.3)	10(22.7)	Ref		Ref	
Upper middle	61(70.1)	26(29.9)	0.69 (0.30 - 1.60)	0.39	0.63 (0.27-1.49)	0.29
Middle class	44(57.1)	33(42.9)	0.39 (0.17 - 0.91)*	0.03	0.33 (0.14-0.78)*	0.001
Lower middle class		34(37.4)	0.49 (0.22 - 1.12)	0.09	0.47 (0.2-1.07)	0.07
Lower class	10(52.6)	9(47.4)	0.33 (0.10 - 1.03)	0.06	0.24 (0.07-0.78)*	0.02
Food/vector borne disease in past 1 year						
Yes	150(66.1)	77(33.9)	1.22 (0.74 - 2.02)	0.43	1.09 (0.64-1.85)	0.75
No	56(61.5)	35(38.5)	Ref		Ref	

*p <0.05 indicates statistical significance; cOR – Crude Odds Ratio; aOR – Adjusted Odds Ratio; CI – Confidence interval

Table 4: Sanitary disposal of waste and its association with sociodemographic profile in selected households, in an urban locality of Karnataka

Variable	Sanitary disposal of waste			
	Yes (n=205)	No (n=113)	Crude OR (95% CI),	p-value
Family with child < 5 years of age				
Yes	62(65.9)	32(34.1)	1.10 (0.66-1.82)	0.71
No	143(63.8)	81(36.2)	Ref	
Family with persons > 60 years of age				
Yes	92(64.3)	51(35.7)	0.99 (0.62-1.57)	0.98
No	113(64.5)	62(35.5)	Ref	
Socioeconomic status				
Upper class	34(77.3)	10(22.7)	Ref	
Upper middle	53(61.6)	34(38.4)	0.46 (0.20 - 1.05)	0.07
Middle class	48(62.3)	29(37.7)	0.49 (0.21 – 1.13)	0.09
Lower middle class	59(64.8)	32(35.2)	0.54 (0.24 – 1.24)	0.14
Lower class	11(57.9)	8(42.1)	0.40 (0.13 – 1.28)	0.12
Food/vector borne disease in past 1 year				
Yes	144(63.4)	83(36.6)	0.85 (0.51 – 1.43)	0.55
No	61(67)	30(33)	Ref	
Location of the house				
Along the main roads and 10m interior to main roads	75(81.5)	17(18.5)	3.25 (1.81-5.87)*	0.001
Along the cross roads	130(57.5)	96(42.5)	Ref	

*p <0.05 indicates statistical significance.

For instance, dry waste was stored predominantly in closed, makeshift waste containers, like cans or buckets. In the same households, other methods such as storing the dry waste in plastic bags or waste baskets also existed. Similarly, wet waste was predominantly collected in closed, dustbins. However, these methods were not exclusive, and other methods of wet waste storage exist within the same household, such as storing in makeshift containers and plastic bags, (Figure 1).

Among 318 households included in the study, 224 households used closed containers as one of the methods of wet waste storage. Among them, 206 households (64.8%), wet waste was segregated and collected only in closed containers. The odds of using a closed container for storage of wet waste was 2.04 times in households with a child less than 5 years of age, compared to a family not having a child less than 5 years. This was found to be significant after adjusting for other variables. The odds of using closed containers for storage of wet waste were less in Lower socioeconomic classes, when compared to upper-class households.

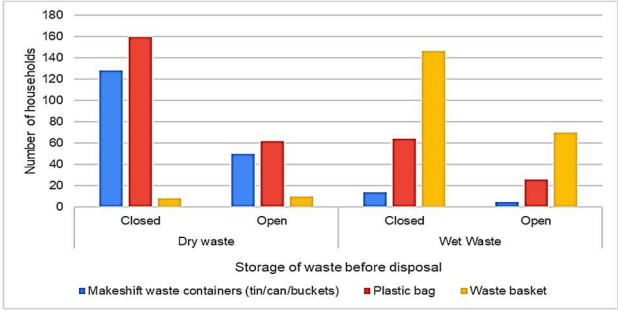

Figure 1: Self-reported household solid waste storage methods used before disposal in households that practised segregation (N=299) in an urban locality of Karnataka

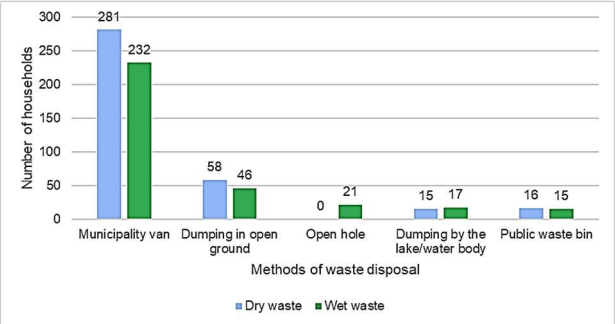

Figure 2: Self-reported methods of household solid waste disposal, by type, in selected households of urban Karnataka

However, the strength of association was not consistent across the different socioeconomic classes. The inconsistent association between socioeconomic status and closed container use may be due to non-uniform distribution of municipal-supplied waste bins across classes. In many lower socioeconomic households, broken or makeshift containers were prevalent due to lack of replacements. The occurrence of food/vector-borne disease in the household in the past 1 year was not associated with usage of closed container for storage of wet waste (Table 3).

Multiple methods of disposal existed in the same households. Only 205 households (64.4%) disposed of all their waste sanitarily through the municipal collection system.

There was no significant association between the sociodemographic profile and sanitary disposal of waste. However, the odds of sanitary disposal of waste were significantly higher in houses which were located along the main road and within 10m of the main road, compared to the houses located much interior, along the cross roads, (Table 4).

Upon further exploration, 89 of the 92 houses (96.7%) located on the main roads reported that the Municipality Waste Collection was punctual (once in two days), whereas only 36 of 226 houses along the crossroads reported that the vans were punctual (χ^2 =178, df=2, p value = 0.000). Among the 92 houses that disposed of waste in Municipality collection vans, 52 (56.5%) also reported that the timing of the collection vans suited them (5.30 am to 9.30 am). Among the respondents of 113 households who did not dispose of the waste through Municipality vans, 70 (61.9%) responded that the dump site was nearby and hence convenient.

Discussion

This cross-sectional study was conducted in an urban locality in the Kolar District of Karnataka, involving 318 households, representing 1514 residents. Most of these households belonged to lower middle (28.6%), (24.2%), middle (24.2%) and upper middle (27.4%) socioeconomic class.

In the two weeks preceding this study, the houses had predominantly generated types of food and kitchen waste, plastics, and paper waste. This study did not quantify the waste or its type, collected in each household. However, most households (92%) generated food and kitchen waste, regardless of their socioeconomic status. Similarly, another study conducted in Indonesia revealed that predominant types of waste generated in households were organic waste, including food waste, leaves, paper, and wood, which accounted for 81.34% of the total waste.[15] In a study carried out to find the solid waste composition in various socioeconomic groups in India, it was noted that food waste was a major component in both high and low socioeconomic groups.[16] Though the waste characterization was similar in all socioeconomic groups in the study conducted by Khan D et al., plastic waste was found to be maximum (15%) in high socioeconomic groups. In the present study, it was found that comparatively higher proportion of Upper-class households generated medical waste and e-waste. However, these wastes were not segregated and disposed of along with dry waste. Similarly, it is important to note that the households did not recognize sanitary pads and diapers separately, and considered them as “plastic waste”. Our segregation rate (94%) aligns closely with findings from Delhi (80%) but exceeds rates observed in Warangal, where poor infrastructure limited proper segregation and disposal. Hence, during data collection, the participants had to be asked particularly regarding disposal of sanitary pads and diapers along with other solid waste, to which 102 replied in affirmative. This also highlighted that the study participants were not aware of the need to dispose of sanitary pads and diapers separately from other solid waste.

The study further aimed to document household waste management practices. We have found that 299 households (94%) segregated dry and wet waste at the household level. However, as stated above, the households did not recognize sanitary waste, medical waste and e-waste as separate entities. The metal waste, if generated, was also handed over to local scrappers or dealers. Similarly, a study conducted in Delhi reported a high proportion of waste segregation, with 80% of households practising it [17]. Households with a child less than 5 years had 2.43 (1.36-4.34) odds of storing wet waste only in closed containers, probably because of their increased concern towards general hygiene, compared to a family not having a child less than 5 years. The socioeconomic status, did not show a consistent association with the use of only closed containers for wet waste. This was further explained by the fact that most of the households that used closed containers received it from the Municipality local government, whereas the others had not received it or had not replaced damaged containers. A study in Warangal city showed inadequate solid waste management, including the absence of closed containers for storing wet waste, plays a critical role in the spread of vector-borne diseases.[18] In the present study, the occurrence of food/vector-

borne disease in the household in the past 1 year was not associated with the usage of closed container for storage of wet waste, showing that the health education following the occurrence of food or vector borne disease in the family did not penetrate as practice of primary level of prevention.

The households practised multiple methods of waste disposal. Sanitary disposal of waste was significantly associated with the distance from the main road, which in turn influenced the frequency of the municipality collection van. Open dumping spots were also being used in households away from the main road. The frequency, timing and punctuality of municipality waste collection vans had an impact on sanitary disposal of waste. In a study on municipal solid waste burning in neighbourhoods, it was found that a lack of awareness among the waste handlers and residents contributed to the open burning of waste in Indian cities. The study also recommended that in addition to arrangements for waste pick up, local restrictions must be placed informally, to prevent waste burning. In this study, open dumping of waste was found to be a behaviour, not influenced by socioeconomic status or other factors, but rather by the feasibility and convenience to utilize the waste collection system.[19]

Several challenges exist in the solid waste management in India. The strength of this study is that it explored factors such as the presence of under-five child, elderly persons and previous experience of a vector borne disease in households, along with socioeconomic status, as factors associated with segregation, storage and sanitary disposal of waste. Additionally, factors associated with utilization of existing waste collection systems were also explored.[20]

The limitation of this study is that interviews with only one adult household member, in a restricted location. Waste collection and storage were directly observed but methods of waste disposal were not observed directly. The history of food and vector borne disease was collected through interviews and not from medical records. This study relied on self-reported practices and disease history, introducing potential recall bias. Waste disposal behaviours were not directly observed, which may affect accuracy. The study was confined to a single urban locality, limiting generalizability.

Conclusion

This study revealed high levels of waste segregation (94%) but inadequate management of sanitary waste. Use of closed containers was associated with the presence of children under five years in the household. Accessibility to municipal waste collection was a key determinant of sanitary waste disposal. This study conducted in an urban locality in South India, puts forth three important recommendations. Firstly, enhancing the reach and timing of municipal waste collection, especially in households located along cross roads. Targeted educational interventions could help increase awareness of sanitary waste segregation practices. The waste segregation activities must further include categories such as medical waste, e-waste and sanitary waste. Secondly, the instances in which households suffer from food and vector borne diseases, or have vulnerable groups (pregnant mother, under five children or geriatric age group) must be used for targeted educational interventions and that could help in increasing awareness on sanitary waste segregation practices. Thirdly, the waste collection system must be revamped, to improve accessibility, feasibility and convenience of residents. This can be carried out by GPS tracking system of collection vehicles, route mapping and citizen's mobile app to track and plan the disposal. The urban governance must implement a sustainable waste management system, shifting from linear waste management mechanisms to circular waste management mechanisms, that improves accountability and saves resources. Future studies could adopt a longitudinal approach to evaluate the impact of improved municipal services on household waste management behaviours.

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Authors' Contributions: SBA was responsible for the conception and design of the study, acquisition of data, analysis and interpretation of data, drafting of the manuscript, critical revision of the manuscript, and statistical analysis. UCS contributed to the analysis and interpretation of data, drafting and critical revision of the manuscript, statistical analysis, administrative, technical, or material support, and provided supervision throughout the study.

Availability of Data: Data can be obtained on request from the author.

No use of generative AI tool: No generative AI tools were used in the creation of this manuscript.

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