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Households' Awareness and Participation in Sustainable Waste Management

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Abstract: The city is the place that accommodates the needs of society now and in the future. However, meeting these increasing needs while addressing environmental threats requires a collaborative approach. This research aims to evaluate the awareness level of citizens in Makkah, Saudi Arabia, regarding waste management practices. In addition, it aims to study the willingness of the local community to engage in managing waste. The research adopted a descriptive and inductive approach to identify the possibilities and challenges of community participation in this issue. A questionnaire survey investigated citizens' awareness of environmental issues and their current and potential contribution to waste management initiatives. The findings revealed a strong interest among Makkah citizens in contributing to waste management initiatives. Furthermore, the study found that cultural and personal norms are the most important reason for not segregating household waste.

Keywords: Sustainability, household solid waste, Waste management, Makkah, Saudi Arabia

1. Introduction:

Cities face great challenges to meet the increasing needs resulting from continuous population growth. Uncontrolled population growth can have negative impacts on the urban environment Moreover, climate change, driven by the increasing rise in greenhouse gas emissions, is another challenge. Cities consume large amounts of natural resources and produce tons of air pollution and waste. Waste generation from various sources, such as individual households, industries, and agricultural activities, leads to environmental degradation and danger to human health. Waste increases greenhouse gas emissions, ocean plastic accumulation, and nitrogen pollution. Poorly managed landfills can also allow leachate to seep into surrounding soil and water sources. This pollution of water, land, and air can result in the depletion of natural resources and the spread of diseases.

Solid Waste Management:
Traditional methods of waste disposal, such as storing it in landfills, are being abandoned due to their harmful effects on humans and the environment. Solid waste management (SWM) refers to the activities involved in collecting, transporting, converting, recycling, or disposing of waste products resulting from human activities. It aims to prevent or reduce the impact of waste on human health, the environment, and aesthetics, while also recovering resources from waste. Solid waste management practices vary across different levels such as developed countries, developing countries, and urban, rural, residential and industrial areas. Municipalities are responsible for the disposal of non-hazardous residential waste in urban areas, while generators of industrial waste are responsible for its appropriate recovery and disposal. Sustainable and integrated solid waste management is considered a solution to the growing global challenges of disposing of household solid waste (HSW) as a major part of municipal solid waste, with a focus on optimizing waste management from all sectors and involving all stakeholders.
According to the United Nations Environment Programme, managing and recycling waste is extremely important because of its negative impact on the environment and human life. The world annually produces a huge amount of waste estimated at (2.3) billion tonnes in 2023. This production is expected to increase to 3.80 billion tons by 2050. Interest in the concept of "waste recycling" has increased in KSA, as about 9.7 million tons of HSW are collected annually, most of them is food waste.
Saudi Arabia, as one of the developed countries, is experiencing fast industrial development, a high inhabitant growth rate and rapid urbanization which have caused an increase in levels of pollution and waste. With a

population of around 37.3 million in 2024, Saudi Arabia generates more than 20 million tons of solid waste per year [10]. Data from General Authority for Statistics (GASTAT) shows that in 2020, Saudi Arabia generated 76,000 tons of hazardous waste, all of which was treated. The country is effectively managing its hazardous waste, which is crucial for ensuring environmental sustainability and protecting human health. According to 2021 statistics, the amount of waste generated in homes was 9.7 million tons. Waste is usually not sorted at home. In 2021, the percentage of households that sort waste is about 20.9%, sorting about 2.2 million tons [10].
Aligned with Saudi Vision 2030 focus on sustainability, solid waste management becomes a critical issue to consider. Therefore, household solid waste management (HSWM) has been given serious attention by the authorities of Saudi Arabia. Significant investments have concentrated on waste management, including reducing waste generation, promoting recycling, and improving waste collection and disposal methods. The government has promoted the sustainable management of waste and natural resources. For example, the government has built several waste-to-energy plants and has launched recycling initiatives to reduce the amount of waste generated in cities. The National Centre for Waste Management (MWAN) was established to regulate and oversee waste management activities while encouraging investment in the sector and granting licenses and permits to service providers, such as those for recycling. Intending to recycle 35% of all waste types by 2035, the centre also seeks to manage non-recyclable waste through the production of alternative fuels or energy generation. The government has also adopted a waste management strategy to help reduce waste.

1.1. Zero-Waste Hierarchy:
In the context of the zero-waste hierarchy, value preservation prioritizes keeping products and packaging in use for longer periods. This means they remain valuable materials and products, not simply waste. The goal is to design waste out of the system entirely. This can be achieved by influencing consumption habits, rethinking business models to be waste-free by design and making these approaches the main focus of economic and environmental policies and funding. The Zero-Waste hierarchy has 7 levels, two related to products and 5 related to waste (Figure 1):

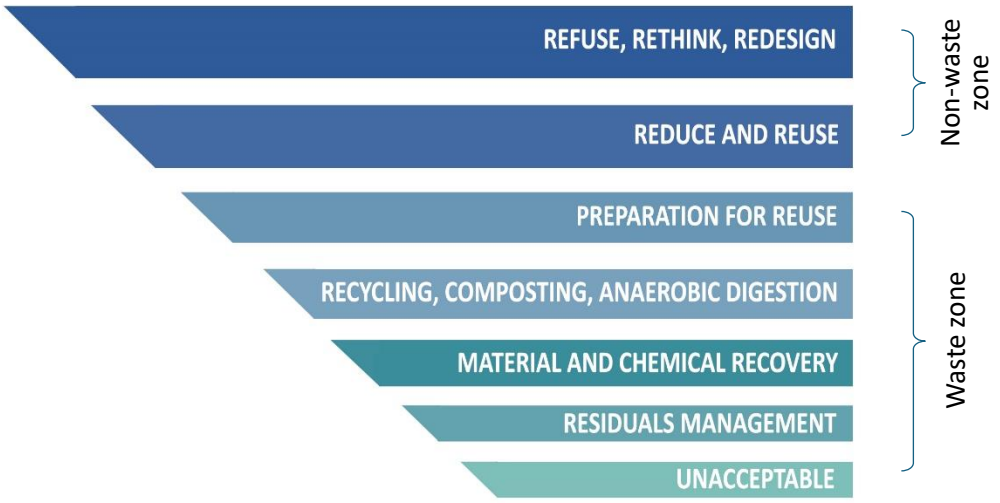

Figure 1. Zero-Waste hierarchy.

(a) Refuse, Rethink, Redesign: The first level includes any activity related to stopping waste from being produced. Be it by creating a system that is waste-free by design or by stopping the commercialisation of single-use items that can be easily replaced with alternatives; (b) Reduce and Reuse: Staying in the non-waste zone, the second level of the hierarchy tackles the scaling up of the market for used items that have not become waste, remain an underutilised asset of economies or will become waste despite not having lost their use value. The goal is to prevent them from being discarded and instead find ways for them to go back into the economy; (c) Preparation for Reuse: Moving into the waste zone, the third level of the Zero Waste hierarchy. Preparation for reuse involves cleaning, repairing, and refurbishing items that have become waste, giving them a new life as products; (d) Recycling, Composting, Anaerobic Digestion: The 4th level of the hierarchy deals with what, in an ideal scenario, should be the last option to retain materials in sustainable resource management, namely, to turn the separately

collected waste into high-quality secondary raw materials. This could be achieved through recycling, composting, and anaerobic digestion converts organic waste into biogas; (e) Material and Chemical Recovery: The Zero Waste hierarchy prioritises the extraction of valuable materials from mixed waste and the discards from sorting processes. This is better aligned with the vision of the Circular Economy, which is basically about retaining materials and resources within the loop, whereas thermal treatment shows as a "leakage of resources"; (f) Residuals Management: Non-stabilised waste like food waste must be separately sorted. This makes it easier to pre-treatment before landfilled. This practice increases amounts of source-separated organics and decreases amounts of residual waste; (g) Unacceptable: Waste-to-energy incineration, landfilling non-stabilized waste without treatment, littering, illegal dumping, and open burning are options that should become part of the past because they absorb investments that should be directed to the highest levels of the hierarchy [14].

1.2. Empowering Communities for Zero Waste Management:

"Empowering Communities" refers to the process of enabling and strengthening the capabilities, resources, and decision-making authority of community members. It involves providing individuals and groups within a community with the knowledge, skills, support, and opportunities they need to actively participate in shaping their own futures and influencing the decisions that affect their lives. Empowering communities often entails fostering a sense of ownership, autonomy, and collective agency, thereby enhancing their ability to address challenges, pursue opportunities, and achieve positive social, economic, and environmental outcomes. Empowering communities is one of the most important means of achieving justice in the decision-making process. Interest in this matter has increased at the global level, especially after a number of United Nations reports stressing the necessity of community participation in development. In the context of sustainability and green city transformation, empowering communities involves engaging them as active stakeholders in the planning, implementation, and evaluation of initiatives aimed at creating more environmentally friendly and socially inclusive urban environments.

The issue of empowering communities has recently become a key element in any successful urban planning and urban design project. The city is the place that accommodates the needs of society now and in the future. Hence, its residents must have the right to participate in the urban planning and design process that affects their environment and their lives in general. Therefore, stakeholder engagement including involving the public, private sector, NGOs, and communities in the urban decision-making process is a must through participatory planning and citizen engagement.

Communities must participate in the zero-waste management process to make this system successful. To empower communities in achieving this goal, a multifaceted approach is needed. This includes organizing workshops on composting, waste reduction, recycling and reusable products, alongside public awareness campaigns utilizing social media, local media, and community events to spread the message. Additionally, integrating waste management principles into school curriculums can cultivate responsible waste disposal habits in children from a young age, fostering a more sustainable future for all.

1.3. Household Waste Statistics of Makkah According To GASTAT:

According to GASTAT, households in the region of Makkah generated about 2.5 million tons of HSW in 2021 [10] (Table 1). This amount represents 25.66% of the total amount of household waste generated in KSA. The landfills of the region of Makkah receive this amount of HSW daily. However, these quantities become (3.1) and (4.6) thousand tons per day during Ramadan and Hajj, respectively.

Table 1. The amount of waste generated in homes (Ton)

2021	**The amount of waste generated in homes (Ton)**
Makkah	2499233
Total KSA	9738486
Percentage	25.66%

In 2021, households that sort waste were about 20.9%. They sorted about half a million tons of waste [10].

In 2021, the frequency of waste disposal in Makkah was consistent with KSA average. Most households dispose of waste daily (Table 2).

Table 2. Frequency of waste disposal (%)

2021	Once a week	More than once a week	Daily

Makkah	2.54	24.04	73.42
KSA average	3.09	23.99	72.93

In 2021, methods for discarding unsorted household waste were consistent with the KSA average. Most households across Makkah disposed of waste in municipal containers (Table 3).

Table 3. Methods for discarding unsorted household waste (%)

2021	**Municipal containers**	**Burning**	**Burial**
Makkah	99.9	0.1	0.0
KSA average	99.56	0.40	0.04

Improper disposal of electronic waste (e-waste) in municipal containers has several disadvantages. Firstly, e-waste contains hazardous substances such as heavy metals, hydrocarbons, and dioxins, which can contaminate the environment and pose risks to human health. Dumping and improper recycling of e-waste can lead to the contamination of soil and water, and various health problems including respiratory infections, cancers, and congenital disabilities. In addition, the unorganized handling of e-waste exposes workers to hazardous substances without proper protective gear, further endangering their health and the environment. However, e-waste contains valuable materials such as gold, silver, and copper, which can be extracted and reused, providing economic benefits. In 2021, households in Makkah disposed of 26% of all electronic household waste in KSA (Table 4). Most households in Makkah disposed e-waste in municipal containers (Table 5).

Table 4. Number of e-wastes produced in homes

2021	**Number of e-wastes produced in homes**
Makkah	14987152
Total KSA	57583692
Percentage	26.0%

Table 5. Methods for disposing of e-waste in homes (%)

2021	**Municipal Containers**	**sale**	**Hand it over to a recycling authority**	**Other**
Makkah	77.11	4.26	6.89	11.74
KSA Average	76.54	3.51	7.75	12.21

Most households throw medicine directly into the municipal containers (Table 6). Children, pets, or even scavenging animals can easily access medicines in these containers. This can lead to accidental ingestion and potential poisoning. Furthermore, many medicines contain chemicals that can be harmful to the environment. When medications are thrown in landfills, these chemicals can leach into the soil and water, contaminating the environment and potentially harming wildlife and human health. Moreover, medicines left in the trash can be retrieved by people seeking to misuse or abuse them.

Table 6. Percentage breakdown of medicine disposal practices in homes

2021	**Donating them**	**Throw them directly in the trash**	**Pour them into toilets or sinks**
Makkah	11.23	79.85	6.3
KSA Average	8.65	79.69	6.73

2. Materials and Methods:

This study was conducted among sample of households in the city of Makkah. A total of 307 participants responded to the survey questionnaire. The first part of the questionnaire included socio-demographic characteristics. The second part assessed the household's awareness about waste management. The last part

assessed waste management habits, and reasons for not segregation. The questionnaire experienced a pilot test to ensure clarity, question flow, and appropriate length. It was implemented online using Google Forms, in January 2024. The participants were informed that the data were only used for the intended purposes of this study.

3. Results:

3.1. Socio-Demographic Characteristics:

Considering age group, (28.3%) of participants were in the 38–47 age range, (26.1%) between 18 and 27 years old, and (7.5%) above 58 years old. In terms of gender, the majority were female (69.1%), while only (30.9%) were male. Regarding the household education level, most participants (67.4%) were university educated. With regard to the homemaker education level, there were (38.1%) high school graduates and (34.9%) were university graduates. In terms of the household income, half of the participants (50.5%) reported a middle monthly income.

Table 7. Socio-demographic Characteristics

Socio-demographic Characteristics	Count	%
Age		
18-27 years	80	26.1
28-37 years	55	17.9
38-47 years	87	28.3
48-57 years	62	20.2
More than 58 years	23	7.5
Gender		
Male	95	30.9
Female	212	69.1
Household education level		
High school and lower	52	16.9
Diploma	29	9.4
University Education	207	67.4
Postgraduate	19	6.2
Homemaker education level		
Illiterate	57	18.6
High school and lower	117	38.1
Diploma	19	6.2
University Education	107	34.9
Postgraduate	7	2.3
Monthly income		
Very low Income	23	7.5
Low Income	29	9.4
Middle Income	155	50.5
High Income	30	9.8
Very high Income	70	22.8

3.2. Awareness of Waste Management:

It is noteworthy that most respondents (84.4%) considered waste management to be a big problem in KSA. However, awareness of any laws regarding waste management in KSA was significantly low (28.7%). The survey results indicated positive attitudes towards reusing items (87.9%). Awareness of household waste segregation and recycling is significantly high (86.6%). 83.5% believe that waste recycling is a shared responsibility among family members. Moreover, 87.1% of respondents agreed that waste reusing and recycling helps conserve the natural resources (Table 8). Most participants (82.4%) have the intention to involve in future recycling process. The study

found that women and older people are more likely to manage their waste compared to men and younger individuals. Moreover, households who had university education or higher were more interested in segregation practices than others.

Table 8. Awareness of Waste Management

	Agree		**Disagree**	
Awareness of Waste Management	Count	%	Count	%
Do you consider waste management to be a big problem in KSA?	259	84.4	48	15.6
Is there a waste collection service available in your area?	276	89.9	31	10.1
Are you aware of any laws regarding waste management in KSA?	88	28.7	219	71.3
Are you interested in reusing items at home to reduce waste?	270	87.9	37	12.1
Are you aware of household waste recycling?	266	86.6	41	13.4
Is recycling waste a shared responsibility within families?	260	84.7	47	15.3
Do you believe that reusing and recycling waste helps conserve natural resources?	264	86.0	43	14.0
Do you have the intention to involve in recycling process?	253	82.4	54	17.6

3.3. Waste Typology:
The study found that plastic was the most common type generated by both male and female households, accounting for 45.5% of the total waste. Food waste (10.1%), e-waste (3.9%), and medicine (2.6%) were the least common types of waste generated (Table 9).

Table 9. Waste Typology

Waste Types	Count	%
Food waste	31	10.1
Plastic	141	45.9
Glass	39	12.7
Paper	47	15.3
e-waste	12	3.9
Medicines	8	2.6
Others	30	9.8
Total	307	100.0

3.4. Reasons for Not Segregation Waste at Homes:
The cultural and personal norms considering recycling are the most important reason for not recycling at the source (23.5%), followed by a lack of awareness of segregation process (20.2.1%) (Table 10). The lack of supportive recycling laws, low benefits (17.6%), and poor infrastructure that support recycling (15%) are additional reasons for the lack of segregation of household waste.

Table 10. Reasons for Not Segregation Waste at Homes

Reasons for Not Segregation Waste at Homes	Count	%
Lack of awareness of segregation process	62	20.2
Cultural and Personal Norms	72	23.5
Time constraints	29	9.4
Poor infrastructure that supports recycling	46	15.0
Limited storage space in home	44	14.3
Lack of supportive recycling laws and low perceived benefit	54	17.6

4. Discussion:

This study examines household waste management awareness and intention to practice in Makkah. It emphasizes the importance of reusing items and separating waste at home (source segregation) to reduce landfill burden. The research reveals a high level of awareness about household waste reusing and recycling among participants.
Education level influences how likely people are to reuse or segregate waste at home. Those with higher education are more aware of environmental issues and the value of recycling due to their studies. Females and those with higher education with good waste management awareness were more likely to reuse, segregate their waste responsibly.
Females and older people are more likely to manage their waste compared to men and younger individuals. Older adults might be more environmentally conscious and engaged in recycling compared to younger generations. For women, their traditional roles associated with household chores might make them more likely to prioritize waste sorting and responsible disposal.
The lack of awareness about waste management laws is a critical problem. People unaware of proper disposal, sorting, and recycling regulations are more likely to litter, dump illegally, or contaminate recycling streams. This strains waste collection systems, reduces recycling efficiency, and hinders environmental benefits. Additionally, a lack of awareness about hazardous waste handling can increase health risks.
The study found plastic, paper, glass, food waste, and electronic waste as the most common household waste types. A high percentage of plastic waste indicates a strong correlation between waste composition and certain human activities, such as increased use of disposable plastic bottles during hot weather.
The study found that cultural and personal norms are the most important reason for not recycling. This finding aligns with the understanding that cultural norms have a substantial impact on people's recycling habits. Additionally, personal norms, which are influenced by social, legal, and descriptive norms, are found to be important drivers for recycling behaviour. Lack of awareness of segregation process is the second most important reason. Therefore, municipal programs in emerging economies tend to focus on educational and motivational actions in order to manage solid waste.

5. Conclusions and Recommendations:

Most households in Makkah have a good awareness of waste management and appreciate its role in environmental and public health. However, they had poor awareness of any laws regarding waste management. In addition, they had poor awareness of waste segregation. The cultural and personal norms considering recycling are the most important reason for not recycling at home, followed by a lack of awareness of segregation process. These findings indicate a need for a multi-pronged approach to tackle household waste management challenges. Educational campaigns can cultivate a stronger sense of environmental responsibility and encourage people to prioritize sustainable practices. Similarly, raising awareness about waste management laws is crucial. Furthermore, strengthening recycling efforts requires a combination of measures. This includes improving collection systems with frequent pickups and accessible drop-off points, along with standardized labelling on packaging to indicate recyclable materials. Supportive recycling laws should be implemented, and benefits should be provided to encourage recycling. In addition, investing in infrastructure for efficient sorting and processing facilities is equally important to ensure the effective handling of recycled materials. By putting these strategies into action, a significantly more sustainable future could be achieved.

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