Solid Waste and Environmental Sustainability: Educational Approaches to Managing Urban Waste in Bahawalpur City

Nimra Khalid [1] **Muhammad Rafiq-uz-Zaman** [2] **Wardah Tahira** [3] **Mudassar Maqbool** [4]

[1] MS Environmental Science, Department of Hostels, The Islamia University of Bahawalpur, Punjab, Pakistan.
Email: nimrakhalid.nts@iub.edu.pk

[2] Doctor of Philosophy(Ph.D.), Department of Education, The Islamia University of Bahawalpur, Punjab, Pakistan.

[3] M. Phil Education, University of Agriculture Faisalabad, Punjab, Pakistan.
Email: wardahtahira92@gmail.com

[4] Department of Zoology, The Islamia University of Bahawalpur, Punjab, Pakistan.
Email: mudassirzoologist@gmail.com

Corresponding Author: mrzmuslah@gmail.com

ABSTRACT

This study aims to fill the emerging gaps in managing urban wastes in Bahawalpur City, Pakistan. This study uses data from the Bahawalpur Waste Management Company (BWMC) together with survey-based analysis to determine awareness levels among the public and the effectiveness of education interventions in waste management. The results show a strong relationship between educational programs and the residents practicing better waste disposal practices through education as a tool to promote sustainable practices. By combining local perception and BWMC data on waste trends, the study highlights many health risks and environmental problems and how improvement of awareness campaign necessitate collaboration between government and community. Suggested policies involve concerted awareness campaigns to raise local inhabitants' ecological awareness and improve sustainable waste management, thereby establishing urban ecology. The implications of this research guide policymakers in establishing structures that will enable sustainable waste management and environmental objectives.

1. Introduction

The rapid expansion and increase in population in cities where the city's development deteriorates the infrastructure, and environmental problems arise due to the non-disposal of urban waste in a proper manner. Bahawalpur City is also an example of urban waste. When the capacity of the single dumping site is exhausted, it is filled with soil and antibacterial drugs, and the waste is collected at temporary sites. Bahawalpur is facing many significant challenges. These increasing problems in Bahawalpur City are a threat to the local environment and a hindrance to the city's sustainability efforts. There is a discussion on technical solutions for waste disposal among the public, but public awareness still needs to be improved. Sustainable waste practices are not made a topic of conversation through education to raise awareness. However, according to recent research, with the help of latest technologies like AI, waste sorting and recycling systems are being improved (Fang et al., 2023; Hossen et al., 2023). The same approach can be adopted to improve the waste management framework of Bahawalpur. According to Haseli et al. (2023), ensuring public participation and appropriate educational measures to improve waste management and achieve environmental sustainability is very important.

1.1. Background

Solid waste management plays an important role in achieving a sustainable environment in a rapidly expanding city like Bahawalpur. Improper disposal and treatment of solid waste Land degradation is a major source of water and air pollution. This pollution is a threat to public health and ecological balance. No matter how many efforts are made ँby Bahawalpur Waste Management Company (BWMC), but without public awareness and public participation, these problems will always remain as a challenge. Research shows that a major reason for the failure of waste management strategies is a need for more community education and engagement. A comparative analysis of diverse settings in Zambia, Indonesia, Uganda, and Asian countries suggests that community Waste management strategies are more successful after community participation (Chisanga et al., 2024; Nurhayati & Nurhayati, 2023; Brotosusilo & Nabila, 2020). Environmental education changes social attitudes and waste management practices. Got an opportunity to perform more responsibly. However, there is a lack of comprehensive studies in Bahawalpur that examine the role of educational approaches in promoting sustainable waste management practices. This mindset needs to be revised to understand the positive effects of community education on environmental sustainability. This study aims to bridge this gap by improving environmental sustainability by promoting public participation in waste management through education in Bahawalpur.

1.2. Research Gap

Current research focuses only on technical solutions for addressing environmental pollution in urban areas, using technologies for waste treatment and recycling systems. At the same time, little attention has been given to driving sustainable practices with the help of educational strategies. As for Bahawalpur, the interaction between public awareness, education, and environmental outcomes has not been adequately considered. This study brings together the environmental science and educational development fields to address this major gap. This study will highlight the importance of education in sustainable waste management practices.

1.3. Novelty of the Research

Hence, this study calls for enhanced provisions and practices in the interface of environmental science and education towards improved dismal urban waste management, which is the novelty of this research, as it employs a multidisciplinary approach. Thus, it states that using educational

approaches is crucial instead of methods used to enforce environmental sustainability. This study will underline educational programs about their quantitative contributions since it will reveal favorable shifts in public perception regarding the tendencies in urban waste management systems.

1.4. Problem Statement

Bahawalpur's waste management system faces critical technical barriers that hinder its effectiveness, leading to unsustainable environmental practices. Despite the efforts of the Bahawalpur Waste Management Company (BWMC), significant inefficiencies persist due to outdated infrastructure, insufficient collection mechanisms, and a lack of access to modern recycling and disposal technologies. The city generates approximately 325 tons of waste daily, but the system's capacity is stretched thin, with over 20% of waste remaining uncollected or improperly disposed of at temporary dumping sites (Mohsin et al., 2020). These sites are responsible for poor air and water quality of the environment, increased challenges to health, and state-of-the-art land degradation (Hasan et al., 2018).

Many technical challenges remain relevant today, but the most critical one is linked to the worn-out equipment used in waste collection and transportation, such as a small number of trucks, compactors and front-end loaders that constrain the expansion of geographical areas for waste collection zones (Jensen et al., 2015). Moreover, there is a lack of initial formal recycling facilities, and other tactics such as open dumping and burning also contribute to the new environmental problems that kill the city's attempt to recycle wastes sustainably (Majeed et al., 2019).

Equally suspicious is a need for more public participation and knowledge resulting from insufficient and all-in-all educational initiatives. Of the similar past campaigns meant to enhance community involvement in the separation and recycling of wastes, few have been effective because of poor messaging, poor coverage, poor sensitization, and the absence of structured awareness campaigns that would fit the current socio-economic structure of the city (Oonyu et al., 2018). The campaigns mainly focused on creating awareness without prescribing effective and sustainable community solutions. They also should have considered important behavioral elements to their work or actual problems faced by the residents, like the near absence of proper waste disposal sites in their areas. This phenomenon has resulted in Bahawalpur having technical waste management issues that require education (Debrah et al., 2021).

The absence of technical skills and awareness in Bahawalpur's waste management plan shows that there is a need to find a solution that embraces both the establishment of infrastructures and coming up with a better and proper educational method. If these three linked threats are not tackled, the city's waste management will not meet sustainable targets. Poor management of properly disposed solid waste is one of the largest challenges to human wellbeing and solving environmental issues including land and water pollution. If citizens do not participate in proper waste disposal or awareness of recycling, local authorities cannot achieve proper outcomes. Present approaches are directed at applying technical and policy-making for conventional waste treatment and developing environmentally friendly methods.

What is more, the role of education in promotion should be considered. Thus, as part of this study and with the help of education, an effort has been made to identify the expected enhancement in waste management in Bahawalpur, enhanced public awareness and involvement, and the impact of education on the environment. Current research has pointed to raising civil awareness on issues through community-based educational campaigns (Thakur & Kumar, 2024).

1.5. Objectives

1. To evaluate the existing SWM practices in Bahawalpur City and their effects on the environment.
2. To understand the processes of raising public awareness and educational interventions for sustainable waste management.
3. To outline strategies for increasing people's involvement in sustainable solid waste management in Bahawalpur through educational interventions based on a systematic review of the literature.

2. Literature Review

The SWM in Bahawalpur, Pakistan, too, has risen with manifold problems because of the increase in population and urbanization. The city generates an estimated 273.69 tons of waste daily, but only 80% is collected and thrown away irresponsibly (Mohsin et al., 2020). Five throwing and burning disposal sites have various environmental and health impacts (Mohsin et al., 2020; Mohsin & Chinyama, 2017). The thrown-out garbage depends more on biodegradable items at 64%, followed by reusable items at 27% and other unnecessary objects at 9% (Majeed et al., 2018). Lack of infrastructure, funds, and weak public awareness enhance poor SWM practices (Mohsin et al., 2016). Experimental data show that, in terms of life cycle assessment, transportation induces critical effects on the climate and ecotoxicity. High-source separation and recycling elements provide certain environmental advantages (Majeed et al., 2018). For the enhancement of SWM in Bahawalpur, many issues related to infrastructure, awareness, and proper disposal systems need to be resolved to decrease the number of hazardous diseases and the environment effectively (Mohsin et al., 2016; Mohsin & Chinyama, 2017).

Awareness is a vital part of waste management since the public is directly involved through participation in properly disposing of waste. A survey revealed that higher awareness of waste management problems leads to higher acceptance of practices in the community (Hasan, 2004; Oonyu et al., 2018). Briefing sessions, flops, and mass media campaigns, have been used as educational approaches to enhance waste management behaviors. However, there needs to be more knowledge on how, when, and what to dispose of and where to eliminate the wastes that one should separate from the organic wastes (Oonku et al., 2018). One of the important peculiarities involved in waste management is the involvement of the public in addition to the required legislation, technical assistance, and funds (Hasan, 2004). Stakeholder perceptions of waste management services and factors influencing sustainable disposal and recycling are relevant determinants for creating efficient waste management programs. Civic consequences have been suggested to enhance environmental responsibility, but the kind, recurrence, and outcome of educational instruments require more analysis (Sewak et al., 2021). In general, awareness created among the public through education in schools and mass media communication helps encourage proper waste preferences and recycling (Dey, 2020; Wafula et al., 2024).

There are several constraints regarding SWM in Bahawalpur, Pakistan: low rates at which solid wastes are collected, lack of adequate funds, and poor community support. The city is estimated to dispose of approximately 273.69 tons of waste daily, and 218.95 were collected, which gives a collection rate of 61-80% (Mohsin et al., 2020). Uncontrolled dumping and inadequate waste disposal methods cause pollution and diseases. However, the company could be more efficient, as pointed out by Mohsin and Chinyama in their work. Both awareness and involvement of the public play an important role in waste management, as Hasan pointed out in 2004. One can improve public awareness of waste management problems, including through schools (Hasan, 2004). Enhancing SWM means encompassing factors, such as unplanned growth of cities, high generation

of waste, dysfunctional systems, and community, government, and private sectors (Khan et al., 2012).

SWM is one of the leading issues in the developing countries especially the urban cities of Pakistan being a case in point Bahawalpur district. Research indicates the shortcomings in the collection rates the restricted coverage of the limited-service, and poor dumping methods, which cause environmental and health challenges (Mohsin et al., 2020; Mohsin & Chinyama, 2017). The city produces an average of 274 tons' waste per day of which 155 tons are organic wastes. The reason for keeping solid waste in an open dumping place and burning it has adverse effects on the climate, where toxicity increases in the environment. On the other hand, recycling solid waste has more environmental benefits (Majeed et al., 2018). Studies show that community mobilization and outreach comprise of poor knowledge and sensitization as the two significant challenges associated with proper SWM (Mohsin and Chinyama, 2017). However, the results showed that students possess positive environmental attitude, yet, there is a lack of practical knowledge for both the student and the teacher when it comes to SWM. Incorporation of environmental sustainability education in curricula of schools at all levels is important in tackling the challenges of SWM in the developing countries (Debrah et al., 2021).

Over the years, solid waste management has become a daunting task, especially in developing nations with growing urban centers similar to Bahawalpur, Pakistan. The findings show low collection rates, restricted limited-service connectivity, and correct discard disposal, resulting in environmental and health problems (Mohsin et al., 2020; Mohsin & Chinyama, 2017). Disposal of waste in the open and burning are widely practiced, while households generate the most waste in the country. The absence of proper disposal sites, recycling centers, and obsolete equipment compounds this. Most people in the public domain need more knowledge and are willing to pay for waste management services, as observed by Mohsin et al. (2016). Students are identified as having positive environmental attitudes, but they equally lack practical knowledge, and hence, education is also identified to have a significant role in intervening in SWM challenges. Promotion of higher education, enhanced training, and avails of improved SWM systematics into environmental sustainability in the school curricula at all levels has been recommended to close the existing knowledge gap and enhance SWM practices in developing countries (Debrah et al., 2021).

People's awareness campaigns allow for enhancing approaches to waste management and increasing sustainability. More studies in various areas demonstrate how education and community involvement positively change perceptions toward waste reduction and recycling (Abbas et al., 2020; Ramsey & Abdulaal, 2016). In Bahawalpur, Pakistan, poor practices in managing solid waste were realized, resulting in environmental pollution and diseases, implying the need for awareness and institutional participation (Mohsin & Chinyama, 2017). Studies show that good environmental campaigns can greatly increase public knowledge, attitude, and behavior change about waste management programs (Ramadan et al., 2016). Other forms of education concerning the environment and its usage have used innovative teaching tools such as design thinking to address problems about solid waste (Abtahi et al., 2017). Overall, all studies confirm that education and campaigns are essential to promote responsible waste disposal practices and create a sustainable urban environment.

Therefore, this work evaluates the prospect of applying educational solutions to handle the complex SPWM issues in Bahawalpur. The evaluated focus on public engagement meets this existing research gap to some extent. This research's contribution to the search and formulation of efficient waste disposal techniques in Bahawalpur is of particular significance.

3. Methodology

3.1. Research Design

This work integrated quantitative and qualitative data methods to ensure a better understanding of solid waste management practices in Bahawalpur in their entirety. It looked at the ability of an educational perspective in environmental stewardship and proper waste management. For an analysis, the study was split into two sections to present the details. In the first section, Bahawalpur Waste Management Company (BWMC) figures were computed in official numerations. Instead, in the second section, an attempt was made to collect public opinion using a structured questionnaire. A survey was conducted through online google form generate survey.

3.4. Sampling Strategy

A survey was conducted with the help of a structured questionnaire from citizens living in different areas of Bahawalpur to find out their views on solid waste management and educational initiatives. Through ten carefully designed questions, data were collected on public awareness, their opinions on solid waste disposal, and the importance of education in promoting sustainable practices. The form was sent to them through email and WhatsApp. In order to maintain a comprehensive understanding and gender balance in the survey, 200 men and women with different ages, occupations, and educational backgrounds were included. A random sampling technique was used to select the participants in the survey.

3.5. Data Collection Procedures

1. **Bahawalpur Waste Management Company (BWMC) Data**
   BWMC data for Bahawalpur city was obtained directly from company sources. This data provided detailed information about various zones of Bahawalpur city for solid waste collection, logistical aspects, company performance, resource allocation, operational challenges**.**

The data was obtained from BWMC sources; this company manages the solid waste in Bahawalpur. The data is included:

- Daily solid waste generation figures.
- Daily waste collection rates.
- Worker attendance and efficiency.
- Number and types of equipment used in waste collection.
- Geographic distribution of waste management zones.

This information was analyzed to understand the operational capacity, coverage, and effectiveness of current waste management practices in the city.

2. **Survey Data**

The public opinion survey was conducted online, and the questionnaires were emailed to participants. The questionnaire format was in Google Forms. The expected time duration to fill-up the google form for this survey was about 10 minutes.

3.6. Data Analysis

Descriptive statistics were employed on BWMC data to determine daily waste generation, waste collection efficiency, and resources available and spent in different zones of Bahawalpur. Assembly lines, worker attendance patterns, availability of machines and equipment, and system

constraints in each zone were realized. The findings allowed for the evaluation of BWMC's operations and for the evaluation of how educational interventions can support existing waste management. The survey data was analyzed using SPSS 2022.

4. Results and Discussions

4.1. Bwmc Data

4.1.1. Map of Operation Zones of Bahawalpur City

Figure 1: Operation Zone in Bahawalpur City

4.1.2. Solid Waste Detail

Figure 2: Daily waste management activities

Table 1: *Solid waste generation and collection of daily bases*

Solid Waste Generation Per Day	325 tons
Solid Waste Collection Per Day	318 tons
Waste Collection Efficiency Per Day	98%
Operational Hours	Working in 3 shifts

Table 1 outlines the daily solid waste management operations. It indicates that the total amount of solid waste generated each day is 325 tons. Out of this, 318 tons are collected daily, resulting in % collection efficiency of 98%. The table also highlights that waste collection is carried out across three operational shifts each day.

Table 2: *Operational Area and Work Load*

Operational Area	Bahawalpur City
Serving Population	0.81 million
Waste Collection Efficiency	80-90%/Day
Sanitary Staff Attendance	85-90%/Day

Table 2 provides details about the operational area and the associated workload. The table focuses on Bahawalpur City, which has a serving population of 0.81 million. The efficiency of daily waste collection ranges between 80% and 90%. Additionally, the attendance of sanitary staff is recorded between 85% and 90% per day.

Table 3: *BWMC employs a range of equipment for its operations:*

Equipment Type	Number
Mini Dumpers	45
Arm Roll Trucks	6
Dumper Trucks	6
Waste Compactors	14
Front-End Loaders	8
Waste Containers (0.8 m^3)	850
Waste Containers (5 m^3)	70
Tractor Mounted Mechanical Sweeper	2
Road Washers	3
Front Blades	2

Table 3 lists the various types of equipment used by BWMC for its waste management operations. The company utilizes 45 mini dumpers, 6 arm roll trucks, and 6 dumper trucks. It also operates 14 waste compactors and 8 front-end loaders. For waste storage, BWMC uses 850 containers with a capacity of 0.8 m³ and 70 containers with a capacity of 5 m³. In addition, they have 2 tractor-mounted mechanical sweepers, 3 road washers, and 2 front blades for additional cleaning and maintenance tasks.

4.2. Survey Data

The survey result provides insights into the awareness and practices related to solid waste management and environmental sustainability among residents of Bahawalpur. It includes responses from 200 individuals, with key demographic information such as gender, age, and educational qualifications. The survey may contain some questions about waste management: awareness about waste management, habits in sorting wastes, perceived need to manage waste properly, and participation in waste management education. Thus, the respondents' profile derived from the sample data can be described as predominantly male, with more than half of the respondents above 50 years old and having a Master's degree. Awareness of the practices relating to solid waste management ranges from a high level of awareness to none at all. Waste segregation practices also differ, with some always segregating waste and others doing so rarely. Most respondents recognize the importance of proper waste disposal and agree that improper disposal contributes to environmental issues. Participation in educational programs is mixed, with some having participated and others not. Public awareness campaigns are generally seen as effective, and government programs are trusted sources of information. Barriers to proper waste management include inadequate infrastructure and lack of enforcement. There is a willingness among respondents to participate in educational programs, and many agree that education can improve environmental sustainability in Bahawalpur. This data highlights the need for targeted educational initiatives and improved waste management infrastructure to enhance environmental sustainability in the region.

4.2.1. Awareness Levels by Age Group

Table 4: *The relationship between the respondents age and their awareness of solid waste management practices.*

Age Group	Extremely aware %	Moderately aware %	Not aware at all %	Somewhat aware %	Very aware %	Total
21 to 30 Years	3.57	32.14	28.57	21.43	14.29	100
31 to 40 Years	0	40	10	40	10	100
41 to 50 Years	0	50	0	50	0	100
More than 50 Years	25	37.5	12.5	0	25	100
less than 20 Years	0	50	0	50	0	100

The analysis of awareness levels reveals distinct patterns across various age groups. Among individuals aged 21 to 30 years, there are high frequencies in the "Moderately aware" (9.0) and "Not aware at all" (8.0) categories, indicating limited awareness in this group. Moderate levels of awareness are also noted in the "Somewhat aware" (6.0) and "Very aware" (4.0) categories. In the 31 to 40 years' age group, responses are predominantly "Moderately aware" (4.0) and "Somewhat aware" (4.0), while those aged 41 to 50 show limited awareness with few responses in "Moderately aware" (1.0) and "Somewhat aware" (1.0). Individuals over 50 years exhibit higher awareness, primarily categorized as "Extremely aware" (2.0) and "Moderately aware" (3.0). Conversely, individuals younger than 20 demonstrate minimal awareness across all categories. Visual representations indicate that the 21 to 30 age group has the highest awareness levels, while older age groups display a more varied awareness distribution. This highlights the differing awareness patterns among younger and older populations, with younger individuals showing higher overall awareness, albeit with some members also falling into the "Not aware at all" category.

Figure 3: The relationship between age groups and their awareness of solid waste management practices in Bahawalpur.

4.2.2. Statistical Trends

The data on awareness levels across age groups reveals significant trends. The mean awareness for the "Extremely aware" category is low at 0.60, with a standard deviation of 0.89, indicating a general lack of extreme awareness across demographics. In the "Moderately aware" category, the mean is higher at 3.60, but the substantial standard deviation of 3.29 reflects considerable variability in awareness levels. The "Not aware at all" category has a mean of 2.00 and a standard deviation of 3.39, suggesting that while some groups exhibit very low awareness, others may have none. The "Somewhat aware" category shows a mean of 2.40 and a standard deviation of 2.51, indicating moderate awareness but with noticeable variation. Lastly, the "Very aware" category presents a mean of 1.40 and a standard deviation of 1.67, suggesting only a small segment of the population demonstrates significant awareness. Further analysis by age groups reveals distinct patterns. Younger individuals (under 20) and those aged 21-30 predominantly exhibit moderate awareness, while the 31-40 age group shows a more balanced distribution between moderate and high awareness levels. The 41-50 age group has minimal awareness, with only a few participants categorized as moderately aware. This variation underscores the necessity for targeted educational initiatives to enhance awareness, particularly among older populations, who display greater variability in their awareness levels and significant gaps in both the "extremely aware" and "very aware" categories.
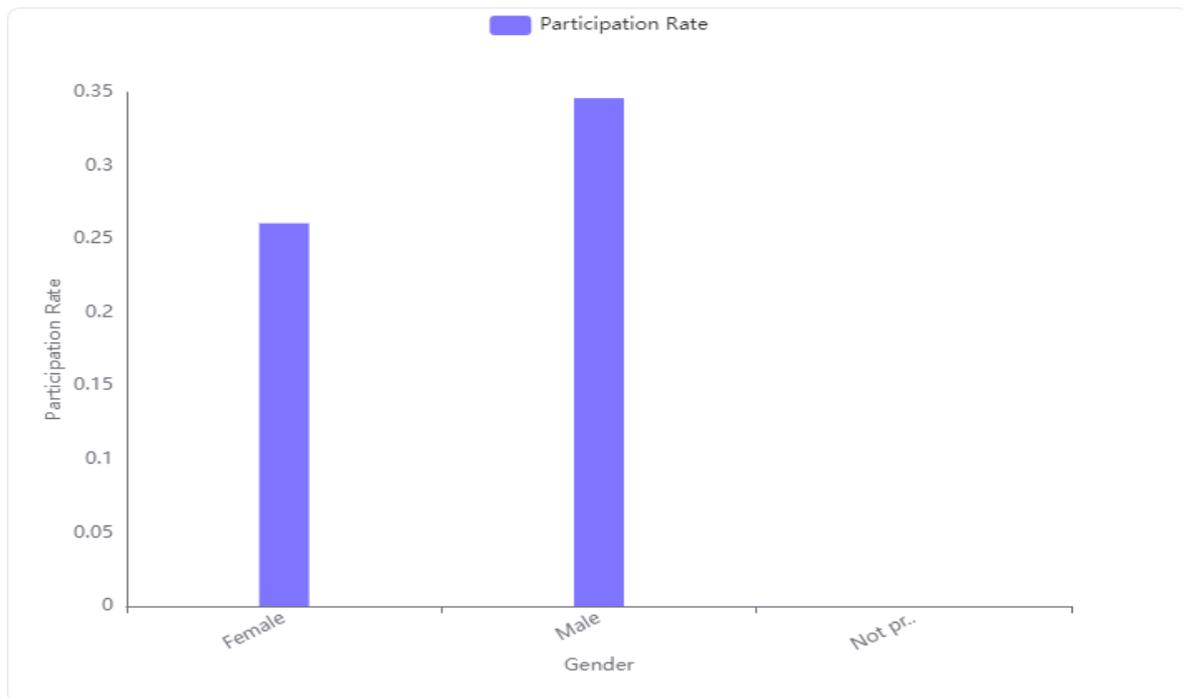

Figure 4: Participation in educational programs on solid waste management vary by gender

4.2.3. Participation Rates

The analysis of participation rates in educational programs on solid waste management reveals notable gender-based differences. Approximately 26.1% of females participated, which is lower than the 34.6% participation rate among males, indicating greater male engagement in these educational initiatives. Interestingly, individuals who chose not to disclose their gender reported a 0% participation rate, reflecting a complete lack of engagement within this group.

Visual representations, such as bar charts, confirm these findings, illustrating a clear gap in participation rates between males and females. In particular, the absence of respondents who stated that they have not disclosed their gender proves that the problem of inclusive recruitment is vital. Although male participants have a satisfactory level of stakeholder engagement, the outcome is quite low for the female participants. This is why steps are needed to reach out to gender minorities and guarantee all the key possibilities for acquiring education in solid waste management for any person.
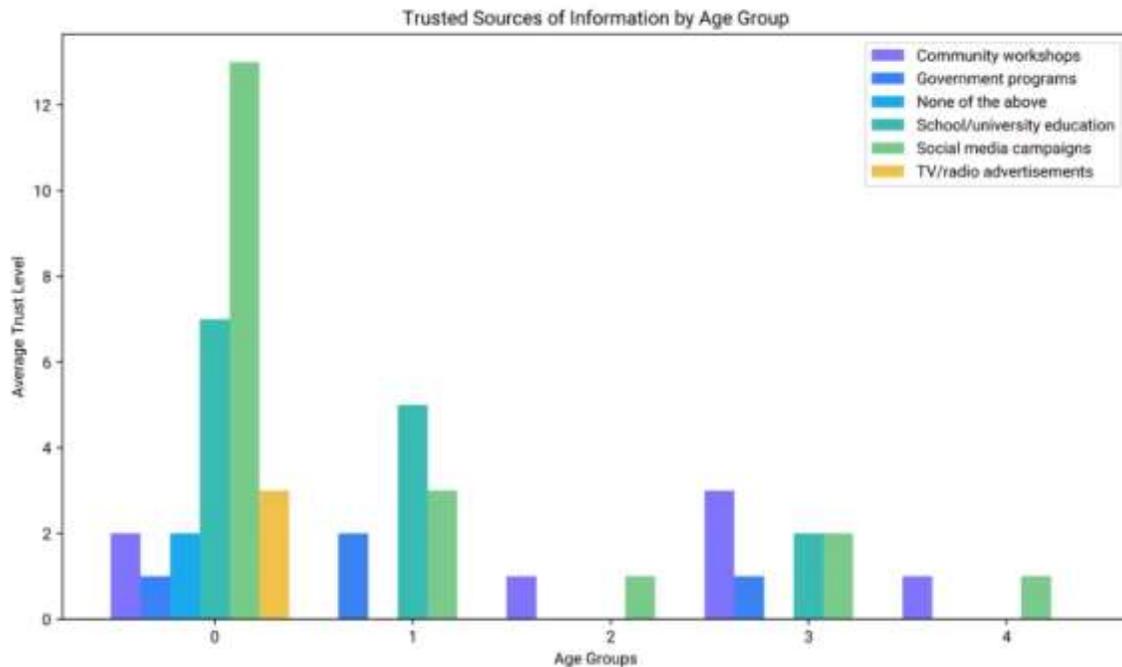

Figure 5: The various sources of information that users believed to be the most accurate regarding waste disposal and environmental sustainability and how they differed based on age.

4.2.4. Most Trusted Sources

The dynamics of verifying trust levels of different educational sources indicate important distinctions in confidence. Social media campaigns are noted as the most trusted means, receiving an average trust score of 4.00, showing that the participant's reliance on social media information is high. School and university education follows with a trust level of 2.80 yet is perceived with much less confidence than social media. It was observed that the participants enabled community workshops with a trust score of 1.40, which means a moderate level of trust as compared to the other sources. Contrary to the levels of trust, maturity levels differ from one age group to another. As seen from the responses above, young people aged below 20 years fully trust social media ahead of school and university education. In contrast, the 21-30 age group prioritizes school and university education, while social media still holds significant influence. The 31-40 age group shows a preference for community workshops, indicating a balanced trust across multiple sources. Older age groups (41+) generally exhibit lower trust levels, although social media remains slightly more trusted.

Overall, social media campaigns and educational institutions emerge as the most trusted sources of information, with notable variations across age demographics. Younger individuals tend to favor social media, while older populations are more inclined to rely on traditional educational

resources and community workshops. This underscores the need for tailored communication strategies that resonate with the specific preferences of different age groups.
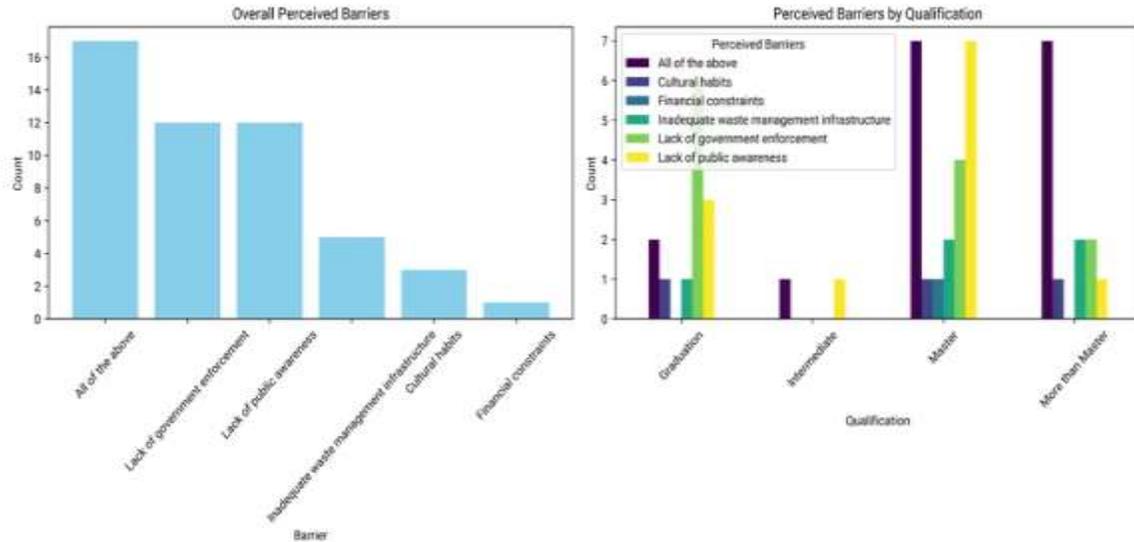

Figure 6: The perceived biggest barriers to proper waste management, and do these perceptions differ by qualification level

4.2.5. Perceptions by Qualification Level

The data on educational levels reveals key concerns regarding perceived barriers to effective waste management. Among individuals with a graduation-level education, the primary barriers identified are a lack of government enforcement (32%) and insufficient public awareness (26%), indicating institutional and societal shortcomings. Conversely, individuals with a master's degree or higher perceive "All of the above" as the main barrier, reflecting comprehensive concerns that encompass government enforcement and public awareness. Although data for those at the intermediate level is limited, there is still a notable acknowledgment of multiple barriers.
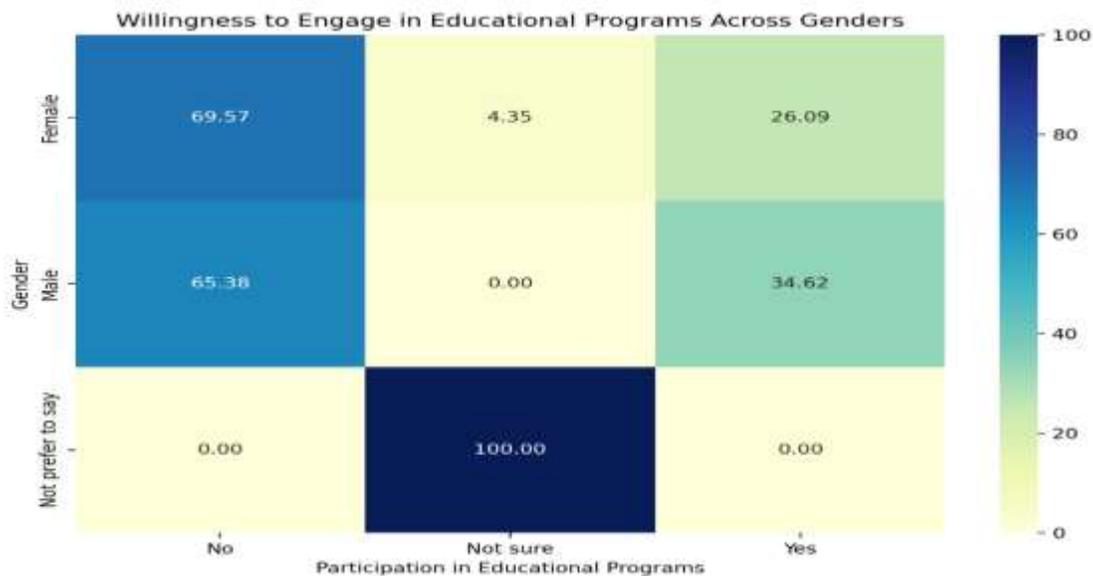

Figure 7: Heat chart of participation in educational programs

4.2.6. Willingness Levels by Gender

Table 5: *Highlighting the differences in willingness to engage in educational programs across genders*

Gender	No %	Not Sure %	Yes %
Female	69.57	4.35	26.09
Male	65.38	0	34.62
Not Prefer to Say	0	100	0

Table 5 highlights the differences in willingness to participate in educational programs across different genders. Among females, 69.57% are not willing to engage in such programs, 4.35% are unsure, and 26.09% express willingness. For males, 65.38% are unwilling, while 34.62% are willing, with none expressing uncertainty. The group that chose not to specify their gender shows complete uncertainty, with 100% of them being unsure about their willingness to participate.

4.2.7. Willingness Level by Age Group

The willingness to engage in waste management activities varies significantly across age groups. Among individuals aged 21 to 30 years, 35.7% express willingness, and 21.4% are classified as very willing; however, 25% report no willingness at all. In the 31 to 40 age group, there is a high willingness, with 40% willing and another 40% very willing, indicating strong engagement; notably, none report being unwilling. The 41 to 50 age group shows a split in willingness, with 50% somewhat willing and 50% willing, but no participants categorized as very willing. For those over 50 years, 37.5% are willing and another 37.5% very willing, though 25% are not willing at all. In contrast, individuals under 20 demonstrate the least willingness, with 50% reporting no willingness and the other 50% somewhat willing.

Visualization of these data indicates that the 31 to 40 age group stands out as the most willing demographic for waste management education. Conversely, the younger (under 20) and older (over 50) age groups exhibit low willingness, suggesting the need for targeted strategies to engage these populations. This highlights the importance of tailoring approaches to promote participation across all age groups and underscores the necessity of understanding varying willingness levels to enhance educational outreach and initiatives in waste management.
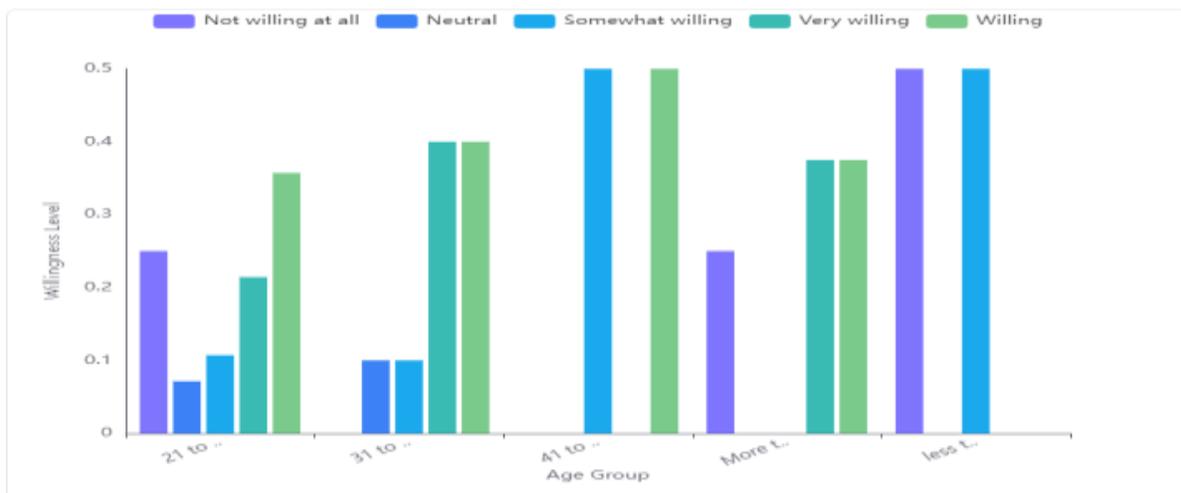

Figure 8: The willingness to participate in educational programs on waste management differ across different age groups

4.2.8. Influence of Age on Perception of Waste Disposal Importance

The study categorizes participants into age groups: up to 20, 21-30, 31-40, 41-50, and more than 50 years. The data reveals that people between 21 and 30 find waste disposal "extremely important" or "very important. Similarly, the under-20 group also recognizes its importance, affirming a high level of environmental awareness among the youth. High recognition of waste disposal importance was seen in groups such as 18-34 years and 35-49 years, while lower recognition was observed in the older group of persons over 50. This variance goes on to show why there is a need to have tailored education programs for the different age groups to ensure a total understanding of the proper disposal of waste.

4.2.9. Influence of Qualification on Perception of Waste Disposal Importance

The first examination of the findings shows that the participants who belong to the 'Intermediate,' 'Graduation,' 'Master,' and 'More than Master' education levels predict that 'Master' and 'More than Master' perceived the waste disposal as 'Extremely important' and 'Very important'. This trend suggests that the level of education increases with awareness and concern over waste management issues. Orientation of educational programs to persons with low levels of education may facilitate an increase in knowledge of waste management activities.

4.2.10. Influence of Age on Belief in Environmental Impact

Opinion about the environment that unveils the perception toward waste management was defined in the 'Agree,' 'Disagree,' 'Neutral,' 'Strongly agree,' and 'Strongly disagree' scales. A generally positive belief in the importance of waste management is also once again seen in the percentage response across all age brackets. However, counts in the 'Agree' and 'Strongly agree' categories are higher. Still, young people are seen to be surer of themselves, meaning they can be relied upon to get more involved in supporting environmental changes.

4.2.11. Influence of Qualification on Belief in Environmental Impact

The results of the data analysis show that respondents with higher education (master's or higher) clearly shifted their preferences toward the 'Agree' and 'Strongly agree' options concerning the environmental consequences of waste management. This finding reinforces the connection between educational levels and beliefs about waste disposal's importance, suggesting that educational programs could effectively enhance awareness and positive perceptions across various demographic groups.
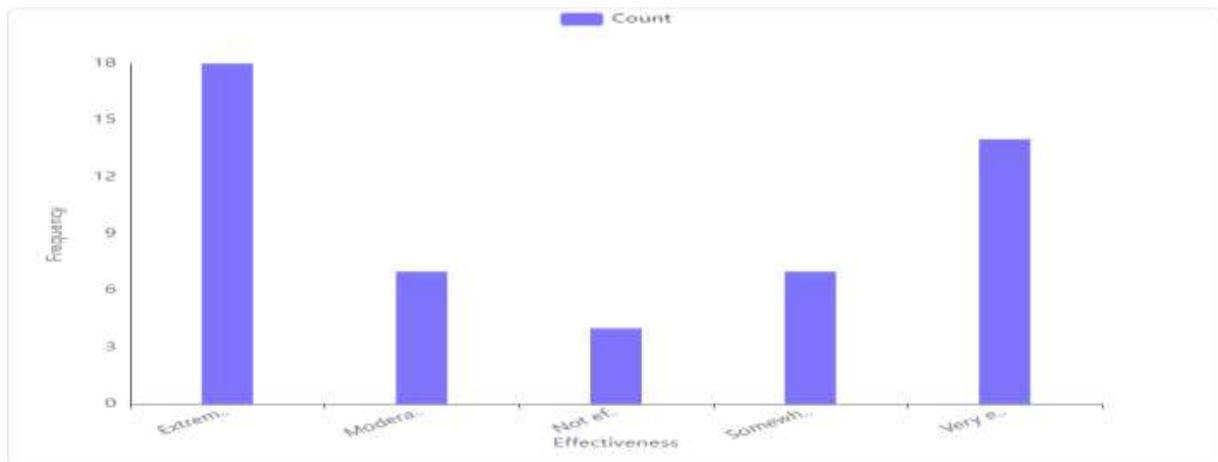

Figure 9: The distribution of opinions on the effectiveness of public awareness campaigns in promoting better waste management practices

4.2.12. Opinion Data Analysis

The assessment of perceived effectiveness of initiatives yielded a variety of responses across five categories. The 'Extremely effective' category received the highest count with 18 responses, indicating strong consensus among participants regarding the initiative's effectiveness. The 'Very effective' category followed closely with 14 responses, reflecting significant confidence in the initiative's impact. Both 'Moderately effective' and 'Somewhat effective' categories garnered 7 responses each, suggesting moderate perceptions of effectiveness. Conversely, the 'Not effective at all' category recorded the lowest frequency with only 4 responses, indicating that very few participants viewed the initiative as ineffective.

Visual representations reinforce these findings, showing that 'Extremely effective' is the most frequently expressed opinion among respondents. The positive perceptions of public awareness campaigns are further underscored by substantial responses in the 'Very effective' category. While the 'Moderately effective' and 'Somewhat effective' categories show mixed feelings, the minimal responses for 'Not effective at all' suggest that most respondents acknowledge some level of effectiveness. Overall, the data indicates a predominantly positive perception of the initiatives, although the presence of moderate opinions points to potential areas for improvement in campaign strategies to enhance their overall impact.
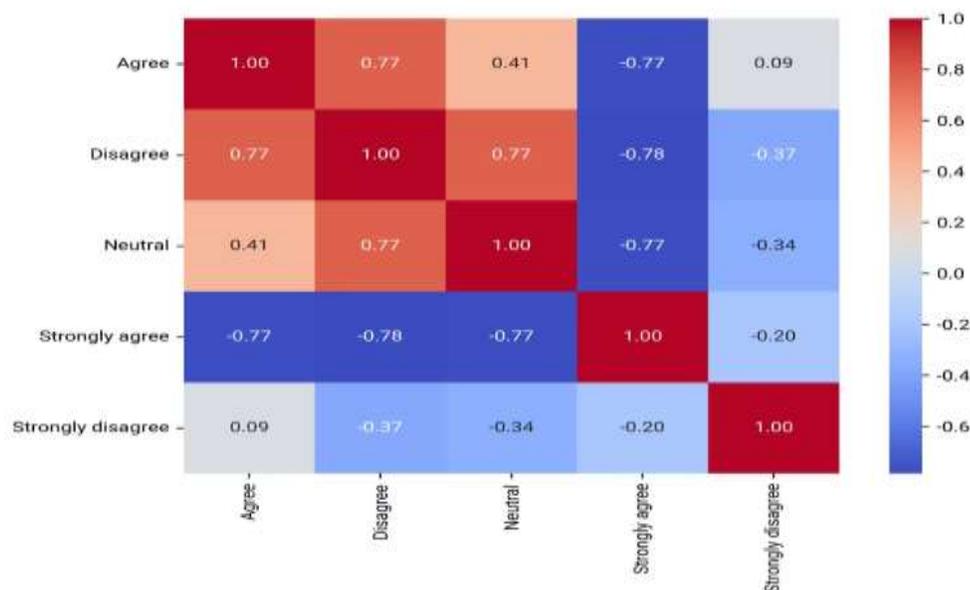

Figure 10: The belief in the impact of educating people on waste management correlate with the frequency of waste segregation practices.

4.2.13. Educational qualifications and their waste segregation

Table 6: *The relationship between respondents' educational qualifications and their waste segregation habits.*

Qualification	Always %	Never %	Often %	Rarely %	Sometimes %
Intermediate	0	0	0	100	0
Graduation	15.38	23.08	0	23.08	38.46
Master	27.27	18.18	18.18	13.64	22.73
More than Master	23.08	23.08	23.08	0	30.77

Table 6 examines the connection between respondents' educational qualifications and their habits of waste segregation. Individuals with an intermediate education reported never or rarely engaging in waste segregation, with 100% falling into the "rarely" category. Among those with a graduate degree, 15.38% always segregate waste, while 23.08% never do, and a significant 38.46% engage in this practice only sometimes. Respondents with a Master's degree show varied habits: 27.27% always segregate, and 18.18% do so often or never, while 22.73% sometimes follow the practice. For those with more than a Master's degree, 23.08% always, often, or never segregate waste, with the largest group (30.77%) doing so sometimes.

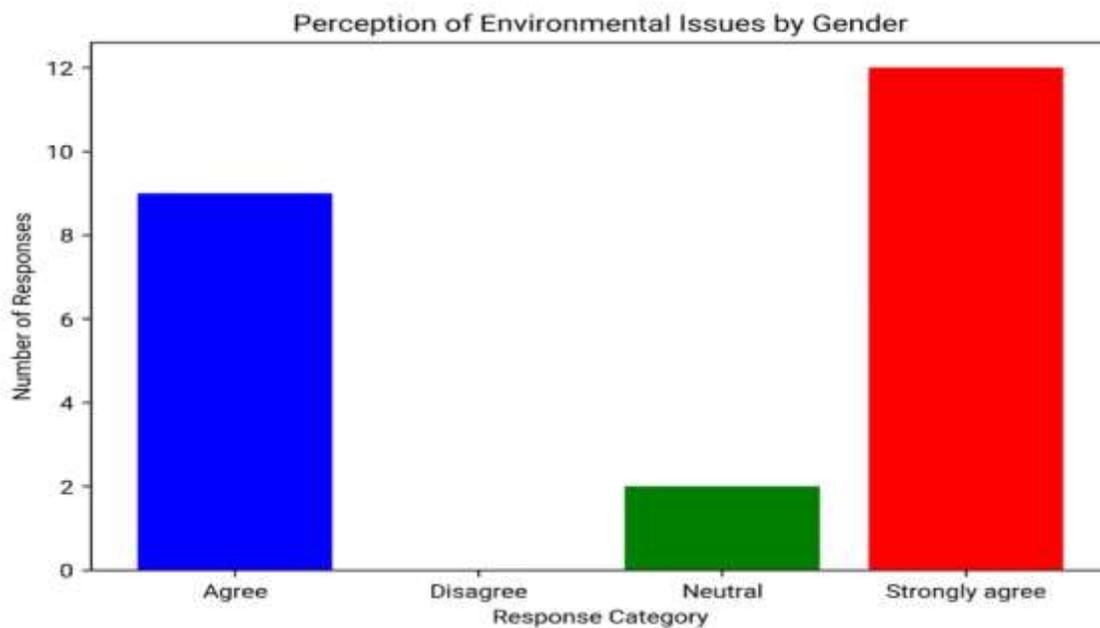## 4.2.14 Perception of Environmental Issues by Gender

Figure 11: Perception of Environmental issues by gender

The correlation analysis reveals notable patterns in respondents' beliefs about waste management practices. A positive correlation between "Agree" and "Disagree" responses indicates that those who support waste management initiatives tend to express less disagreement with opposing views. Conversely, a strong negative correlation exists between "Strongly Agree" and both "Agree" and "Disagree," suggesting that individuals who firmly support waste management are less likely to hold neutral or opposing opinions.

Neutral responses show a moderate positive correlation with "Disagree" and a negative correlation with "Strongly Agree," reflecting the complexity of attitudes among respondents. Additionally, the analysis underscores a significant belief in the role of education in improving waste management practices, as indicated by high mean scores for agreement. Importantly, individuals who strongly believe in the effectiveness of educational initiatives are more likely to engage in proper waste segregation practices, highlighting the critical influence of education on environmental behavior.

4.2.15. Statistical Analysis

The analysis of response data reveals distinct trends in participants' attitudes toward waste management initiatives. The "Agree" category shows a standard deviation of 4.58, indicating moderate consensus among respondents. In contrast, the "Disagree" category has a low average of 0.33 and a standard deviation of 0.58, suggesting minimal opposition to the initiatives. Neutral responses average at 1.67 with a standard deviation of 1.53, reflecting some ambivalence among participants. The "Strongly Agree" category stands out with an average of 9.67 responses and a higher standard deviation of 7.77, indicating that a significant portion of respondent's express strong support for the initiatives.

Visual analysis of the data highlights key trends regarding perceptions of the environmental impact of improper waste disposal. The "Strongly Agree" category dominates, reflecting robust recognition of the issues linked to poor waste management practices. The few responses in the "Disagree" category indicate a general consensus on the seriousness of the problem.

Overall, the strong representation of "Agree" and "Strongly Agree" responses reinforces the widespread acknowledgment of the need for improved waste disposal practices to mitigate environmental issues. The minimal disagreement suggests that most respondents share a unified stance on the significance of waste management, emphasizing the urgent need for increased awareness and action in this area.

5. Findings and Recommendations

There are several key insights in this research on solid waste management in Bahawalpur:

1. Inefficiencies in Waste Collection: The solid wastes generated by Bahawalpur city are almost 70% which is collecting by the Bahawalpur Waste Management Company (BWMC). Nonetheless, an old structure of waste management infrastructure and facilities, as well as a scarcity of collection tools and proper recycling facilities on the island, decrease its efficiency considerably. About 20% of waste is not collected especially in developing countries, thus causing such problems as land degradation, polluted air and water.

2. Public Awareness and Participation: Knowledge of adequate waste disposal methods differs among different age brackets and different levels of education. The study reveals that older people exhibit the highest level of awareness about the existence of the brand compared to the other age groups; though groups of 21 to 30 years also show moderate to low awareness. Education activities enrollment is still low particularly the women.

3. The Role of Education: youth are a keen user of social media which makes this media trusted source of information hence revealing an opportunity of enhancing public engagement in management of wastes. This contribution of educational programs shows that enhanced practices of waste segregation and recycling have been achieved but they fail due to bad infrastructures and poor enforcement.

4. Gender Disparities: This study has also revealed that male participants are more engaged in waste management programs than the female participants, therefore the need to make these programs more gender sensitive.

5. Infrastructure and Enforcement: Despite the positive effects observed from educational approaches, the lack of modern facilities together with poor policies implementation ensures that improper waste disposal remains high. Additional government support, harsher enforcement measures and proper and increased waste collection methods are needed for the long run.

5.1 Discussion

The outcomes of this study are meaningful in identifying the trends of the present SWM in Bahawalpur, including success and failure regarding sustainable environmental development through public awareness and preferences.

Discovered through the assessment of Bahawalpur's waste management practices are the following, which echo global trends in developing nations, where both waste collection efficiency and appropriate disposal structures are often undermined (Mohsin et al., 2020). This means that while current efforts undertaken by the Bahawalpur Waste Management Company (BWMC) are quite encouraging, the inefficiency of the buildings is the most pressing problem hindering better waste collection rates in the city. These infrastructural deficits, along with low public sensitivity, add to environmental problems such as land degradation and pollution that has been pointed out by the different scholars (Khan et al., 2012; Mohsin & Chinyama, 2017). It is urgent that these issues are addressed to prevent further environmental degradation.

A variation was also noted regarding the disposition of public awareness across the various population segments. The awareness of most respondents regarding proper waste management was moderate to low, especially among the young people in the age bracket of 21–30 years. This correlates with past literature, which associates age and education with environmental attitudes and behaviors (Hasan, 2004; Oonyu et al., 2018). Thus, there are some gaps in the utility of WtE systems, which still need to be widely adopted even today, though most waste generators are aware of their need. This concurs with earlier questions whereby respondents attributed poor infrastructure and enforcement as some of the key factors likely to hinder people from adopting sustainable waste management practices, as observed in the waste systems of developing countries (Mohsin et al., 2016).

It has been established that educational programs and specially designed public awareness have yields some results though not impressive, and this has been enhanced through the social media platform since majority of the youthful people said that they frequently used the social media platforms and considered it as the most reliable source of information. About this, previous studies have shown that social media can have a major influence on moderating environmental behaviors (Ramsey & Abdulaal, 2016; Abbas et al., 2020). Nevertheless, traditional educational institutions still seem relevant among older individuals, widely meaning that adopting the best of digital and traditional engagements is the best way of expanding engagement cross generations Dey, 2020; Wafula et al., 2024).

Sex as a factor of participation in educational initiatives also emerged with an implication that male participants have higher participation as compared to female participants. Such gender differences imply that their regard to gender equality, collective and individual approaches should be developed to encourage women and girls to participate in waste management awareness as the previous studies prove the significance of gender-sensitive approach to environmental conservation (Sewak et al., 2021).

Thus, the findings obtained in the framework of the study support the hypothesis about the potential benefits of educational effects on waste management behaviors, contributing to heightened public interest. Those participants who supported the opinion on the ability of education to bring about positive changes in the environment were more likely to practice waste segregation than the rest of participants; The current finding supports other research done which shows the power of education in bringing about positive changes in the environment (Debrah et al., 2021). The above mentioned above edifices portrays the viability of education in the right direction to a sustainable waste management in Bahawalpur.

At the same time, the results show that an increased awareness and a better education do not necessarily mean that improper waste disposal can be significantly reduced. There remains a general lack of infrastructural structures and enforcement mechanisms to encourage much broader uptake of sustainable practices. This is in agreement with the assertion by Mohsin et al. (2016) that SWM strategies require complementary institutional development to enhance public awareness.

5.2 Recommendations

1. Strengthen Waste Management Infrastructure

This study shows that the need for appropriate facilities and structures hinders effective waste management practices in Bahawalpur. Local governments should ensure they adopt effective waste collection methods, extend service delivery to more people, and provide adequate disposal and recycling centers in the city. In detail, introducing better equipment like waste compactors and dump trucks or setting up other centers for recycling would improve the facilities of this system of waste disposal.

2. Enhance Government Enforcement and Support

Another factor that spurs the success of any SWM expansion is the enforcement of the current waste management policies. BWMC and local government should raise the severity of the consequences for failing to dispose of waste properly and increase the oversight of waste disposal processes. Also, increasing the amount spent on waste management means there are enough people and resources to solve all current and future problems of city waste management.

3. Develop Targeted Educational Campaigns

One of the most crucial issues is to make the public ensure proper waste management strategies are embraced. Courses should be developed within a certain demographic for minorities such as women and youth. Campaigns that are targeted and include indications of environmentally friendly material, how to dispose of it, and where it is recycled can make instances better. Since social media platforms are considered to be one of the trusted sources of information, it is advisable to use them to get our messages across, particularly to the youth.

4. Integrate Waste Management into Educational Curricula

Information and education have to be integrated into the curriculum in schools and universities for effective change and long-term sustainability of waste management practices. Early education on solid waste management will ensure that younger generations practice good waste disposal. Other agencies can also conduct workshops with experience in waste segregation and recycling.

5. Promote Gender-Inclusive Educational Programs

The research studies show that male enrolment and attendance in education programs related to waste management are higher than in the case of female participants. An attempt should be made to create gender-sensitive educational workshops for women responsible for household waste

disposal. Such a gap could be filled by community workshops and campaigns to sensitize women to their expected contribution towards managing waste at the household level.

6. Facilitate Community-Based Waste Management Initiatives

To enhance community engagement, municipalities and NGOs should actively promote communal waste management programs. These initiatives, which could involve neighborhood waste collection, composting, and recycling, contribute to a cleaner environment and empower residents to take an active role in sustainability. Drawing from successful models in other developing regions, these programs can be adapted for Bahawalpur, fostering a grassroots approach to environmental stewardship.

5.3 Conclusion

In light of the results of the current study, it can be appreciated that the management of sustainable waste in Bahawalpur depends on three broadly conceived aspects: public awareness, education, and infrastructural resources. Educational measurements manifest that they positively affect WM behaviors, but continued structural problems and enforcement constrain the effectiveness of these interventions. In the further developmental process, enhanced coordination between education methods and Infrastructure development, along with stable support from the government, will play a crucial role in enhancing the level of environmental sustainability in the region.

References

Abbas, S. Y., Kirwan, K., & Lu, D. (2020). Measuring the public awareness toward household waste management in Muharraq Governorate-Kingdom of Bahrain. *Journal of Environmental Protection*, *11*(3), 196-214.

Abtahi, M., Saeedi, R., Boroojerdi, M., Fakhraeefar, A., Bayat, A., Mokari, S., Aliasgari, F., Ankoti, A., & Alizadeh, M. (2017). Public awareness, education and participation in solid waste management in Tehran. *Journal of Health in the Field, 3*

Brotosusilo, A., & Nabila, S. H. (2020). Community engagement and waste management policy: A comparative analysis. In *E3S Web of Conferences* (Vol. 211, p. 03022). EDP Sciences.

Chisanga, A., Saul, S. T., Daka, S., Masebe, E., Mulenga, R., Banda, D., ... & Mwansa, P. (2024). Community Engagement in Solid Waste Management: An In-Depth Analysis of Household Participation and Practices in Chelstone Township in Lusaka, Zambia. *International Journal of Research and Innovation in Social Science*, *8*(4), 2168-2194.

Debrah, J. K., Vidal, D. G., & Dinis, M. A. P. (2021). Raising awareness on solid waste management through formal education for sustainability: A developing countries evidence review. *Recycling*, *6*(1), 6.

Dey, S.S. (2020). Solid Waste Management. *Concise Handbook of Waste Treatment Technologies*.

Fang, B., Yu, J., Chen, Z., Osman, A. I., Farghali, M., Ihara, I., ... & Yap, P. S. (2023). Artificial intelligence for waste management in smart cities: a review. *Environmental Chemistry Letters*, *21*(4), 1959-1989.

Fang, B., Yu, J., Chen, Z., Osman, A.I., Farghali, M., Ihara, I., Hamza, E.H., Rooney, D., & Yap, P. (2023). Artificial intelligence for waste management in smart cities: a review. *Environmental Chemistry Letters*, 1 - 31.

Hasan, S. E. (2004). Public awareness is key to successful waste management. *Journal of environmental science and health, Part A*, *39*(2), 483-492.

Haseli, G., Torkayesh, A. E., Hajiaghaei-Keshteli, M., & Venghaus, S. (2023). Sustainable resilient recycling partner selection for urban waste management: Consolidating perspectives of decision-makers and experts. *Applied Soft Computing*, *137*, 110120.

Hossen, M. M., Ashraf, A., Hasan, M., Majid, M. E., Nashbat, M., Kashem, S. B. A., ... & Chowdhury, M. E. (2024). GCDN-Net: Garbage classifier deep neural network for recyclable urban waste management. *Waste Management*, *174*, 439-450.

Khan, A. A., Ahmed, Z., & Siddiqui, M. A. (2012). Journal of Environmental and Occupational Science. *Journal of Environmental and Occupational Science*, *1*(2), 129-131.

Majeed, A., Batool, S. A., & Chaudhry, M. N. (2018). Environmental quantification of the existing waste management system in a developing world municipality using EaseTech: The case of Bahawalpur, Pakistan. *Sustainability*, *10*(7), 2424.

Mohsin, M., & Chinyama, A. (2016). Impacts of solid waste management practices on environment and public health: A case of Bahawalpur city, Pakistan. *Journal of Environmental and Agricultural Sciences*, *9*(1), 69-79.

Mohsin, M., Khan, A. A., Nasar-u-Minallah, M., & Barkat, T. (2020). Assessment of municipal solid waste management practices in Bahawalpur city, Pakistan. *International Journal of Economic and Environmental Geology*, *11*(2), 1-5.

Nurhayati, E., & Nurhayati, S. (2023). Community waste management education: strategies and impacts. *JURNAL DIMENSI*, *12*(3), 677-686.

Oonyu, J., Fredrick, M., & Sentongo, J. (2018). Influence of Education on the Solid Waste Management Practices of Communities in Kampala City.

Ramadan, B.S., Alam, F.C., & Rahardyan, B. (2016). The influence of environmental campaign on public awareness in maintaining the cleanliness and waste reduction program: a case study of Bandung City. *Scientific Journal of PPI - UKM, 3*, 32-37.

Sewak, A., Deshpande, S., Rundle-Thiele, S., Zhao, F., & Anibaldi, R. (2021). Community perspectives and engagement in sustainable solid waste management (SWM) in Fiji: A socioecological thematic analysis. *Journal of Environmental Management*, *298*, 113455.

Thakur, A., & Kumar, A. (2024). Community Engagement and Education for Eco-Conscious Health. In *Preserving Health, Preserving Earth: The Path to Sustainable Healthcare* (pp. 81-102). Cham: Springer Nature Switzerland.

Wafula, G. W., Kamiri, H., & Ouna, T. (2024). Assessment of Solid waste generation and composition in Bungoma County Urban Centres for appropriate waste management approaches. *Eastern African Journal of Humanities and Social Sciences*, *3*(1), 171-181.