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Research Article

Evaluating Awareness and Practices in Household Wastewater Management in Riverside Dwellers: Implications for Policy and Education

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Abstract: In rapidly urbanizing regions like Bambang, Bocaue, Bulacan, managing household wastewater has become a pressing challenge, primarily due to rapid population growth and inadequate infrastructure. Effective wastewater management is critical to safeguarding environmental and public health, yet it often remains overlooked in developing areas. This study investigates riverside dwellers' awareness levels and practices regarding household wastewater management, aiming to bridge data gaps and provide valuable insights for policymakers, researchers, and stakeholders. By addressing these issues, the research contributes to a deeper understanding of the current challenges and opportunities for improving wastewater practices in the area. The study employs quantitative methods, including surveys and statistical analyses, to examine the demographic profiles, awareness levels, and wastewater management practices of 111 households. Findings reveal a troubling lack of awareness among respondents regarding proper wastewater management, disposal methods, and their environmental impacts. Most households report directly discharging wastewater into nearby water bodies, with only minimal use of appropriate treatment facilities. This practice poses substantial risks, including water pollution, ecosystem degradation, and threats to community health, particularly in a densely populated and ecologically sensitive area like Bambang. These findings underscore the urgent need for targeted interventions to address this critical issue. Community education programs are essential to raise awareness of wastewater management's importance and environmental impacts. Simultaneously, infrastructure investments—such as constructing affordable and accessible treatment facilities—are crucial for enabling proper wastewater handling. The study also emphasizes the necessity for robust policy measures, including stricter regulations and enforcement, to ensure sustainable wastewater management practices.

Keywords: Environmental Pollution; Public Health; Policy Interventions; Water Pollution; Water Disposal Systems.

1. Introduction

Rapid population growth, industrialization, and the diversification of economic activities have significantly increased water demand, particularly in developing urban areas [1]–[3]. Once considered an abundant resource, water now faces scarcity challenges in many growing cities in developing countries [4], [5]. This issue is compounded by the improper disposal of household wastewater, which includes contaminants such as human waste, food scraps, oils, soaps, and chemicals. Often referred to as "grey water," household wastewater encompasses water from showers, washing machines, kitchens, and toilets [6], [7]. According to UN-Water, 42% of global household wastewater is improperly treated, causing severe environmental degradation and significant health risks [8].

The inability to manage household wastewater effectively poses a significant threat to the environment and human health [9], [10]. In low-income urban areas, untreated wastewater is often discharged directly into drainage canals or nearby water bodies [11]. Globally, over 80% of wastewater is released untreated, contaminating ecosystems and endangering water sustainability [12]. The challenges in developing regions such as Asia stem from inadequate treatment infrastructure, limited public awareness, and weak policy enforcement. The lack of

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proper wastewater management threatens critical ecosystems, mainly coastal and marine environments. The detrimental effects of untreated wastewater on marine biodiversity, noting that the discharge of pollutants into water systems harms aquatic habitats and undermines the sustainability of natural resources [13], [14]. Furthermore, a lack of public awareness often leads to indiscriminate wastewater disposal, compounding the problem in urban communities [15].

Addressing these challenges requires a multidimensional approach. According to Trang et al. [16], investments in wastewater infrastructure, community-based education, and stringent environmental policies can significantly mitigate untreated wastewater's impact. They argued that community participation and government subsidies for wastewater projects reduced pollution in Vietnam. Similarly, Tiwari et al. [17] demonstrated that adopting low-cost wastewater treatment technologies, such as biofiltration systems, could effectively address wastewater challenges in resource-limited settings, reducing pollution by up to 60%.

Previous studies have highlighted the importance of managing domestic wastewater to sustain water resources, particularly in developing regions. Roozhabani [11] emphasized that wastewater management involves collecting, treating, and reusing wastewater to minimize its environmental impact. However, the primary challenge lies in inadequate infrastructure to support these processes, especially in low- to middle-income countries.

Southeast Asian research highlights the need to raise public awareness of wastewater management. Palanca-Tan (2017) argued that low public awareness often hinders the adoption of sustainable wastewater practices. Furthermore, limited environmental education and information contribute to irresponsible waste disposal practices, such as dumping domestic wastewater directly into rivers or drainage systems. These findings align with Islam et al. [18], who observed that public education initiatives could improve awareness and compliance with wastewater management policies by up to 35% in urban Bangladeshi communities.

In Southeast Asia, Sotelo [19] pointed out that inadequate wastewater management harms the environment and threatens marine biodiversity, as the region is a global biodiversity hotspot. Sotelo recommended community-based approaches integrating infrastructure development, environmental education, and policy enforcement. This recommendation is consistent with Trang et al. [16], whose research in Vietnam demonstrated that successful wastewater management projects rely on local community participation and government support through subsidies and incentive policies.

The potential of technological innovations such as biofiltration or plant-based treatment systems as cost-effective solutions for resource-limited areas. Their study in Nepal revealed that adopting these simple technologies could reduce pollution by up to 60% and provide additional benefits such as clean water for irrigation [20].

Approximately 80% of daily water use in the Philippines is discharged as wastewater. The United Nations Development Programme [21], reported that of this volume, 80% flows back into natural water bodies without adequate treatment. Palanca-Tan [22] highlighted that only 4% of the population is connected to a sewer system. Even in Metro Manila, the most developed urban center in the country, the sewer network covers only 8% of the area. This means less than one-tenth of Metro Manila's wastewater undergoes proper treatment before being discharged into rivers or other water bodies. Most of the remaining wastewater is in septic tanks for primary treatment, where solids settle at the bottom, and the liquid overflows into drainage canals. In informal settlements lacking septic tanks, toilet wastewater often flows directly into flood or drainage canals without treatment.

In 2009, roughly 30% of urban residents in Southeast Asia lived in slums or low-income areas, where drainage systems are often unsafe or inefficient. In developing countries, water pollution primarily stems from human activities, both domestic and industrial, exacerbated by population pressure, poor governance, and mismanagement [23], [24]. Wastewater is commonly disposed of in surface drains or informal drainage channels [25], [26]. Slums, often the only affordable housing for new urban residents, lack proper drainage infrastructure.

However, Takeda et al. [27] underscored that safely treated wastewater could be a sustainable source of water, energy, nutrients, and other recoverable materials. Jalilov [28] argued that raising public awareness and fostering proper wastewater management practices are critical for achieving sustainable urban water environments. Effective collection systems play a vital role in ensuring efficient wastewater management. Despite some countries having wastewater treatment facilities, many struggle to maintain them effectively. The biggest challenge is changing the public perception of wastewater as a resource rather than a problem [29]–[32].

Raising residents' awareness and improving their wastewater practices are essential for successful wastewater management. This study examines the awareness and practices of riverside dwellers in Bambang, Bocaue, Bulacan, regarding household wastewater. The study aims to assist local governments and organizations in addressing these challenges by collecting comprehensive and readily available data. A lack of reliable information hampers the local government's ability to

secure funding for infrastructure improvements and conservation efforts [33], [34]. Establishing primary data on demographics, wastewater practices, and awareness levels would empower local government units (LGUs) to formulate policies, design wastewater treatment plans, and inform stakeholders about the importance of proper wastewater management. This study explores the demographic characteristics of Bambang, Bocaue, Bulacan riverside dwellers, their level of awareness regarding wastewater types, disposal, management, and environmental impact, as well as their practices related to wastewater discharge and household wastewater generation.

2. Material and Methods

This section outlines the methodology used to collect and analyze data for the study on wastewater management awareness and practices among riverside dwellers. The quantitative approach was employed to gather measurable data and conduct statistical analysis, ensuring reliability and objectivity in the findings.

2.1. Research Design and Approach

The study used a quantitative research design to gather numerical data to answer specific research questions. This design allowed for collecting of measurable and objective data that could be analyzed using statistical techniques. By applying this approach, the researchers ensured the data was accurate, reliable, and gathered quickly, minimizing bias [35], [36].

The researchers conducted descriptive research to assess riverside dwellers' awareness and practices regarding wastewater management. Descriptive research helped answer critical questions about "what," "when," and "how," offering detailed insights into the current behaviors and attitudes of the population. Since it does not involve manipulating variables, this approach is ideal for documenting and analyzing existing practices and perceptions [37]. The researchers aimed to capture a clear picture of the respondents' awareness levels and wastewater practices, providing a solid foundation for policy development and further interventions [38].

2.2. Population and Sample Size

The study targeted 153 households as the population. Using Slovin's formula, the researchers determined that a sample size of 111 households was necessary to ensure representativeness and maintain an acceptable margin of error. This formula is commonly employed to calculate an appropriate sample size based on a specified confidence level and margin of error, ensuring the data accurately reflects the population characteristics [39]. The selected 111 households were surveyed to collect the required data for analysis.

2.3. Data Collection

The researchers collected data using a structured questionnaire designed to capture demographic profiles and assess awareness and practices regarding wastewater management. The demographic section gathered vital information such as age, gender, and income to analyze the influence of these variables on the findings.

The researchers used a 4-point Likert scale to measure awareness levels, which effectively quantifies subjective perceptions [40], [41]. Dichotomous yes/no questions were employed to evaluate respondents' practices, providing clear insights into their behaviors [42]. This combination of methods ensured a comprehensive and structured data collection process.

2.4. Instrument Validity and Reliability

The researchers ensured the validity of the survey questionnaire by consulting three experts in the field. These experts assessed the questions' clarity, relevance, and potential biases, ensuring they aligned with the study's objectives and avoided ambiguity. This review helped validate the questionnaire as a reliable tool for capturing accurate and relevant data [43], [44].

To ensure reliability, the researchers applied Cronbach's Alpha coefficient to test the internal consistency of the questionnaire. This statistical method evaluates how well the items in a scale measure the same concept, ensuring dependable and consistent data collection. A high Cronbach's Alpha value confirmed that the questionnaire reliably measured awareness and practices related to wastewater management [45]–[47].

2.5. Data Processing and Analysis

The researchers analyzed the survey data using mean and percentage calculations. The mean was applied to Likert scale responses to determine average awareness levels about wastewater management. At the same time, percentages were used to analyze categorical data from dichotomous questions, highlighting the proportions of specific practices and demographic patterns. These methods provided clear insights into the respondents' awareness and practices, ensuring an accurate interpretation of the results [48].

2.6. Data Processing and Analysis

While not explicitly stated in the original text, it is essential to emphasize that ethical considerations should be

followed throughout the research process. This includes obtaining informed consent from participants, ensuring their confidentiality, and respecting their rights to withdraw from the study at any time.

3. Result and Discussions

After surveying through a Google form questionnaire, the researchers gathered over 111 respondents from the barangay Bambang, Bocaue Bulacan residents. Below is a discussion of the results that were collected and interpreted.

3.1. Demographic Profile of the Riverside Dwellers

The demographic profile of the riverside dwellers provides essential information to understand their socio-economic and personal characteristics. This section presents data on the respondents' household composition, age distribution, income classification, educational attainment, and length of residency. Figures 1 to 5 below illustrate the details to provide a comprehensive overview of the study population.

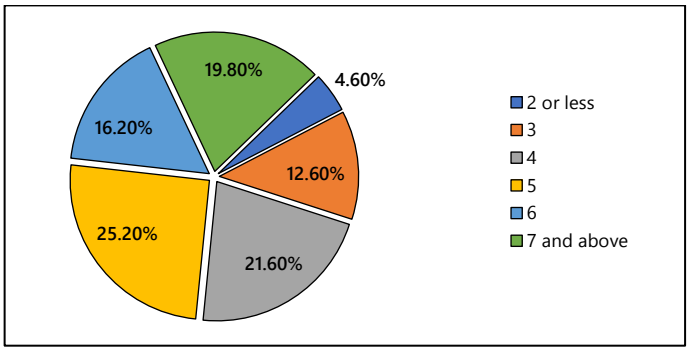

Figure 1. Number of Members in the Household

Figure 1 illustrates the family size distribution among respondents from Barangay Bambang. The data shows that most households are moderately large, with 25.20% (28 respondents) having five family members, representing the most common family size. This is closely followed by 21.60% (24 respondents) with four family members and 19.80% (22 respondents) with seven or more members, suggesting that extended families are relatively common. Additionally, 16.20% (18 respondents) reported having six members, while the minor proportion, 12.60% (14 respondents), comprised households with three members. These findings reflect a tendency towards larger family units, which could affect resource distribution, housing needs, and overall community dynamics.

Figure 2 illustrates the age distribution of respondents, grouped into three categories. Nearly half of the respondents (49.55% or 55 respondents) were aged 50 years and above, indicating that the population is predominantly older, which may reflect either the area's long-term residency patterns or a preference for stability among older individuals. Respondents aged 30 to 49 made up 27.03% (30 respondents), suggesting a presence of middle-aged residents likely contributing to the workforce. Meanwhile, the younger group aged 18 to 30, comprising 23.42% (20 respondents), represents a smaller proportion, possibly indicating a tendency for younger individuals to migrate for education or employment opportunities.

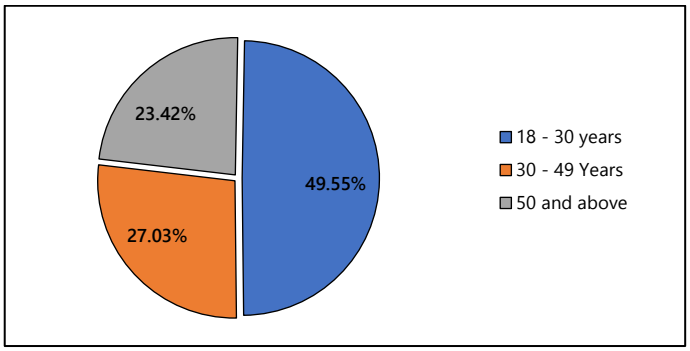

Figure 2. Age Group of the Respondents

Figure 3 presents the income classification of the respondents. The majority, 78.38% (87 individuals), were categorized as low-income, earning less than Php 10,000 per month. This highlights the economic challenges most riverside dwellers face, potentially impacting their access to essential services and resources. The middle-income group, representing 19.82% (22 respondents), indicates some degree of economic diversity, while the high-income group, with only 1.80% (2 respondents), underscores the rarity of financial affluence within this community.

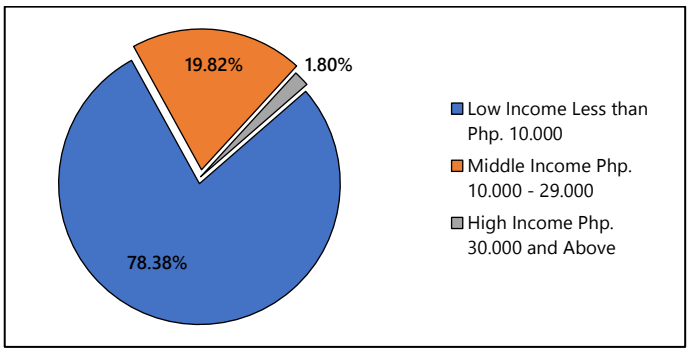

Figure 3. Income Class of the Respondents

Figure 4 depicts the respondents' highest educational attainment. 36.04% (40 respondents) reported completing elementary education, indicating limited educational opportunities. The 27.93% (31 respondents) who had either completed junior high school or earned a bachelor's degree reflect a moderate level of educational advancement, while the small proportion (8.11% or nine respondents) with senior high school education points to

gaps in access to higher levels of education, which could hinder opportunities for social mobility.

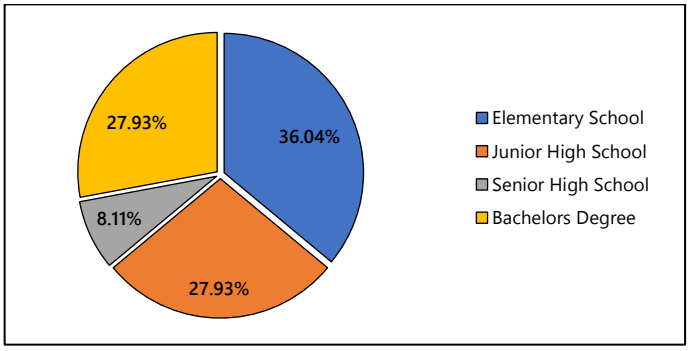

Figure 4. Highest Educational Attainment of Respondents

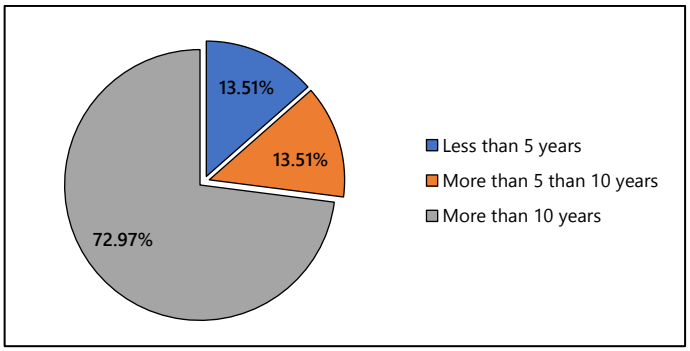

Figure 5. Years as a Resident/Dweller of the Respondents

Figure 5 shows the length of residence of respondents in Barangay Bambang. A significant majority, 72.97% (81 individuals), had lived in the area for over 10 years, suggesting solid ties to the community and potential generational residency. The remaining respondents were evenly divided, with 13.51% (15 individuals) residing for less than five years and 13.51% (15 individuals) living there for five to ten years. This indicates some level of population turnover, which may result from factors such as migration, employment opportunities, or changing living conditions in the area.

3.2. Awareness of Riverside Dwellers

The table shows the respondents' level of awareness of wastewater. The questions were categorized in five (5) ways: awareness, disposal, management, and environmental impact.

Table 1. Awareness on Wastewater

Scales	Mean	SD	Interpretation
Wastewater Awareness (5 Questions)	2.33	1.00	Moderately Low
Wastewater Disposal (5 Questions)	2.28	1.11	Moderately Low
Wastewater Management (6 Questions)	2.30	1.08	Moderately Low
Environmental Impact (5 Questions)	2.51	1.08	Moderately High
Total	2.36	1.07	Moderately Low

The study revealed that the overall awareness level of riverside dwellers regarding wastewater management was moderately low, as indicated by a total mean score of 2.36 and a standard deviation of 1.07. Awareness was deficient in specific areas, including wastewater awareness (mean 2.33, SD 1.00), wastewater disposal (mean 2.28, SD 1.11), and wastewater management (mean 2.30, SD 1.08). However, the respondents demonstrated a relatively higher level of awareness concerning the environmental impact of wastewater, with a mean score of 2.51 and a standard deviation of 1.08.

These findings suggest that residents are somewhat aware of the environmental consequences of improper wastewater handling, but their knowledge and understanding of wastewater disposal and management remain limited [49]. Such gaps in awareness could lead to unsustainable practices that harm public health and the environment [50]. The moderately low awareness in critical areas underscores the urgent need for targeted educational interventions to enhance understanding and promote responsible practices.

Low awareness levels may result from limited access to environmental education or insufficient community engagement initiatives. Studies have shown that awareness and knowledge are critical for motivating sustainable behavior, particularly in wastewater management [49]. Without adequate knowledge, residents may inadvertently contribute to environmental degradation and public health risks through improper disposal and lack of wastewater treatment practices.

The relatively higher awareness of environmental impacts highlights the potential for leveraging this knowledge as a starting point to introduce more comprehensive educational campaigns. Informing residents about how improved wastewater management can mitigate these impacts could help bridge the knowledge gaps and promote better practices [51], [52].

An urgent need for community-based educational programs to address gaps in wastewater management awareness. Local authorities and stakeholders must design and implement targeted interventions, such as workshops, visual campaigns, and household training sessions, to actively improve residents' knowledge and practices. These efforts should empower communities to adopt sustainable wastewater management methods.

In addition to education, stakeholders must upgrade wastewater infrastructure and enforce policies to ensure long-term sustainability. Authorities should build and expand sewerage systems, enhance wastewater treatment facilities, and offer affordable septic tank collection services to prevent environmental pollution. Combining these actions with continuous education will create a well-rounded strategy that fosters understanding and encourages responsible behavior.

By actively engaging communities and improving infrastructure, stakeholders can protect the environment, enhance public health, and significantly improve the quality of life for riverside dwellers, driving meaningful and lasting change.

3.3. Practices of Riverside Dwellers

The practices of the riverside dwellers are categorized into two parts: Discharge method and generated household wastewater.

Table 2. Discharge Method

Wastewater Disposal Method	Frequency	Percentage
Direct Flow to the River	75	67.60 %
Septic Tank	29	26.10 %
Septic Tank and Collected for Treatment	7	6.30 %
Sewerage system connected to Treatment Facility	0	0.00 %
Total	111	100 %

Most respondents (67.60%) directly discharged wastewater into the river, indicating a high prevalence of unsustainable practices. Approximately 26.10% of respondents utilized septic tanks, while only 6.30% had their septic tanks serviced and wastewater treated. Notably, none of the households used sewerage systems connected to treatment facilities, reflecting a lack of access to centralized wastewater infrastructure.

These findings suggest limited adoption of environmentally sustainable wastewater management practices among riverside households. Direct discharge into the river is a primary contributor to water pollution and poses risks to public health and aquatic ecosystems [53]. The low use of septic tanks and their collection for treatment highlights the need for improved infrastructure and services.

The absence of sewerage systems connected to treatment facilities underscores systemic gaps in wastewater infrastructure. Studies have shown that such infrastructure is vital for mitigating pollution and supporting sustainable water management (UNEP, 2022). These unsustainable practices will likely persist without significant investments in wastewater treatment systems and community education.

One priority is the development of accessible and cost-effective sewerage systems connected to treatment facilities. Such infrastructure is essential for reducing direct discharge into rivers, significantly contributing to water pollution and public health risks. Investments in modern and inclusive systems can ensure that even underserved communities can access sustainable wastewater solutions.

Equally vital is the need for robust community education programs. By raising awareness of the environmental and health consequences of improper wastewater disposal, these initiatives can encourage residents to adopt responsible practices. Tailored campaigns incorporating local languages and cultural contexts can improve engagement and foster behavior change. Practical training in wastewater management, such as maintaining septic tanks or segregating hazardous waste, efficiently bridges knowledge gaps.

Expanding septic tank collection and treatment services is another critical step. Many households rely on septic systems but lack access to regular maintenance and waste collection services. Establishing affordable and efficient collection systems can prevent untreated waste from contaminating water sources, enhancing overall sanitation and environmental quality.

These measures are fundamental to promoting sustainable water resource management, mitigating environmental degradation, and protecting public health. By prioritizing infrastructure development, community education, and service expansion, stakeholders can create a comprehensive framework for effective wastewater management, benefiting current and future generations.

Table 3. Types of Household Wastewater Generated

Wastewater Household	Frequency	Percentage
Bathroom Wastewater	111	100 %
Laundry Wastewater	111	100 %
Toilet Wastewater	110	99.10 %
Kitchen Wastewater	110	99.10 %
Gardening Wastewater	75	67.57 %
Pets Wastewater	78	70.27 %
Medical Wastewater	90	81.08 %

The study identified seven types of household wastewater from riverside dwellers: bathroom, laundry, toilet, kitchen, gardening, pets, and medical. Bathroom and laundry wastewater were reported by all respondents (100%), followed closely by wastewater from toilets and kitchens (99.1%). Medical wastewater was generated by

81.08% of respondents, while 70.27% reported wastewater from pets, and 67.57% reported wastewater from gardening.

These findings highlight the diversity and volume of wastewater generated by households. The near-universal presence of wastewater from bathrooms, laundry, toilets, and kitchens underscores the critical need for effective wastewater management systems. 81.08% of respondents reported that medical wastewater raises particular concerns due to its potential to contain hazardous substances, including pharmaceutical residues and pathogens, which can pose significant risks to human and environmental health [54].

Though generated by fewer households, wastewater from pets and gardening contributes to the overall burden on local water systems. Pet wastewater may contain harmful bacteria, while gardening runoff often includes fertilizers or pesticides, which can lead to nutrient pollution in nearby water bodies [55].

Effectively managing diverse household wastewater types demands comprehensive and tailored solutions that address the specific challenges associated with each category. One critical area is the improvement of wastewater infrastructure. Local authorities must invest in developing treatment facilities capable of processing a variety of waste streams, including hazardous medical wastewater. These facilities should incorporate advanced treatment technologies to mitigate the risks posed by pharmaceutical residues and pathogens, which can have long-term detrimental effects on human health and aquatic ecosystems.

Equally important is the role of community education in promoting responsible wastewater practices. Public awareness campaigns should be designed to inform residents about the environmental and health risks linked to improper disposal, particularly concerning medical and pet wastewater. These initiatives must emphasize practical and actionable steps that households can adopt, such as segregating waste at the source and using environmentally safe cleaning products.

In addition, developing and enforcing policies that encourage sustainable practices are vital. Policymakers should prioritize regulations limiting harmful chemicals in household and gardening activities while promoting the adoption of biodegradable alternatives. Incentives, such as subsidies for eco-friendly products or penalties for improper disposal, can further encourage compliance and sustainable behavior.

These measures are essential for safeguarding water quality, minimizing environmental degradation, and protecting public health. Addressing the complexities of wastewater management requires a collaborative approach, where infrastructure improvements, community engagement, and robust policy frameworks work synergistically. Such an integrated strategy can empower communities to adopt sustainable practices, ensuring the long-term well-being of both residents and the environment.

4. Conclusion

The research findings have painted a concerning picture, indicating that the overall awareness among riverside dwellers towards wastewater management is moderately low. This lack of understanding extends across various aspects, including wastewater awareness, disposal methods, management practices, and the environmental impact of improper wastewater handling. Further examination of the practices employed by the riverside dwellers has revealed alarming trends. Most respondents were found to directly discharge their wastewater into the nearby river, with only a tiny percentage utilizing septic tank for primary treatment. None of the respondents reported using sewerage systems connected to proper treatment facilities. The types of household wastewater generated by the riverside dwellers were diverse, ranging from bathroom and laundry wastewater to toilet, kitchen, gardening, pet, and even medical waste. This diverse array of wastewater streams and inadequate disposal methods paint a grim picture of the potential environmental and public health consequences. These findings underscore the urgent need for comprehensive interventions to address the alarming state of wastewater management in the riverside communities of Bambang, Bocaue, Bulacan.

Implementing sustainable and responsible wastewater management practices requires a comprehensive and collaborative approach. First, local authorities should actively educate and engage the riverside community by launching targeted programs highlighting the importance of proper wastewater management. These initiatives should emphasize the environmental impacts of improper disposal and provide practical guidance on sustainable practices, empowering residents to make informed decisions.

Second, authorities must prioritize the development and improvement of wastewater treatment infrastructure. Investing in efficient collection systems, modern treatment facilities, and safe disposal or reuse mechanisms is essential to ensure the effective management of household wastewater.

Lastly, policymakers should strengthen the enforcement of regulations on wastewater management. By implementing strict policies and promoting compliance with responsible disposal methods, authorities can encourage sustainable practices within the community.

Through these integrated efforts, stakeholders can transform the current wastewater management conditions in Bambang, Bocaue, Bulacan. This multi-pronged approach will empower riverside communities to protect the environment, adopt sustainable practices, and improve their overall quality of life.

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