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Spatial and Socio-Economic Determinants of Public Acceptance and Management of Domestic Wastewater Treatment Plants

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***Abstract*—** Domestic wastewater treatment systems play an important role in maintaining environmental sustainability and protecting public health. This study aims to analyze the level of public acceptance, knowledge, attitudes, management behavior and evaluation of existing condition toward Wastewater Management System (WWMS) in Lhokseumawe City, Aceh Province, Indonesia. The research employed a quantitative method using a cross-sectional approach. Data analysis was conducted using univariate and bivariate statistical methods through the Chi-Square test to identify relationships between WWMS variables and respondent characteristics, such as age, gender, latest education, occupation criteria, and income. The results indicate that most residents possess positive knowledge (75%), attitudes (86%), actions (65%), management behavior (63%), and evaluations of existing WWMS conditions (67%). Educational level showed a statistically significant relationship with knowledge, attitudes, actions, management, and assessment of WWMS conditions ($p < 0.05$). Age and occupation were also found to influence certain management aspects, while gender had no significant effect. Spatial analysis revealed that residents in Muara Satu District demonstrated the highest level of positive engagement toward WWMS management, whereas communities in Blang Mangat required greater educational intervention. The study concludes that strengthening community-based education, awareness campaigns, and participatory management programs is essential to improve sustainable domestic wastewater management in Lhokseumawe City.

Keywords—WWMS, Cross Sectional, Community Knowledge

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I. INTRODUCTION

Domestic wastewater management represents a critical cornerstone of modern environmental health and urban sustainability, directly aligning with the United Nations Sustainable Development Goal (SDG) 6 to ensure universal access to clean water and safe sanitation. However, to achieve these targets requires an integrated understanding of localized sociocultural and institutional indicators alongside technical frameworks [1]. Wastewater treatment systems play an indispensable role in safeguarding public health and preserving ecological integrity[2]. Communal Wastewater Treatment Plants (WWTPs) ensure that liquid waste generated from dense residential zones is effectively treated, neutralizing harmful pathogens and organic load before environmental discharge. In developing urban contexts, the functional success of this infrastructure is heavily contingent upon institutional governance and regulatory backbones. Domestic Wastewater Management legal seeks to maintain sustainable wastewater treatment, establish safe processing parameters, and foster clean and healthy living behaviour across the community.

Wastewater treatment systems are a series of infrastructure, equipment, and processes designed and used to treat wastewater from various sources, such as households, industries, agriculture, and communities, so that the wastewater can be safely discharged into the environment or can be reused [3][4]. With the importance of wastewater treatment systems, it must ensure that wastewater produced by various human activities can be effectively treated before being discharged into the environment, so as to protect the environment, society, and the sustainability of the ecosystem as a whole[5].

However, the formalization of municipal regulations and the physical installation of wastewater infrastructure do not independently guarantee systemic sustainability; the true challenge lies in the deep-seated spatial and socio-economic determinants that govern public acceptance and long-term community management. Spanning a total area of 181.06 km², approximately 60% of Lhokseumawe City is classified as residential space. Spatial disparities across four districts in Lhokseumawe are stark; Muara Dua

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encompasses the largest administrative expense covering 57.80 km², whereas Banda Sakti represents the smallest, most hyper-congested urban core covering just 11.24 km².

These spatial discrepancies introduce highly non-uniform topologies, uneven land-use pressures, and varying physical access to centralized networks, which mirror findings from broader spatial sanitation assessments in developing macro-urban frameworks[6] [7]. Crucially, this geographic heterogeneity intersects with distinct household socio-economic stratifications, including disparities in income, formal education, and local environmental awareness. When public works planning overlooks these spatial constraints and socio-economic realities, wastewater infrastructure frequently encounters localized community resistance, public non-acceptance, and a total breakdown in community-based maintenance frameworks, culminating in premature system failures and serious localized waterborne health risks.

A critical review of current scientific literature reveals that the contemporary paradigm remains fragmented, typically decoupling technical engineering parameters from localized social dimensions. For instance, extensive studies examine macro-level regional wastewater characteristics and chemical load fluctuations across changing socio-economic gradients [8], or calculate isolated physical parameters such as peak discharge rates and off-site PVC pipeline layouts for specific low-income residential zones [9]. Where spatial analytics are actively applied, research is frequently limited to regional point-of-interest mapping of expansive sewage treatment plant clusters [10] or macro-scale GIS site-suitability simulations for newly designed master-planned mega-cities [7]. Conversely, socio-behavioral assessments tend to investigate community perceptions generically, focusing exclusively on public willingness to accept recycled water reuse [11] or applying macro qualitative evaluative models (such as the CIPP framework) to public health programs without conducting micro-level empirical demographic testing [5]. Otherwise, public awareness and local social factors are fundamental to long-term sanitation success, these qualitative factors are rarely integrated into empirical, localized quantitative models[12]. However, the success of WWTP management is not only influenced by technical aspects, but also by spatial and socio-economic factors of the community. Determining the location of a WWTP must consider land suitability, distance to residential areas, pollution risk, and the potential for future regional development. Research shows that land availability and regional characteristics are important factors in determining the effectiveness of a domestic wastewater treatment system.

The stems from bridging this specific literature gap by presenting an integrated, quantitative cross-sectional analysis that evaluates the concurrent impacts of micro-level spatial configurations (district-specific dynamics across Lhokseumawe) and fine-grained household socio-economic variables (age, education level, and income brackets) on the Knowledge-Attitude-Practice (KAP) nexus regarding domestic WWTP infrastructure. Rather than treating a medium-sized coastal city as a completely homogeneous unit, this study isolates how geographical variations between a compact, hyper-dense urban center (Banda Sakti) and sprawling, rural-urban interfaces (such as Blang Mangat and Muara Dua) compound socio-economic factors to determine public compliance and ownership. This provides a highly localized socio-behavioral and spatial diagnostic tool that moves beyond generic urban sanitation models.

The primary aim of this study is to analyze the domestic wastewater management system in Lhokseumawe City by identifying and evaluating the critical spatial and socio-economic determinants that shape community knowledge, attitudes, and behavioral practices regarding local Wastewater Treatment Plants (WWTPs). Specifically, this research utilizes bivariate and cross-sectional empirical analyses via Chi-Square testing to isolate significant correlations between respondent demographic profiles and their management acceptance across the distinct environments of Banda Sakti, Muara Dua, Muara Satu, and Blang Mangat districts. Ultimately, these findings are leveraged to establish targeted strategic pathways and localized education interventions to support long-term, community-based sanitation governance.

II. METHOD

A. Study Area

This research was conducted in Lhokseumawe City, Aceh Province. Geographically, it is located between 4˚54’ - 5˚18’ North Latitude and 96˚20’ - 97˚21’ East Longitude. Lhokseumawe City is divided into 4 sub-districts, namely Banda Sakti Sub-district, Muara Dua Sub-district, Muara Satu Sub-district, and Blang Mangat Sub-district.

B. Method of Collecting Data

Data collection in the form of primary data that is needed is to conduct a survey to see directly in the field how the IPAL placement is planned, the existing conditions of domestic wastewater disposal, water use and road conditions. Meanwhile, secondary data used includes population data, number of buildings, sanitation information, city maps.

C. Types and Research Design

Data processing analysis by conducting questionnaires and interviews with the community regarding the level of community acceptance and satisfaction with the waste water treatment system, including complaints or input received from the community regarding the quality of services in Lhokseumawe City. The type of research used is quantitative research with a cross sectional approach. The goal is to be able to describe and explain a phenomenon or situation. Data analysis uses the chi-square test to analyze the relationship between respondent characteristics as independent variables (age, occupation, gender, education, and income level) with knowledge, attitudes, actions, management, and current conditions evaluation as dependent variables of domestic

WWTP. There are two stages of data testing and analysis explained below[13]:

1. Univariate analysis aims to describe the frequency distribution of each variable consisting of certain characteristics (age, occupation, gender, last education, and level of income, knowledge, attitudes, actions, management, current conditions evaluation) in management of WWTP. Presentation of frequency distribution data and percentages of variables.

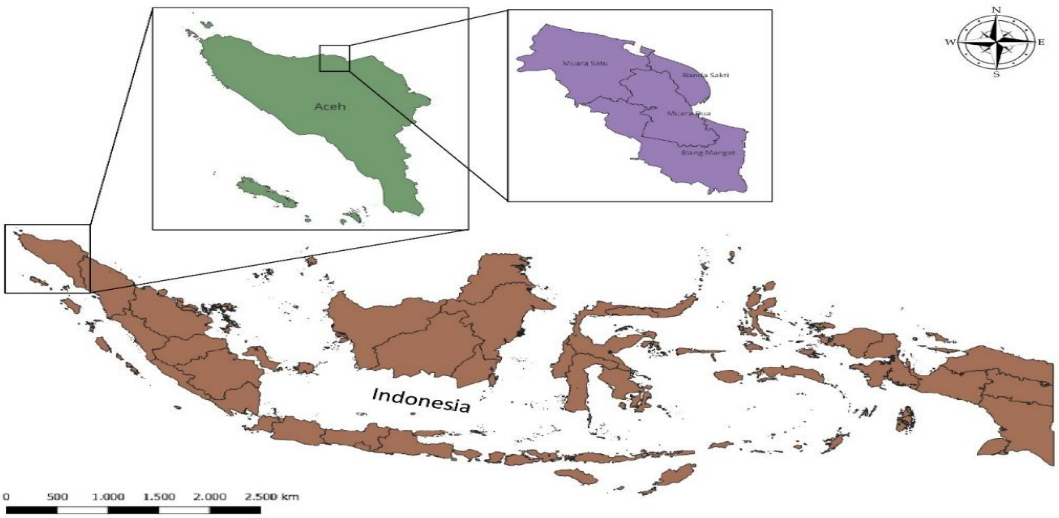

Figure 1 Study Location

2. Bivariate analysis aims to determine the relationship between dependent and independent variables. Data were analyzed for bivariate calculations in this study to determine the relationship between education level, knowledge, attitudes, economic status, and the role of health workers on wastewater treatment plant (WWTP) management. The data scale used is nominal and ordinal based on the aim of testing proportions, therefore the statistical test used is the Chi-Square test with Confident Interval (CI) < 95% with a significance limit ($\alpha < 0.05$). The next conclusion can be drawn, if $\alpha < 0.05$ Ho is accepted, meaning there is a significant relationship between the independent variable and the dependent variable[14].

D. Research Framework

The research framework for this activity starts from the research preparation stage, to creating documentation. The preparation stage includes literature study and field study to identify problems. Data collection stages were carried out through literature study and interviews with community leaders (respondents). The next stage is to determine the solution to the problems found. At this stage the research team discusses to find the right solution to solve the problems found. The next stage is to determine the results of the respondents using the chi-square model approach in order to find out the influence of community knowledge on domestic waste water management in Lhokseumawe City, so that it can be seen in Figure 2.

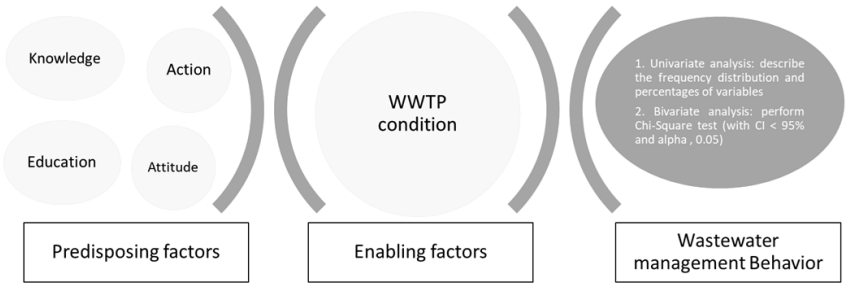

Figure 2 Study Analysis

III. Results and Discussion

The results of the WWTP study in Lhokseumawe City found several results, namely the relationship between age, occupation status, education level, and gender with community behavior and knowledge regarding the study material. The results of this study can be presented as follows:

A. Respondent Characteristics

The study of WWTP is to see how the people in Lhokseumawe City behave based on the ages observed, namely the productive age (UP), namely 18-63 years old, while the unproductive age (UTP) is >63 years old. Based on Figure 3, the distribution of UP respondents is UP 77.8% and UTP 22%.

Figure 4 depicts the distribution of respondents based on age regarding the variables studied. In the UP and UTP age groups, the community has a positive level of knowledge, attitudes, actions, management and assessment of the existing state of WWTP.

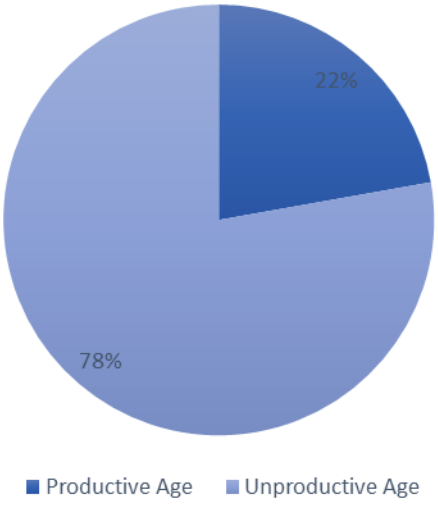

Figure 3 Distribution of Respondent Characteristics Based on Age Category

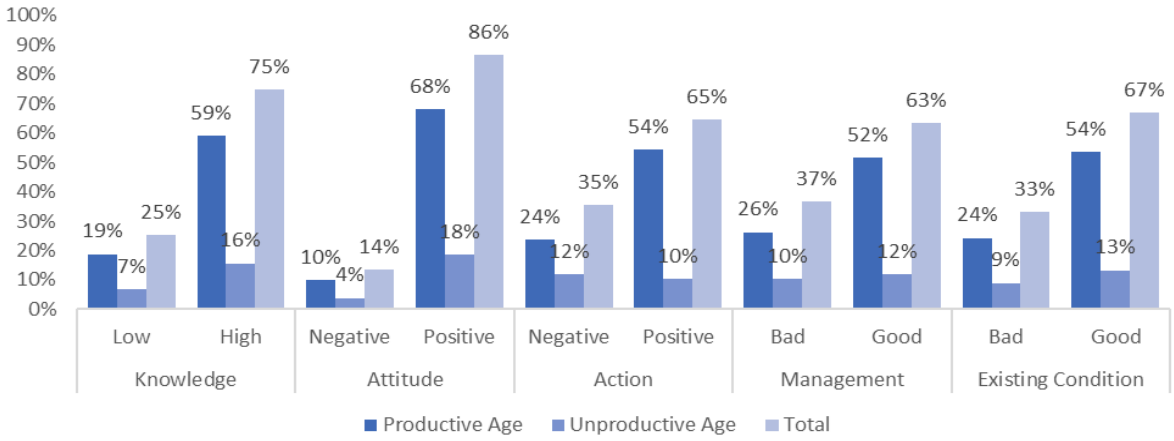

Figure 4 Distribution of Respondents Based on Age

After carrying out the chi square test (Table 1), the significance values obtained for the influence of the age factor on the level of knowledge, attitudes and assessment of existing conditions were 0.302, 0.332 and 0.132. Correlation test results >0.05 means that there is no significant relationship between age and the level of knowledge, attitudes and assessment of the existing state of society in WWTP management.

Meanwhile, the significance values for the influence of the age factor on management actions and conditions are 0.000 and 0.036 (Table 1). Correlation test results <0.05 mean that there is a significant relationship between age and WWTP management actions and conditions. So it can be seen that the age factor influences the actions and conditions of WWTP management.

TABLE 1
RELATIONSHIP BETWEEN AGE FACTORS AND STUDY VARIABLES

Variable	Value	df	Asymptotic Significance (2-sided)
Knowledge	1.063[a]	1	0.302
Attitude	0.942a	1	0.332
Action	13.703	1	0.000
Management	4.397a	1	0.036
Existing Condition	2.263a	1	0.132

This study on WWTP also analyzed people's behavior based on work, thus providing an idea of how a person understands the management of WWTP based on their occupation status. Grouping respondents based on working and non-working status, both formal and non-formal. Based on Figure 5, the distribution of respondents in the working category was 68.9%, while those who did not work were 31.1%.

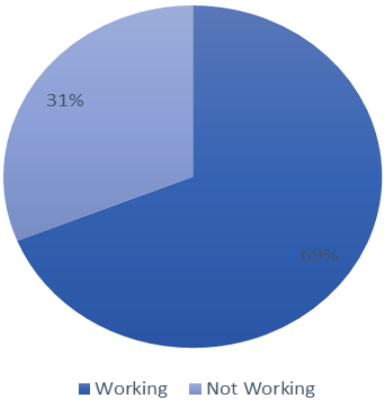

Figure 5 Distribution of Respondent Characteristics Based on Occupation Category

Figure 6 depicts the distribution of respondents based on work on the variables studied. In the working and non-working occupational groups, the community has a positive level of knowledge, attitudes, actions, management and assessment of the existing state of WWTP.

After carrying out the chi square test (Table 2), the significance values obtained for the influence of work factors on the level of knowledge, attitude, management and assessment of existing conditions were 0.871, 0.069, 0.552 and 0.2. Correlation test results >0.05 means there is a significant relationship between work and the level of knowledge, attitudes, management and community assessment of existing conditions in WWTP management.

Figure 6 Distribution of Respondents Based on Occupation

Meanwhile, the significance value for the influence of work factors and actions on existing conditions is 0.009. Correlation test results <0.05 mean that there is a significant relationship between work and community action. So it can be seen that work factors influence people's actions in assessing WWTP.

TABLE 2
RELATIONSHIP BETWEEN OCCUPATION FACTORS AND STUDY VARIABLES

Variable	Value	df	Asymptotic Significance (2-sided)
Knowledge	0.027a	1	0.871
Attitude	3.313a	1	0.069
Action	6.748a	1	0.009
Management	0.354a	1	0.552
Existing Condition	1.645a	1	0.2

This study on WWTP also analyzed people's behavior based on gender, thus providing an idea of how a person understands the management of WWTP based on their gender status. Grouping respondents based on gender categories, both male and female. Based on Figure 7, the distribution of respondents in the male category is 52.7%, while female is 47.3%.

Figure 8 depicts the distribution of respondents based on gender regarding the variables studied. In the male and female gender groups, the community has a positive level of knowledge, attitudes, actions, management and assessment of the existing state of WWTP.

After carrying out the chi square test (Table 3), the significance values obtained for the influence of the gender factor on knowledge, attitudes, actions, management and assessment of existing conditions were 0.257, 0.575, 0.799, 0.500 and 0.093. Correlation test results > 0.05 means that there is no significant relationship between gender and the level of knowledge, attitudes, actions, management and assessment of the existing state of society in WWTP management.

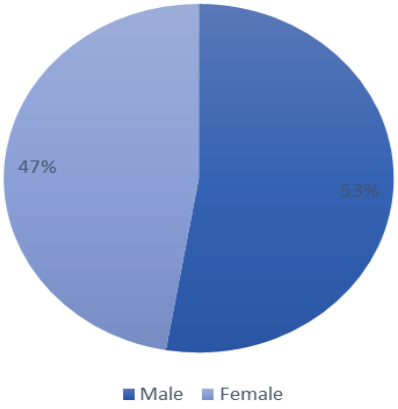

Figure 7 Distribution of Respondent Characteristics Based on Gender Category

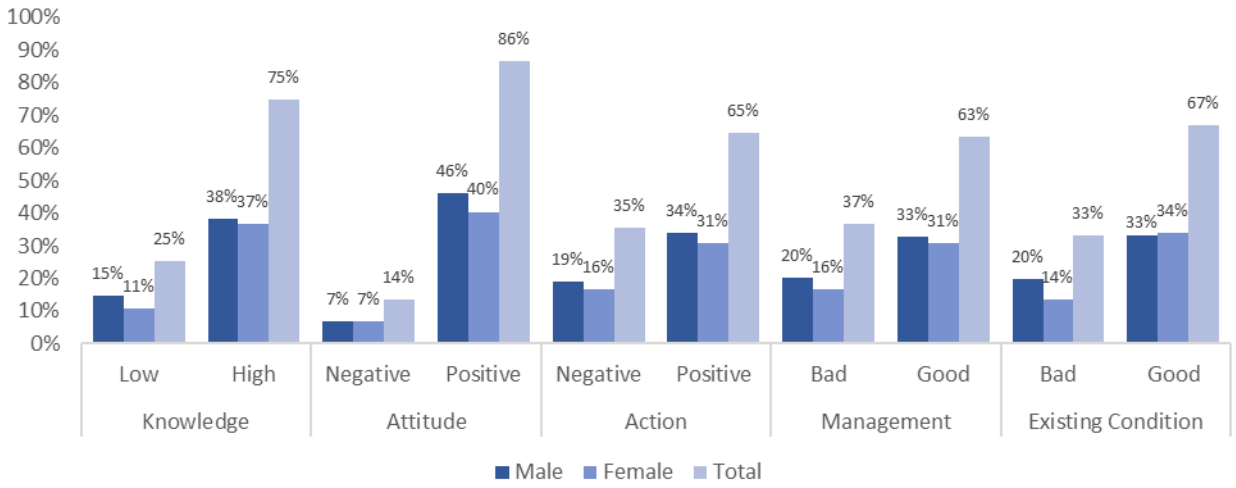

Figure 8 Distribution of Respondents Based on Gender

TABLE 3
RELATIONSHIP BETWEEN GENDER FACTORS AND STUDY VARIABLES

Variable	Value	df	Asymptotic Significance (2-sided)
Knowledge	1.287a	1	0.257
Attitude	0.315a	1	0.575
Action	0.065a	1	0.799
Management	0.455a	1	0.500
Existing Condition	2.820a	1	0.093

The study examined community behavior and understanding regarding Wastewater Treatment Plant (WWTP) management by analyzing respondents based on their highest educational attainment. Educational background was stratified into four categories: elementary school, middle school, high school, and university (comprising Bachelor, Master, or Doctorate degrees). As illustrated in Figure 9, the demographic distribution was predominant among those with a high school education (60.2%), followed by university graduates (20.5%), middle school (11.2%), and elementary school (5.8%). An examination of this

distribution (Figure 10) indicates that across all educational strata, respondents exhibited a generally positive outlook across the specific study variables, including knowledge, attitudes, actions, management conditions, and the assessment of the existing WWTP state.

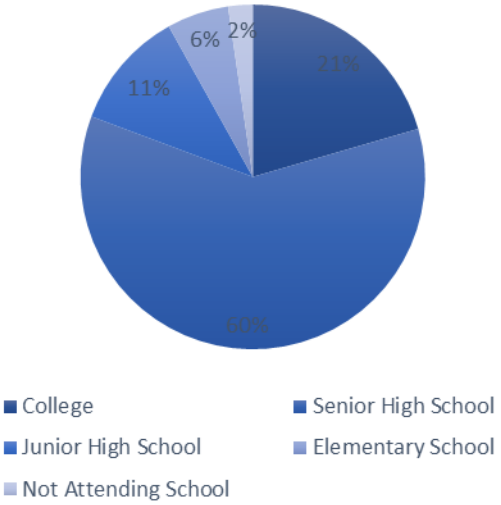

Figure 9 Distribution of Respondent Characteristics Based on Latest Education Category

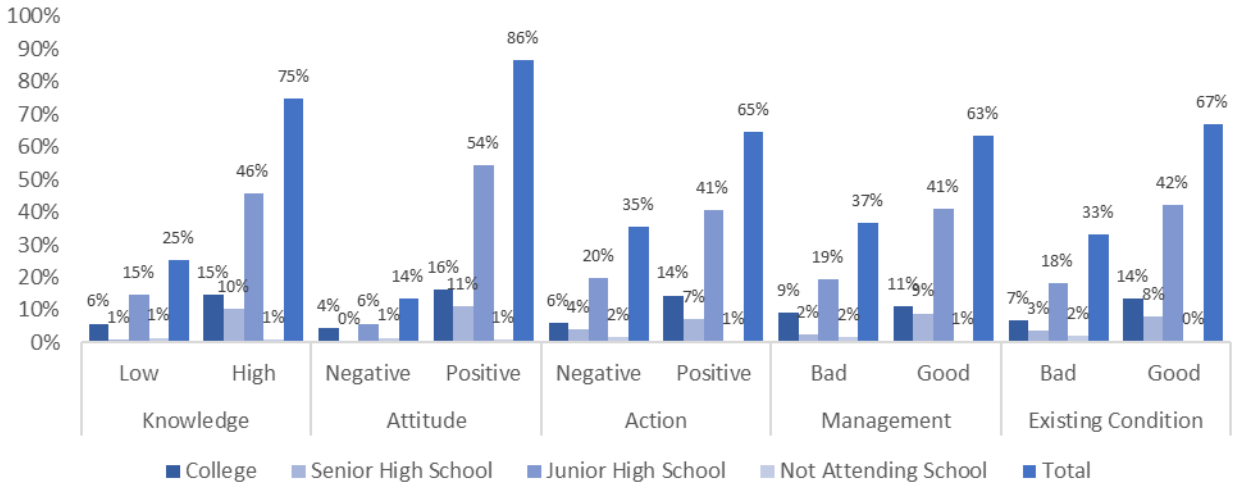

Figure 10 Distribution of Respondents Based on Latest Education

To further scrutinize this relationship, a Chi-Square analysis was performed (Table 4). The significance values obtained for the influence of the latest educational factor on the level of knowledge, attitudes, actions, management conditions and assessment of existing conditions were 0.002,0.000, 0.001, 0.000 and 0.012, respectively. Because all correlation results were below the designated alpha level, the study demonstrates a statistically significant relationship between an individual's latest educational status and their level of knowledge, attitudes, proactive actions, management capabilities, and perception of existing WWTP conditions.

TABLE 4
RELATIONSHIP BETWEEN RECENT EDUCATION FACTORS AND STUDY VARIABLES

Variable	Value	df	Asymptotic Significance (2-sided)
Knowledge	16.734a	4	0.002
Attitude	31.319a	4	0.000
Action	17.751a	4	0.001
Management	23.103a	4	0.000
Existing Condition	12.898a	4	0.012

The investigation further examined community behavioral factors based on respondent income levels to determine whether economic status correlates with the understanding and practice of WWTP management. Respondents were stratified into two economic categories based on a threshold of USD 143. According to the demographic distribution illustrated in Figure 11, 47% of respondents reported an income

exceeding USD 143, while 53% reported an income below this threshold.

As depicted in the cross-tabulation analysis (Figure 12), community members across both economic strata demonstrated generally positive responses regarding their knowledge levels, attitudes, proactive actions, management conditions, and assessments of current WWTP conditions.

Chi-Square tests were subsequently performed to analyse the statistical relationship between income factors and these study variables (Table 5). The analysis revealed that income did not exert a statistically significant influence on knowledge (p=0.741), attitudes (p=0.200), proactive actions (p=0.127), or management conditions (p=0.414), as all resulting p-values exceeded the designated alpha level ($p > 0.05$). However, a statistically significant correlation was observed between income factors and the assessment of the existing condition (p=0.022).

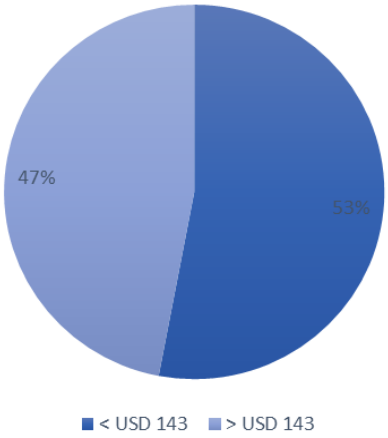

Figure 11 Distribution of Respondent Characteristics Based on Income Category

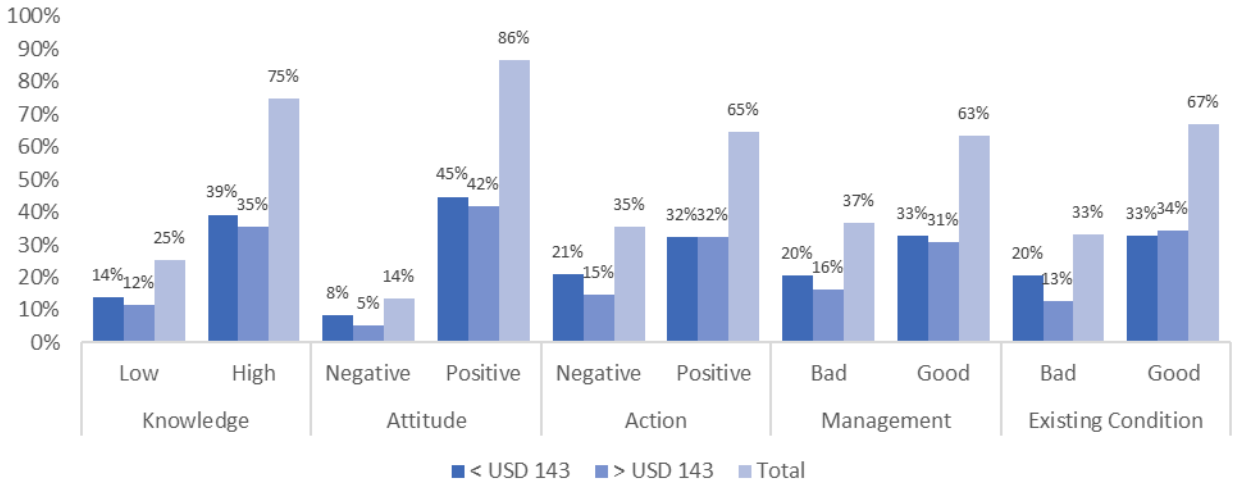

Figure 12. Distribution of Respondents Based on Income

TABLE 5
RELATIONSHIP BETWEEN INCOME FACTORS AND STUDY VARIABLES

Variable	Value	df	Asymptotic Significance (2-sided)
Knowledge	0.109a	1	0.741
Attitude	1.643a	1	0.200
Action	2.323a	1	0.127
Management	0.667a	1	0.414

To investigate the potential association between community knowledge levels and the remaining study variables regarding WWTP management behavior, a Chi-Square test analysis was conducted. The detailed statistical outcomes are summarized in Table 6. The analysis revealed highly significant relationships across all examined parameters. Statistically robust associations were observed between knowledge factors and respondents' attitudes, proactive actions, management conditions, and their assessment of the existing WWTP conditions.

As all calculated asymptotic significance values were below the established alpha level of 0.05 ($p < 0.05$), the findings demonstrate a statistically significant relationship between community knowledge levels and their respective attitudes,

proactive actions, management capabilities, and perception of current WWTP conditions. Consequently, the data indicates that the knowledge factor substantially influences the standard of action, the state of management, and the overall evaluation of the existing WWTP situation.

TABLE 6
RELATIONSHIP BETWEEN KNOWLEDGE FACTORS AND STUDY VARIABLES

Variable	Value	df	Asymptotic Significance (2-sided)
Attitude	151.009a	1	0.000
Action	76.044a	1	0.000
Management	114.598a	1	0.000
Existing Condition	132.031a	1	0.000

Spatial Distribution of Community Knowledge on WWTP Management

To evaluate how regional dynamics shape public literacy regarding decentralized sanitation infrastructure, the study cross-analyzed respondents' baseline knowledge across four levels of comprehension: *"very good," "good," "fair,"* and *"least good."* As illustrated in Figure 13, the geographic mapping of these categories reveals a stark socio-spatial gradient across Lhokseumawe City. The highest concentration of respondents falling within the *"very good"* and *"good"* knowledge thresholds is localized predominantly within the Muara Satu District, followed sequentially by Banda Sakti, Muara Dua, and lastly, Blang Mangat. This spatial layout reflects the underlying socio-demographic profiles of the respective areas. Muara Satu, operating historically as the industrial center of the city, houses a larger share of formal-sector workers and individuals with higher formal educational factors previously shown to have a statistically significant correlation with technical wastewater comprehension ($p < 0.05$). Conversely, the low literacy metrics observed in the peri-urban and agricultural landscape of Blang Mangat point to a slower rate of environmental health information transmission, highlighting it as an area requiring immediate, targeted educational outreach.

The knowledge assessment directly influences the structural distribution of public perception. Figure 14 maps community sentiment across binary categories of *positive* versus *negative* WWMS attitudes. The empirical data reveal that the highest concentration of optimal *positive* attitudes occurs within the Muara Satu and Muara Dua districts, with Banda Sakti presenting a moderate-high baseline, and Blang Mangat registering the lowest positive alignment. The strong showing in Muara Satu aligns with its high baseline knowledge, whereas the positive attitudes in Muara Dua suggest a growing community awareness of peri-urban degradation caused by rapid, unmanaged residential expansion. Interestingly, while the hyper-dense commercial core of Banda Sakti faces severe aesthetic and odor issues from open greywater discharge, its positive attitude scores are slightly lower than those in the industrial zones. This suggests a degree of public fatigue or normalization of sub-optimal sanitation conditions among dense urban populations.

Figure 15 details the spatial variations in concrete individual actions regarding WWMS management. Muara Satu and Muara Dua district lead the positive action category, followed by Banda Sakti, with Blang Mangat trailing significantly. The high performance of Muara Satu and Muara Dua indicates an environment where household economic stability and spatial lot conditions allow individuals to actively invest in proper plumbing and regular maintenance.

Finally, institutional sustainability relies on community-level governance, financial compliance, and collective ownership. Figure 16 highlights the spatial distribution of proactive community management behaviors, such as paying desludging tariffs and participating in the upkeep of local communal WWMS. The data show that active management behavior is highest in Muara Satu, followed by Banda Sakti and Muara Dua, while Blang Mangat records the lowest participation rates. In Muara Satu, high residential stability foster a collaborative environment that supports community-managed sanitation systems.

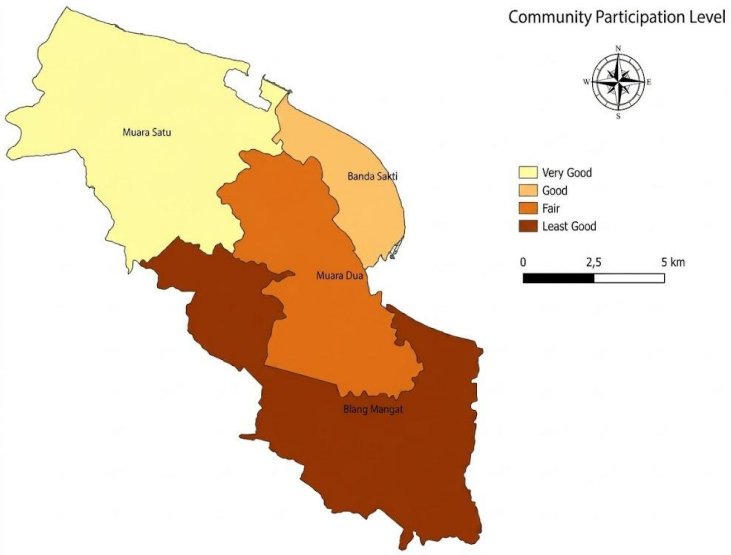

Figure 13. Distribution of Respondent Characteristics Based on Community Knowledge Category

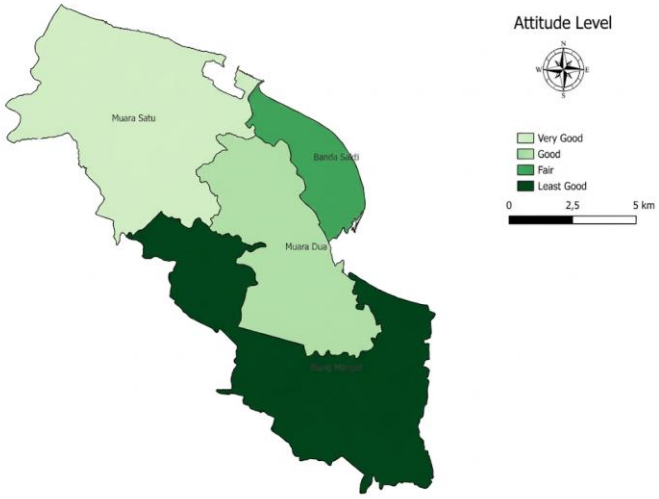

Figure 14 Distribution of Respondent Characteristics Based on Community Attitude Categories

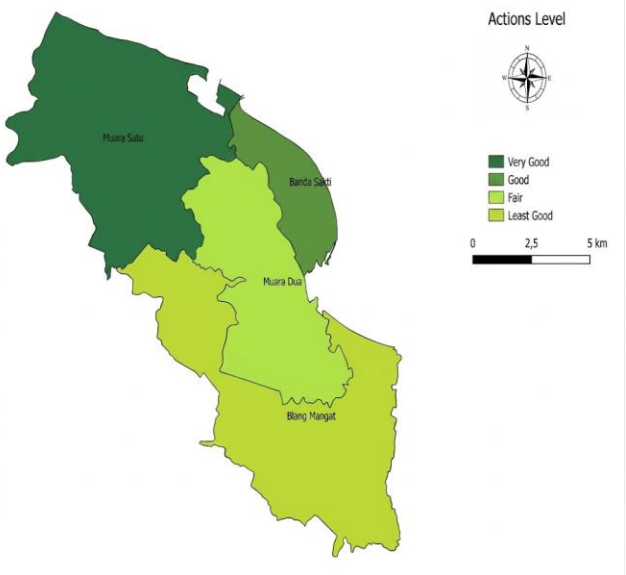

Figure 14 Distribution of Respondent Characteristics Based on Community Action Categories

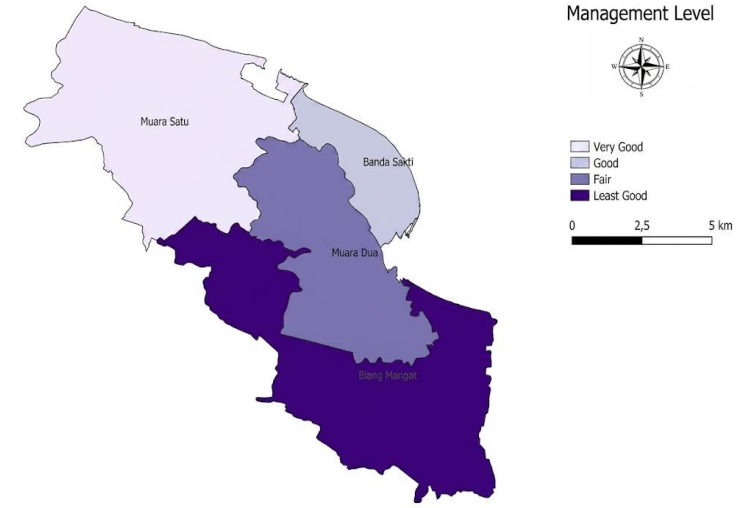

Figure 15 Distribution of Respondent Characteristics Based on Management Category

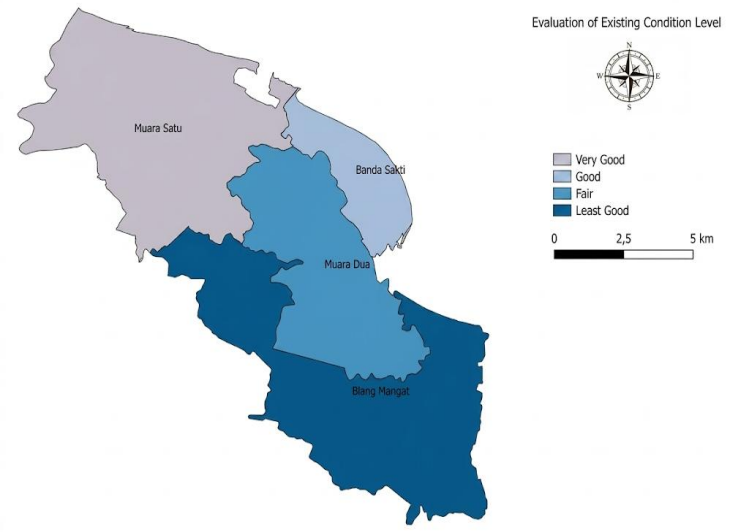

Figure 16 Distribution of Respondent Characteristics Based on Existing Condition Category

Figure 17 shows the percentage of respondents who chose positive answers on the five parameters assessed. The cognitive peaks, including attitude and knowledge consistently score the highest across all districts. This indicates that public education and the high visibility of localized sanitation challenges have successfully established a strong baseline of environmental awareness and moral alignment. Contrary, a distinct drop occurs when moving to evaluation, actions and management behavior. This visual pattern confirms that while residents understand the importance of domestic wastewater treatment, their ability to execute positive actions or participate in institutional management is structurally bottlenecked by spatial constraints, economic realities, and network availability [15].

Muara Satu District shows the highest levels of public awareness and participation in WWMS across Lhokseumawe City. This strong performance is directly linked to its role as the city's primary industrial zone. Decades of economic development have brought major advantages to the area, such as a higher concentration of educated residents, stable formal employment, and active Corporate Social Responsibility (CSR) programs from local industries. Because of this background, residents have a strong understanding of environmental health standards. This solid foundation of knowledge translates directly into positive attitudes and practical actions, with households actively maintaining their systems and preventing local water pollution. Furthermore, strong community cohesion and regular institutional support make residents highly willing to pay desludging fees and help maintain communal WWTPs[16]. As a result, residents evaluate their current sanitation conditions very positively, reflecting their satisfaction with reliable decentralized facilities.

Otherwise, Banda Sakti District presents a unique challenge: residents have high environmental awareness but face severe spatial limitations, creating a major gap between their positive attitudes and actual behavior. As the crowded commercial and administrative center of Lhokseumawe, the district has a very high population density and small residential lots. This lack of space makes it physically impossible to build proper individual septic tanks, making public or communal wastewater treatment a clear necessity to prevent health crises.

However, because this dense area has many renters and temporary residents, neighborhood social ties are weak. This lack of permanent ownership causes a "tragedy of the commons" effect, where individuals expect the local government to handle all sanitation duties rather than managing it together as a neighborhood. Consequently, while residents have positive intentions, they lack the space or property rights to take individual action or support community management, leading to critical evaluations when dense urban systems become overloaded [17].

Muara Dua District is a growing peri-urban area that links the city center with rural zones, resulting in moderate scores across most sanitation categories. Because land is abundant here, most households rely on individual septic tanks, which changes how they view wastewater management. From an educational perspective, public knowledge about WWMS is relatively low because public health campaigns spread more slowly in scattered neighborhoods. While residents value general cleanliness and express positive attitudes, they lack the immediate sense of urgency found in crowded urban areas. The spread-out layout allows households to tolerate simple practices, like discharging greywater onto open land, without seeing immediate problems [18]. Because houses are far apart, residents do not feel a shared responsibility for local environmental issues. This low density also makes building public piping networks very expensive per household, and wider income gaps mean families prioritize immediate living needs over sanitation investments, leading to low community participation [19].

Blang Mangat District requires the most urgent attention, as it records the lowest levels of sanitation knowledge and active participation in the study. This district is primarily agricultural and has a highly dispersed rural population, which limits residents' exposure to environmental education and modern wastewater systems. Although local cultural values support basic personal hygiene, the lack of information restricts proper wastewater practices. Because open land is readily available, households often discharge wastewater directly into the soil or fields, reducing any perceived need for proper maintenance [20]. This physical separation prevents residents from seeing wastewater as a shared community issue. Additionally, due to lower average household incomes, residents view investments in shared public systems as an unaffordable luxury rather than a public need. Because families rely on simple backyard pits and are isolated from shared infrastructure failures, they report passive satisfaction with their current conditions, emphasizing the need for direct government subsidies and door-to-door education [21]. Table 7 synthesizes the spatial and socio-economic variables observed in the four districts.

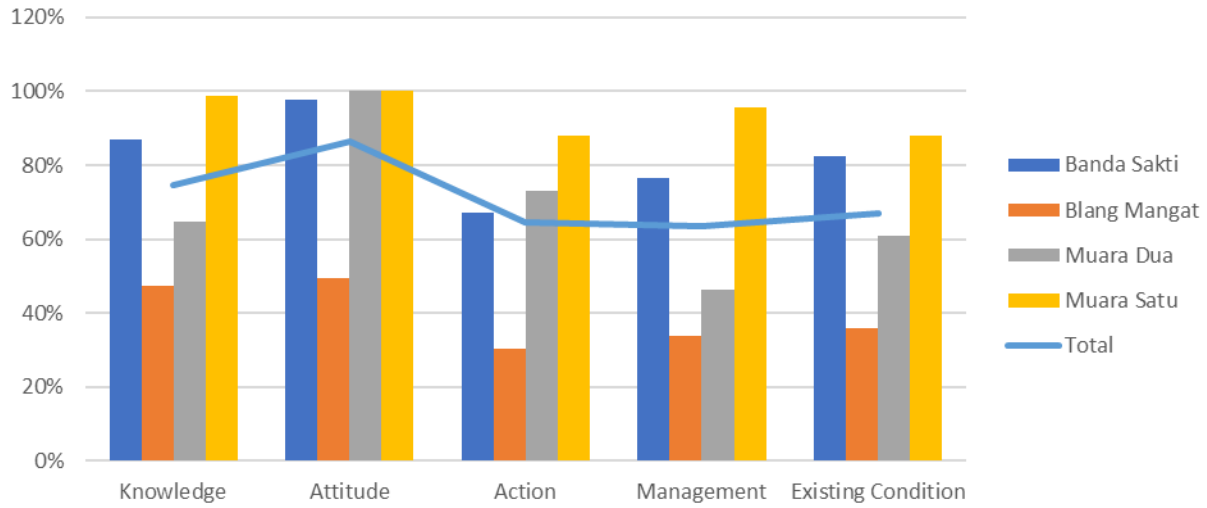

Figure 17 Percentage of Respondents with Positive Answers

TABLE 7.
VARIABLES OBSERVED IN LHOKSEUMAWE CITY

Variables	Banda Sakti	Muara Satu	Muara Dua	Blang Mangat
Spatial Typology	Hyper-Dense Urban Core	Industrialized Center	Rural-Urban Interface	Dispersed Peri-Urban Sprawl
Socio-Economic Driver	Commercial mix, high renter ratio	Higher education, stable formal income	Transitional income, mixed employment	Agricultural dominance, lower expenditure
Dominant KAP Profile	High awareness, low individual capacity	Highest overall engagement across all metrics	Moderate awareness, fragmented behavior	Lowest knowledge baseline and management participation
Primary System Bottleneck	Extreme space constraints for septic tanks	Network capacity scaling limits	High per-capita piping cost due to sprawl	Absolute lack of communal infrastructure
Targeted Strategic	Off-site communal	Model community scaling &	Targeted capital subsidies	Intensive, door-to-door

Variables	Banda Sakti	Muara Satu	Muara Dua	Blang Mangat
Pathway	systems & regulatory zoning	institutional delegation	for decentralized links	educational & technical interventions

IV. CONCLUSION

Overall, people of Lhokseumawe City have positive knowledge, attitudes, actions, management and understanding of existing conditions. It is known that income and occupation factors influence the level of knowledge in WWMS. The latest educational factor influences the level of knowledge, action and assessment of existing management conditions in WWMS. The gender factor influences the level of action in WWMS. The age factor influences the level of knowledge and action in WWMS. Apart from that, it is known that there is a relationship between knowledge and community attitudes in WWTP management. However, there is no significant relationship with action, management and assessment of existing conditions.

Therefore, as a result of this study, it is recommended that education and training programs regarding WWTP management be strengthened, especially for community groups with low levels of education. This is important to improve their knowledge and attitudes towards good management. In addition, awareness campaigns targeting young age groups and women can be carried out to encourage active action in WWTP management. The development of community-based programs that involve people directly, taking into account aspects of income and type of occupation, will also help make initiatives more relevant and easier to accept. Furthermore, further research is needed to understand other factors that influence WWTP management as well as deeper relationships between knowledge, attitudes and actions. Finally, encouragement for local governments to formulate policies that support community participation in WWTP management is very important to achieve effective and sustainable management. With these steps, it is hoped that WWTP management in Lhokseumawe City can improve significantly.

Data analysis was performed using univariate and bivariate statistical methods through Chi-Square tests to identify the relationships between Wastewater Management System (WWMS) variables and respondent characteristics, such as age, gender, latest education, employment criteria, and income. The results showed that most residents possess positive knowledge (75%), attitudes (86%), actions (65%), management behavior (63%), and evaluations of existing WWTP conditions (67%). Educational level showed a statistically significant relationship with knowledge, attitudes, actions, management, and assessment of WWMS conditions ($p < 0.05$). Age and occupation were also found to influence certain management aspects, while gender had no significant effect. Spatial analysis revealed that residents in Muara Satu District demonstrated the highest level of positive engagement toward WWMS management, whereas communities in Blang Mangat required greater educational intervention. This study concludes that strengthening community-based education, awareness campaigns, and participatory management programs is essential to enhance sustainable domestic wastewater management in Lhokseumawe City.

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