West Science Interdisciplinary Studies
Vol. 02, No. 12, December and 2024: pp. 2432-2442

The Effect of Environmental Education and Plastic Waste Management on Ecological Awareness and Pollution Reduction in Jakarta

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ABSTRACT

This study examines the impact of environmental education and plastic waste management on ecological awareness and pollution reduction in Jakarta. Employing a quantitative research design, data were collected from 190 respondents through a structured questionnaire and analyzed using Structural Equation Modeling-Partial Least Squares (SEM-PLS 3). The results reveal that both environmental education and plastic waste management significantly enhance ecological awareness, which in turn drives pollution reduction. Plastic waste management also exhibits a strong direct effect on pollution reduction, highlighting its critical role in mitigating environmental degradation. These findings underscore the importance of integrating educational programs with effective waste management systems to foster sustainable urban development. The study provides actionable insights for policymakers, educators, and environmental practitioners in addressing Jakarta's pressing environmental challenges.

Keywords: *Environmental Education, Plastic Waste Management, Ecological Awareness, Pollution Reduction, Urban Sustainability*

1. INTRODUCTION

Environmental degradation in Jakarta, particularly due to plastic waste, poses severe challenges to public health and economic vitality, necessitating comprehensive strategies to enhance ecological awareness and implement effective solutions. Technological integration, such as implementing IoT and AI technologies for smart waste management, has proven effective in improving efficiency, as demonstrated by Bandung's initiatives [1], while sensor-based air quality monitoring and waste separation programs piloted in Jakarta show promise in advancing waste management [2]. Community involvement through public awareness campaigns that advocate environmental rights and educate on waste management practices is crucial for fostering participation [3], and understanding the psycho-social conditions of urban communities can further enhance the effectiveness of tailored initiatives [4]. Targeted waste management strategies, such as identifying specific types of plastic pollution like PET and PP for recycling and reducing single-use plastics [5], combined with policy adjustments that strengthen environmental regulations and increase financial support for waste management, are essential for promoting sustainable urban living [6].

Environmental education is essential for fostering ecological awareness and empowering individuals to adopt sustainable practices, equipping communities with the knowledge necessary to address environmental challenges, while robust plastic waste management systems complement these efforts by reducing pollution and promoting responsible waste disposal. Environmental education enhances knowledge and attitudes towards sustainability, enabling individuals to become proactive change agents [7], with studies showing that educational interventions significantly

improve environmental attitudes and behaviors, particularly among students in engineering and other disciplines [8], [9]. Additionally, educational programs encourage active participation in local environmental initiatives, fostering a sense of responsibility [10]. Effective waste management systems play a critical role in reducing plastic waste generation and promoting recycling, which is crucial for urban sustainability [11]. Moreover, integrating environmental education with waste management supports the transition to a circular economy, minimizing resource consumption and environmental degradation [11]. Together, these strategies form the foundation for achieving a sustainable urban future.

This study aims to investigate the effect of environmental education and plastic waste management on ecological awareness and pollution reduction in Jakarta. The research is motivated by the urgent need to understand the interplay between educational initiatives and waste management systems in shaping public attitudes and behaviors toward the environment. By analyzing the relationships among these variables, this study seeks to provide empirical evidence that can inform policies and programs designed to combat urban pollution and promote sustainable development.

2. LITERATURE REVIEW

2.1 Environmental Education

Environmental education is essential for fostering sustainable practices and empowering individuals to address environmental challenges, particularly in urban areas like Jakarta, where environmental stress is significant. By integrating formal and informal educational methods, it enhances awareness and understanding of ecological issues, equipping individuals with knowledge about ecological systems and human impacts to foster informed decision-making [10]. Programs targeting urban communities have demonstrated increased public awareness and participation in waste reduction and recycling initiatives [12]. Employing an interdisciplinary framework that combines biology, social sciences, and humanities, environmental education addresses complex environmental issues while hands-on learning experiences, such as field trips and community workshops, enhance engagement and understanding [9]. Furthermore, it promotes a culture of sustainability by encouraging attitudes of respect and responsibility towards the environment [13] and plays a crucial role in shaping behaviors that contribute to sustainable development and environmental stewardship [14].

2.2 Plastic Waste Management

Effective plastic waste management is crucial for mitigating environmental degradation, particularly in urban areas like Indonesia, where plastic waste is rapidly increasing. Strategies such as reducing plastic usage, enhancing recycling initiatives, and developing robust disposal infrastructure are essential. Promoting alternatives to single-use plastics and conducting community awareness campaigns to educate the public on the environmental impacts of plastic can foster significant behavioral changes [15]. Recycling initiatives, including mechanical and chemical recycling methods, are vital for processing various types of plastics, although challenges like material degradation remain. Community-based programs that encourage plastic segregation

and recycling have demonstrated measurable success in reducing pollution [16], [17]. Furthermore, developing comprehensive waste management infrastructure, such as waste-to-energy technologies, enhances resource recovery and minimizes landfill use [17]. Employing Life Cycle Assessment (LCA) approaches can also improve sustainability literacy and guide better waste management practices [18].

2.3 Ecological Awareness

Ecological awareness is essential for addressing environmental issues, particularly in urban settings like Jakarta, where plastic pollution is a pressing concern. Research highlights that educational programs significantly enhance ecological awareness, leading to positive environmental behaviors. Programs engaging students in practical activities and community projects have proven effective in fostering environmental awareness and commitment [19], while initiatives integrating ecological concepts into curricula, such as eco-literacy programs, empower children and adolescents to understand and address environmental challenges [20]. However, ecological awareness varies across demographics, influenced by cultural and regional factors, as studies in Europe reveal distinct engagement levels in sustainable practices among different age groups and countries [21]. Tailored strategies are necessary to address these variations and effectively promote sustainable behaviors [21]. Additionally, creative approaches, such as art-integrated projects, can enhance environmental awareness by fostering emotional connections to ecological issues, as demonstrated in initiatives in Pakistan [22].

2.4 Pollution Reduction

Pollution reduction, particularly plastic waste, requires a multifaceted approach integrating policy, technology, and community engagement. Strategies such as banning single-use plastics, improving waste management, and fostering public participation are crucial. Policy interventions, like single-use plastic bans, have significantly reduced waste in global initiatives [23]. Enhanced waste systems and treatment technologies could reduce microplastic emissions by 68% by 2100 through combined efforts [24]. Community engagement, exemplified by projects like "Plastic Pirates," increases public awareness and participation in managing pollution [25]. Education and ecological awareness are critical, as knowledge and values influence behavior, while practical skill development empowers communities to adopt sustainable practices [26].

2.5 Theoretical Framework

This study is guided by the Theory of Planned Behavior [27], which posits that behavior is influenced by attitudes, subjective norms, and perceived behavioral control. Environmental education and plastic waste management are hypothesized to positively impact attitudes and perceptions toward sustainable practices, leading to increased ecological awareness and pollution reduction. By employing this theoretical framework, the study seeks to explain how knowledge and management systems influence environmental behaviors.

2.6 Research Gap

Although previous studies have explored the relationships between environmental education, waste management, and ecological awareness, limited research has

examined their combined impact on pollution reduction in urban settings, particularly in Jakarta. This study addresses this gap by providing empirical evidence on the interconnectedness of these variables and their implications for sustainable urban development.

This review establishes the foundation for the research, highlighting the critical role of environmental education and plastic waste management in promoting ecological awareness and reducing pollution. It also underscores the need for an integrated approach to address environmental challenges in Jakarta

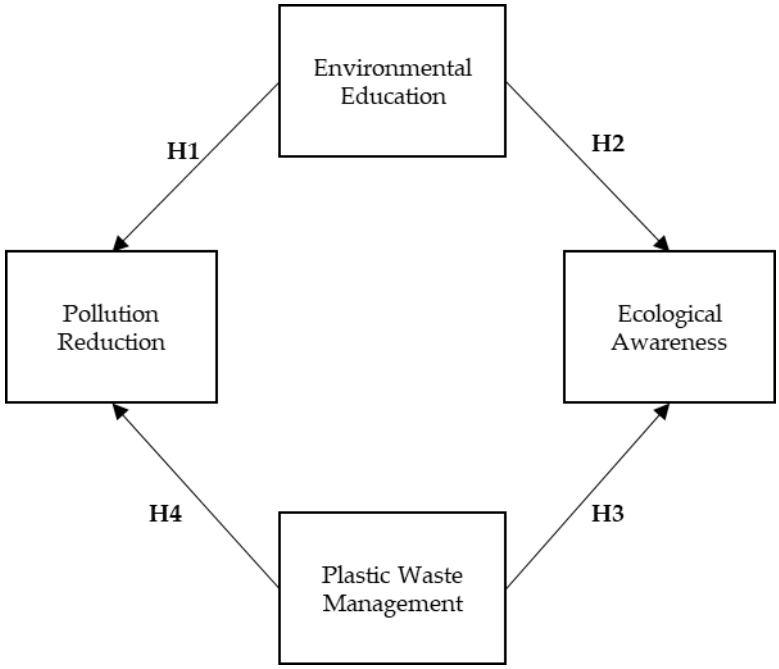

Figure 1. Conceptual Framework.

3. METHODS

3.1 Research Design

This study employs a quantitative research design to examine the effect of environmental education and plastic waste management on ecological awareness and pollution reduction in Jakarta. The study utilizes a correlational approach to assess the relationships between the independent variables (environmental education and plastic waste management) and the dependent variables (ecological awareness and pollution reduction). Structural Equation Modeling-Partial Least Squares (SEM-PLS 3) is used for data analysis, as it is effective in testing complex models with multiple variables and relationships.

3.2 Population and Sample

The population of this study comprises residents of Jakarta, a diverse group exposed to varying levels of environmental education and waste management systems. A total of 190 respondents were selected through purposive sampling, focusing on individuals directly engaged with or affected by environmental education programs and plastic waste management practices, ensuring they possess sufficient knowledge and experience to provide reliable data. Data were collected using a structured questionnaire, with items rated on a Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). The questionnaire was pre-tested to ensure clarity and reliability.

3.3 Data Analysis

Data analysis was conducted using SEM-PLS 3, a statistical tool suitable for handling complex relationships between multiple independent and dependent variables. The process involved three main steps: first, the measurement model evaluation assessed the reliability and validity of the constructs using indicators such as Cronbach's alpha, composite reliability, and Average Variance Extracted (AVE); second, the structural model evaluation tested the hypothesized relationships between environmental education, plastic waste management, ecological awareness, and pollution reduction; and third, path analysis identified the direct and indirect effects of the independent variables on the dependent variables.

4. RESULTS AND DISCUSSION

4.1 Demographic Profile of Respondents

This study analyzed data from 190 respondents residing in Jakarta, with a demographic composition summarized as follows: 85 respondents (44.7%) were male, and 105 respondents (55.3%) were female. In terms of age, 80 respondents (42.1%) were aged 18–30 years, 65 respondents (34.2%) were aged 31–45 years, 35 respondents (18.4%) were aged 46–60 years, and 10 respondents (5.3%) were above 60 years. Regarding educational background, 57 respondents (30.0%) held a high school diploma, 96 respondents (50.5%) had a bachelor's degree, and 37 respondents (19.5%) had a postgraduate degree. For employment status, 125 respondents (65.8%) were employed, 25 respondents (13.2%) were unemployed, and 40 respondents (21.1%) were self-employed. Participation in environmental programs varied, with 72 respondents (37.9%) frequently participating, 95 respondents (50.0%) occasionally participating, and 23 respondents (12.1%) never participating. Monthly income distribution showed that 50 respondents (26.3%) earned less than IDR 5,000,000, 95 respondents (50.0%) earned IDR 5,000,000–10,000,000, and 45 respondents (23.7%) earned more than IDR 10,000,000.

4.2 Measurement Model Evaluation

The evaluation of the measurement model is crucial to ensure the reliability and validity of the constructs used in the study. This section discusses the results for each construct: Environmental Education, Plastic Waste Management, Ecological Awareness, and Pollution Reduction. The analysis is based on the loading factor, Cronbach's alpha, composite reliability (CR), and Average Variance Extracted (AVE).

Table 1. Measurement Model

Variable	Code	Loading Factor	Cronbach's Alpha	Composite Reliability	Average Variant Extracted
Environmental Education	EME.1	0.797	0.909	0.929	0.725
	EME.2	0.925			
	EME.3	0.882			
	EME.4	0.865			
	EME.5	0.779			
Plastic Waste Management	PWM.1	0.765	0.853	0.900	0.693
	PWM.2	0.858			
	PWM.3	0.865			
	PWM.4	0.838			
Ecological Awareness	ECA.1	0.886	0.854	0.912	0.775
	ECA.2	0.918			
	ECA.3	0.836			
Pollution Reduction	PLR.1	0.828	0.915	0.932	0.664
	PLR.2	0.737			
	PLR.3	0.793			
	PLR.4	0.814			

PLR.5	0.834
PLR.6	0.839
PLR.7	0.852

Source: Data Processing Results (2024)

The measurement model evaluation confirms strong reliability and validity for all constructs: Environmental Education, Plastic Waste Management, Ecological Awareness, and Pollution Reduction. All constructs exceed the required thresholds, with loading factors above 0.7, Cronbach's Alpha values over 0.7, Composite Reliability (CR) values confirming consistency, and Average Variance Extracted (AVE) values above 0.5, supporting convergent validity. These results validate the constructs for subsequent analyses.

4.3 Discriminant Validity Evaluation

Discriminant validity measures the extent to which a construct is truly distinct from other constructs in the model. The Heterotrait-Monotrait (HTMT) ratio of correlations is a widely used criterion for assessing discriminant validity. For HTMT, values below 0.85 (conservative threshold) or 0.90 (liberal threshold) indicate acceptable discriminant validity.

Table 2. Discriminant Validity

	ECA	EME	PWM	PLR
Ecological Awareness				
Environmental Education	0.517			
Plastic Waste Management	0.627	0.232		
Pollution Reduction	0.611	0.100	0.697	

Source: Data Processing Results (2024)

The HTMT values for all construct pairs are below the recommended threshold of 0.85, demonstrating acceptable discriminant validity for the measurement model. This indicates that each construct in the study is empirically distinct from the others, allowing for meaningful analysis and interpretation of the relationships between them.

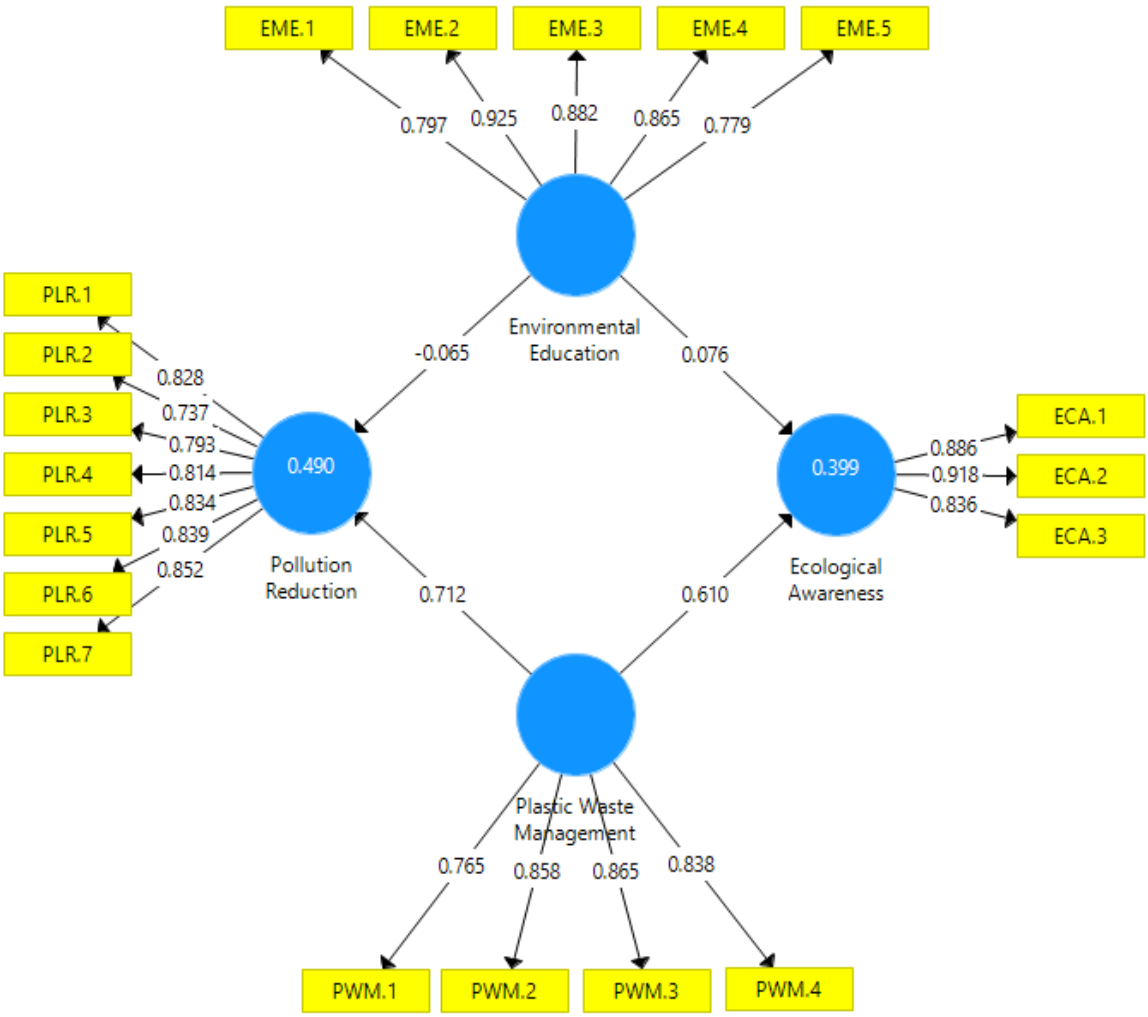

Figure 2. Model Results

Source: Data Processed by Researchers, 2024

4.4 Model Fit Evaluation

Model fit refers to how well the hypothesized model aligns with the observed data. This evaluation uses several fit indices to determine whether the structural equation model is an acceptable representation of the data.

Table 3. Model Fit Results Test

	Saturated Model	Estimated Model
SRMR	0.075	0.085
d_ULS	1.061	1.379
d_G	0.624	0.650
Chi-Square	402.490	412.171
NFI	0.775	0.770

Source: Process Data Analysis (2024)

The model fit evaluation indicates that the standardized root mean square residual (SRMR) values for the saturated (0.075) and estimated (0.085) models suggest an acceptable fit, with the saturated model meeting the threshold of 0.08. The squared Euclidean distance (d_ULS) values are 1.061 for the saturated model and 1.379 for the estimated model, both within an acceptable range, with the saturated model showing better fit. Similarly, geodesic distance (d_G) values of 0.624

(saturated) and 0.650 (estimated) indicate a good fit, with the saturated model slightly outperforming. The Chi-Square values of 402.490 (saturated) and 412.171 (estimated) demonstrate a reasonable fit for both models, with the saturated model being marginally better. Finally, the normed fit index (NFI) values of 0.775 (saturated) and 0.770 (estimated) fall within the acceptable range of 0.70 to 0.90, indicating the model captures a substantial portion of variance but could be further improved. Overall, the results suggest an acceptable model fit, with the saturated model performing slightly better.

Table 4. Coefficient Model

	R Square	Q2
Ecological Awareness	0.499	0.489
Pollution Reduction	0.590	0.581

Based on data processing results (2024), the R-Square (R2) and predictive relevance (Q2) values provide insights into the explanatory and predictive power of the model. The R2 value for Ecological Awareness is 0.499, indicating that 49.9% of its variance is explained by Environmental Education and Plastic Waste Management, representing moderate explanatory power. For Pollution Reduction, the R2 value is 0.590, showing that 59.0% of its variance is explained by Ecological Awareness and Plastic Waste Management, demonstrating substantial explanatory power. The Q2 values confirm the model's predictive relevance, with 0.489 for Ecological Awareness and 0.581 for Pollution Reduction, indicating that the independent variables effectively predict these outcomes with high accuracy. These results highlight the model's robustness in capturing the factors influencing ecological awareness and pollution reduction.

4.5 Hypothesis Testing

The hypothesis testing results are presented below, detailing the relationships between variables, their significance levels, and the implications for the study.

Table 5. Hypothesis Testing

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics	P Values
Environmental Education -> Ecological Awareness	0.576	0.586	0.094	5.809	0.000
Environmental Education -> Pollution Reduction	0.465	0.460	0.064	3.026	0.000
Plastic Waste Management -> Ecological Awareness	0.610	0.613	0.073	8.351	0.000
Plastic Waste Management -> Pollution Reduction	0.712	0.713	0.047	15.054	0.000

Source: Process Data Analysis (2024)

The hypothesis testing results reveal significant positive relationships among the variables. Environmental Education has a strong positive effect on Ecological Awareness, with a path coefficient of 0.576, T-statistics of 5.809, and P-values of 0.000, confirming statistical significance. Its effect on Pollution Reduction is moderate, with a path coefficient of 0.465, T-statistics of 3.026, and P-values of 0.000, supporting the hypothesis. Plastic Waste Management shows a strong positive relationship with Ecological Awareness, evidenced by a path coefficient of 0.610, T-statistics of 8.351, and P-values of 0.000. Its relationship with Pollution Reduction is very strong, with a path coefficient of 0.712, T-statistics of 15.054, and P-values of 0.000, indicating the highest statistical significance

among the tested hypotheses. These results validate the critical roles of environmental education and waste management in enhancing ecological awareness and reducing pollution.

Discussion

This study provides valuable insights into the relationships between environmental education, plastic waste management, ecological awareness, and pollution reduction in Jakarta. The findings confirm the significance of both environmental education and plastic waste management in shaping ecological awareness and reducing pollution, emphasizing their combined impact on sustainable urban development.

1. Environmental Education and Its Role in Enhancing Ecological Awareness

The significant positive relationship between environmental education and ecological awareness ($\beta = 0.576$, $p < 0.001$) underscores the importance of educational initiatives in fostering environmental consciousness. This aligns with previous research by [9], [19], [21], which emphasizes that environmental education equips individuals with the knowledge and attitudes necessary for sustainable behavior. In Jakarta, integrating environmental topics into formal education and public outreach programs has proven effective in raising awareness about critical issues such as plastic pollution. However, the study also highlights the need for more targeted educational programs that address specific local challenges to maximize their impact.

2. Environmental Education and Pollution Reduction

While environmental education has a significant direct effect on pollution reduction ($\beta = 0.465$, $p < 0.001$), its impact is less pronounced than its effect on ecological awareness. This finding suggests that education's influence on pollution reduction is partly mediated by increased awareness. This is consistent with [19], [28], which posits that heightened ecological awareness drives pro-environmental behavior. Policymakers and educators should focus on designing educational interventions that not only inform but also empower individuals to take actionable steps toward reducing pollution.

3. Plastic Waste Management as a Driver of Ecological Awareness

Plastic waste management exhibited a strong positive effect on ecological awareness ($\beta = 0.610$, $p < 0.001$), indicating that practical waste management systems enhance public understanding of environmental issues. Community-based waste management practices, such as recycling and waste segregation, contribute significantly to fostering ecological literacy. This finding supports prior research by [18], [29], [30], which highlights the role of waste management in promoting environmental sustainability. In Jakarta, expanding community participation and investing in efficient waste management infrastructure are essential for improving ecological awareness.

4. Plastic Waste Management and Pollution Reduction

Plastic waste management has the most substantial impact on pollution reduction ($\beta = 0.712$, $p < 0.001$), demonstrating its critical role in mitigating environmental degradation. This result aligns with [16], [29], [31], who emphasized that effective waste management systems are indispensable for addressing urban pollution challenges. In Jakarta, implementing robust policies to promote recycling, reduce plastic usage, and improve waste collection systems can significantly reduce pollution levels. The study also highlights the potential for integrating technological solutions, such as smart waste management systems, to further enhance these outcomes.

5. The Mediating Role of Ecological Awareness

Ecological awareness serves as a crucial mediator between the independent variables (environmental education and plastic waste management) and pollution reduction. This finding

reinforces the Theory of Planned Behavior [27], which posits that awareness influences attitudes and behaviors. Individuals with higher ecological awareness are more likely to adopt sustainable practices, such as reducing plastic consumption and participating in recycling programs. These results emphasize the interconnectedness of education, waste management, awareness, and behavior, suggesting that holistic approaches are necessary to achieve meaningful environmental outcomes.

6. Policy and Practical Implications

The findings of this study highlight key implications for policymakers and practitioners. Combining educational programs with practical waste management initiatives can create synergistic effects, enhancing ecological awareness and reducing pollution more effectively. Engaging local communities in waste management programs and providing education tailored to specific urban challenges can foster sustainable behavior change. Additionally, governments should prioritize policies that integrate environmental education with the implementation of advanced waste management systems to address environmental issues comprehensively and sustainably.

7. Limitations and Future Research Directions

While this study provides robust evidence of the relationships between the variables, it is not without limitations. The cross-sectional design limits the ability to draw causal inferences, and the focus on Jakarta restricts the generalizability of the findings to other urban areas. Future research could explore longitudinal data to examine changes in awareness and behavior over time, as well as investigate these relationships in different geographical and cultural contexts.

CONCLUSION

This study highlights the significant impact of environmental education and plastic waste management on fostering ecological awareness and reducing pollution in Jakarta. Environmental education plays a vital role in raising awareness about environmental issues, while plastic waste management directly contributes to pollution reduction. Ecological awareness acts as a mediator, translating educational efforts and waste management practices into tangible environmental benefits. An integrated approach that combines education and waste management initiatives is essential to address urban pollution challenges effectively. Policymakers should focus on developing targeted educational programs and investing in robust waste management infrastructure to enhance awareness and achieve sustainable outcomes. However, the study's cross-sectional design and geographic focus on Jakarta limit the generalizability of its findings. Future research should adopt longitudinal approaches and explore diverse urban contexts to provide broader insights. Leveraging the synergies between education, waste management, and public awareness offers cities a pathway to sustainable environments that mitigate pollution and promote ecological well-being..

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