Linking Environmental Knowledge and Attitudes To Residential Environmental Management Behavior in Makassar Housing Community

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ABSTRACT

Residential environmental quality reflects both the infrastructure available in a neighborhood and the everyday practices of its residents. This cross-sectional correlational study examined environmental-management behavior, environmental knowledge, and environmental attitudes among 60 household heads in the Bumi Tamalanrea Permai residential complex in Makassar, Indonesia. Behavior was assessed through field observation of household waste management, residential drainage maintenance, and open-space management; knowledge was measured with a knowledge test, and attitude with a questionnaire. Descriptive statistics and simple and multiple linear regression were used. Most respondents were classified in the moderate category for environmental-management behavior (41.8%), knowledge (40.0%), and attitude (46.6%). Environmental knowledge was strongly associated with behavior in the bivariate model ($R = .812$, $R^2 = .659$, $B = 2.930$, 95% CI [2.375, 3.485], $p = 3.71\times10^{-}15$). Environmental attitude showed an even stronger bivariate association ($R = .985$, $R^2 = .969$, $B = 1.044$, 95% CI [0.996, 1.092], $p = 1.18\times10^{-}45$). In the multiple model, attitude remained strongly associated with behavior ($B = 1.032$, $\beta = .974$, 95% CI [0.946, 1.118], $p = 1.33\times10^{-}31$), whereas knowledge no longer showed a significant unique association after adjustment for attitude ($B = .049$, $\beta = .013$, 95% CI [−0.243, 0.341], $p = .7396$). The unique incremental variance attributable to knowledge was negligible ($\Delta R^2 \approx .00006$; full-model $R^2 = .970$). Environmental knowledge was therefore related to residential environmental behavior only at the bivariate level, whereas attitude accounted for nearly all of the unique association. These findings should be interpreted cautiously because the sample was small and drawn from a single site.

Keywords: environmental attitudes; environmental knowledge; household environmental behavior; residential environmental management; pro-environmental behavior

INTRODUCTION

Environmental sustainability in residential areas depends not only on the services and infrastructure available to residents but also on the choices they make in everyday life. Decisions about waste disposal, the upkeep of shared spaces, and care of the immediate residential environment can directly affect local environmental quality. For this reason, research on environmental behavior increasingly considers the psychological and social processes that shape environmentally responsible action rather than treating environmental problems as purely technical matters. Pro-environmental behavior reflects a combination of personal knowledge, attitudes, values, perceived responsibility, social influence, and opportunities for action rather than any single determinant (Gifford & Nilsson, 2014; Steg & Vlek, 2009). Meta-analytic evidence further suggests that the strength of these psychological determinants varies across societies and cultural settings (Morren & Grinstein, 2016), while a stronger connection with nature is positively associated with pro-environmental behavior (Whitburn et al., 2020). Residential environmental management is therefore both a behavioral and an infrastructural challenge.

Environmental knowledge and attitudes feature prominently in many explanations of environmentally responsible behavior. Early work in environmental education proposed that knowledge, issue awareness, attitudes, and action skills could contribute to responsible environmental citizenship (Hungerford & Volk, 1990).

The Theory of Planned Behavior later formalized the role of attitude, together with subjective norms and perceived behavioral control, in explaining behavioral intention and action (Ajzen, 1991). Subsequent evidence has supported these relationships while also showing that they are more complex than a simple progression from knowledge to action. In a meta-analysis, Bamberg and Möser (2007) found that pro-environmental behavior arises from several interconnected psychosocial determinants rather than from environmental knowledge alone. More recent meta-analytic evidence indicates that environmental education can improve knowledge, attitudes, intentions, and behavior, although the magnitude of these effects varies substantially across studies (van de Wetering et al., 2022). Contemporary analyses of waste behavior likewise underscore the importance of attitudes and behavioral control while pointing to meaningful differences across populations and contexts (Hu et al., 2026; Novanda et al., 2026).

A persistent challenge is the gap between knowing about environmental problems and acting on that knowledge. Kollmuss and Agyeman (2002) argued that knowledge and awareness do not automatically translate into pro-environmental action because behavior is shaped by multiple internal and external constraints. Later studies have reinforced this point. Among university students in Beijing, knowledge, attitudes, and waste-classification practices were related, yet important gaps in knowledge and environmental education remained (Liu et al., 2024). Indonesian household research provides a similar example: Sembiring et al. (2026) found that waste-sorting knowledge was associated with environmental awareness and concern but did not directly predict sorting behavior; instead, environmental concern mediated the knowledge-behavior relationship. Such findings caution against assuming that environmental information by itself will lead to sustained changes in household practice.

The knowledge-action gap has prompted researchers to examine cognitive factors alongside attitudes, motivation, perceived control, social norms, infrastructure, and opportunities for action. In South Denpasar, knowledge, attitude, and perceived behavioral control were each associated with household waste-management behavior, suggesting that cognitive and evaluative factors operate together within the same residential context (Jacob & Dwipayanti, 2022). A global meta-analysis similarly identified attitude, perceived behavioral control, intention, infrastructure, education, and other contextual factors as relevant determinants of household waste separation (Hu et al., 2026). Another meta-analysis found that the strength of Theory of Planned Behavior relationships varies by regional and socioeconomic context (Novanda et al., 2026). Taken together, this evidence suggests that environmental programs should extend beyond the provision of information. Education may be more effective when it is accompanied by favorable attitudes, accessible facilities, community support, and practical opportunities for residents to act on what they know.

Researchers have examined this problem through several complementary frameworks and intervention strategies. The knowledge-attitude-practice approach, for example, has been used to assess whether environmental understanding and favorable evaluations correspond with actual environmental practices; recent Indonesian household research applied this framework to food-waste management (Sholihah et al., 2025). Extended Theory of Planned Behavior (TPB) models have incorporated environmental knowledge, awareness, government intervention, subjective norms, and perceived behavioral control to explain household waste behavior (Ariyani & Ririh, 2020), while integrated TPB models continue to identify attitude and perceived control as important predictors of residents' waste-sorting intentions (Cao et al., 2026). Other studies have used a stimulus-organism-response framework to examine indirect pathways from knowledge through environmental concern (Sembiring et al., 2026). Intervention research has also tested behavior change more directly. Visual information and educational campaigns improved waste-sorting knowledge and practices in Indonesian households (Sembiring et al., 2024), and a recent cluster-randomized trial found that monetary incentives and environmental-information nudges increased recyclable deposits in community waste banks, although persistence differed by intervention and material type (Bestari et al., 2026).

Despite these advances, Indonesian evidence remains concentrated on particular forms of waste behavior. Research in large-type housing in Soppeng examined environmental knowledge, local wisdom, attitudes, and waste-management behavior (Karim et al., 2022). Studies in South Denpasar likewise focused on household waste management (Jacob & Dwipayanti, 2022), whereas work on Barrang Lompo Island in South Sulawesi reported a mismatch between relatively good knowledge and less favorable household practices (Ridwan et al., 2025). More recent Indonesian studies have addressed household food waste (Sholihah et al., 2025), waste

sorting in Bali (Padmayani et al., 2026), and knowledge and environmental-maintenance motivation in an urban Makassar housing complex (Amir, 2026). Although these studies provide useful evidence, environmental behavior is still generally operationalized through waste-related outcomes. Integrated residential environmental-management behavior that includes household waste, drainage maintenance, and residential open space has received less attention. Examining these domains together provides a broader view of how environmental knowledge and attitudes relate to day-to-day stewardship of the residential environment.

Against this background, the present study characterizes environmental-management behavior, environmental knowledge, and environmental attitudes among residents of the Bumi Tamalanrea Permai (BTP) residential complex in Makassar and examines how knowledge and attitudes are associated with environmental-management behavior. Five questions guide the analysis: (1) what is the level and distribution of residents' environmental-management behavior in relation to household waste, drainage, and open-space management? (2) what is the level and distribution of their environmental knowledge? (3) what is the level and distribution of their environmental attitudes? (4) what is the relationship between environmental knowledge and environmental-management behavior? and (5) what is the relationship between environmental attitudes and environmental-management behavior? By bringing several dimensions of residential environmental stewardship into a single empirical setting, the study extends a predominantly waste-centered Indonesian literature and offers evidence relevant to locally targeted environmental education and community environmental-management strategies.

Conceptually, the outcome brings together three related but distinct behavioral domains. Household waste management is primarily a household-level practice involving decisions about storage, sorting, handling, and disposal. Drainage maintenance has both household and collective dimensions because actions at individual frontages can affect the functioning of shared drainage systems. Open-space management likewise spans household stewardship of adjacent space and collective responsibility for common residential areas. Knowledge is expected to support each domain by helping residents recognize appropriate practices and their environmental consequences, whereas attitude reflects an evaluative commitment to carrying out those practices. The Theory of Planned Behavior, however, indicates that attitude alone is not sufficient: perceived behavioral control and social norms also shape action, while infrastructure, service availability, and community support can either enable or constrain environmentally responsible behavior. The present analysis therefore focuses on knowledge and attitude as measured individual-level correlates while recognizing perceived control, norms, infrastructure, and community support as important contextual variables for future models.

MATERIALS AND METHODS

2.1 Study Design and Setting

The study used an observational survey design to examine environmental-management behavior among residents of the Bumi Tamalanrea Permai (BTP) residential complex in Makassar. It was cross-sectional and correlational, with the observed data treated as ex post facto. This design allowed environmental-management behavior, environmental knowledge, and environmental attitudes to be described and their statistical relationships to be examined. Because there was no experimental manipulation or assignment to intervention conditions, the observed relationships were interpreted as associations rather than evidence of causality.

Household environmental management in BTP was defined across three domains. Waste management represented primarily household-level decisions and practices. Drainage maintenance represented a mixed household–collective domain because actions around individual properties can affect the functioning of shared drainage channels. Open-space management similarly combined household stewardship of immediately adjacent space with collective stewardship of common residential areas. These domains were used consistently in the conceptual definitions of behavior, knowledge, and attitude.

2.2 Population and Sampling

Household heads living in the BTP residential complex comprised the study population, and 60 household heads formed the analytical sample. A stratified random sampling approach with equal allocation was used, with 12

household heads randomly selected from each of the five *Rukun Warga* (RW; neighborhood administrative units) in BTP.

2.3 Study Variables and Operational Definitions

Environmental-management behavior was the dependent variable (Y) and referred to observed actions by household heads in managing the residential environment across the waste, drainage, and open-space domains. Waste behavior was treated as predominantly household-level, whereas drainage and open-space behavior included both household and collective dimensions because individual actions can affect shared environmental conditions.

Environmental knowledge was the first independent variable (X_1) and represented factual understanding relevant to waste management, drainage, and open-space management. Environmental attitude was the second independent variable (X_2) and represented respondents' evaluative orientation toward responsible management of the same domains. The cognitive, affective, and psychomotor components identified in this study were not interpreted as separate validated constructs. The analytic model tested whether knowledge and attitude were associated with observed environmental-management behavior and whether knowledge retained a unique association after adjustment for attitude.

2.4 Research Instruments

Three instruments were used: direct observation to assess environmental-management behavior, a knowledge test to assess environmental knowledge, and a questionnaire to assess environmental attitude. Behavior and attitude were scored on a 14–70 scale, whereas knowledge was scored on a 0–17 scale.

2.5 Data Collection

Environmental-management behavior was recorded through direct field observation using a guide that covered waste management, drainage maintenance, and open-space management. The same respondents also completed the environmental-knowledge test and the environmental-attitude questionnaire.

2.6 Statistical Analysis

Descriptive analyses summarized environmental-management behavior, environmental knowledge, and environmental attitude using the sample size, mean, standard deviation, observed minimum and maximum, and predefined category frequencies. The behavior mean was $M = 46.06$, and the behavior standard deviation was $SD = 11.48$, as implied by the reported regression equations and standardized coefficients.

Separate simple linear regressions examined the bivariate associations of knowledge and attitude with environmental-management behavior, followed by a multiple linear regression that included both predictors. Two-sided p-values were calculated from the reported t or F statistics and their stated degrees of freedom. Confidence intervals for the regression coefficients were calculated as $B \pm t_{.975,df} \times SE$. The unique incremental contribution of knowledge beyond attitude was derived from the knowledge t statistic and the full-model R^2 using $\Delta R^2 = t^2(1 - R^2_{full})/\text{residual df}$; the reported R^2 values were rounded to three decimals. The knowledge–attitude correlation was approximately $r = .820$, corresponding to tolerance $\approx .328$ and VIF ≈ 3.05 for each predictor. These values indicate substantial shared variance between the two predictors.

3. Results

The analysis included 60 household heads from five RWs in the Bumi Tamalanrea Permai residential complex. Descriptive findings are presented first, followed by the simple and multiple regression results. Regression statistics are reported with p-values and 95% confidence intervals.

Table 1 summarizes the descriptive statistics. Environmental-management behavior had a mean of 46.06 (SD = 11.48; range 31–70), environmental attitude had a mean of 43.60 (SD = 10.83; range 20–66), and environmental

knowledge had a mean of 8.75 (SD = 3.18; range 3–16). Both simple-regression equations imply a behavior mean of approximately 46.06, and both standardized coefficients imply a behavior SD of approximately 11.48.

Table 1. Descriptive statistics for study variables

Variable	n	Mean	SD	Minimum	Maximum
Environmental-management behavior	60	46.06	11.48	31	70
Environmental attitude	60	43.60	10.83	20	66
Environmental knowledge	60	8.75	3.18	3	16

Table 2 presents the categorical distributions. Environmental-management behavior was most often classified as moderate (41.8%), followed by high (30.0%) and very high (13.2%). Overall, 43.2% of participants fell in the high or very high categories, whereas 15.0% were classified as low or very low. Environmental attitudes were moderate for 46.6% of participants; 26.6% were classified as high or very high and 26.8% as low or very low. Environmental knowledge showed a similar concentration in the middle of the distribution: 40.0% of respondents were classified as moderate, with 30.0% in the high or very high categories and 30.0% in the low or very low categories.

Table 2. Distribution of environmental behavior, attitudes, and knowledge

Variable and category	Score range	n	%
Environmental-management behavior			
Very high	59.2-70.0	8	13.2
High	47.9-59.1	18	30.0
Moderate	36.6-47.8	25	41.8
Low	25.3-36.5	6	10.0
Very low	14.0-25.2	3	5.0
Environmental attitude			
Very high	59.2-70.0	8	13.3
High	47.9-59.1	8	13.3
Moderate	36.6-47.8	28	46.6
Low	25.3-36.5	12	20.1
Very low	14.0-25.2	4	6.7
Environmental knowledge			
Very high	13.6-17.0	5	8.4
High	10.2-13.5	13	21.6
Moderate	6.8-10.1	24	40.0
Low	3.4-6.7	17	28.3
Very low	0-3.3	1	1.7

Table 3 summarizes the simple linear regression models. Environmental knowledge was positively associated with environmental-management behavior in the bivariate model ($R = .812$, $R^2 = .659$, adjusted $R^2 = .653$), $F(1, 58) = 111.888$, exact $p = 3.72\times10^{-}15$. The knowledge coefficient was $B = 2.930$ ($SE = .277$, $\beta = .812$, $t = 10.578$, 95% CI [2.375, 3.485], exact $p = 3.71\times10^{-}15$), yielding the equation $\hat{Y} = 20.428 + 2.930X_1$.

Environmental attitude showed a stronger bivariate association with behavior ($R = .985$, $R^2 = .969$, adjusted $R^2 = .969$), $F(1, 58) = 1843.507$, exact $p = 1.18\times10^{-}45$. Its regression coefficient was $B = 1.044$ ($SE = .024$, $\beta = .985$, $t = 42.936$, 95% CI [0.996, 1.092], exact $p = 1.18\times10^{-}45$), yielding the equation $\hat{Y} = 0.545 + 1.044X_2$.

Table 3. Simple regression models predicting environmental-management behavior

Predictor	R	R^2	Adjusted R^2	B	SE	β	t	F(1, 58)	Exact p	95% CI for B
Environmental knowledge	.812	.659	.653	2.930	.277	.812	10.578	111.888	3.71×10^{-15}	[2.375, 3.485]
Environmental attitude	.985	.969	.969	1.044	.024	.985	42.936	1843.507	1.18×10^{-45}	[0.996, 1.092]

In the multiple regression, the overall model was statistically significant, F(2, 57) = 907.687, exact p = 6.02×10^{-44}, with R = .985, R^2 = .970, adjusted R^2 = .968, and a standard error of estimate of 2.039. The model therefore explained approximately 97.0% of the observed variance in behavior.

After adjustment for the other predictor, environmental attitude remained strongly associated with behavior (B = 1.032, SE = .043, β = .974, t = 24.129, 95% CI [0.946, 1.118], exact p = 1.33×10^{-31}). By contrast, environmental knowledge showed no significant unique association after adjustment for attitude (B = .049, SE = .146, β = .013, t = .334, 95% CI [−0.243, 0.341], exact p = .7396). Based on the t statistic and full-model R^2, the unique incremental variance attributable to knowledge was approximately ΔR^2 = .00006 (<0.01%). Direct subtraction of the rounded R^2 values (.970 − .969 = .001) is less precise because both values were reported to only three decimals.

As shown in Table 4, environmental attitude remained strongly associated with environmental-management behavior after adjustment for knowledge, whereas environmental knowledge showed no significant unique association after adjustment for attitude.

Table 4. Multiple regression model predicting environmental-management behavior

Predictor	B	SE	β	t	Exact p	95% CI for B
Constant	.630	1.129	—	.558	.5790	[−1.630, 2.890]
Environmental knowledge	.049	.146	.013	.334	.7396	[−0.243, 0.341]
Environmental attitude	1.032	.043	.974	24.129	1.33×10^{-31}	[0.946, 1.118]

Model statistics: R = .985; R^2 = .970; adjusted R^2 = .968; standard error of estimate = 2.039; F(2, 57) = 907.687, exact p = 6.02×10^{-44}. The correlation between environmental knowledge and attitude was approximately r = .820; tolerance ≈ .328; VIF ≈ 3.05. Approximate unique ΔR^2 for knowledge beyond attitude ≈ .00006.

DISCUSSION

Three findings stand out. First, the largest proportion of respondents fell in the moderate category for behavior, knowledge, and attitude. Second, knowledge and attitude were each strongly associated with environmental-management behavior when examined separately. Third, and most important, knowledge no longer showed a statistically significant unique association once attitude was included in the same model, whereas attitude remained strongly associated with behavior. The findings therefore require a clear distinction between the bivariate knowledge–behavior association and the results of the adjusted model.

The first three research questions concerned the distributions of behavior, knowledge, and attitudes. For each variable, the largest group of respondents fell in the moderate category, with smaller groups distributed above and below it. This pattern suggests that environmentally responsible residential practices are present in the study community but are not uniformly established. Comparable variation has been reported in other Indonesian settings. Ridwan et al. (2025), for example, found relatively favorable environmental knowledge alongside less favorable household waste-management practices in South Sulawesi. Karim et al. (2022) linked knowledge, local wisdom, and attitudes with waste-management behavior in residential Soppeng, while Padmayani et al.

(2026) reported relationships among knowledge, attitudes, and household waste sorting in Bali. Research on household food waste has likewise shown variation across knowledge, attitude, and practice dimensions rather than uniformly high environmental engagement (Sholihah et al., 2025). These findings reinforce the value of treating what residents know, how they evaluate environmental responsibilities, and what they actually do as related but distinct aspects of environmental stewardship.

Environmental knowledge showed a strong bivariate association with environmental-management behavior ($R = .812$; $R^2 = .659$). This finding is consistent with the view that knowledge can provide a cognitive foundation for recognizing appropriate environmental practices (Hungerford & Volk, 1990; van de Wetering et al., 2022). The bivariate relationship, however, should not be interpreted as an independent knowledge effect. Once environmental attitude was controlled, the knowledge coefficient was close to zero ($\beta = .013$, $p = .7396$), and its 95% CI included zero. The study therefore supports a bivariate association between knowledge and behavior, but not a significant unique association after adjustment for attitude.

Knowledge may covary with attitude because people who understand environmental consequences may also evaluate responsible practices more favorably. The strong simple knowledge model may therefore reflect, to a large extent, variance that knowledge shares with attitude rather than a demonstrable unique contribution of knowledge. This pattern is compatible with the broader knowledge–action-gap literature, which argues that information alone is rarely sufficient to produce pro-environmental action (Kollmuss & Agyeman, 2002; Bamberg & Möser, 2007).

Environmental attitude was the dominant correlate of behavior. It showed an exceptionally strong bivariate association ($R = .985$; $R^2 = .969$) and remained strongly associated with behavior after adjustment for knowledge ($\beta = .974$, 95% CI for B [0.946, 1.118], $p = 1.33\times10^{-}31$). This result is consistent with the Theory of Planned Behavior, in which attitude is a proximal determinant of intention and action alongside subjective norms and perceived behavioral control (Ajzen, 1991). In South Denpasar, knowledge, attitude, and perceived behavioral control were each associated with household waste-management behavior (Jacob & Dwipayanti, 2022). More recent studies and meta-analyses likewise identify attitudes and perceived control as relevant determinants of waste-related decisions (Cao et al., 2026; Hu et al., 2026; Novanda et al., 2026).

The exceptionally high attitude–behavior association may partly reflect the close alignment between the content domains of the attitude questionnaire and the observation guide. If the attitude items were behaviorally worded—for example, if they referred directly to performing the same waste, drainage, or open-space practices scored by observers—criterion contamination or conceptual redundancy could have inflated the relationship.

The multivariable model is especially important for interpreting environmental knowledge. The knowledge coefficient was $B = .049$ ($\beta = .013$, $p = .7396$), with a 95% CI from -0.243 to 0.341. Its approximate incremental R^2 beyond attitude was only .00006, indicating essentially no unique explanatory contribution in this sample. This result is consistent with evidence that knowledge may operate indirectly through evaluative or motivational processes rather than through a direct independent association with behavior (Liu et al., 2024; Sembiring et al., 2026). The study should therefore not be interpreted as showing that knowledge independently predicts behavior.

From a practical perspective, these results do not imply that environmental education is unimportant. Rather, they suggest that information provision alone may be insufficient. Interventions may be more effective when they connect knowledge with favorable attitudes and with conditions that make action feasible. Future models should directly measure perceived behavioral control, subjective and descriptive social norms, infrastructure and service availability, and community support. These contextual variables are particularly relevant because waste management is largely household-based, whereas drainage and open-space stewardship have collective dimensions that depend on coordination, shared facilities, and neighborhood norms.

A broader contribution of this study is its treatment of residential environmental stewardship as more than waste management. Much of the Indonesian literature represented here focuses on waste sorting, household waste, or food-waste behavior (Ariyani & Ririh, 2020; Padmayani et al., 2026; Sholihah et al., 2025). Recent work in Makassar has also examined environmental knowledge and maintenance motivation in relation to household

waste management (Amir, 2026). The present study instead brings household waste, residential drainage, and open-space management into a common behavioral outcome. This wider operational scope matters because residential environmental quality depends on interconnected practices rather than on waste management alone. The findings add localized evidence on how cognitive and attitudinal factors relate to several dimensions of everyday environmental management.

Several limitations should be considered when interpreting these findings. The sample comprised only 60 household heads from one residential complex and five RWs, which limits statistical precision and external validity. Because observations were nested within RWs, responses may also have been correlated within neighborhood units; with only five clusters, however, conventional cluster-robust estimation would itself be unstable. The analysis should therefore be understood as a single-site, individual-level analysis rather than as representative of Makassar or urban Indonesia. The cross-sectional correlational design also precludes causal inference. In addition, the study did not include psychometric evidence, observer-training records, inter-rater reliability, respondent demographics, the full sampling frame, or respondent-level data needed to verify residual and influence diagnostics or bootstrap confidence intervals.

Taken together, the findings show that environmental knowledge and behavior were strongly related at the bivariate level, but knowledge had no statistically significant unique association after adjustment for attitude. Environmental attitude remained the dominant correlate. This distinction is central to the study's contribution: the results are more consistent with a model in which knowledge is intertwined with evaluative and contextual processes than with a simple knowledge-to-behavior pathway. The three-domain outcome also highlights the need for future research to distinguish household practices from collective neighborhood stewardship and to model the social and infrastructural conditions that support each.

CONCLUSION

Among 60 household heads in Bumi Tamalanrea Permai, environmental-management behavior, environmental knowledge, and environmental attitude were most commonly classified at moderate levels. Environmental knowledge was strongly associated with behavior in the bivariate analysis ($R = .812$, $R^2 = .659$), but this relationship did not represent a significant unique association after adjustment for environmental attitude ($B = .049$, $\beta = .013$, 95% CI [−0.243, 0.341], $p = .7396$; approximate $\Delta R^2 = .00006$). Environmental attitude showed a very strong bivariate association and remained the dominant correlate in the adjusted model ($B = 1.032$, $\beta = .974$, 95% CI [0.946, 1.118], $p = 1.33\times10^{-}31$). The study therefore supports the conclusion that knowledge was associated with residential environmental behavior only at the bivariate level, whereas attitude accounted for nearly all of the unique association.

These findings should be generalized cautiously. The study involved a small sample from a single residential complex, included only five RW clusters, and did not measure several theoretically relevant contextual determinants. Future research should use larger multisite samples, validated multidimensional instruments, longitudinal or intervention designs, and explicit measures of perceived behavioral control, social norms, infrastructure, and community support. It should also distinguish household-level practices from collective environmental stewardship and use appropriate multilevel or cluster-aware analyses when residents are sampled within neighborhood units.

Ethics, funding, and conflict of interest

Ethics: Ethical approval for this study was granted by the Institutional Ethics Committee of Universitas Negeri Makassar.

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Conflicts of interest: The authors declare no conflicts of interest.

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