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Plastic waste characteristics and community responses in mangrove-influenced coastal villages of Kampung Laut, Cilacap, Indonesia

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Abstract. *Astuti AR, Putri DS, Arlysia V, Santika YE, Safitri FE, Setyawan AD. 2025. Plastic waste characteristics and community responses in mangrove-influenced coastal villages of Kampung Laut, Cilacap, Indonesia. Indo Pac J Ocean Life 9: 36-45.* Plastic pollution presents a significant threat to coastal and mangrove ecosystems, particularly in low-income and infrastructure-deficient regions of Southeast Asia. This study investigates the composition of plastic waste and the perceptions and behaviors of local communities in three mangrove-influenced villages of Kampung Laut Sub-district, Cilacap, Indonesia. Field surveys conducted in 33 sampling plots revealed that plastic waste was predominantly composed of single-use items, especially polypropylene (PP), low-density polyethylene (LDPE), and polyethylene terephthalate (PET), reflecting both domestic consumption and livelihood-related activities such as fisheries and aquaculture. A structured questionnaire grounded in the Knowledge-Attitude-Practice (KAP) framework was administered to 91 respondents. Statistical analyses, including Principal Component Analysis, Pearson correlation, and Partial Least Squares Structural Equation Modeling (PLS-SEM), were employed to explore the relationships among cognitive and behavioral variables. The results indicated that knowledge significantly influenced attitudes, which were positively associated with pro-environmental behavior; however, knowledge alone did not directly predict action. Sociodemographic constraints—particularly low education and income levels—further limited behavioral change despite moderate awareness. Comparisons with regional and global studies suggest that such gaps are common in coastal communities. These findings underscore the need for integrated waste governance strategies that combine education, infrastructure, and locally adapted regulations, alongside stronger integration between plastic waste management and mangrove conservation efforts.

Keywords: Coastal village, KAP model, mangrove ecosystem, plastic pollution, waste behavior

INTRODUCTION

Plastic pollution has emerged as a critical environmental challenge, particularly in coastal and estuarine ecosystems where land-based activities intersect with marine processes (Eriksen et al. 2014; Jambeck et al. 2015; Suyadi and Manullang 2020). The proliferation of single-use plastics and inadequate waste management infrastructure has led to significant accumulations of plastic debris in rivers, mangroves, and coastal zones (Evode et al. 2021). In Southeast Asia, which hosts some of the most productive mangrove ecosystems, plastic contamination threatens biodiversity, fisheries, and community livelihoods (Thao et al. 2023). As plastic waste degrades, it fragments into microplastics that can enter food chains and pose health risks to both wildlife and humans (Abreo et al. 2020).

Mangrove ecosystems are particularly vulnerable due to their geomorphology and hydrodynamics, which enable them to trap and retain floating debris (Martin et al. 2019). These forests provide vital ecological services such as shoreline protection, carbon sequestration, and nursery grounds for marine life (Hilmi et al. 2021; Jennerjahn et al. 2022; Garmaeepour et al. 2025). However, the accumulation of plastic waste can disrupt these functions by smothering pneumatophores, altering sediment dynamics, and introducing toxic compounds into the food web (Jayapala et al. 2024). The situation is exacerbated in mangrove-adjacent communities with limited access to waste collection services and strong dependence on natural resources (Akram et al. 2023).

Indonesia is among the largest contributors to marine plastic pollution, with over 620,000 tons estimated to enter the ocean annually (Lebreton et al. 2017). This crisis reflects structural issues in waste governance, public awareness, and economic capacity. Recent studies have highlighted the importance of integrating local knowledge and behavior into waste reduction strategies, especially in rural and semi-urban settings (Kurniawan et al. 2020; Shakuto et al. 2024). In this context, understanding how communities perceive and manage plastic waste is essential for developing context-sensitive interventions that are ecologically effective and socially accepted.

One widely adopted framework for assessing public environmental engagement is the Knowledge-Attitude-Practice (KAP) model. This approach has been used to explore public behavior in various domains, including health, sanitation, and environmental protection (Tejada and Cauilan 2019). KAP studies help identify gaps between awareness and action, thereby guiding policy and education initiatives. In the context of plastic waste, KAP assessments

have revealed that even where awareness is high, behavior change may lag due to cultural, economic, or infrastructural constraints (Nasir et al. 2023).

Kampung Laut Sub-district in Cilacap, Central Java, presents a unique case for studying plastic pollution in a mangrove-dominated setting. The area is composed of small fishing villages located within the Segara Anakan Lagoon system, a biodiverse estuary characterized by tidal creeks, fishponds, and dense mangroves (Jennerjahn et al. 2022). Due to its geographical isolation, limited waste management services, and high dependence on fisheries, Kampung Laut faces multiple environmental and socio-economic pressures. Informal disposal of plastic waste in rivers, ponds, and mangrove areas has become a visible and chronic issue, affecting both environmental quality and local well-being (Hilmi et al. 2021; Garmaeepour et al. 2025).

Previous research in similar settings has emphasized the need for spatially explicit assessments of plastic distribution and community-level diagnostics of waste behavior (Abreo et al. 2020). However, studies specifically focused on Indonesia's rural mangrove villages remain limited, particularly in terms of integrating quantitative waste data with socio-cognitive models like KAP. This gap hampers efforts to design holistic interventions that align environmental goals with local realities. Understanding the relationship between knowledge, attitudes, and behavior in these communities is key to promoting responsible waste practices and fostering resilience in coastal social-ecological systems.

This study aims to characterize the composition of plastic waste and examine community perceptions and practices related to plastic management in three villages of Kampung Laut Sub-district. Specifically, it (i) quantifies the types and sources of plastic debris across mangrove-influenced habitats, (ii) assesses the levels of knowledge, attitudes, and practices regarding plastic waste among residents, and (iii) explores the interrelationships between KAP components using multivariate statistical models. The findings are intended to inform evidence-based interventions that support sustainable waste governance in vulnerable coastal communities.

MATERIALS AND METHODS

Study area

This study was conducted in Kampung Laut Sub-district, located within the Segara Anakan Lagoon system in Cilacap District, Central Java, Indonesia. The area is characterized by extensive mangrove forests, tidal rivers, and brackish aquaculture ponds. Administratively, Kampung Laut comprises four main villages, of which three—Ujungalang, Klaces, and Ujunggagak—were selected as the study sites due to their high dependency on fisheries and visible accumulation of plastic waste along coastlines and village peripheries.

The region is geographically isolated, accessible mainly by boat, and lacks comprehensive municipal waste services. It is surrounded by mangrove belts that function as natural barriers and nurseries for aquatic species (Jennerjahn et al. 2022). However, these same mangrove areas are also prone to entrap plastic waste due to tidal movement and human dumping behavior, as documented during the field observations.

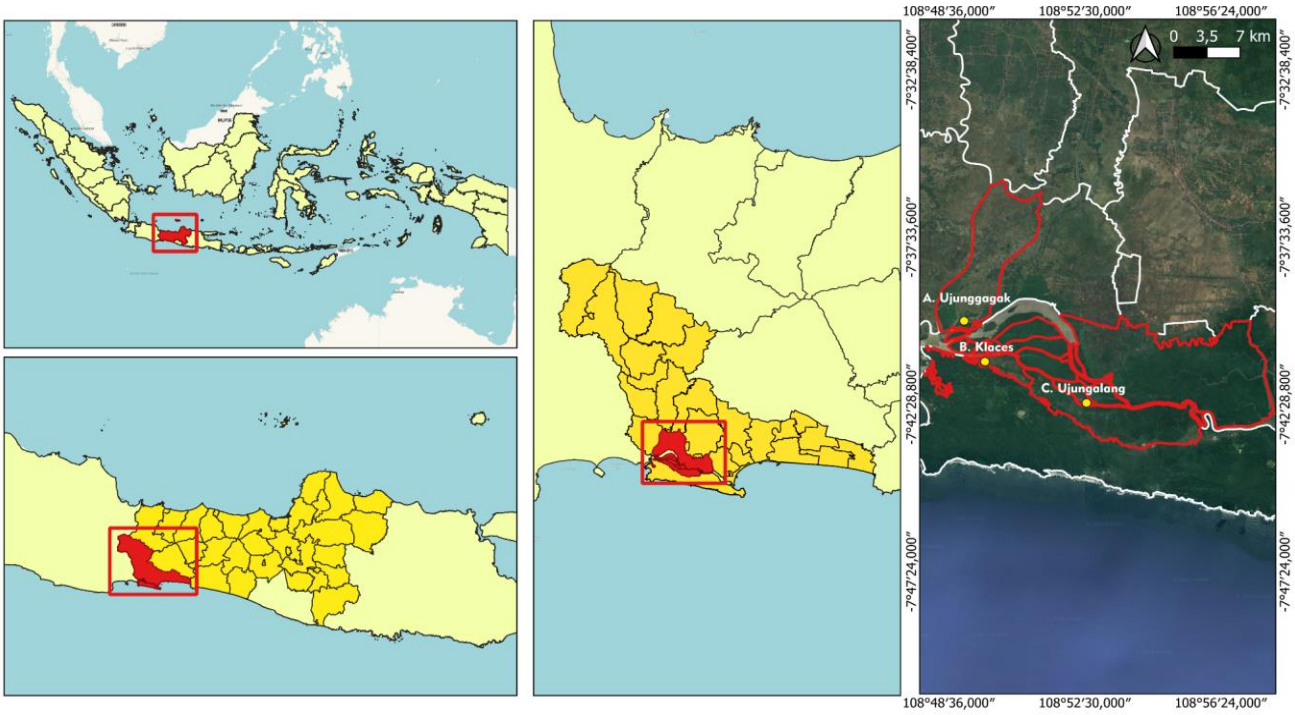

Figure 1. Study site of Plastic waste identification sampling locations and community perceptions in Kampung Laut Sub-district, Cilacap District, Central Java, Indonesia. A. Ujunggagak, B. Klaces, and C. Ujungalang

Small-scale fisheries, brackish pond aquaculture, and informal fish processing dominate the livelihoods of the local population. The area's limited road infrastructure and remote location pose additional challenges to effective waste management and education outreach (Hilmi et al. 2021; Garmaeepour et al. 2025). The selection of the three villages was based on differences in population size, mangrove density, and exposure to plastic accumulation, allowing for comparative analysis across spatial and socio-economic gradients.

Research procedures

Field sampling of plastic waste

Field sampling was conducted in 33 plots distributed equally across Ujungalang, Klaces, and Ujunggagak Villages. Each plot measured 10×10 meters and was selected to represent typical land-use settings within the coastal village environment, including residential yards, riverbanks, fishpond margins, and mangrove fringes. Plastic debris within each plot was manually collected, sorted, and classified in situ.

Plastic items were categorized based on polymer type–such as polypropylene (PP), low-density polyethylene (LDPE), polyethylene terephthalate (PET), and polyvinyl chloride (PVC)—as well as by physical form, including bottles, wrappers, sachets, and ropes. This classification procedure followed standardized field protocols adapted from Thao et al. (2023) and UNEP guidelines. All items were counted individually (pieces) to estimate the abundance of each plastic type.

Photographic documentation was taken at each sampling location to capture contextual information regarding site conditions, land use, and the spatial arrangement of debris. The overall aim of this procedure was to represent actual conditions of unmanaged plastic accumulation in mangrove-affected environments, including both surface and partially buried plastic items. Fieldwork was scheduled during low tide periods to ensure full access to intertidal zones and increase sampling efficiency.

Household survey and questionnaire design

In addition to physical waste sampling, a structured household survey was administered to 91 respondents selected using stratified random sampling across the three villages. Inclusion criteria included permanent residency in the study area, a minimum age of 17, and a willingness to participate voluntarily.

The survey instrument consisted of four sections: (i) sociodemographic characteristics, (ii) knowledge of plastic waste and its impacts, (iii) attitudes toward waste management and the environment, and (iv) self-reported practices related to plastic disposal and reduction. The questionnaire was developed based on prior KAP studies in environmental research (Tejada and Cauilan 2019) and was pre-tested for clarity and local comprehension.

Responses were recorded using Likert scales for attitudinal and behavioral items and multiple-choice or open-ended formats for knowledge-based items. Enumerator training was conducted to ensure consistency in data collection across the three locations. The collected data were then coded, tabulated, and prepared for descriptive and inferential analysis using spreadsheet and statistical tools. No identifying information was collected, and ethical considerations were maintained throughout the survey process.

Data analysis

Descriptive statistical analysis

Descriptive statistics were used to summarize the composition, frequency, and spatial distribution of plastic waste items collected from field plots. Each plastic item was classified by polymer type and physical form, and the percentage contribution of each category was calculated per village. Graphical tools such as bar charts and pie charts were used during the analysis stage to facilitate comparison of dominant plastic waste types across different locations.

The sociodemographic characteristics of the respondents—including age, gender, education, income, and occupation—were tabulated to reveal patterns relevant to plastic waste behavior. KAP questionnaire responses were transformed into ordinal or interval-scale data and assigned numerical values where applicable, enabling subsequent statistical analysis.

Principal Component Analysis (PCA)

To reduce data dimensionality and identify latent variables within the KAP questionnaire, Principal Component Analysis (PCA) was performed using SPSS version 26. Items with low factor loadings (<0.5) or Measures of Sampling Adequacy (MSA) below 0.5 were excluded from further analysis. The retained principal components were used to construct indices representing knowledge, attitude, and behavior dimensions.

Structural Equation Modeling (SEM)

To examine causal relationships among KAP variables, Partial Least Squares Structural Equation Modeling (PLS-SEM) was applied using SmartPLS 4. This variance-based SEM approach is suitable for small to moderate sample sizes and allows the estimation of both direct and indirect effects (Schreiber 2008). Latent constructs (knowledge, attitude, behavior) were modeled from PCA outputs, and path coefficients, factor loadings, and model fit indices were assessed. Model reliability and significance were tested using bootstrapping with 5,000 iterations. The resulting structural model was interpreted to assess how knowledge influences attitudes and how both contribute to behavioral patterns related to plastic waste.

Pearson correlation analysis

In addition to SEM, Pearson correlation analysis was performed to explore bivariate associations among the three KAP domains. Correlation coefficients (r) and significance levels (p-values) were calculated to validate the direction and strength of relationships independently of the SEM model. These correlation results provided complementary insights into the consistency between knowledge, attitude, and practice variables among respondents.

RESULTS AND DISCUSSION

Characteristics of respondents

The survey involved 91 respondents drawn from Ujungalang, Klaces, and Ujunggagak Villages. Their demographic characteristics form a foundational context for interpreting community-level responses to plastic waste issues. Women made up a slightly larger proportion of the sample (57.14%) than men (42.86%), indicating their prominent role in domestic and environmental responsibilities.

In terms of age distribution, the majority of respondents (65.93%) were over 40, while 26.37% were between 25 and 40, and only 7.69% were aged 17 to 24. This skew toward older age groups may reflect entrenched behavioral norms and experiential knowledge related to local environmental changes.

Educational attainment was generally low, with 60.44% of respondents having completed elementary school and 9.89% never attending formal education. Only 17.58% and 12.09% reached junior and senior high school, respectively. Limited educational exposure may constrain understanding of waste management systems and reduce access to sustainability-related information.

Respondents' income levels were concentrated in the lower economic bracket. Nearly half (46.15%) earned between IDR 1,000,000 and 2,000,000 per month, while 21.98% earned below IDR 1,000,000. Only 10.99% reported earnings above IDR 3,000,000. Most respondents (52.75%) were engaged in fisheries-related occupations, such as fishers, fishpond workers, or seafood processors, while the rest worked as traders, laborers, or homemakers. This strong dependence on marine-based livelihoods suggests heightened vulnerability to environmental degradation, including plastic pollution in mangrove zones.

Overall, these patterns indicate structural challenges that may hinder the adoption of formal waste management practices, including financial limitations, informational gaps, and labor priorities centered on subsistence activities. Therefore, intervention strategies should be tailored to the community's socio-economic realities and capacity for behavioral change. Detailed respondent characteristics are presented in Table 1.

Composition and distribution of plastic waste

Plastic debris collected from 33 field plots across Ujunggagak, Klaces, and Ujungalang Villages exhibited substantial variation in both material composition and spatial distribution. The most frequently encountered plastic types were polypropylene (PP), low-density polyethylene (LDPE), and polyethylene terephthalate (PET), which collectively represented the majority of waste items in all surveyed locations. These materials were commonly found in the form of food wrappers, plastic bags, sachets, ropes, and beverage bottles, typically associated with household activities and small-scale fisheries.

As illustrated in Figure 2, PP emerged as the most dominant plastic type across all villages, followed by LDPE and PET, underscoring the prevalence of single-use packaging materials. Quantitatively, Table 3 shows that PP accounted for 59.2% of plastic items in Ujunggagak, 56.0% in Klaces, and 51.7% in Ujungalang. LDPE contributed between 19.4% and 24.9%, while PET ranged from 7.0% to 10.0%. These site-specific proportions are further visualized in Figure 3, which compares the relative percentage composition of key plastic types across the three villages. The observed patterns are closely linked to local consumption behavior and livelihood strategies, particularly those related to aquaculture, fish processing, and coastal household provisioning, which directly affect the type and quantity of plastic waste generated.

In Ujunggagak, plastic debris was most frequently found along riverbanks and residential perimeters, suggesting direct household disposal and tidal deposition. In Klaces, field notes documented rope-like plastics and packaging waste entangled in mangrove roots and trapped along dikes and pond edges–possibly reflecting aquaculture and boat-related activities. In Ujungalang, the high presence of LDPE was likely linked to fish processing and packaging waste. Fragments of PVC pipes and plastic twine were also recorded, indicating diverse and unmanaged plastic sources.

The spatial differences in plastic waste composition among villages reflect varied livelihood strategies, levels of market integration, and proximity to mangrove zones. These findings underscore the need for site-specific waste reduction strategies that consider local plastic use patterns and community infrastructure.

Table 1. Sociodemographic characteristics of respondents in the study area (n=91)

Category	Subcategory	Frequency (n)	(%)
Age	17-25 years	7	7.69
	25-40 years	24	26.37
	>40 years	60	65.93
Gender	Male	39	42.86
	Female	52	57.14
Education	No formal education	9	9.89
	Elementary school	55	60.44
	Junior high school	16	17.58
	Senior high school	11	12.09
Income (IDR)	No income	2	2.20
	<1,000,000	20	21.98
	1,000,000-2,000,000	42	46.15
	2,000,000-3,000,000	19	20.88
	3,000,000-4,000,000	6	6.59
	>4,000,000	2	2.20
Occupation	Fisherman and boat crew	43	47.25
	Aquaculture farmer	18	19.78
	Laborer (non-fisheries)	11	12.09
	Housewife	10	10.99
	Other (trader, services)	9	9.89

Table 3. Composition of plastic waste by village (in pieces and %)

Plastic type	Ujunggagak (pcs)	(%)	Klaces (pcs)	(%)	Ujungalang (pcs)	(%)	All villages (pcs)	(%)
PP	1211	59.2	752	56.0	1016	51.7	2979	56.1
LDPE	491	24.0	261	19.4	489	24.9	1241	23.4
PET	143	7.0	134	10.0	177	9.0	454	8.6
HDPE	103	5.0	117	8.7	151	7.7	371	7.0
PS	88	4.3	67	5.0	118	6.0	273	5.1
PVC	10	0.5	12	0.9	14	0.7	36	0.7
Total	2046	100.0	1343	100.0	1965	100.0	5354	100.0

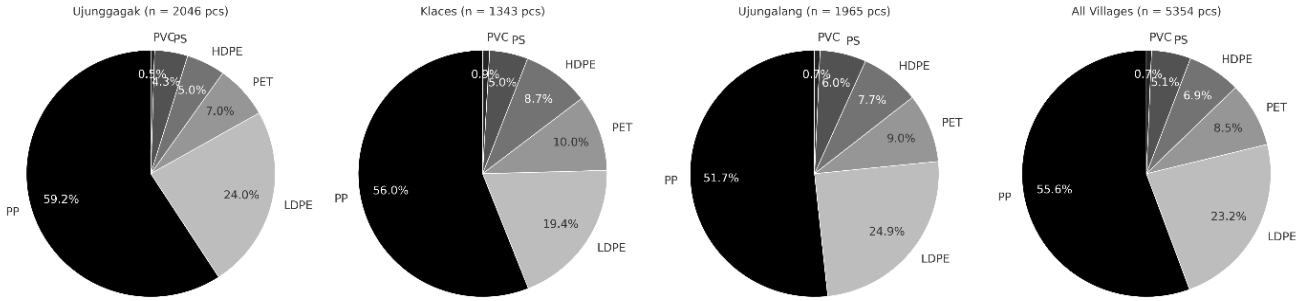

Figure 2. Composition of plastic waste by village and overall in Kampung Laut, Cilacap, Indonesia

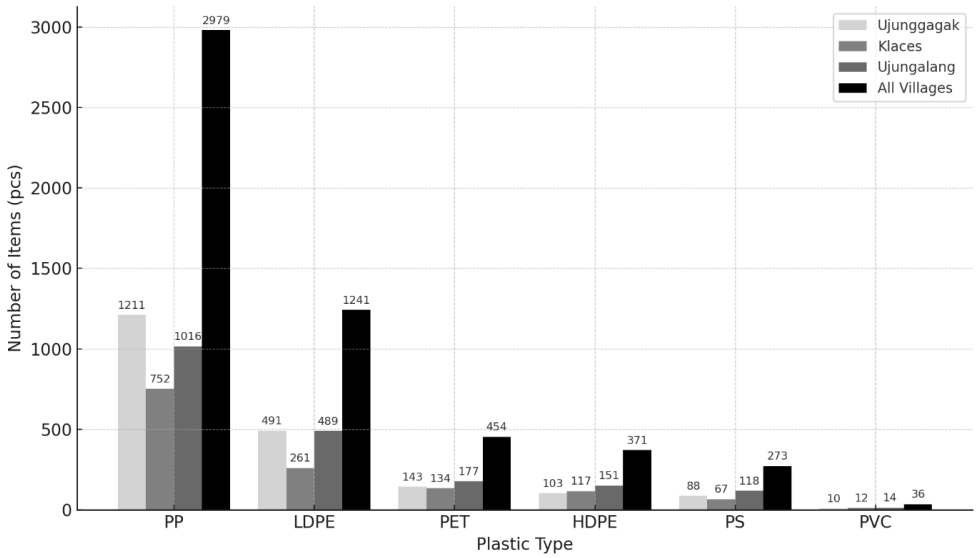

Figure 3. Composition of plastic waste by village and overall (pcs)

Community Knowledge, Attitudes, and Practices (KAP)

Analysis of the KAP questionnaire revealed varying levels of understanding and behavioral responses to plastic waste across the study sites. In practice, the dominant household disposal method was open burning (45.1%), followed by dumping into rivers or the sea (17.3%) and discarding waste behind houses (13.0%). Burying plastic waste and using managed collection services were less frequent, while only 2.6% of respondents reported engaging in recycling or sorting activities (Table 4). These results illustrate an urgent need for effective household-level interventions to reduce plastic leakage into the environment.

Visual representation of these disposal methods confirms the prevalence of unsustainable practices, with open burning standing out across all villages (Figure 4). The reliance on informal or harmful disposal reflects infrastructural gaps and weak enforcement mechanisms.

Despite these behavioral trends, knowledge about the environmental impacts of plastic was generally moderate. A majority of respondents (76.9%) recognized that plastic pollution harms rivers and aquatic life, and more than 60% were aware that plastic materials decompose very slowly. However, key misconceptions remained—only 38.5% could correctly identify recyclable material symbols, and 29.7%

believed that burning plastic posed no serious risk (Figure 5).

Attitudes toward waste management were broadly positive. Around 83.5% of respondents considered plastic pollution a serious local issue, and 79.1% agreed that community participation is essential in solving the problem. Furthermore, 57.1% felt a personal responsibility to reduce plastic consumption, though others perceived that institutional actors such as village leaders or the government should lead waste mitigation efforts (Figure 6).

This attitude—behavior gap was further evidenced by civic engagement patterns: although 72.5% of respondents expressed concern about plastic pollution, fewer than 20% had ever joined cleanup activities or attended environmental outreach programs. These discrepancies reveal structural constraints, including limited waste management infrastructure, low household income, and minimal exposure to environmental education.

The patterns identified through surveys were supported by field observations, which revealed substantial plastic accumulation near homes, waterways, and mangrove zones. Frequently observed forms included scattered packaging, entangled ropes, and burnt residue, all indicating both passive neglect and active disposal in ecologically sensitive areas (Figure 7). These findings underscore the importance of integrated and community-responsive strategies for plastic waste reduction—ones that go beyond awareness to address material and institutional limitations. Field observations supported these self-reported practices, documenting widespread plastic accumulation in mangrove zones, waterways, and domestic surroundings (Figure 8).

Table 4. Reported household plastic waste disposal methods (n=115)

Disposal method	Frequency (n)	Percentage (%)
Open burning	52	45.1
Dumped in river or sea	20	17.3
Thrown behind the house	15	13.0
Buried in the ground	12	10.4
Managed waste collection	10	8.6
Recycled or sorted	3	2.6
Total	115	100.0

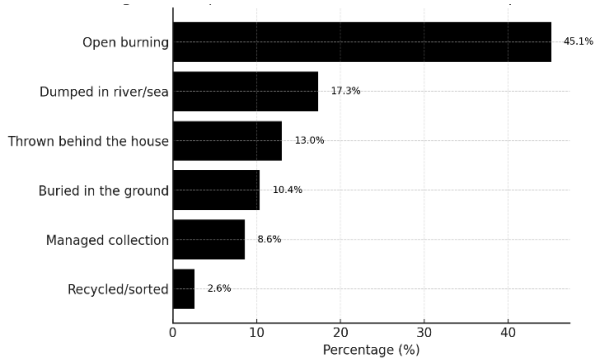

Figure 4. Reported household plastic waste disposal practices

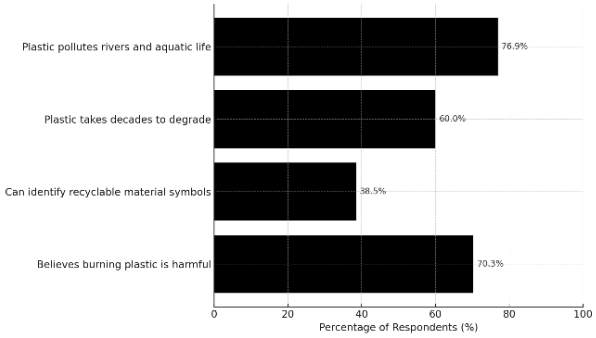

Figure 5. Knowledge of plastic waste impacts among respondents

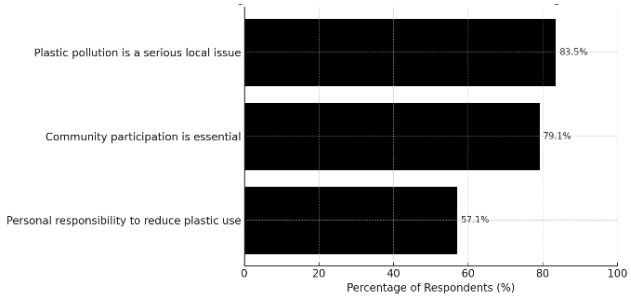

Figure 6. Attitudes toward plastic waste management (%)

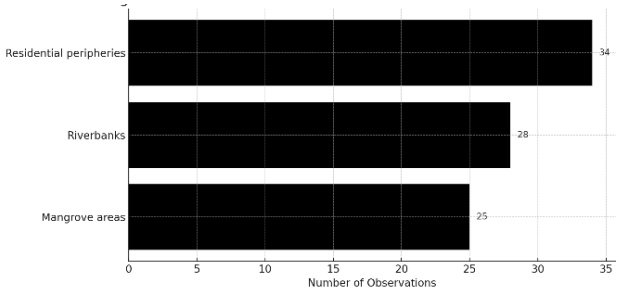

Figure 7. Field observation of plastic waste accumulation near settlements

Figure 8. Field observation. Photos of plastic accumulation in Kampung Laut, Cilacap. A. Dumped along mangrove-lined coastlines, B. Thrown into tidal waterways, C. Discarded and burned in residential yards, highlighting the need for improved waste governance

Structural relationships among KAP variables

Structural Equation Modeling (SEM) was employed to examine the causal relationships among the three main KAP components: knowledge, attitude, and practice. The model fit indicators confirmed that the structural model was statistically valid, with satisfactory factor loadings and path coefficients. The analysis showed that knowledge significantly influenced attitude (path coefficient = 0.62, $p<0.01$), suggesting that a greater understanding of plastic-related issues leads to more favorable environmental attitudes. Attitude, in turn, exhibited a strong positive effect on behavior (path coefficient = 0.55, $p<0.01$), indicating that concern for environmental impacts encourages more responsible plastic disposal and reduction practices. Interestingly, the direct effect of knowledge on behavior was weaker and only marginally significant (path coefficient = 0.21, $p=0.07$), suggesting that awareness alone may not be sufficient to drive behavioral change unless accompanied by supportive attitudes (Figure 9). These findings support the idea that behavioral interventions should focus not only on information delivery but also on motivational and value-based approaches.

These results are consistent with prior environmental KAP studies, which found that attitudes often serve as mediators between knowledge and behavior (Nasir et al. 2023). The implications are clear: improving knowledge is necessary but not enough. Efforts to reduce plastic waste must also foster pro-environmental values and provide enabling conditions that make sustainable behavior feasible in everyday life.

Correlation patterns among KAP components

To complement the structural modeling results, Pearson correlation coefficients were calculated to explore linear relationships between knowledge, attitude, and practice (KAP) regarding plastic waste. These correlations reinforce the causal pathways identified in the Structural Equation Model. A strong and statistically significant correlation was observed between knowledge and attitude ($r=0.63$, $p<0.01$), indicating that individuals with better understanding of environmental impacts tend to exhibit more supportive attitudes. A moderate positive correlation was also found between attitude and behavior ($r=0.57$, $p<0.01$), suggesting that internalized environmental concern is associated with more responsible plastic management. In contrast, the correlation between knowledge and behavior was weaker and only marginally significant ($r=0.29$, $p=0.06$) (Figure 10), mirroring the structural model's implication that knowledge alone is insufficient to drive behavioral change without attitudinal mediation.

These results highlight the importance of integrating cognitive, affective, and contextual factors in designing plastic waste education and intervention programs.

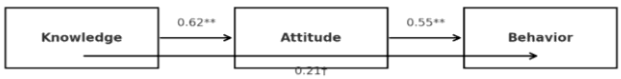

Figure 9. Structural Equation Model (SEM) of the relationships among knowledge, attitude, and behavior

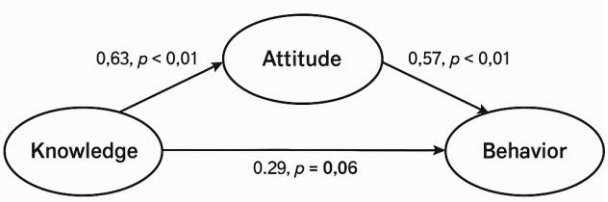

Figure 10. Pearson correlation matrix among knowledge, attitude, and behavior variables

Discussion

Sociodemographic influences on plastic waste behavior

The sociodemographic characteristics of the respondents–particularly education level, income, and occupation–emerged as critical factors shaping community engagement with plastic waste. A large proportion of respondents had only completed elementary school or lacked formal education entirely, which may limit access to environmental information and hinder comprehension of plastic pollution risks. Previous studies have shown that low educational attainment is associated with inadequate waste disposal practices and poor risk perception, especially in rural and coastal contexts (Nasir et al. 2023).

Income constraints further exacerbate the challenge. Many residents in Kampung Laut subsist on modest earnings from small-scale fisheries and informal labor, with limited capacity to invest in alternative packaging, waste bins, or transport to centralized disposal facilities. Similar findings have been reported in Philippine and Vietnamese coastal areas, where economic hardship often leads to short-term disposal strategies such as open burning or dumping (Abreo et al. 2020; Thao et al. 2023). This suggests that even when residents are aware of the negative impacts of plastic, structural limitations prevent the adoption of better practices.

Gender roles also appear to influence plastic waste behavior. The higher proportion of female respondents reflects their central role in managing household waste. Yet despite their involvement, women often face unequal access to formal environmental training or decision-making forums. This reinforces the need for inclusive education programs that engage women as key actors in sustainable waste governance (Shakuto et al. 2024).

Overall, these findings highlight the interplay between knowledge, material resources, and cultural expectations. Addressing plastic waste in mangrove communities, therefore, requires a nuanced approach that accounts for social heterogeneity, builds capacity, and removes structural barriers to behavior change.

Site-specific plastic waste composition and livelihood patterns

The composition and distribution of plastic waste across Ujunggagak, Klaces, and Ujungalang Villages reflect localized livelihood strategies and access to consumer goods. Polypropylene (PP), low-density polyethylene (LDPE), and polyethylene terephthalate (PET) were dominant in all sites, but the proportions varied depending on village activities. For example, the prevalence of LDPE and PVC in Ujungalang likely corresponds with its role as a fishing and trading hub, where plastic sheeting, packaging, and pipe fragments are commonly used in daily operations.

Klaces Village showed a relatively higher proportion of HDPE and multilayer plastics, which are associated with aquaculture infrastructure such as fertilizer sacks, fish feed bags, and rope. This aligns with field observations and supports the interpretation that plastic usage patterns are directly linked to the material demands of local livelihoods. In contrast, Ujunggagak exhibited more domestic-oriented waste, such as snack wrappers and sachets, suggesting greater dependency on household consumption rather than market-driven production.

These village-specific profiles mirror findings from other mangrove or estuarine communities in Southeast Asia. Studies in Thailand and the Philippines have similarly linked plastic debris composition to the nature of subsistence and economic activities in coastal villages (Jambeck et al. 2015; Abreo et al. 2020; Thao et al. 2023). The implication is that a one-size-fits-all waste intervention is unlikely to succeed; rather, waste management must be contextualized to local practices and material flows.

Moreover, the spatial concentration of plastic along mangrove fringes and tidal creeks points to both intentional dumping and tidal trapping. Mangrove forests act as natural filters for floating debris (Martin et al. 2019), but without proper intervention, they become long-term sinks of pollution that undermine their ecological function.

In sum, addressing plastic waste in Kampung Laut requires understanding how environmental degradation is rooted in place-specific interactions between material culture and ecological context. Tailoring solutions to these patterns is essential for improving both environmental quality and community livelihoods.

Knowledge–Attitude–Practice dynamics and behavior gaps

The KAP analysis revealed a structured yet incomplete pathway: while higher knowledge levels were significantly correlated with more favorable attitudes, this did not consistently translate into environmentally responsible behavior. Structural Equation Modeling (SEM) and Pearson correlation analysis both confirmed this pattern, showing a strong link between knowledge and attitude ($r=0.63$, $p<0.01$), and between attitude and behavior ($r=0.57$, $p<0.01$), but only a weak and marginally significant correlation between knowledge and behavior ($r=0.29$, $p=0.06$). This indicates that attitudes function as a key mediating variable between cognitive awareness and concrete action–a finding that echoes trends in other coastal and rural communities (Nasir et al. 2023).

Despite widespread recognition of the dangers posed by plastic pollution—such as threats to aquatic life, food safety, and community health—field data and observations (Figure 8) revealed persistent reliance on unsustainable practices like open burning, river dumping, and unmanaged disposal behind homes. Respondents frequently cited barriers such as limited access to formal waste services, lack of viable alternatives, and competing daily priorities as reasons for non-compliance. Similar structural constraints have been noted in Malaysian and Vietnamese coastal villages, where high environmental awareness does not guarantee behavioral change (Mazelan and Yusuff 2021; Thao et al. 2023).

These findings imply that educational interventions must extend beyond the mere dissemination of facts. Instead, fostering pro-environmental norms, strengthening personal responsibility, and creating enabling environments are crucial. The role of community role models and leadership is particularly salient: Klaces Village, for example, showed more active engagement in clean-ups and informal recycling, coinciding with the presence of a local waste group. Such

grassroots initiatives can help bridge the attitude—behavior gap by generating peer influence and shared accountability.

Addressing the KAP dynamics thus requires an integrated, multisectoral strategy that improves knowledge access, nurtures positive environmental attitudes, and removes practical barriers through inclusive infrastructure, targeted incentives, and local regulation.

Comparison with regional and global studies

The patterns identified in Kampung Laut closely mirror broader trends observed in other mangrove-influenced coastal regions across Southeast Asia and beyond. Studies from the Philippines and Vietnam, for example, have reported similar profiles of plastic pollution dominated by low-value, single-use plastics such as polypropylene (PP) and low-density polyethylene (LDPE), largely originating from household consumption, small-scale fisheries, and aquaculture (Abreo et al. 2020; Thao et al. 2023). These polymers are lightweight, inexpensive, and widely used, making them pervasive in rural coastal economies.

At a global level, mangrove ecosystems have consistently been described as effective yet problematic "plastic traps" due to their complex root systems and tidal hydrodynamics (Martin et al. 2019). Research in Sri Lanka confirms that mangroves capture both macroplastics and microplastics, which accumulate in sediments and detrital layers, threatening benthic organisms and increasing the risk of trophic transfer and bioaccumulation (Jayapala et al. 2024). These findings underscore the ecological urgency of preventing plastic entry into mangrove systems rather than relying on their capacity for passive retention.

Community responses to plastic pollution, including the knowledge—behavior gap identified in Kampung Laut, are likewise a global phenomenon. Jambeck et al. (2015) noted that even when awareness is high, behavior change often stalls due to systemic constraints such as inadequate infrastructure, limited economic options, and weak regulatory enforcement. This study's Structural Equation Modeling (SEM) reinforces that while knowledge fosters positive environmental attitudes, actual behavioral transformation is hindered by structural and contextual barriers.

Consequently, the policy implications derived from Kampung Laut align with global best practices: effective plastic waste governance in coastal zones must integrate education, infrastructure development, and community participation. Tailoring these elements to local cultural and socio-economic contexts—through approaches such as incentive-based collection systems, eco-brick initiatives, or social enterprises–can promote sustained behavioral change and reduce plastic leakage into marine and estuarine systems (Kumar et al. 2021).

By situating the Kampung Laut findings within this broader discourse, the study contributes empirical support to the argument that successful plastic management in vulnerable ecosystems depends on context-sensitive, community-driven, and multi-level governance strategies.

Policy implications for mangrove-based communities

The findings from Kampung Laut highlight the urgent need for integrated, community-responsive strategies to manage plastic waste in mangrove-influenced coastal areas. The predominance of low-value, single-use plastics and the persistence of informal disposal methods suggest that interventions must move beyond awareness campaigns to confront the underlying socio-economic and infrastructural constraints that perpetuate pollution.

First, strengthening local waste infrastructure is essential, particularly in geographically isolated villages with limited or no access to municipal waste services. Low-cost, decentralized solutions—such as community-managed drop-off sites, boat-based collection systems, or floating bins tailored for tidal environments—can offer immediate relief. These efforts should be complemented by upstream interventions, including policies that encourage material substitution (e.g., biodegradable packaging) and plastic use reduction in fisheries and trade sectors.

Second, educational initiatives must shift focus from simple knowledge dissemination to fostering behavioral change. School-based programs, peer-led campaigns, and culturally grounded messages—such as those drawn from religious or traditional narratives—can be powerful drivers of normative shifts. Given their central roles in household management and intergenerational transmission of values, empowering women and youth as environmental change agents should be prioritized.

Third, institutional mechanisms must be adaptive and participatory. Locally enacted regulations (*Peraturan Desa*) on waste segregation and disposal can be made more effective through community monitoring and incentive-based compliance schemes. Pilot partnerships with NGOs or private-sector actors—such as waste banks, eco-brick producers, or plastic-for-goods exchanges—can stimulate circular economy models that align ecological goals with livelihood generation.

Importantly, mangrove ecosystems should not be treated merely as passive recipients of pollution, but as active components of coastal waste dynamics. In Kampung Laut, mangrove forests function both as physical traps for plastic debris and as ecological victims of chronic contamination. Accumulated plastics smother pneumatophores, inhibit seedling regeneration, and introduce toxic compounds into the substrate and water column—thereby compromising essential functions such as shoreline stabilization, carbon sequestration, and nursery provisioning for marine life (Martin et al. 2019; Jayapala et al. 2024). This dual role—as both buffer and casualty—demands that plastic waste removal and ongoing protection be explicitly integrated into mangrove conservation and restoration efforts.

Sustainable waste governance in mangrove-based communities thus requires a hybrid approach—one that blends technological innovation, behavioral transformation, and institutional support, grounded in local socio-ecological realities while aligned with broader regional and global frameworks. Such alignment is critical to maintaining the ecological resilience of coastal systems and safeguarding the livelihoods of communities who depend on mangrove services.

In conclusion, this study presents an integrated assessment of plastic waste and community perceptions in the mangrove-influenced villages of Kampung Laut, Cilacap.

The dominant waste types—polypropylene, polyethylene, and PET—mainly stem from household use and fishing activities. Despite relatively high environmental awareness, behavioral change is limited due to low education, limited income, and poor infrastructure. Structural Equation Modeling reveals that attitudes mediate the link between knowledge and behavior, echoing patterns seen in other Southeast Asian coastal areas. These results highlight the urgent need for context-specific interventions that combine improved infrastructure, behavioral education, and localized regulations. Strengthening social capital and utilizing existing community networks are vital to ensure long-term success. Furthermore, integrating plastic management with mangrove conservation efforts is crucial for protecting ecosystem services and building community resilience. The study offers practical guidance for policymakers to design inclusive, ecologically grounded strategies for plastic waste governance in vulnerable coastal regions.

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