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Research Article

Initial Screening of Halophilic Plastic-Degrading Bacteria from Mangrove Water and Sediment in Pekalongan, Indonesia

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Abstract

Microplastic pollution in tropical mangrove ecosystems represents an increasing environmental concern, particularly in coastal regions such as Pekalongan, Indonesia, where industrial and residential activities contribute substantially to plastic waste. This study aimed to isolate and preliminarily screen halophilic bacteria from mangrove sediments and seawater collected from a plastic-impacted coastal area. Using mineral salt medium (MSM) supplemented with polyethylene glycol (PEG), six bacterial strains were obtained and evaluated for their potential to interact with polyethylene (PE) and polypropylene (PP) on the basis of gravimetric weight loss measurements. Among the isolates, *Halomonas Cupida* A1, *Marinobacter nauticus* A6.3, and *Marinobacter nauticus* SD5.2 exhibited relatively greater plastic-associated weight loss during the 15-day incubation period. The greatest weight loss was observed for polyethylene with isolate SD5.2 (1.0%), whereas isolate A1 resulted in the greatest amount of polypropylene-associated weight loss (0.301%). Although the observed reductions were modest and derived from preliminary screening, gravimetric weight loss alone does not confirm plastic biodegradation. Therefore, the results indicate that only potential indigenous halophilic bacteria are involved in plastic-associated processes in saline mangrove environments. This study provides baseline data for future investigations incorporating molecular, enzymatic, and surface characterization analyses to further elucidate plastic biodegradation mechanisms and enhance bioremediation applications in coastal ecosystems.

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Introduction

Plastic pollution is among the most critical environmental concerns of the modern era, with increasing quantities of plastic waste entering aquatic ecosystems worldwide. The persistent potential for bioaccumulation and widespread distribution of microplastics in marine, freshwater, and terrestrial ecosystems make them a major concern among the many types of plastic pollution (Choong et al., 2021; Christensen et al., 2020). Microplastics pose a threat to human health since they are difficult to eradicate once they are in the environment and because many kinds of organisms can inadvertently ingest them (Xie et al., 2021). PE and PP are synthetic polymers widely used in packaging, textiles, and disposable products and are highly resistant to microbial degradation (Friedrich, 2024). Consequently, these polymers tend to persist in the environment for extended periods, which contributes significantly to the accumulation of these compounds in aquatic environments over time.

As natural barriers to coastal erosion, carbon sinks, and nurseries for marine organisms, mangrove ecosystems

are highly valuable coastal wetland habitats. Mangrove and lagoon ecosystems in Pekalongan City, Central Java, Indonesia, are impacted by microplastics and other pollutants because of the city's urbanization, aquaculture, textile and batik industries, and other anthropogenic activities (Maharani et al., 2023). Previous studies have reported heavy metal contamination in the coastal waters of Pekalongan, particularly that of chromium (Cr) and copper (Cu), with elevated Cr concentrations observed in river and estuarine areas influenced by industrial activities (Ismanto et al., 2024). These contaminants weaken the ability of mangrove ecosystems to withstand the effects of climate change, endanger biodiversity, and disturb ecological functioning.

Microbial biodegradation has emerged as an environmentally friendly alternative to physical and chemical approaches for plastic removal, which are frequently expensive and ineffective, particularly for microplastic contamination. Because some species produce hydrolytic and oxidative enzymes, including cutinase, esterase, and lipase, certain bacterial genera, such as *Marinobacter* and *Halomonas*, have been recognized as possible plastic degraders (Khandare et al., 2022; Sahu et al., 2023). More broadly, microbial bioremediation has also been explored as a biological approach for mitigating other contaminants in coastal environments, including heavy metals associated with industrial activities. In Pekalongan, for example, the presence of heavy metal contaminants, particularly Cr and Cu, has been documented in coastal waters affected by industrial activities (Maharani et al., 2023). Bioremediation projects along coastlines could benefit greatly from the use of these halophilic bacteria because of their exceptional adaptation to saline habitats, such as mangroves. Research on native bacterial strains from Indonesian mangrove habitats is limited, particularly on their interactions with commonly prevalent polymers such as polyethylene (PE) and polypropylene (PP), although studies conducted elsewhere have documented the microbial degradation of plastics. The development of site specific, sustainable bioremediation techniques requires a thorough understanding of the microorganisms potentially associated with plastic transformation by indigenous bacteria.

The primary objective of this study was to isolate and preliminarily screen halophilic bacteria from mangrove sediments and seawater in Pekalongan Lagoon for their potential to interact with PE and PP microplastics under controlled laboratory conditions. This study contributes baseline information to the growing field of marine microbial biotechnology and the identification of indigenous bacterial isolates with potential plastic-associated activity.

Materials and methods

1) Sampling

The sampling took place in the mangrove and lagoon regions of Pekalongan City, Central Java, Indonesia, specifically at the coordinates 109.6601–109.6759 east and -6.86051–-6.85175 south. Table 1 provides an explanation of the sampling sites. The area exhibits significant human activity, particularly in the batik and textile sectors. A total of 10 sampling points were identified throughout the lagoon area, encompassing former aquaculture ponds, mangrove patches, and regions adjacent to human settlements. Seawater samples of 1 liter and surface sediment samples of 100 grams were meticulously collected from each site using sterile equipment. The samples were promptly preserved at −4°C and transported to the laboratory for subsequent analysis.

2) Bacterial isolation and screening

To isolate bacteria with potential plastic-associated activity, 1 mL of each water sample and 1 g of sediment sample were introduced into mineral salt medium (MSM) agar supplemented with 2% polyethylene glycol (PEG) as the sole carbon source.

PEG was used as a water-soluble and structurally simpler polymeric carbon source for preliminary enrichment. Growth on PEG was considered only an initial screening criterion and was not interpreted as evidence of PE or PP biodegradation. The plates were maintained at room temperature (28–30°C) for a duration of 48 hours. Colonies that exhibited growth under PEG-supplemented conditions were selected as candidate isolates for further screening.

Table 1 Sampling site characteristics

Sampling point	Longitude	Latitude	Area representation
1	109.6601	-6.85175	Close to the river mouth and is a former pond location
2	109.6638	-6.85417	Open lagoon area and there is a little mangrove vegetation
3	109.6693	-6.85563	Close to the pier and is a former shrimp farm
4	109.6723	-6.85699	Residents' houses that have begun to sink
5	109.6759	-6.85826	Crematorium which is actively used
6	109.6745	-6.86051	Close to the sea embankment
7	109.6722	-6.85925	Close to the reclamation pier
8	109.6666	-6.85819	Near river mouth
9	109.6651	-6.85818	Used to be a pond
10	109.6603	-6.85486	Near to the ponds, mangrove vegetation and fishing spot in Pekalongan Regency

The MSM consisted of KH_2PO_4 (0.01 g), K_2SO_4 (0.01 g), $Mg_2SO_4 \cdot 7H_2O$ (0.01 g), $(NH_4)_2SO_4$ (0.1 g), and agar (1 g) for every 100 mL prepared. The isolation of these bacteria from mangrove sediments in a saline coastal environment suggests that they are adapted to conditions characterized by elevated salinity. However, their specific salt requirements and tolerance ranges were not evaluated in this study. Further investigation of bacterial growth and plastic-associated activity across different salinity levels is therefore necessary to determine whether their activity can be maintained under the fluctuating salinity conditions typical of mangrove ecosystems.

3) Morphological and gram staining characterization

Purified colonies were characterized on the basis of colony morphology (color, shape, margin, and elevation) and cell morphology through Gram staining. Microscopic examination was performed to identify the cell shape and Gram reaction.

4) Molecular identification

The selected isolates were submitted to a certified laboratory for 16S rRNA gene sequencing. Genomic DNA was extracted using a commercial bacterial genomic DNA extraction kit. Amplification of the 16S rRNA gene was performed utilizing the universal primers 27F (5′-AGAGTTTGATCCTGGCTCAG-3′) and 1492R (5′-GGTTACCTTGTTACGACTT-3′) (Zhang et al., 2023). The PCR products were confirmed via 1% agarose gel electrophoresis, followed by purification and sequencing with a capillary electrophoresis system. Analysis of sequence homology was conducted utilizing the NCBI BLAST tool, while the construction of a phylogenetic tree was performed through the neighbor-joining method in MEGA 7 software (Khandare et al., 2022).

5) Microplastic biodegradation assay

Pellets of PE and PP with a particle size of less than 5 mm were utilized as the target microplastics. The pellets were sterilized using 70% ethanol, followed by UV irradiation for 30 minutes, and subsequently oven-dried at 60°C for one hour. In each assay, 100 mL of MSM, enhanced with 0.2% PE or PP pellets, was inoculated with 1 mL of overnight bacterial culture. The cultures were incubated on a rotary shaker at 29°C and 120 rpm for 15 days. Bacterial growth was monitored by measuring the optical density at 600 nm (OD_{600}). The experiment was carried out in two replicates.

6) Observing bacterial growth

Bacterial growth was monitored by measuring optical density (OD_{600}) using a Shimadzu UV-1280 spectrophotometer at three-day intervals over a 15-day incubation period (Nademo et al., 2023). Bacteria-free control flasks were used to establish the baseline for the OD_{600} measurements. These controls were used for bacterial growth monitoring and were not included as abiotic controls in the subsequent gravimetric weight loss assay.

7) Gravimetric analysis of microplastic weight loss

After incubation, the microplastic particles were recovered from the mineral salt medium by filtration, rinsed with 70% ethanol, and dried in a desiccator. The initial dry mass and postincubation dry mass of the microplastic particles were measured using an analytical balance with a precision of 0.0001 g. The percentage of weight loss was calculated using the following Eq.1.

$$\%\ \text{Weight loss} = ((W_i - W_f)/W_i) \times 100\% \qquad \text{(Eq.1)}$$

Where;

W_i = initial dry weight of the microplastics (g)

W_f = final dry weight of the microplastic after incubation (g)

However, gravimetric weight loss alone does not confirm biodegradation, as changes in mass may also result from nonbiological processes, such as physical fragmentation, the leaching of polymer additives, or biofilm adhesion and associated material removal. Because an abiotic control was not included in the gravimetric assay, the contribution of nonbiological processes to the observed weight loss could not be independently quantified.

Results and discussion

1) Bacterial isolation and identification

Six bacterial isolates with distinct colony morphologies were isolated and purified using marine salt agar medium supplemented with 2% PEG (Table 2). Growth under PEG-supplemented conditions was used only as an initial enrichment and screening step and did not confirm the ability of the isolates to metabolize PE or PP (Azizi et al., 2024). The colonies were predominantly round with different edges (flat, irregular, and wavy) and colors (yellow, orange, white milk, and cream white). Most of the isolates were gram-negative bacilli, with only two gram-positive isolates (SD.1.3 and SD.5.1). Gram staining revealed differences in peptide-glycan content between gram-positive (thicker layer) and gram-negative (thinner layer) bacteria.

The most active isolates were identified by 16S rRNA gene sequencing as *Halomonas Cupida* strain A.1 (GenBank accession no. PZ575774), *Marinobacter nauticus* strain A.6.3 (GenBank accession no. PZ575775), and *Marinobacter nauticus* strain SD.5.2 (GenBank accession no. PZ575776). The 16S rRNA gene identification results revealed that three isolates had more than 99% sequence similarity. In accordance with the

standards published by Janda and Abbott (2007), the criteria used for species identification include examining sequence similarity, with a minimum threshold of 99% and an ideal level of 99.5%. Percentages of 97% to 98% are typically used to obtain genus-level identification. Figure 1 shows the results of the phylogenetic analysis.

2) Polyethylene-associated weight loss

The polyethylene-associated mass loss observed for each isolate after 15 days of incubation is presented in Figure 2. Among the tested strains, *Halomonas Cupida* A.1 resulted in a polyethylene weight reduction of 0.75%, whereas *Marinobacter nauticus* A.6.3 and *Marinobacter nauticus* SD.5.2 resulted in higher values of 0.98% and 1%, respectively. All experiments were conducted in duplicate over a 15-day incubation period under saline conditions.

Changes in the bacterial optical density (OD_{600}) during incubation are shown in Figure 3. Because measurements were collected at three-day intervals, the data were interpreted as changes in optical density rather than as complete bacterial growth curves. Optical density (OD) measurements indicated that compared with the control medium, several isolates demonstrated enhanced growth in the presence of polyethylene, particularly during the early incubation period (days 0–3). In some isolates, such as A.6.3 and SD.5.2, polyethylene-associated weight loss was observed despite a decrease in cell density during later incubation stages, suggesting that plastic-associated processes may persist beyond active cell proliferation (Novitasari et al., 2023; Seo et al., 2023).

Polyethylene is a synthetic polymer composed of long chains of repeating ethylene units ($–CH_2–CH_2–$) and is characterized by a chemically inert hydrocarbon backbone lacking readily accessible functional groups. This structural stability renders polyethylene highly resistant to biological degradation under natural conditions (Friedrich, 2024). Consequently, any observed PE weight reduction in microbial systems must be interpreted with caution, particularly when derived from gravimetric screening methods.

In the present study, several halophilic bacterial isolates—most notably *Halomonas Cupida* and *Marinobacter* nauticus—exhibited measurable PE-associated weight loss. Although the recorded percentages were relatively modest, these findings suggest the presence of preliminary interactions between indigenous halophilic bacteria and PE under saline conditions. Similar outcomes have been reported in earlier studies, where weight loss during initial screening phases was attributed to surface oxidation, biofilm formation, or partial enzymatic modification rather than complete polymer mineralization (Sarsan et al., 2024). The proposed mechanisms underlying PE transformation in microbial systems generally involve oxidative processes mediated by free radicals or extracellular enzymes. Such oxidative reactions may introduce carbonyl or carboxyl functional groups into the polymer backbone, thereby increasing surface hydrophilicity and increasing susceptibility to subsequent microbial colonization and modification. Enzymes, including esterases and cutinases, have been implicated in PE-associated transformations, particularly in halophilic and marine bacteria such as *Halomonas* and *Marinobacter* species (Giangeri et al., 2023; Khandare et al., 2022; Sahu et al., 2023).

One possible explanation is residual extracellular enzymatic activity in the culture medium after cell growth has declined. However, this mechanism was not directly assessed in the present study. Previous studies have demonstrated that extracellular enzymes can retain catalytic activity for limited periods after cell death, depending on environmental conditions and enzyme stability (Seo et al., 2023). Nevertheless, in the absence of molecular, spectroscopic, or chemical structure analyses, it remains uncertain whether the observed weight reduction reflects true polymer chain scission.

3) Polypropylene-associated weight loss

Changes in bacterial optical density (OD_{600}) during incubation are shown in Figure 4. The observed fluctuations indicate changes in cell density over time; however, the sampling frequency was insufficient to resolve distinct growth phases reliably. During the first three days of incubation, most isolates exhibited clear exponential growth in PE-containing medium, as reflected by an increase in OD on day 3. This trend indicates that the isolates remained physiologically active and were able to adapt to the presence of polypropylene in the growth medium.

Polypropylene-associated weight loss after 15 days of incubation is summarized in Figure 5. Among the tested isolates, *Marinobacter nauticus* A.6.3 resulted in a decrease in the weight of polypropylene by 0.202%, even when the culture had entered the decline phase by the end of the incubation period. Interestingly, isolate A.1 showed relatively low cell growth but produced the greatest amount of polypropylene-associated weight loss (0.301%). In contrast, the bacterial growth of isolate SD1.3 remained relatively stable throughout the experiment, yet only a limited degree of decrease in the weight of PE was observed.

Table 2 Bacterial isolation results

Isolate	Colony morphology			Cell morphology		
	Color	Shape	Edge	Color	Shape	Gram
A.1	yellow	circular	flat	red	bacillus	negative
A.6.3	yellow	circular	irregular	red	coccus	negative
SD.1.2	orange	circular	wavy	red	bacillus	negative
SD.1.3	white milk	circular	irregular	purple	bacillus	positive
SD.5.1	cream	circular	flat	purple	coccus	positive
SD.5.2	white	circular	flat	red	bacillus	negative

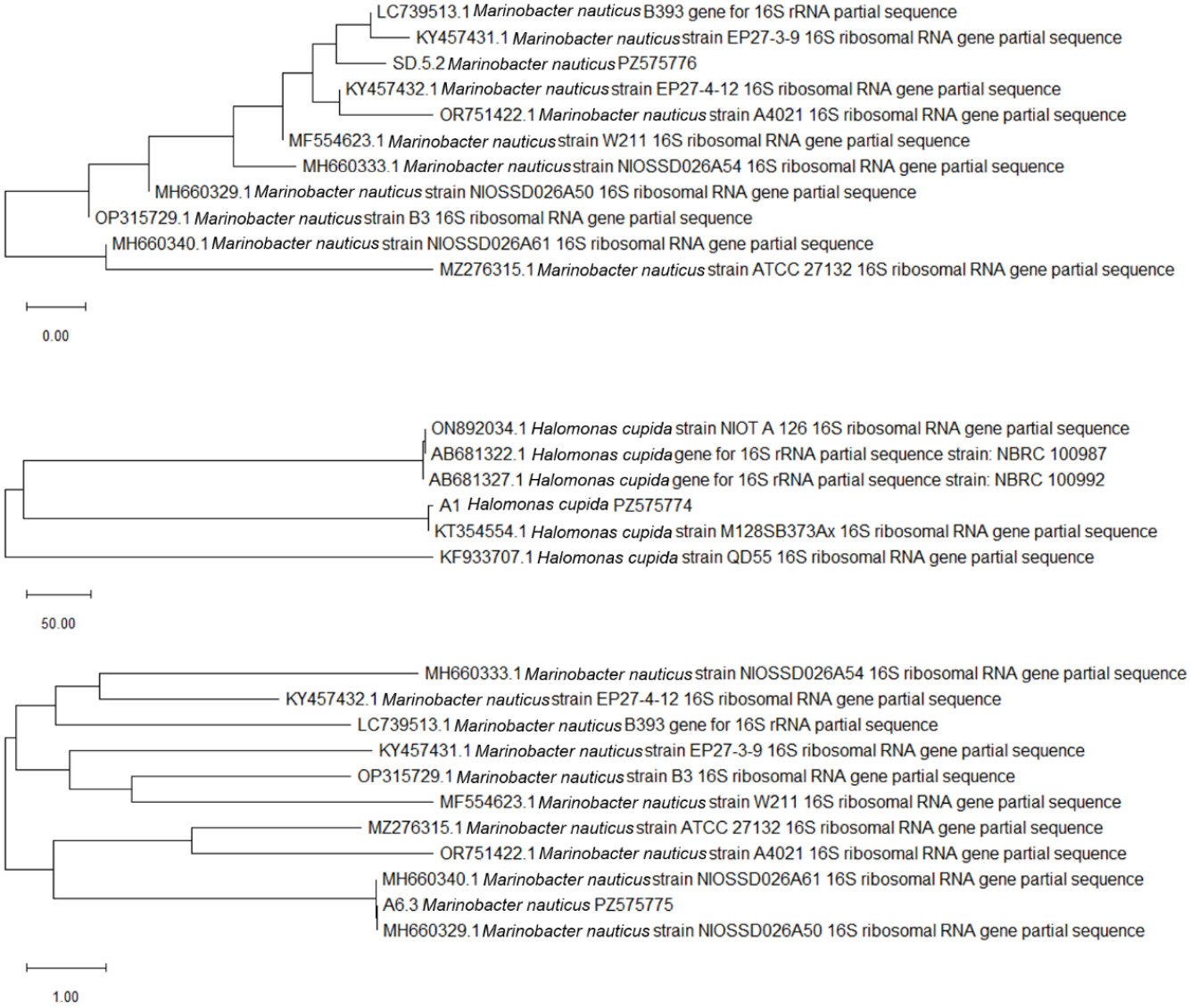


Figure 1 Phylogenetic tree based on 16S rRNA gene sequences showing the relationships of isolates A.1 (*Halomonas Cupida*), A.6.3 (*Marinobacter nauticus*), and SD.5.2 (*Marinobacter nauticus*) with closely related reference strains. The corresponding GenBank accession numbers of the isolates are PZ575774, PZ575775, and PZ575776.

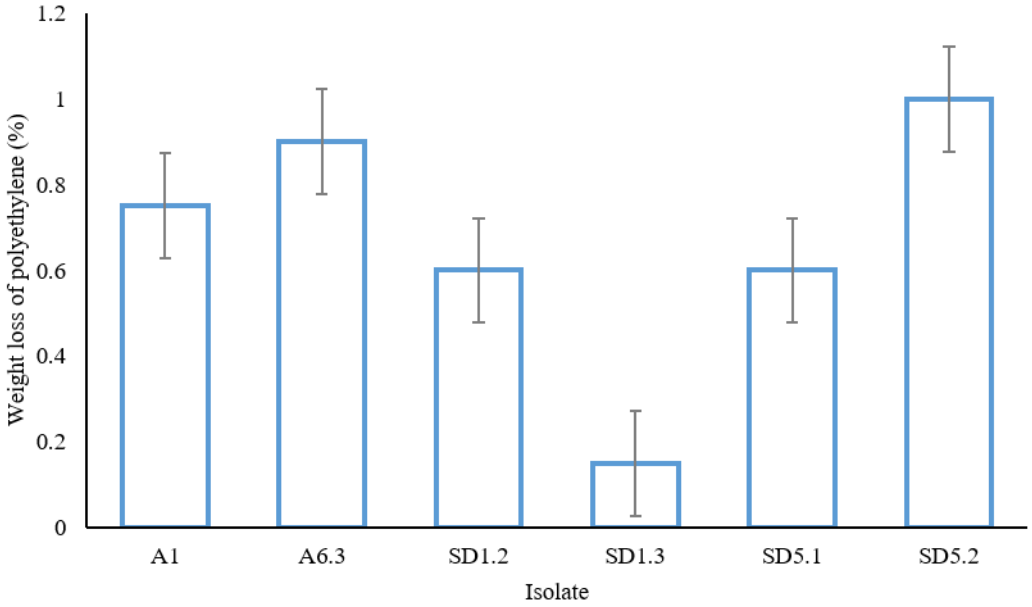


Figure 2 Percent weight loss of the PE pellets after 15 days of incubation with halophilic bacterial isolates. The error bars represent the standard error (n = 2).

Several other isolates (SD.1.2, SD.5.1, and SD.5.2) also demonstrated measurable PE-associated weight loss, ranging from 0.063% to 0.197%, despite a decrease in cell density during the later stages of incubation. This observation suggests that the interaction between PP particles may persist even when active cell growth declines. One possible explanation is the continued activity of extracellular enzymes remaining in the medium after cell lysis, nutrient limitation, or the accumulation of inhibitory metabolites, as previously described (Novitasari et al., 2023). Overall, these results indicate that bacterial growth patterns do not directly correspond to the extent of PP-associated weight loss.

Molecular identification of selected bacterial isolates was performed using 16S rRNA gene sequencing. Isolates A.1, A.6.3, and SD.5.2, which exhibited greater plastic-associated weight reduction during the screening assays, were subjected to phylogenetic analysis. Sequence comparison revealed that isolate A.1 (GenBank accession no. MG309470.1) was 100% similar to *Halomonas cupida* (GenBank accession no. CP000514.1), whereas isolates A.6.3 and SD.5.2 were more than 99% similar to *Marinobacter nauticus*. According to the criteria proposed by Janda and Abbott (2007), sequence similarity values above 99% support species-level identification, whereas values between 97% and 98% generally indicate genus-level affiliation. On the basis of these criteria, the three isolates were confidently assigned to their respective species.

Polypropylene is a synthetic polymer composed of repeating propylene units (–CH_2–$CH(CH_3)$–) and has a highly hydrophobic backbone with limited reactive functional groups, making it particularly resistant to biological degradation (Friedrich, 2024). For this reason, the polypropylene-associated weight loss observed in microbial systems should be interpreted as an early indication of plastic–microbe interactions rather than as direct evidence of complete polymer breakdown.

Previous studies suggest that microbial interactions with PP may involve oxidative processes driven by free radicals or extracellular enzymes, which can introduce carbonyl or carboxyl functional groups into the polymer structure and increase its susceptibility to further modification (Sarsan et al., 2024). Halophilic and marine bacteria, including species of *Halomonas* and *Marinobacter*, have been reported to possess enzymatic systems capable of supporting such oxidative transformations (Giangeri et al., 2023; Sahu et al., 2023).

In the present study, the continued observation of PP-associated weight loss even in cultures with reduced cell density supports the possibility that extracellular enzymes remain active in the medium after bacterial growth has declined. However, without direct spectroscopic or molecular evidence, the nature and extent of polymer modification cannot be confirmed. Future work should therefore include surface characterization, chemical structure analysis, and targeted enzyme assays to clarify the mechanisms underlying PP transformation.

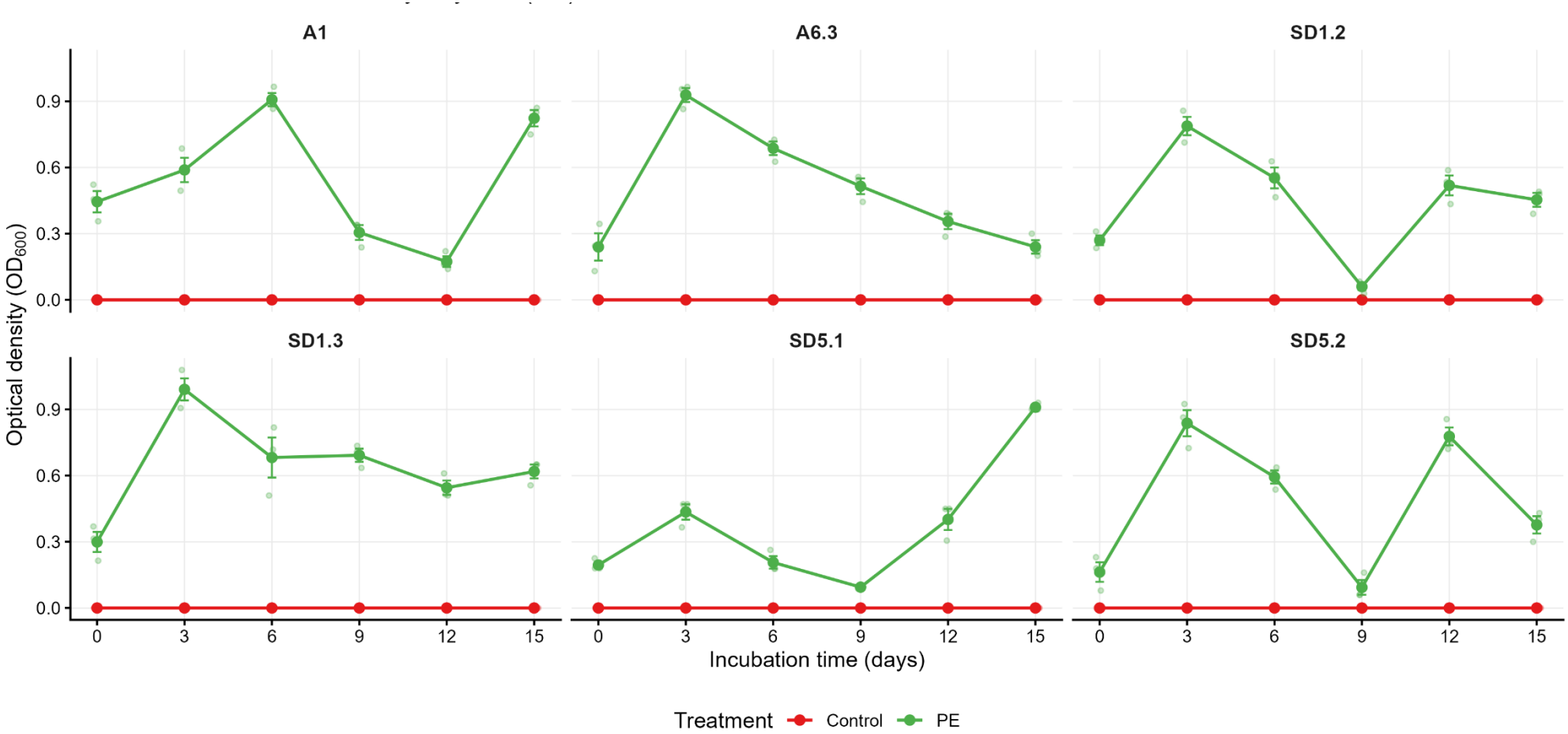


Figure 3 Changes in bacterial optical density (OD_{600}) during incubation with polyethylene (PE) microplastics. Data are presented as the mean ± standard error (SE) of two replicates (n = 2) measured at 0, 3, 6, 9, 12, and 15 days. The control represents the corresponding bacterial culture without PE microplastics.

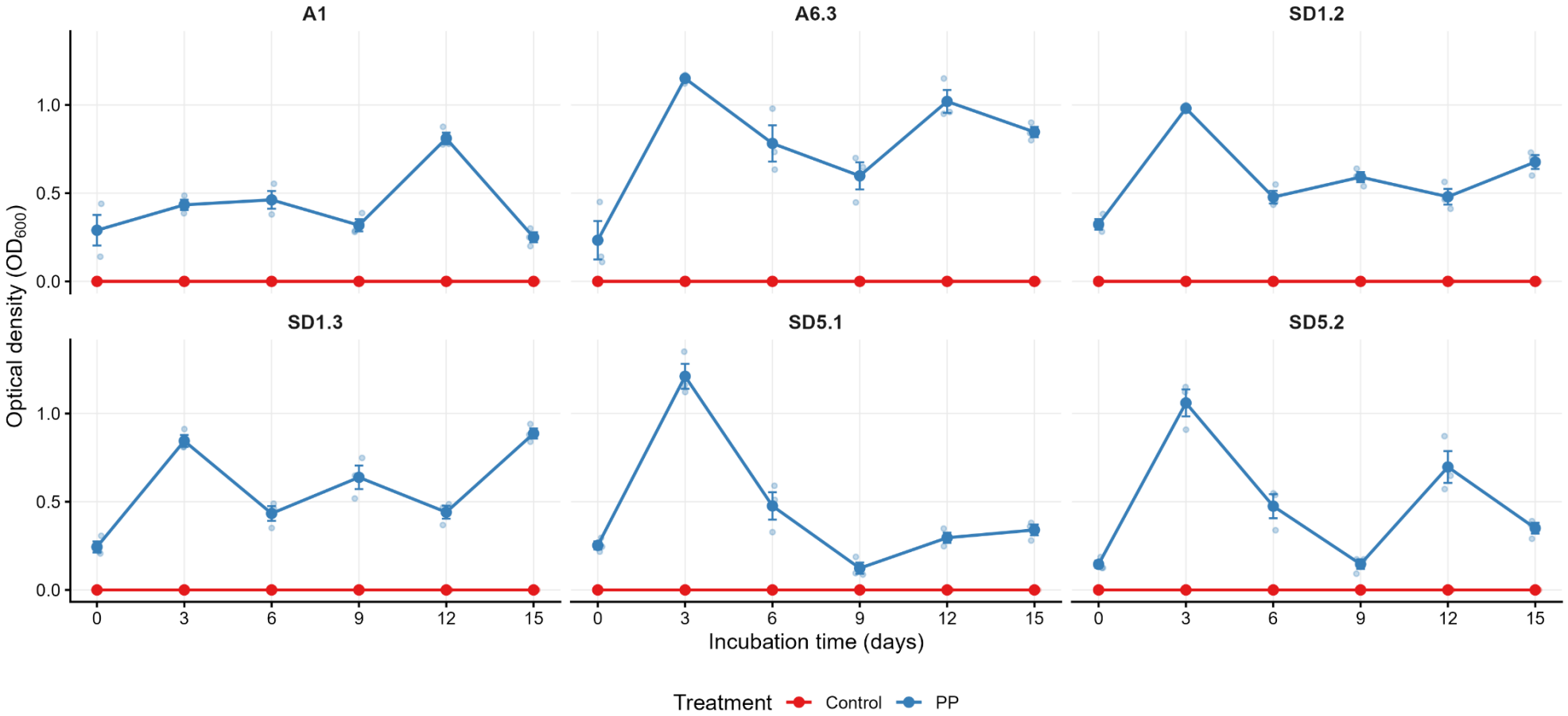


Figure 4 Changes in bacterial optical density (OD_{600}) during incubation with polyethylene (PP) microplastics. Data are presented as the mean ± standard error (SE) of two replicates (n = 2) measured at 0, 3, 6, 9, 12, and 15 days. The control represents the corresponding bacterial culture without PP microplastics.

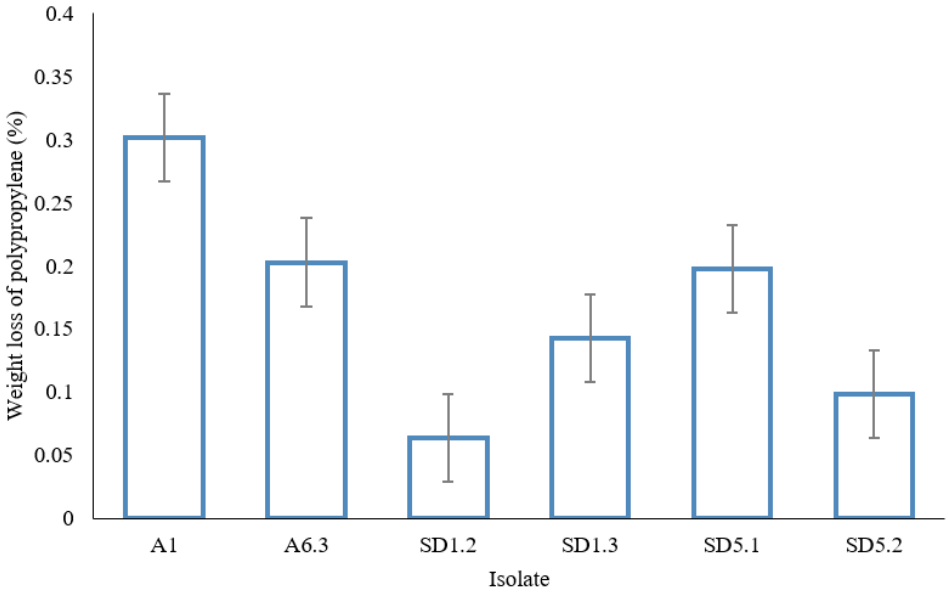


Figure 5 Percent weight loss of PP after 15 days of incubation with halophilic bacterial isolates. Weight reduction was determined using a gravimetric method as part of an initial screening assay. The error bars represent the standard error (n = 2).

4) Comparison with previous studies

Both PE and PP are among the most prevalent synthetic polymers and are frequently utilized in plastic bags, food packaging, disposable containers, and medical items. Owing to their hydrophobic characteristics and stable molecular configuration, both polymers exhibit significant resistance to microbial destruction and are likely to endure in the environment for prolonged durations (Friedrich, 2024).

Various studies in diverse geographic regions have investigated the ability of various bacterial strains to degrade plastic polymers. Table 3 encapsulates pertinent material about the microbial degradation of PE, PP, and other polymers. In Zi-Ni Town, Zhangzhou, China, Gordonia, a gram-positive bacillus, degraded polystyrene (PS) by 4.69% over 30 days, but *Novosphingobium* and *Rhodococcus* ruber demonstrated lower degradation rates of 2.66% and 0.8%, respectively (Liu et al., 2023). In Shenzhen, China, *Hyphomicrobium* sp. and *Pandoraea* sp. degraded up to 9.20% of PS within 30 days (Ren & Ni, 2023). In the mangrove habitats of Peninsular Malaysia, *Bacillus cereus* destroyed polyethylene by 1.6%, while *Sporosarcina globispora* degraded PP by 11–12% over a period of 40 days (Auta et al., 2017; Helen et al., 2017). *Rhodococcus* sp. strain 36 and *Bacillus sp*. strain 27, both obtained from the same area, degraded 6.4% and 4.0% of PP, respectively, over a comparable duration (Auta et al., 2018). Marine microorganisms, such as *Halomonas titanicae* and *Pseudoalteromonas caenipelagi*, have exhibited notable activity. *H. titanicae* decomposed 3.8% of PS after 30 days, but *P. caenipelagi*, sourced from Surabaya, Indonesia, destroyed 8.73% of polyethylene terephthalate (PET) after 40 days (Lv et al., 2018; Novitasari et al., 2023). Various marine bacteria, such as *Marinobacter* and *Halomonas* sp., have demonstrated the ability to degrade LDPE by 1.68–1.72%, resulting in noticeable structural alterations, including surface erosion, biofilm development, and weight reduction (Delacuvellerie et al., 2019; Khandare et al., 2022). Degradation processes are generally mediated by oxidative or hydrolytic enzymes, such as esterase, cutinase, laccase, and lipase, which decompose hydrocarbon chains and produce oxidized functional groups (e.g., carbonyls and carboxyls) that are more susceptible to microbial degradation (Sarsan et al., 2024).

The current investigation revealed low reduction rates over a 15-day incubation period when individual bacterial strains were used. Although these reductions were modest, they are consistent with the preliminary nature of the present screening study. Previous studies reporting higher degradation efficiencies have typically employed longer incubation periods (30–90 days), pr-treated polymers, microbial consortia, or complementary physicochemical characterization techniques such as FTIR and SEM. Therefore, direct comparison with the present study should be made cautiously because this work was designed as an initial screening using single bacterial isolates under short-term incubation conditions.

Importantly, plastic biodegradation cannot be confirmed by gravimetric weight loss alone. The observed mass reduction may result from biological and nonbiological processes, including surface modification, physical fragmentation, additive leaching, or biofilm-associated material removal. Because the present study did not include complementary physicochemical or chemical analyses, such as FTIR, SEM, or GC–MS, the observed weight loss cannot be used to confirm polymer chain scission or mineralization.

Table 3 Previous studies on the microbial degradation of plastic

Location	Microbes	Microbial characteristics	Plastic type	Incubation period	Weight reduction (%)	Reference
Zi-Ni Town, Zhangzhou, China	*Gordonia*	Shape: Bacillus Grams: Positive	PS	30 days	4.69% ± 1.91%	Liu et al. (2023)
	Novosphingobium	Grams: Negative Shape: Rod			2.66% ± 0.50%	
	Rhodococcus ruber	Grams: Positive Shape: cocci			0.8%	
	Exiguobacterium sp	Grams: Positive Shape: Rod short			± 0.4%	
Mangrove Ecosystems, Peninsular Malaysia	*Bacillus cereus*	Grams: Positive Shape: Rod	PE	40 Days	1.6%	Auta et al. (2017)
Shenzhen, China	*Hyphomicrobium* sp.	Grams: Negative Shape: Rod or pleomorphic	PS	30 days	9.20%	Ren and Ni (2023)
	Pandoraea sp.	Grams: Negative Shape: Rod	PS	30 days	9.20%	Ren and Ni (2023)
Na	*Enterobacter asburiae YT1*	Grams: Negative Shape: Rod	PE films	60 days	6.1 ± 0.3%	Yang et al. (2014)
	Bacillus sp. *YP1*	Grams: Positive Shape: Rod			10.7 ± 0.2%	
Gulf Of Mannar, India	*Arthrobacter* sp.	Grams: Positive Form: Pleomorphic (changes from stem to cocci)	HDPE	30 days	12.23 ± 0.6%	Balasubramanian et al. (2010)
	Pseudomonas sp.,	Grams: Negative Shape: Rod			15.18± 0.7%	
Sand mangrove white, Surabaya Indonesia	*Pseudoalteromonas caenipelagi*	Grams: Negative Shape: Rod	polyethylene terephthalate *(PET)*	40 days	8.73%	Novitasari et al. (2023)
Marine bacteria, location not applicable	*Halomonas* sp.	Grams: Negative Shape: bacillus	LDPE	90 days	1,72%	Khandare et al. (2022)
	Marinobacter	Grams: Negative Shape: coccus			1,68%	

Table 3 Previous studies on the microbial degradation of plastic *(Continued)*

Location	Microbes	Microbial characteristics	Plastic type	Incubation period	Weight reduction (%)	Reference
Marine bacteria, location not applicable	*Halomonas titanicae*	Grams: Negative Shape: Rod	PS	30 days	3,80%	Lv et al. (2018)
Mangrove ecosystems and lagoon, Pekalongan	*Halomonas cupida A.1*	Grams: Negative Shape: bacillus	PE	15 days	0.75%	This study
	Marinobacter nauticus A.6.3	Grams: Negative Shape: coccus			0.98%	
	Marinobacter nauticus SD. 5.2	Grams: Negative Shape: coccus			1%	
Mangrove ecosystems and lagoon, Pekalongan	*Halomonas cupida A.1*	Grams: Negative Shape: bacillus	PP	15 days	0.301%	This study
	Marinobacter nauticus A.6.3	Grams: Negative Shape: coccus			0.202%	
	Marinobacter nauticus SD. 5.2	Grams: Negative Shape: coccus			0.098%	

Accordingly, the results should be interpreted as preliminary evidence of plastic-associated activity rather than definitive evidence of biodegradation. Further studies incorporating longer incubation periods, surface characterization, chemical analysis, and targeted enzymatic assays are needed to verify the underlying degradation mechanisms.

Despite these limitations, this study provides baseline information on indigenous halophilic bacterial isolates obtained from a plastic-impacted tropical mangrove ecosystem in Indonesia. The isolation of *Halomonas cupida* and *Marinobacter nauticus* provides candidate strains for future mechanistic investigations, including enzyme characterization, strain optimization, and evaluation under environmentally relevant conditions.

Conclusions

This study successfully isolated and conducted an initial screening of indigenous halophilic bacteria from mangrove sediments and saline waters of the Pekalongan coastal lagoon to evaluate their potential interactions with PE and PP microplastics. Among the six isolates obtained, *Halomonas Cupida* A.1, *Marinobacter nauticus* A.6.3, and *Marinobacter nauticus* SD.5.2 consistently showed higher levels of plastic-associated weight reduction during the screening assays. After 15 days of incubation, isolate SD.5.2 resulted in the greatest PP-associated weight loss (1%), whereas isolate A.1 resulted in the greatest polypropylene-associated weight loss (0.301%). Although the observed weight reductions were relatively small and based on gravimetric measurements, they nonetheless point to early interactions between indigenous halophilic bacteria and highly recalcitrant plastic polymers under saline conditions. Importantly, the observed gravimetric weight loss should not be interpreted as definitive evidence of plastic biodegradation, as weight loss alone cannot distinguish biological degradation from abiotic processes, additive leaching, physical fragmentation, or other sources of mass variation.

Future studies should therefore move beyond preliminary screening and focus on confirming degradation mechanisms through detailed chemical, enzymatic, and surface characterization analyses. Enzyme activity assays and enzyme characterization should be conducted to investigate the biochemical processes potentially involved in plastic transformation. In parallel, cultivation conditions, including salinity, temperature, and nutrient availability, should be optimized. Cocultivation and mixed bacterial consortia should also be explored to assess whether interactions among microorganisms improve plastic transformation compared with that among individual strains. Furthermore, metagenomic analyses could be employed to identify functional genes potentially associated with plastic transformation and to provide deeper insights into the metabolic potential of these indigenous halophilic bacteria. Such approaches will be essential for distinguishing true biodegradation from other sources of gravimetric weight loss and for evaluating the potential of these isolates under environmentally relevant conditions. Overall, this study provides baseline evidence supporting the potential of native halophilic bacteria as biological resources for the development of environmentally friendly strategies to mitigate microplastic pollution in tropical coastal ecosystems.

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Data availability statement

All the data supporting the findings of this study are available within the paper.

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Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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