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Research Article

Microplastic contamination in the sediment and blood cockle (*Anadara granosa*) of the mangrove ecosystem of Can Gio, Ho Chi Minh City, Vietnam

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Abstract

Microplastic (MPs) pollution poses a significant threat to coastal ecosystems and marine food resources. The mangrove ecosystem of Can Gio (MEC), Ho Chi Minh City, Vietnam, a UNESCO Biosphere Reserve, is under increasing pressure from anthropogenic activities. This study aimed to quantify and characterize MPs contamination in sediments and the commercially important blood cockle (*Anadara granosa*) to assess the spatiotemporal distribution of pollution. The sediment and cockle samples were collected monthly from two zones with differing human impact levels, Dong Tranh River and Thanh An Island, between July and September 2024. MPs were extracted via density separation and their characteristics (shape, color, and polymer type) were analyzed using microscopy and Fourier-transform infrared spectroscopy. The number of MPs in sediment and cockles ranged from 0.20 to 2.60 MPs/g and 0.20 to 2.20 MPs/g, respectively, with no zone-specific and temporal-specific differences for both types of samples. Black and white MPs were predominant in sediment and cockle, accounting for 50-80% of the total MPs abundance. Fiber contributed to more than 50% of MPs forms, followed by fragments and films. Small-sized particles (<1 mm) were dominant in both samples throughout the two zones and all sampling times. The primary polymers in both sample matrices consisted of nylon, PET, and rayon. Our findings indicate that local anthropogenic pressure is a key driver of MPs distribution in the MEC. The contamination levels in the cockles highlight a potential pathway for human exposure to MPs, emphasizing the need to implement pollution management strategies in the region.

Introduction

Vietnam's plastic production rose from 7.8 million tons in 2017 to 8.3 million tons in 2018. Concurrently, the country generated 2.93 million tons of plastic waste annually, of which about 0.73 million tons were discharged to the marine environment (Truong *et al.*, 2023; WWF-Viet Nam, 2023). Vietnam is ranked fourth in the world for marine plastic pollution (Veettil *et al.*, 2023); Ho Chi Minh City (HCMC) is a major contributor to microplastic (MPs) pollution, particularly in the Saigon River environment (Truong *et al.*, 2023; WWF-Viet Nam, 2023). The mangrove ecosystem of Can Gio (MEC), a vital wildlife sanctuary in Vietnam and a biosphere reserve listed by UNESCO, supports a diverse range of aquatic life and serves as an important area for ecotourism and small-scale aquaculture, particularly in the farming of blood cockles (*Anadara granosa*). This species is cultivated in mudflats, estuarine waters, and along intertidal zones, where it serves as both an economic resource and an ecological indicator. The MEC is situated downstream of multiple waterways that flow through highly urbanized and industrialized areas of the HCMC. These water bodies carry significant quantities of MPs from upstream sources, making Can Gio's aquatic environment vulnerable to pollution (Nhon *et al.*, 2022; Dao *et al.*, 2023b).

Microplastics (MPs) are emerging pollutants with sizes ranging from 1 μm to 5 mm and originating from primary production or secondary production as they are degraded from larger plastics, which are insoluble in water (Frias and Nash, 2019). They are recognized as ubiquitous and persistent environmental pollutants, posing potential risks to ecosystems and biota. Recent studies have shown that MPs have been found in various components of the marine environment, including sediment (Bagheri *et al.*, 2020, 2024; Yazarloo *et al.*, 2024). Due to their small size, microplastics are often mistaken for food and have been ingested by a variety of marine organisms, including zooplankton (Frias *et al.*, 2014; Frias *et al.*, 2020; Langroudi *et al.*, 2024), wild-caught fish (Rummel *et al.*, 2016; Bhattacharjee *et al.*, 2023), etc., especially bivalve molluscs, including blood cockle *A. granosa*.

A. *granosa* are widely found throughout the Indo-Pacific region and are among the key species farmed in Southeast Asia (Broom, 1985). Because blood cockles are filter feeders, they are especially susceptible to accumulation of MPs, raising concerns about food safety and environmental health (Mohan *et al.*, 2024; Rahmatin *et al.*, 2024). Goh *et al.* (2021) found that 100% of the cockles sampled in Songkhla Province, Thailand, contained MPs, with a number of 4.71±0.06 MPs/g and 2.64±0.01 MPs/individual (ind.). MPs accumulated in blood cockles were primarily in the form of fibers, accounting for 98.5%. Moreover, Saleh *et al.* (2023) reported MPs accumulation in blood cockles from Jeneponto, South Sulawesi, Indonesia.

Furthermore, MPs were found in different environmental samples collected from the coastal zones in Vietnam, such as beach sand (Nhon *et al.*, 2022), penaeid shrimp (My *et al.*, 2023), surface waters and sediments (Nga *et al.*, 2025), including *A. granosa* (Dao *et al.*, 2023a).

Understanding MPs characteristics, such as color, type, size, and polymer composition, in various environmental components is crucial for assessing their sources, fate, transport, and ecological impact. Sediments are considered significant sinks for MPs, while filter-feeding organisms, such as cockles (Bivalvia), can ingest MPs from their surrounding environment, potentially serving as bioindicators and a pathway for MPs transfer through food webs. This study was conducted to examine the abundance and characteristics of MPs in sediment and blood cockles from the MEC, HCMC, Vietnam, with an emphasis on spatiotemporal differences.

Materials and methods

Sampling area and sample preparation

The study was conducted at the MEC in the southeastern part of HCMC, Vietnam. Cockle and sediment samples were collected monthly between July and September 2024 from 4-5 locations at two zones: Dong Tranh River (DTR) (from 10°23’37”N, 106°51’34”E to 10°29’40”N, 106°51’54”E) and Thanh An Island (TAi) (from 10°27'11"N, 106°58'01”E to 10°29'56"N, 106°58'48”E) (Fig. 1 and Table 1). The distance between each location was about 2-2.5 Km.

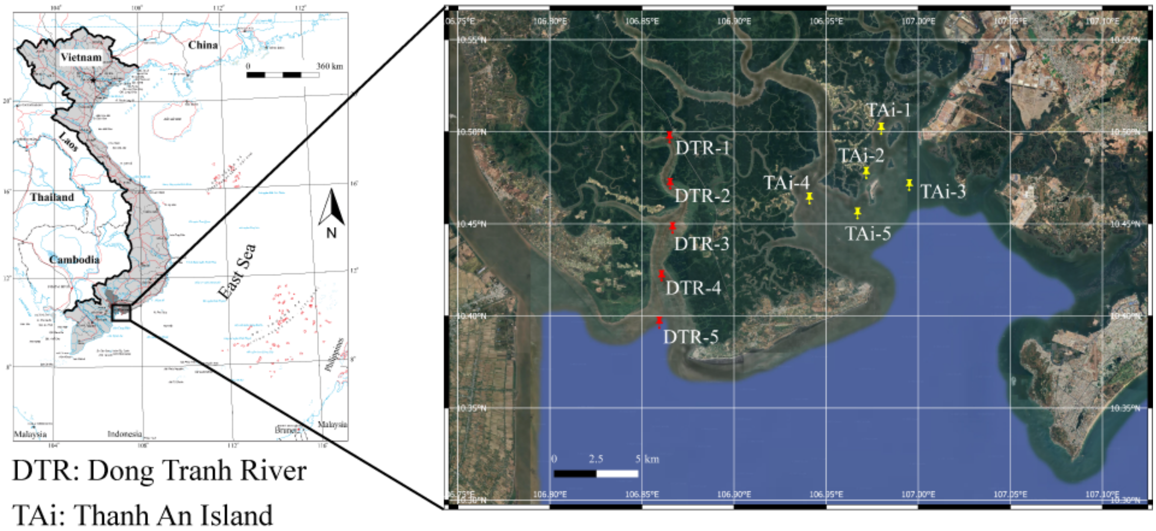

Figure 1: Sampling locations of sediment and cockle from the mangrove ecosystem of Can Gio, Ho Chi Minh City.

Table 1: Morphometric properties of the cockle collected from the mangrove ecosystem of Can Gio, Ho Chi Minh City.

Location	Sampling time	Cockle (*n*)	Whole body wt (g)	Muscle wt (g)	Shell length (mm)	Condition index (%)	Sediment (*n*)
Dong Tranh River (DTR)	July	4	11.9 ± 3.7†	3.2 ± 1.1	33.2 ± 3.5	29.2 ± 20.0	4
	August	4	15.4 ± 4.5	4.6 ± 1.5	34.6 ± 4.1	29.5 ± 4.0	4
	September	5	12.5 ± 3.3	3.6 ± 1.3	26.5 ± 5.5	28.5 ± 6.2	5
Thanh An Island (TAi)	July	5	22.2 ± 5.4	6.4 ± 1.7	40.7 ± 7.6	28.6 ± 4.9	4
	August	5	14.4 ± 2.5	4.3 ± 0.8	33.9 ± 5.7	29.8 ± 3.9	4
	September	5	11.2 ± 2.1	3.4 ± 0.7	23.1 ± 1.4	30.7 ± 3.9	5

† mean ± standard deviation.

The market-size cockles (8-10 g per ind.) were collected and scrubbed outside before being stored in aluminum foil. The upper layer of sediment (0–5 cm) was collected in the farming areas of cockles at the same time using an Ekman grab. At each site, sediment was collected from 4 to 5 subsections, sieved through a 5 mm mesh size, well mixed, and approximately 500 g of sediment was stored in glass jars with aluminum caps. All samples were kept in an icebox, transported to the laboratory of the Research Institute for Biotechnology and Environment at Nong Lam University, and then frozen at –20°C before analysis.

At the laboratory, cockles were washed thoroughly with prefiltered distilled water. The shell length and body weight (wt) of each cockle were determined, and then the whole moist tissue content was thoroughly removed using a surgical blade and weighed. The MPs' analyses were performed on the entire soft tissue of 50-60 individuals of similar body wt. Biometry of the cockles is given in Table 1.

MPs extraction

Cockle samples were extracted according to the procedure described by Masura *et al.* (2015) and My *et al.* (2023) with some modifications. Briefly, the cockles were thoroughly minced with a steel knife. Then, 5 grams of the sample were placed into a 250 mL glass beaker, and 50 mL of 10% KOH was added to the beaker. The beaker was covered with aluminum foil and incubated at 40°C for 48 h, followed by 24 h at room temperature. Then, 6g of NaCl was added to 20 mL of the sample solution for density separation. The solution was well mixed in an ultrasonic cleaner for 30 minutes and allowed to settle for an additional 60 minutes. The supernatant was passed through a Whatman grade GF/B disc (1 µm pore size), and the residue was washed with NaCl twice more. The supernatant was combined and filtered through the filter disc mentioned above. The filter disc was stored in a clean glass Petri dish for visual assessment of MPs using a dissecting microscope.

Sediments were analyzed according to the procedure described by Masura *et al.* (2015). The sample collected at the site was passed through a 0.3 mm mesh sieve. Five grams of a fresh sample were placed into a 500 mL glass beaker, followed by the addition of 20 mL of a 0.05 M Fe(II) solution ($FeSO_4$). Subsequently, 20 mL of 30% H_2O_2 was added to remove organic substances adhering to the surface of the MPs. The MPs in the sample were separated by density using NaCl solution and collected as described above.

Microplastic determination

The abundance and physical characteristics of the MPs on the filter disc were determined and recorded as described in previous studies (Masura *et al.*, 2015; Beaman *et al.*, 2016; My *et al.*, 2023), using an Olympus SZ51 stereomicroscope with a 40× magnification. The MPs were characterized by major colors (red, orange, yellow, green/blue, brown, white, black, and pink), type (fragment, fiber, pellet, and film), and dimension (subdivided in four sizes: <0.3, 0.3-1, 1-3, and 3-5 mm). The MPs' dimension was determined by measuring either their diameter or the highest straight length. The abundance of MPs in sediment and cockle is presented on a wet wt (ww) basis. The abundance of MPs in cockle tissue was presented in g MPs/g, but it was transformed into MPs/ind. A conversion factor of 5, representing the average weight of cockles' fresh tissue, was applied to facilitate comparison with microplastic quantities reported in previous studies.

Polymer identification using µFTIR analysis

Polymer classification of MPs was based on the guidelines in Beaman *et al.* (2016) and combined with µFTIR analysis. The µFTIR analysis was conducted at the Department of Water – Environment – Oceanography, University of Science and Technology of Hanoi, Vietnam. The MPs in sediments and cockles were randomly selected for polymer identification by the µFTIR spectrometer (Nicolet In10Mx Dual Director microscope, Thermo Fisher Scientific). The identified spectra were compared to the Thermo Fisher library (acceptance and validation for spectra matching higher than 70%) to determine their class of polymer; verified non-plastic particles were excluded.

Quality assurance and quality control

To prevent contamination of MPs during sample extraction and analysis, the workspace was cleaned with pre-filtered distilled water, followed by 70% ethanol. During the experiment, only glass, metal tools, or equipment were used. Distilled water and reagents were filtered through 1 µm filter paper (Whatman grade GF/B) before use. Practical blanks are designed to mimic the isolating steps without the actual sample for each batch. The presence of MPs in the working area was also checked by placing a glass microfiber filter (Whatman grade GF/B) in a glass petri dish with the lid open. This was done simultaneously with the analysis of MPs in the samples.

Statistical analysis

A test of normality was conducted by the Shapiro-Wilk test. As the MPs abundance did not conform to a normal distribution, the Mann-Whitney and Kruskal-Wallis nonparametric test was used to compare spatial and temporal variability, respectively, among sampling zones/locations and sampling times. Spearman's rank-order test was used to determine the association between MPs in tissues and sediment, as well as cockles' biometry. A p-value < 0.05 was set for statistical significance. These analyses were conducted using the software SPSS 22 for Windows (SPSS, Chicago, IL, USA).

Results

The abundance of MPs in sediment and cockles is presented in Figures 2 and 3. Results showed relatively heterogeneous MPs abundance in sediment and cockles throughout the MEC (Figs. 2 and 3), with the number of MPs ranging from 0.20 to 2.60 MPs/g and 0.20 to 2.20 MPs/g, respectively.

Regarding the sampling zone, the TAi sediment generally exhibited relatively higher contamination with MPs compared to DTR across the sampling periods; however, TAi cockles had lower MPs levels. In terms of temporal sampling, the MPs abundance in sediment from DTR exhibited an increasing trend from July to September; conversely, the MPs quantity in the TAi cockles showed a decreasing trend from July to September.

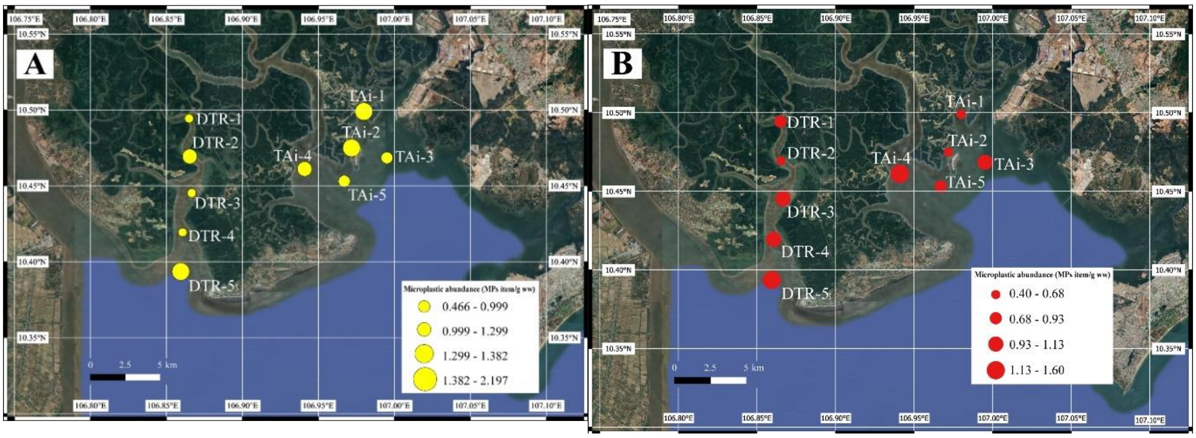

Figure 2: Spatial distribution of MPs abundance in (A) sediment and (B) cockle samples collected across different sampling sites.

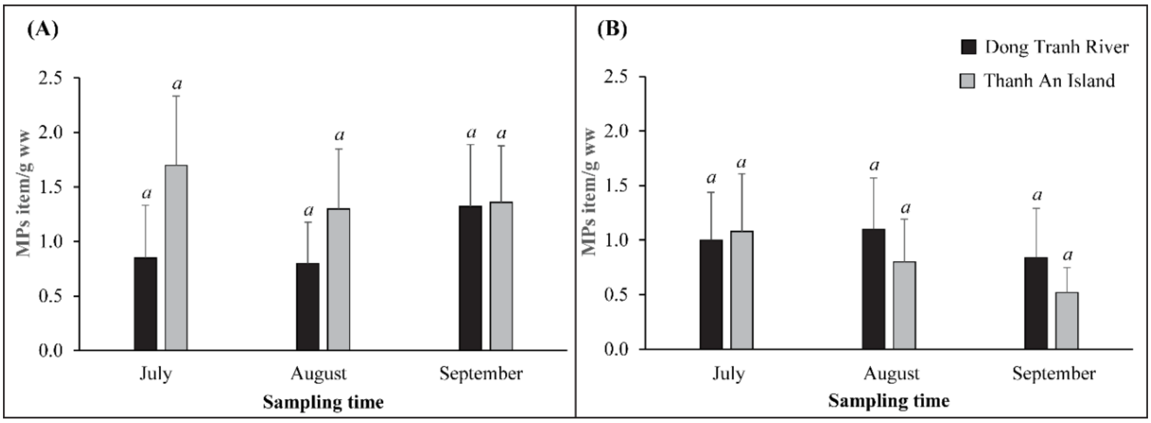

Figure 3: Bar plot showing the mean and standard deviation of the abundance of MPs in (A) sediment and (B) cockle across different sampling times at two sampling zones. Mean values at the same sampling time with different letters differ significantly (p<0.05, Kruskal–Wallis test).

Nevertheless, the quantity of MPs did not differ significantly among zones and sampling times (p>0.05).

The correlations between MPs in cockle tissue and sediment, as well as the cockles' biometry, were not statistically significant (Spearman's rank-order test, p>0.05).

Figure 4 illustrates the relative abundance of different MPs characteristics (color, type, and size) in sediment and cockle samples from DTR and TAi. There was a clear variation in the color of MPs among the sediment and *A. granosa*, with the latter exhibiting major components of black and white (a total of 50-80%), especially in DTR samples (Fig. 4A). Moreover, TAi cockle, particularly in July and September, showed a higher prevalence of more vibrant colors, such as yellow, orange, and green/blue MPs (Fig. 4A). Furthermore, brown MPs was found to be relatively high in the sediment from DTR and TAi, accounting for 11.8-12.5% and 11.5-41.2%, respectively, of the total MPs quantity. As also shown in Fig. 4, the study detected a significant presence of green/blue -colored MPs in the cockle samples, particularly in September at both zones.

In this study, the shape of MPs is categorized into four types, including fragment, fiber, pellet, and film. The analysis results show that fibers consistently constituted the majority of MPs (generally >50%) in all samples (sediment and cockles) at both zones and across all three sampling times, except for TAi sediment in July and September. For sediment, fragments (5.9-52.9%) and film (19.2-35.3%) were the second and third most common types, while pellets (3.8-12.5%) were the least common. Throughout the study, the relative abundance of fragments (11.1-23.8%) and pellets (0-25.0%) was found to be relatively high in cockles, while film (0-18.5%) showed the lowest (Fig. 4B). Figure 5 shows representative microscopic images of MPs in cockles from the MEC.

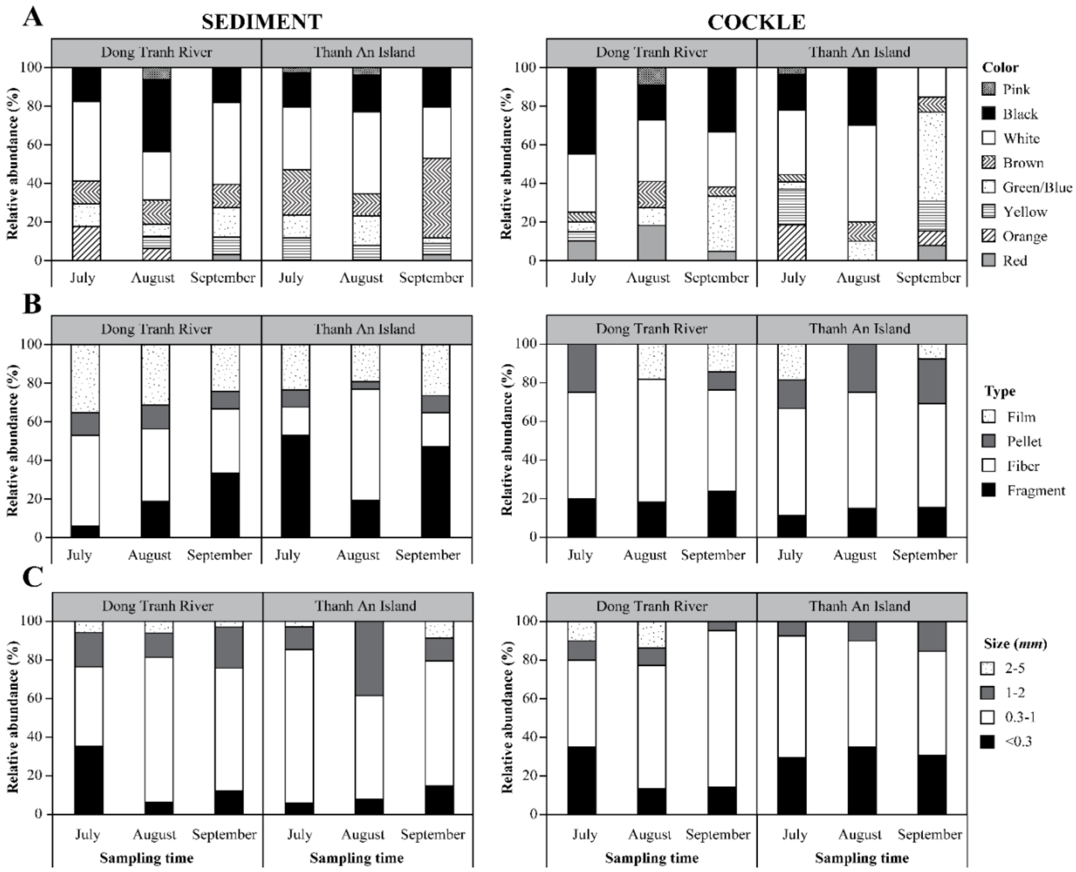

Figure 4: The relative abundance (%) of MPs characteristics, including (A) color, (B) type, and (C) size, in sediment and cockle samples collected across different sampling times at two sampling zones.

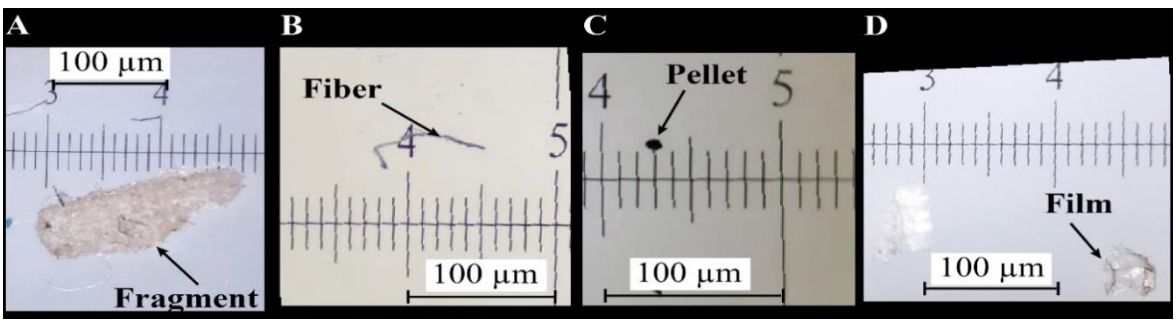

Figure 5: Microscopic images of MPs: (A) fragment, (B) fiber, (C) pellet, and (D) film in sediment and cockle samples across different sampling times at two sampling zones.

The smallest size fractions (<0.3 mm and 0.3-1 mm) were generally the most abundant in both sediment (61.5-85.3%) and cockles (77.3-95.2%) across both zones and all sampling times (Fig. 4C). Sediment at DTR consistently showed a slightly higher proportion of larger particles (1-2 mm and >2-5 mm) compared to TAi sediment, except for TAi sediment in August. A key difference was observed in cockles: those from TAi primarily contained MPs <2 mm, whereas cockles from DTR contained MPs >2-5 mm.

The results of polymer classification of MPs in sediments and cockles based on μFTIR spectral analysis are presented in Figure 6. The study identified 8 and 12 different types of polymers present in sediment and cockle samples, respectively (Fig. 6). Nylon and PET (polyethylene teraphalate) were the leading polymer types in the sediment, collectively accounting for over 80% of the identified MPs, followed by also found in sediment, including PP (polypropylene), PEA (polyethylene/ethyl acrylate copolymer), EVA (nylon/ethylene-vinyl acetate tie layer), PNMA (poly(N-methyl acrylamide)), and POM (high mineral coupled acetal copolymer), accounting for 5.0% of the total MPs. In cockles, PET and rayon were the most dominant, collectively exceeding 60%, with nylon still being a significant component (18.5%), followed by PTO-Sr (poly(terephthaloyl oxamidrazone) + SrCO3, 9.8%). Other compositions of the MPs in the cockle contributed to 7.1% of the total MPs, including PVAC (poly(vinyl ammonium chloride)), PTPS (poly(4-trimethyl silyl phenyl methyl siloxane), MUF (melamine-urea-formaldehyde resin), poly(styrene-4-sulfonate; Mg), PVA (poly(vinyl alcohol)), phenol resin, EVOH (ethylene vinyl alcohol EVAL film), and PNMA.

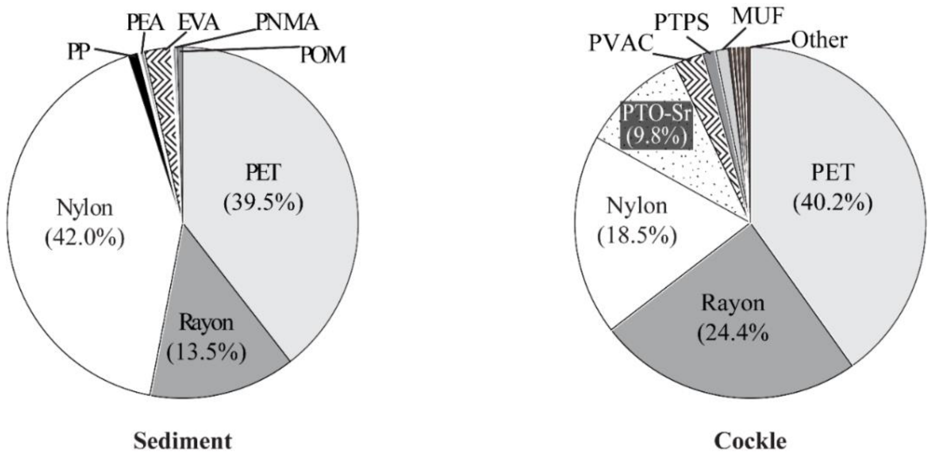

Figure 6: Polymer proportion of MPs from the total sample collections of sediments and cockles across sampling times at two sampling zones. Abbreviations are shown in the text.

Discussion

According to the present study, the MEC area is less contaminated with MPs. The average MPs in blood cockles in DTR and TAi were in ranges of 0.84-1.10 MPs/g and 0.52-1.08 MPs/g, respectively. While sediment in DTR and TAi exhibited 0.80-1.32 MPs/g and 1.30-1.70 MPs/g, respectively. Moreover, this study indicates stability in MPs contamination in both sediment and cockles, independent of the location and sampling time. The blood cockle plays a significant role in the ecosystem and aquaculture in Southeast Asia; therefore, several studies on MPs pollution in this species have been conducted. Compared with previous studies, the MPs in blood cockles in the MEC were comparable to or lower than those collected at market in HCMC, Vietnam (Dao *et al.*, 2023a), Songkhla Province, Thailand (Goh *et al.*, 2021), Penang, Malaysia (Ratnam and Mohd, 2022), South Sulawesi, Indonesia (Saleh *et al.*, 2023), and Peninsular Malaysia (Mohan *et al.*, 2024). However, the number of MPs in *A. granosa* found in the MEC was extremely lower than that in cockles from Jambi, Indonesia (Fitri and Patria, 2019) and Banten, Indonesia (Ukhrowi *et al.*, 2021). Moreover, the concentration of MPs in sediments sampled from the MEC was notably lower compared to the findings from Jambi, Indonesia (Fitri and Patria, 2019), and Banten, Indonesia (Ukhrowi *et al.*, 2021).

This accumulation poses a significant threat to benthic organisms, such as the cockles, which are in constant contact with and may ingest contaminated sediment. As established by other research, such as Bagheri *et al.* (2020, 2024) and Yazarloo *et al.* (2024), the ingestion of MPs not only causes direct physical harm and toxicological effects to these organisms, but it also facilitates the transfer of MPs into the food web. Therefore, the high concentrations of MPs we found in the sediment are not just a measure of accumulated waste, but rather represent a critical entry point for these pollutants into the local food chain, ultimately posing a risk to higher trophic levels, including human consumers.

The differences in abundance of MPs in sediment and cockles among zones across sampling times, as well as insignificant relationships between the two matrices, might reflect different hydrodynamic conditions or pollutant discharge patterns affecting the two zones. Additionally, these results could suggest that factors other than just sediment MPs concentration, such as the bioavailability of MPs, selective feeding behavior, metabolic rates, and the role of the water column as a separate exposure pathway, may influence MPs uptake in cockles.

Temporal variations in color profiles were evident in both zones and matrices (sediment and cockles). Notably, the color profiles in cockles generally reflected those in the sediment from the same location and sampling time, exhibiting major components of black and white, suggesting that cockles are ingesting particles representative of what is available in their immediate benthic environment. Black and/or white were predominant MPs colors found in samples collected from the MEC (Fig. 4A), which is in agreement with other published works (Ruairuen *et al.*, 2022; Rahmatin *et al.*, 2024). Ruairuen *et al.* (2022) reported that MPs in *A. granosa* were primarily black (38 %), followed by white (25%). Similarly, black was the dominant MPs color in sediments (31–47%) and cockle tissues (41–49%) from the coastal waters of East Java, Indonesia (Rahmatin *et al.*, 2024). It has been well-documented that black and white MPs are commonly observed in various environmental samples collected from the coastal zones in Vietnam. White MPs were the main color (40.5%) in beach sand from Can Gio, Ho Chi Minh (Nhon *et al.*, 2022), whereas black MPs were also one of the most abundant colors in *A. granosa* collected at markets in the HCMC, contributing 20-30% of the total quantity (Dao *et al.*, 2023a). These results indicate that these plastic colors are widely utilized in aquaculture or are discharged from upstream into the coastal zone.

The black and white MPs in sediment and cockle samples are likely due to either the primary MPs color, color photodegradation, or other physicochemical causes that alter the color from its original source. The prevalence of black and white MPs, particularly in the DTR, is widespread in many aquatic environments. Black particles can originate from various sources, including the degradation of tires, electronics, and dark-colored packaging products, as well as certain types of fishing gear. In Vietnam, old rubber tyres are commonly used as a substrate for settling oyster spat (Dao *et al.*, 2023b). While white MPs often derive from packaging, plastic bags, and containers (Zhang *et al.*, 2024). Additionally, the degradation of colored MPs over time due to environmental factors such as UV light and weathering is another possible source of white or transparent/translucent MPs (Pan *et al.*, 2020). The periodic dominance of more vibrant colors, such as yellow, orange, and green/blue, especially at TAi, suggests contributions from sources like dyed textiles (fibers), fishing nets and lines (often brightly colored), buoys, and consumer products (My *et al.*, 2023).

Sediment and cockles collected from the MEC were polluted primarily by fibrous MPs (over 50%), followed by fragments and films. The latest published works reported that these MPs were predominantly found in the sediment and blood cockle (Fitri and Patria, 2019; Goh *et al.*, 2021; Ukhrowi *et al.*, 2021; Ratnam and Mohd, 2022; Ruairuen *et al.*, 2022; Dao *et al.*, 2023a; Mohan *et al.*, 2024), which coincides with our observations. There was little apparent difference in the dominant MPs types between the DTR and TAi, or between sediment and cockle samples, suggesting a widespread prevalence of fibrous and fragmental MPs sources and similar accumulation patterns in cockles relative to sediment availability. The presence of fibrous MPs in the MEC is consistent with origins from anthropogenic activities, primarily the degradation of fishing nets and ropes, and the release of synthetic fibers from urban wastewater (Dao *et al.*, 2023b; My *et al.*, 2023).

Regarding MPs size, the predominance of smaller size classes (<1 mm) in cockles is attributed to their easier ingestion compared to larger particles. The predominance of small-size fractions (<1 mm) is characteristic of this coastal area, where plastics undergo significant weathering and fragmentation. Bigger fragments degrade into minor pieces due to physical (*e.g.,* abrasion, wave action), chemical (*e.g.,* oxidation), and biological (*e.g.,* photodegradation enhanced by microbial activity) processes (Sutkar *et al.*, 2023). Minor MPs are more readily moved and are often more bioavailable to filter-feeding species such as cockles (Goh *et al.*, 2021; Ruairuen *et al.*, 2022; Dao *et al.*, 2023a). The presence of MPs with sizes >2-5 mm, particularly in DTR cockles, indicates that larger MPs are also present, possibly from more recent fragmentation events or different hydrodynamic conditions that influence deposition.

Based on µFTIR spectral analysis, the present study found 8 and 12 different types of polymers in sediment and cockle samples, respectively, with a predominance of PET, nylon, and rayon. These polymers have been commonly discovered in recent works on bivalve mollusks, including cockles (Dao *et al.*, 2023a; Mohan *et al.*, 2024). According to Dao *et al.* (2023a), the presence of PET, PE, and rayon was the most prevalent in *A. granosa* and the other two bivalve mollusks (*Meretrix lyrata* and *Ensidens* sp.) sampled from a market in HCMC, Vietnam. Rayon was found to be the most prevalent polymer in blood cockles from Peninsular Malaysia (Mohan *et al.*, 2024). As a leading polymer in both sediment (39.5%) and cockles (40.2%), PET likely originates from single-use beverage bottles, food packaging, and synthetic textiles (polyester clothing) (Crawford and Quinn, 2017). The Can Gio area, with human settlements and tourism, would generate such waste. Nylon (PA) is highly abundant in sediment (42.0%) and has a significant presence in cockles (18.5%), indicating that fishing activities are a major source. Nylon is extensively used in fishing nets, lines, and ropes due to its strength and durability. Abandoned, lost, or otherwise discarded fishing gear (ALDFG) is a well-known contributor to marine plastic pollution (Macfadyen *et al.*, 2009). Textile fibers from clothing and automotive applications are another source of nylon (Crawford and Quinn, 2017). The presence of rayon in sediment (13.5%) and notably in cockles (24.4%) highlights the contribution of semi-synthetic fibers, primarily from textiles and clothing. While derived from cellulose, rayon undergoes chemical processing, and its fibers behave like plastics in the environment, contributing to MPs pollution, even in the deep sea (Woodall *et al.*, 2014). The higher relative abundance in cockles compared to sediment suggests preferential ingestion or retention of these fiber types by the organisms, or different settling velocities compared to denser synthetic polymers.

Conclusions

According to our study results, sediment and blood cockles throughout the MEC were moderately contaminated with MPs. The average quantity of MPs in sediment and cockles was in the range of 0.80-1.70 MPs/g and 0.52-1.10 MPs/g, respectively. Fiber constituted the majority type of MPs, with black and white colors being the predominant colors. The MPs found in both sediment and cockles across both zones and all sampling times were largely small-sized fraction (<0.3 mm and 0.3-1 mm). In terms of polymer type, nylon, PET, and rayon were the primary types in both sample matrices. The differences observed in MPs abundance between locations and sampling times highlight the importance of temporal and spatial considerations in monitoring programs. These data emphasize the dynamic nature of MPs pollution in estuarine environments and the varying responses of different environmental components (sediment) and biota (cockles).

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Conflicts of interest

The authors declare no conflict of interest.

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