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The evidence of microplastics exposured in Le Thuy beach of Quang Ngai, Viet Nam

Le Xuan Thanh Thao[1, 2], Do Van Manh[1, 2, *], Huynh Duc Long[1], Nguyen Thi Linh[1], Vo Anh Thu[1], Dang Thi Thom[1, 2], Nguyen Duy Thanh[2]

[1]*Institute of Science and Technology for Energy and Environmental, Vietnam Academy of Science and Technology, 18 Hoang Quoc Viet Road, Cau Giay District, Ha Noi, Viet Nam*

[2]*Graduate University of Science and Technology, Vietnam Academy of Science and Technology, 18 Hoang Quoc Viet Road, Cau Giay District, Ha Noi, Viet Nam*

[*]Email: *dvmanh@iet.vast.vn*

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Abstract. The distribution and characteristics of microplastics in beach sand and surface seawater samples at Le Thuy beach, Binh Tri commune, Quang Ngai province were first evaluated in this study. The results showed that the average density of microplastics in beach sand and seawater samples was 1283.33 ± 378.32 pieces/kg and 38.09 ± 10.84 pieces/liter, respectively. Fragments and fibers were the main shape of microplastics with the main polymer type being polyethylene terephthalate (PET) with proportions of 37.50 and 44.16 % in seawater and beach sand samples, respectively. The pollution load index (PLI) at level I and the risk assessment based on the chemical composition of the polymer at level II indicate the need to warn about the exposure to this pollution. This could be used as a basis to open up new research directions on microplastics in the future.

Keywords: microplastics, pollution, beach sand, surface seawater.

Classification numbers: 3.2.1, 3.4.2, 3.6.1.

1. INTRODUCTION

Nowadays, plastic pollution has become a major environmental problem and is causing great stress on coastal ecosystems. The amount of plastic waste discharged into the environment is increasing, which is causing harm to the environment and ecosystems, especially the marine ecosystem, entering the food chain, and causing harm to human health. According to a report of the United Nations Environment Program, every year, people use about 500 billion plastic bags, 13 million barrels of oil to produce plastic; 1 million plastic bottles are bought every minute, and 100,000 marine animals die due to plastic waste. The amount of plastic products produced annually has increased 20-fold in the past 50 years and is expected to double in the next 20 years [1]. With high durability, plastic lasts a long time in the marine environment. However, polymers can be degraded slowly by microorganisms or by natural factors such as heat, oxidation, light or hydrolysis [2, 3]. Exposure to sunlight on beach sand or in seawater near the

surface causes fragmentation to happen much faster on land than at sea. Therefore, in a short time, plastic debris on the beach can turn into microplastics due to high waves or strong winds.

Due to their small size (≤ 5 mm), microplastics can act as a source of chemical contamination, including plasticizers, colorants, etc. and additives incorporated in the manufacturing process, or they can absorb chemical pollutants such as POPs, heavy metals, etc. on the surface and transport them away. The coastal environment including beaches, seawater and marine sediments is considered the ultimate destination and is most affected by microplastic pollution [4 - 8].

In the world, Viet Nam is one of the countries with the largest amount of plastic waste discharged into the sea, with about 0.28 - 0.73 million tons per year, which is equivalent to 6 % of the total amount of plastic waste in the sea [5,8]. Therefore, in Viet Nam, plastic waste and microplastics are a matter of concern in the long-term environmental protection strategy. Regarding the status of microplastic pollution, Viet Nam has no official statistics, but recently there have been some studies to determine the distribution of microplastics in beach sand and surface seawater samples [5, 9 - 14]. Therefore, we conducted this study to further evaluate the distribution and composition of microplastics in the coastal environment. The results of the study will bring a new perspective on the current situation of microplastic pollution.

2. MATERIALS AND METHODS

2.1. Sampling sites

The selected research area was Le Thuy beach in Binh Tri commune, Binh Son district, Quang Ngai province. This is considered a beautiful beach located in the countryside with tourism activities and sea services still in its infancy, not yet developed like beaches in Da Nang city as reported in other studies [5, 8]. The collection of beach sand samples was performed based on the guidelines from the National Oceanic and Atmospheric Administration (NOAA) [15], and with reference to a report by Manh *et al*., 2022 [8]. Samples were collected at 9 points spanning over 300 m along the cross-section between the high tide line and the waterline with the distances between points ranging from 30 to 40 m as depicted in Figure 1. Samples were taken at the surface layer (0 - 5 cm) because the highest abundance of microplastics was reported at this depth [5, 8 - 11]. Each sample was taken as a composite in the sampling area at the four corners and the intersection of the two diagonals of a stainless steel frame with dimensions of 50 × 50 cm. The sample was then sieved through a 5 mm mesh stainless steel sieve and stored in a labeled glass bottle at room temperature before being transported to the laboratory for microplastic analysis.

At the same sampling area, surface seawater samples were also collected to comprehensively assess the presence of microplastics in the studied coastal environment. Before sampling, all instruments were washed with distilled water. The water sample was collected using the bucket sampler method by placing it vertically below the sea surface at a depth of about 20 cm similar to that described in the study of Prarat and Hongsawat, 2020 [7]. The sample was then contained in an amber glass bottle, stored in an insulated container at 4 ^{o}C and transported to the laboratory. All samples taken were stored in a refrigerator at 4 °C until analyzed. Sample processing was completed within 1 working week from the time the sample was brought to the laboratory.

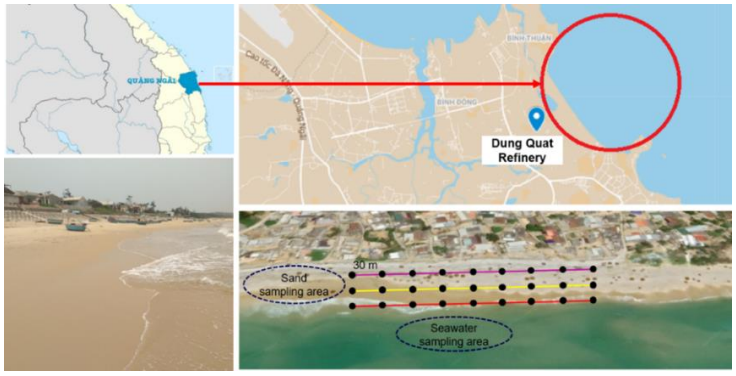


Figure 1. Study sampling sites.

2.2. Sample extraction and analytical method

The microplastic analysis procedure used was based on published works [2, 3, 8, 15] and was adjusted to suit the actual conditions as depicted in Figure 2.

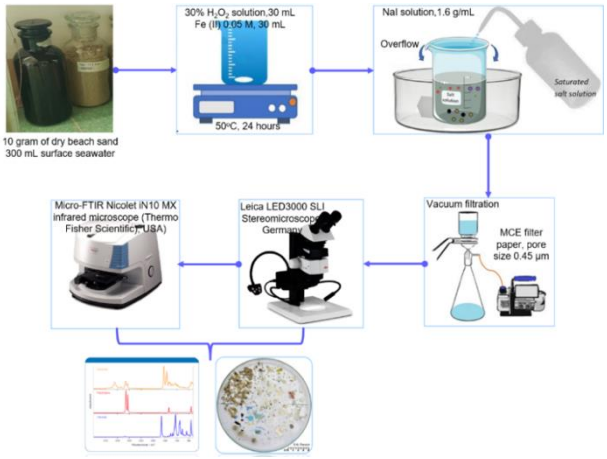


Figure 2. Procedure for analyzing microplastics in research samples.

Firstly, beach samples were homogenized and dried at 55 - 60 ^{o}C for 48 - 72 hours in a drying oven (Yamato DX402, Japan). Samples were analysed in triplicate, with 300 mL of surface water used for seawater analysis and 10 g of dry sediment used for beach sediment analysis each time to determine the presence of microplastics. To remove natural organic compounds, 30 mL of 30 % hydrogen peroxide (H_2O_2, Merck, Germany) and 30 mL of 0.05 M Fe (II) solution ($FeSO_4.7H_2O$, Merck, Germany) were added, followed by keeping at 50 ^{o}C for 24 hours. Then, a density separation step was carried out using sodium iodide solution (d = 1.6 g/mL) (NaI, Merck, Germany). Polymers in the samples can float on the surface of the mixed solution. The next step was to filter the overflow solution through Mix Cellulose Ester (MCE) filter paper (47 mm diameter and 0.45 µm filter mesh) using a diaphragm vacuum pump (Chemical Resistant Vacuum Pump N 840 FT.18, D-79112 Freiburg, KNF NEUBERGER, Germany). Finally, the characteristics of microplastics were determined using a Leica LED3000 SLI Stereomicroscope (Germany) and a Micro-FTIR Nicolet iN10 MX infrared microscope (Thermo Fisher Scientific, USA). Particles that were considered after being identified by Micro-

FTIR with a coincidence of more than 70 % could be accepted as microplastics [6, 8].

To avoid microplastic contamination during the analysis, it is necessary to adhere to the following principles: clean the work area with alcohol; do not use plastic equipment and containers; distilled water and chemical solutions must be filtered through MCE filter paper before use; check for the presence of microplastics in the air by placing the MCE filter in a petri dish and opening the lid. This operation was performed simultaneously when analyzing microplastics in samples.

2.3. Risk assessment of microplastic pollution

From the results of microplastic concentration, the authors proposed to use pollutant load index (PLI) for this study. PLI is considered a baseline parameter to monitor pollution levels between different areas and is calculated according to formulas (1) and (2):

$$CF_i = C_i / C_o \quad (1)$$

$$PLI = \sqrt{CF_i} \quad (2)$$

where CF_i is the quotient between the density of microplastics in the sample (C_i) over the background density value (C_0). Based on Vietnamese publications and the similarity in research methodology, we choose the C_0 value according to the study of Khuyen *et al*., 2021: 60.22 MPs/kg; 6.44 MPs/L [10]. PLI index classification criteria were applied as suggested by Xu *et al*., 2018 [16].

Besides, from the results of the chemical composition of microplastics, we propose to calculate the hazard index of the plastic polymer (H) according to formula 3:

$$H = P_n \times S_n \quad (3)$$

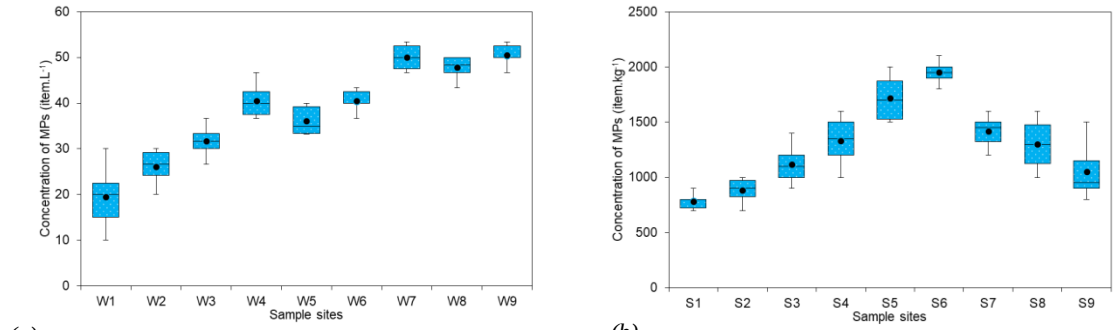
where P_n is the percentage of microplastic polymer; S_n is a hazard index based on the type of polymer and its monomer obtained from the study of Lithner *et al*., 2011 [17]. Calculation results are evaluated and classified according to five hazard classes (IV) with H values ranging from 1 to 10,000 [16,17], in which level V is considered the most dangerous level.

3. RESULTS AND DISCUSSION

3.1. The exposure concentration of microplastics

As shown in Figure 3, the concentration of microplastics in the studied beach sand and seawater samples indicated that microplastics were present at all sampling sites, similar to many other studies [5 - 7, 12, 18, 19]. In surface seawater samples, microplastic concentrations ranged from 19.44 ± 7.12 to 50.56 ± 2.51 MPs/L, with an average of 38.09 ± 10.84 MPs/L. In beach sand samples, the concentration of microplastics ranged from 783.33 ± 75.28 to 1950.00 ± 104.88 MPs/kg with the average value being 1283.33 ± 378.32 MPs/kg. The results of one-way variance calculation showed that the concentration of microplastics at the sampling locations had a statistically significant difference with p value < 0.05. Besides, the relationship of microplastic density in water and sediment was tested by Linear Regression and no significant relationship was detected with $R^2 = 0.207$. This relationship was also tested by Spearman's correlation and Pearson correlation and also showed no relationship of microplastic density in studied areas with p = 0.4553. Our results were similar to the study at the beach in Rayong province, Thailand [7] or in Turkey with $R^2 = 0.09$ and p = 0.272 [19]. Thus, microplastics can be transported and fragmented into smaller pieces by ocean waves, which then drift and accumulate in the beach

sand layer. In addition, plastic fragments undergo decomposition on the sandbank due to heat and sunlight, partly buried in the sand layer and/or washed away by tidal currents to the sea surface.



(a) *(b)*

Figure 3. Density of microplastics in seawater (a) and beach sand (b) samples.

Overall, the density of microplastics in this study was much higher than that of other similar studies in Viet Nam such as Tien Giang province and Vung Tau city [9], Can Gio mangrove biosphere reserve [10], Can Gio sea [11, 14], Da Nang city [5], Thanh Hoa province [12] and Nam Dinh province [13] (Table 1).

The microplastic concentrations measured on other beaches in Turkey, Spain, Thailand and China were also lower than in Quang Ngai, Viet Nam. In the study of Gedik *et al*., 2022, the average microplastic density in sediment and seawater samples along the Turkish coast of the Eastern Mediterranean Sea reached 631 ± 413 MPs/kg and 1.05 ± 0.55 MPs/m^3, respectively [19]. At the coast of Tarragona, Spain, the microplastic density was 10.7 ± 18 MPs/kg for sediment samples and 1.30 ± 0.98 MPs/m^3 for seawater samples [6]. At the coast of Rayong province, Thailand, this value reached 338.89 ± 264.94 particles/kg in beach sand samples and 1781.48 ± 1598.36 particles/m^3 in seawater samples [7]. A study in Shenzen, China showed that the averaged density of microplastics in seawater was 5.5 MPs/L, while this value in beach sand samples was higher than our study, reaching 6000 MPs/kg [18]. However, these comparisons are only relative because of the difference in methodology between studies. The size of microplastics in seawater samples was limited by sampling grids with a size of 75 µm [7,18]; 80 µm [6, 12, 13] or Manta net with a mesh size of 330 µm [19]. Some other studies were only intended to analyze microplastics with a size from 300 µm [5] or 500 µm [6, 9, 11]. The use of low density separation solutions such as NaCl [11 - 13, 18] may also contribute to limiting the recovery of microplastics in the analyzed sample.

Beaches act as an intermediate reservoir, receiving microplastics from activities on land to the beach before transporting them to the ocean [2,3,6,8,18]. Many studies have mentioned that up to 80 % of plastic pollution in the sea is caused by land-based activities such as dumping plastic waste into the sea, runoff, industrial activities, and the rest is due to marine activities such as aquaculture, fishing and maritime activities, offshore oil and gas exploration, etc. [2, 7]. The abundance of microplastics in the coastal environment can be affected by many factors, such as human activities related to urbanization, population growth, fishing, boats, tourism, etc.; waste sources on land or distance from shore [2, 3, 8, 10, 11, 19]. Considering the actual survey, the discharge of wastewater from residential areas, industrial zones, tourisms and activities at sea, and fishing moorings can be a factor contributing to the abundance of microplastics in the study area.

Table 1. Summary of microplastic characteristics in beach sand and surface seawater in Viet Nam and some countries.

	Concentration	**Size**	**Shape**	**Polymer types**	**Ref**
Beach sand	*(MPs/kg)*	*(µm)*			
Quang Ngai province	1283.33 ± 378.32	22.5 - 539.3	Fragments, Fibers	9 types: PET, PTFE, PP, PVA, PE, PA, MUF, PS, CP	This study
Tien Giang province and Vung Tau city	23.4	500 - 5000	Fragments; Fibers; Granules	4 types: PE,PP,PS, PVC	[9]
Can Gio Mangrove Biosphere Reserve, Ho Chi Minh city	60.22 ± 19.05	25.12 - 640.11	Fragments, Fibers	7 types: PE, PP, PS, PET, PA, PVC, PMMA	[10]
Can Gio Coast, Ho Chi Minh city	3.53	< 1000 - 5000	Granules, Fragments, Fibers	3 types: PP, PS, PE.	[11]
Da Nang city	9238 ± 2097	303 - 4996	Fibers; Fragments	6 types:PA, PVOH,PES, PET, PAN, PAC	[5]
Tarragona coast, Spain	10.7 ± 18	500 - 5000	Fragments; Pellets; Films; Fibres	7 types: PP, PS, PE, PET, PMMA, PES, PA	[6]
Rayong province, Thailand	338.89 ± 264.94	< 100 - 5000	Fibers, Fragments, Pellet, Foam, Film	3 types: PP, PE, PS.	[7]
Shenzhen, China	6000	<500 - 5000	Fragments, Film, Fiber, Pellet	4 types: PVC, PE, PS, PP	[18]
Turkish coast, Turkey	631 ± 413	102 - 4990	Fragments, Fiber, Film, Sphere	4 types: PE, PP, PET, AC	[19]
Surface seawater	*MPs/L*	*µm*			
Quang Ngai province	38.09 ± 10.84	22.5 - 838.9	Fragments, Fibers	9 types: PET, PP, PA, PE, PS, CP, MUF, PVA, PTFE	This study
Can Gio Mangrove Biosphere Reserve, Ho Chi Minh city	6.44 ± 2.98	25-599.9	Fragments; Fibers	7 types: PE, PP, PS, PA, PET, PVC, PMMA	[10]
Thanh Hoa province	30.1×10^{-3}	100 - 5000	Fragments, filaments, pellets	-	[12]
Nam Dinh province	6.7- 9.2×10^{-3}	20 - 5000	Fragments; Fibers	4 types: PP, PE, PS, PES	[13]
Can Gio sea, Ho Chi Minh city	$2.08 \pm 2.21 \times 10^{-3}$	500 - 5000	Fragments; Fibers	10 types: PP, PE, EVA, ABS, PS, PET, PA, PC, copolymer PP and PE, copolymer PP and EVA	[14]
Tarragona coast, Spain	$1.30 \pm 0.98 \times 10^{-3}$	80 - 000	Fragments; Pellets; Films; Fibres	11 types: PVC, PP, PS, PE, PU, PET, PC, ABS, PMA, PA, PES	[6]
Rayong province, Thailand	1.781 ± 1.598	< 100 - 5000	Fibers, Fragments, Pellet, Foam, Film	3 types: PP, PE, PS.	[7]
Shenzhen, China	5.5	< 500 - 5000	Fibers; Films; Fragments; Pellets	4 types: PVC, PE, PS, PP	[18]
Turkish coast, Turkey	$1.05 \pm 0.55 \times 10^{-3}$	73.25 - 4984	Fragments, Fiber, Film, Sphere	4 types: PE, PP, PET, AC	[19]

List of abbreviations: PET: Polyethylene terephthalate; PTFE: Polytetrafluoroethylene; PP: polypropylene; PVA: Polyvinyl alcohol; PE: Polyethylene; PA: Polyamide (Nylon); MUF: Melamine-urea-formaldehyde resin; PS: Polystyrene; CP: Cellophane; PVC: Polyvinyl chloride; PMMA: Polymethyl methacrylate; PVOH: Poly-ethylene vinyl alcohol copolymers; Polyester: PES; PAN: Polyacrylonitrile; Polyacrylate; PU: Polyurethane; PC: Polycarbonate; ABS: Acrylonitrile Butadiene Styrene; PMA: Polymethyl methacrylate; EVA: Ethylene-vinyl acetate; AC: Acrylic.

3.2. Morphology of microplastics

The size characteristics of microplastics in surface seawater and beach sand samples are shown in Figure 4. In general, the number of microplastics tended to increase as the size decreases with R^2 coefficients of 0.8992 and 0.9643 in water and sediment samples, respectively. In seawater samples, the average microplastic size was 150.90 ± 150.07 µm, ranging from 22.5 to 838.9 µm. Meanwhile, in beach sand samples, the microplastic size ranged from 22.5 to 539.3 µm, with an average of 84.68 ± 78.96 µm. Microplastics in the size groups 0

- 50 µm and 51 - 100 µm predominated in all samples with distribution ratios of 28.75 and 23.75 % in seawater samples, respectively; 41.56 and 31.82 % in beach sand samples, respectively. This trend has also been demonstrated by several other studies [9,12,18].

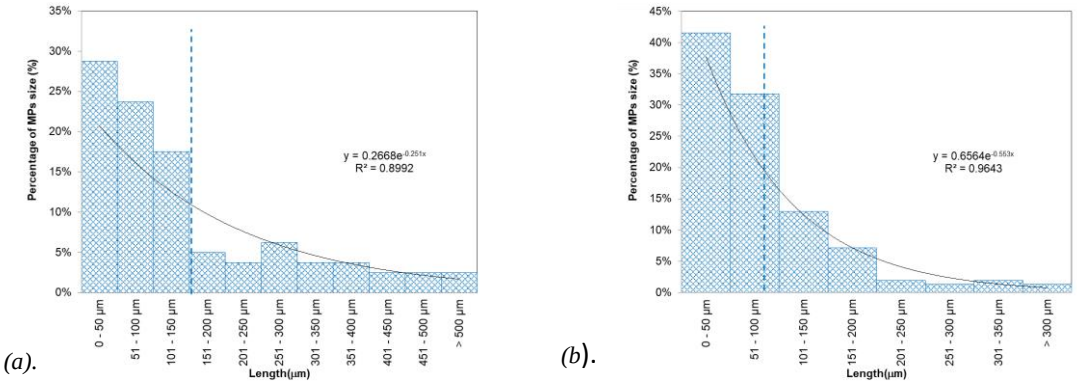


Figure 4. Size distribution of microplastics in seawater (a) and beach sand (b) samples.

The size of microplastics in this study was smaller than that of the study in Turkey with an average length of 1116 ± 1175 µm and 1517 ± 1362 µm, even microplastics were up to 4990 µm in length [19]. According to a study in Rayong province, Thailand, the majority of microplastics in water and sand samples were from 100 to 500 µm with the proportions of 46 and 58 %, respectively, while microplastics smaller than 100 µm accounted for only 0.27 - 4.2 % [7]. Microplastic fibers in beach sand in Da Nang city had an average length of 1701 ± 1029 µm [5]. One-way ANOVA calculation results showed that there was a statistically significant difference in the size of microplastics in seawater and beach sand samples ($p_{value} = 1.47 \times 10^{-5}$). This showed that microplastics tend to be more distributed in the deep beach sand layer, while in the surface water, microplastics were larger in size.

However, similar to microplastic density, the comparison of microplastic size was also difficult to perform because of the limitation of the analyzed microplastic size. Note that the smaller the microplastics, the more dangerous they are for many marine animals such as sea anemones, fish, oysters, etc, and more dangerous are the microplastics containing chemicals derived from additives as well as absorbing pollutants from the surrounding environment such as heavy metals or persistent organic pollutants [5, 7].

The results of microplastic morphology are shown in Figure 5. Fragment was the dominant shape in both seawater and beach sand samples with proportions of 57.50 and 92.86 %, respectively. Second in number was fiber with 42.50 and 7.14 %. Other shapes such as films, spheres, pellets, foams, and granules were not found, which was similar to other studies [6,7,9].

In fact, after being put into the marine environment, plastic polymers would be decomposed for up to hundreds of years [7]. The debris is most likely the result of the decomposition of large plastic parts such as water bottles and packaging in the marine environment by various factors including mechanical, chemical, biological and other factors. Fragment was found to be the dominant shape in both water and sediment samples in a study of Gedik *et al*., 2022, accounting for 70.5 and 57.6 %, respectively [19]. Beach sand samples in the coastal area of Tarragone had a proportion of microplastics up to 68 % [6]. Fragment of microplastics also predominated in seawater in Thanh Hoa, Viet Nam with a rate of 50.2 - 80.2 % [12].

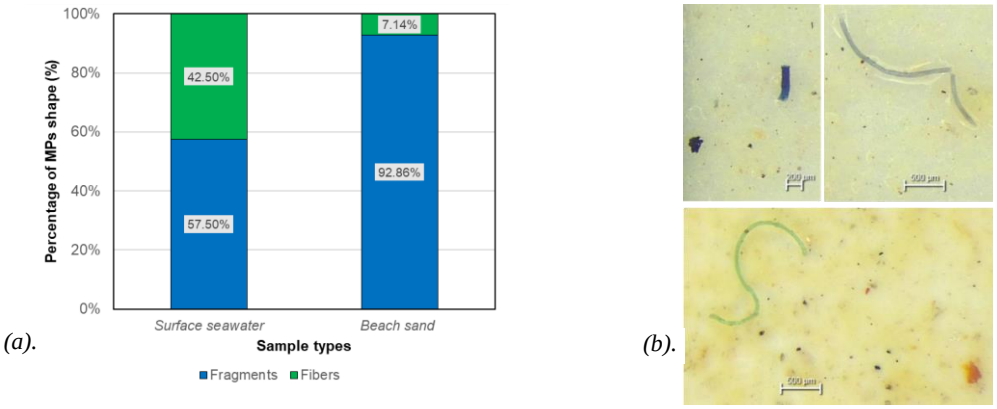


Figure 5. Shape distribution (a) and image of microplastics (b).

The study area is also where fishermen park their boats and cast fishing nets for fishing, so this could be considered a significant source of microplastics. Furthermore, the coastal waters are heavily exposed to municipal waste such as treated wastewater, so the microplastics found with fibrous shapes are reasonable. Studies by Prart and Hongsawat, 2022 [7] and Gedik *et al*., 2022 [19] also mentioned similar explanations for the appearance of microplastic fibers in the ocean and beach sand. Fibrous microplastics could come from synthetic fibers found in casual clothing, sportswear, swimwear, socks, etc. [5, 6].

3.3. Polymer composition of microplastics

Figure 6 shows that a total of nine different polymers were detected in the studied seawater and beach sand samples, among which PET accounted for the largest proportion with 37.50 and 44.16 %, respectively. The descending distribution order of polymer composition in sediment and water samples was relatively different: PTFE (11.04 %) > PP (9.88 %) > PVA (8.29 %) > PE (7.30 %) > PA (6.95 %) > MUF (5.04 %) > PS (4.70 %) > CP (2.65 %); and PP (15.00 %) > PA (14.50 %) > PE (11.25 %) > PS (8.00 %) > CP (6.25 %) > MUF (3.75 %) > PVA (2.50 %) > PTFE (1.25 %), respectively. Other studies also showed similar trends in polymer composition between seawater and beach sand samples [7, 10, 18, 19].

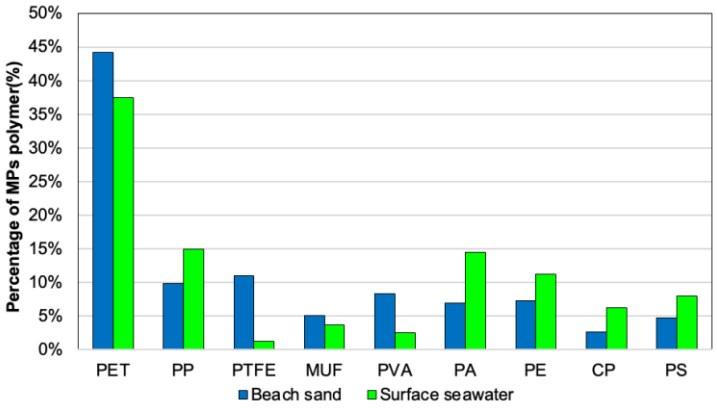
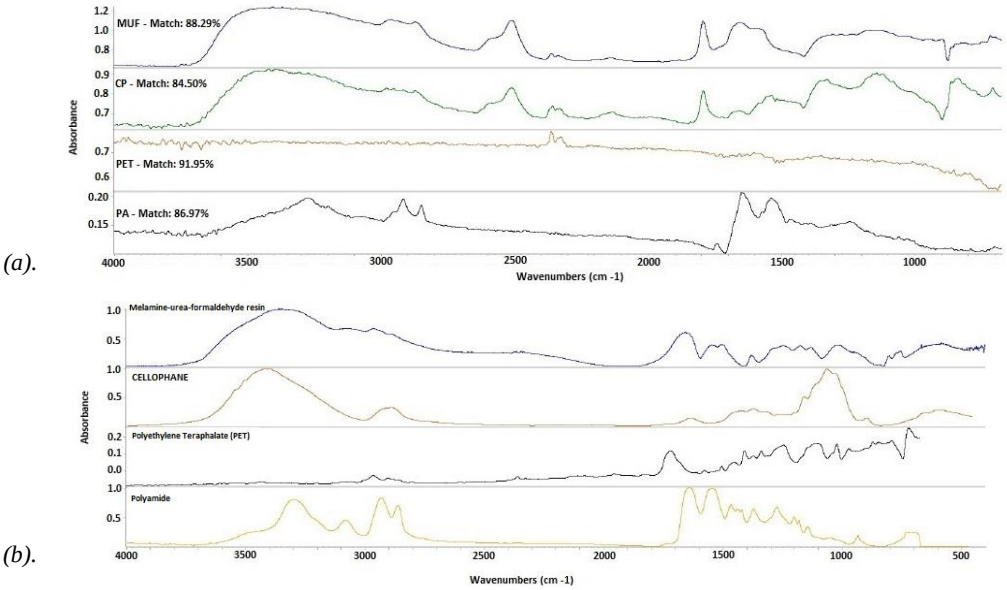


Figure 6. Distribution of polymer composition of microplastics.

Spectral peaks obtained from the microplastic samples are shown in Figure 7.



(a).

(b).

Figure 7. Spectral peaks of several microplastic polymers (a) and standard spectra from the library (b).

Table 2. Information on the polymer components of microplastics [4, 17, 19].

Polymer	Density (g/cm^3)	Hazard score (Sn)	Applications
PET	1.37 - 1.45	4	Bottles of purified water, soft drinks, juices; blister packaging, fast food packaging, plastic film, etc.; textile apparel fibres, household and furnishing fabrics, industrial fibers and yarns for tyre chords, car seat belts, sail cloth, outdoor wear and sports wear.
PA	1.12 - 1.15	50	Mechanical parts; wear-resistant parts, transmission structure parts, chemical machinery parts; automotive, textiles; gears, bearings, kitchen machines, fishing nets and lines, bottles and foils; fibers, toothbrush bristles, tubing, fishing line, etc.
PVA	1.19 - 1.31	1	Papermaking, textile warp sizing, wood glue, food packaging, contact lenses, eye drops.
PTFE	2.15	-	Used for heat-resistant, low-friction coatings, used in things like non-stick surfaces for frying pans, plumber's tape and water slides.
MUF	1.8 - 2.0	882	Laminated surface on chipboards used for cupboards, cabinets, shelves, doors, table tops and worktops; kitchen items: bowls, casserole spoons and tray; used in break-resistance alternatives to ceramic cups, plates and bowls for children.
PP	0.9 - 0.91	1	Bottle caps, drinking straws, yogurt containers, appliances, car fenders (bumpers) and plastic pressure pipe systems.
PE	0.917 - 0.965	11	A wide range of uses including supermarket bags and plastic bottles.
PS	1.04 - 1.07	30	Foam peanuts, food containers, plastic tableware, disposable cups, plates, cutlery, compact disc and cassette boxes.
CP	1.42	-	Food packaging bags.

The occurrence and distribution of microplastic polymers obtained in water and beach sand samples can be explained by the characteristics of the study area, human activities, the surrounding environment and natural factors such as weather, tides, currents, and temperature [6, 7, 9, 10, 18, 19]. The information about the sources of these polymers reported in Table 2 shows that they are consistent by the effect of plastic products that people and tourists use (bags, food wraps, plastic cups), in fishing activities, building construction materials, and electrical equipment. Meanwhile, in terms of density, only PE, PP and PS are lighter than sea water (1.02 g/cm^3), so it can be easily washed away from the sand by tidal currents. Moreover, those polymers have many applications, so they are more abundant in seawater samples with a ratio of

8.00 - 15 %. In the beach sand sample, these three polymers also appeared with a lower rate, reaching 4.70 - 9.88 %. This can be understood that the density of these polymers can increase due to the formation of biofilms and accumulation in the beach sand layer [19]. Meanwhile, the other 6 polymer components including PET, PTFE, PVA, PA, MUF and CP all have a higher density than seawater, so they can accumulate more at the beach surface.

In general, the polymer composition of microplastics obtained from this study was more diverse than that of other studies. However, in terms of polymers, there was a high similarity regarding the common ingredients such as PET, PP, PE, PS, etc. Microplastics along the Turkish coast of the Eastern Mediterranean Sea had only 4 main polymers including PE , PP, PET and AC in both sand and water [19]. PE (73 - 75 %), PP (12 - 17 %) and PS (10 - 13 %) were the 3 main polymers in sand and seawater samples at the beaches of Rayong province, Thailand [7]. In Shenzen, China, the main polymer composition included PP, PE, PVC and PS [18]. Studies on microplastics in beach sand and seawater in Viet Nam also found polymer components similar to our study, with the addition of other components with higher hazard scores such as PAN [5], PVC [9, 10], and ABS [14].

The study at the Tarragona coast [6] showed a diversity of polymer composition similar to our study. Besides the geographical characteristics of each study and related sources of impact, this difference in polymer composition can be explained by the limitation in the proportion of microplastics used to determine chemical composition. For example, in the Thai study, only 8.5 % of the total particles were determined for their polymer composition using an Attenuated Total Reflection-Fourier Transform Infrared Spectrometer (ATR-FTIR) [7]. A research in Spain only determined the polymer composition of particles with a size above 0.5 mm [6] or another research in Viet Nam determined the polymer composition for only 10 particles representing the overall study [5].

3.4. The risk essessement of microplastic exposure

The results of the microplastic pollutant load index calculated in this study show that the risk level in both seawater and beach sand samples in the study area was at the mild pollution level (Hazard Level I), with PLI values of 1.74 - 2.80 and 3.61 - 5.69, respectively. This result was similar to that reported by Prart and Hongsawat *et al*., 2022 [7], whereby the dangerous level of microplastics in both seawater and beach sand samples was at level I.

The danger of these microplastics also lies in their additive composition and the adsorption of toxic substances from the environment as presented in Table 2. The results of H-index showed a high level of hazard (level II) with H values in seawater and beach sand samples being 45.64 and 52.09, respectively. The research in Shenzen, China [18] showed the level of hazard of class III, which was higher than the result in our study. This can be explained that although the chemical composition of microplastics was diverse, the S_n index of the found polymers was quite small, whereas in China, they had PVC with a hazard score of 5001.

4. CONCLUSIONS

Our study showed that microplastics appeared in all beach and seawater samples at Le Thuy beach, Binh Tri commune, Quang Ngai province. In surface seawater samples, microplastic concentrations ranged from 19.44 ± 7.12 to 50.56 ± 2.51 MPs/L, with an average of 38.09 ± 10.84 MPs/L. In beach sand samples, the concentration of microplastics ranged from 783.33 ± 75.28 to 1950.00 ± 104.88 MPs/kg with the average value being 1283.33 ± 378.32

MPs/kg. Microplastics in the size groups 0 - 50 µm and 51 - 100 µm predominated in all samples with distribution ratios of 28.75 and 23.75 % in seawater sample, respectively; 41.56 and 31.82 % in beach sand samples, respectively. Fragment was the dominant shape in both seawater and beach sand samples with proportions of 57.50 and 92.86 %, respectively. PET accounted for the largest proportion with 37.50 and 44.16 %, respectively. Microplastic pollution is at an alarming level at Le Thuy beach, Quang Ngai province with calculated and predicted risks to the environment. The results of this research will be the basis for further studies on the nature and origin of microplastic waste in coastal strips and the marine ecological environment.

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Declaration of competing 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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