Vietnam Journal of Science and Technology ***60*** *(3) (2022) 499-512*

doi:10.15625/2525-2518/16374

MICROPLASTICS ACCUMULATION IN PACIFIC OYSTERS FROM DANANG BAY, VIET NAM

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Received: 13 August 2021; Accepted for publication: 3 November 2021

Abstract. The accumulation of microplastics (MPs) in the marine environment has become a global concern in recent years. MPs in oysters were considered as potential pollution in cultured farms in coastal areas. Accumulation of MPs in seafood may pose a threat to food safety, therefore it is important to investigate the abundance of MPs in bivalves to determine the potential risks of MPs to human health. In this research, MPs were identified and quantified in pacific oysters *Crassostrea gigas* which are cultured in Danang bay, Viet Nam. The obtained results showed that the average MPs concentration in oyster was about 2.36 ± 2.14 items/g (wet weight) and 33.25 ± 25.93 items/individual. The most abundant MPs size was in the range of 0-50µm (43.98 %), followed by the range of 50-100 µm (37.59 %). Besides, the most common shape was fragments (79.32 %), followed by fibers (20.30 %). Chemical composition of MPs polymer types was detected by µFT-IRspectra using a Nicolet iN10 MX Infrared Imaging Microscope. The major polymer types of MPs were Nylon (28.57 %), followed by Rayon (23.31 %), and Phenol resin (PFs 8.65 %). The results indicated that the occurrence of MPs in pacific oysters from Danang bay is indeed a potential risk to human health and further investigations need to be implemented for monitoring and improving MPs assessment in bivalves of Viet Nam.

Keywords: microplastics, pacific oyster, *Crassostrea gigas*, accumulation, polymer types.

Classification numbers: 3.2.1, 3.6.2.

1. INTRODUCTION

Microplastics are defined as plasticparticles less than 5000 µm in size and classified as primary and secondary MPs [1 - 3]. The global occurrence of MPs as an emerging pollutant in the marine environment with the properties and sources of microplastics has been discussed. The occurrence and distribution of MPs in the marine environment with MPs concentration, categories of MPs size, shape, colour and polymer types were demonstrated in many marine creatures, sediments, marine water and the interrelationship of MPs pollution in marine ecosystems was also studied [2 - 9]. MPs are considered as vectors of persistent organic pollutants (POPs) to the marine environment [10]. Microplastics can sink, deposite in sludge or sediment, become suspended in the ocean depending on the density of the polymer, age and fouling levels. Hence, MPs could be ingested by marine organisms such as planktons, bivalves, and fish and stored in cells or tissues [2, 11]. MPs accumulation will directly affect the life cycle of aquatic organisms and indirectly affect the food chain of ecosystems and humans. Characteristics and chemical composition of MPs polymer types were investigated in previous researches [3, 4, 12–18]. They are proven to be toxic chemicals due to the existence of toxic trace elements and organic contaminants such as polycyclic aromatic hydrocarbons, polychlorinated biphenyls, and organochlorine pesticides and persistent polymer types such aspolyethylene (PE), polyethylene terephthalate (PET), polypropylene (PP), polyamide (PA), polystyrene (PS), polycarbonate (PC) and polyvinyl chloride (PVC), polyester, rayon, poly (ethylene: diene: propylene), polystyrene, acrylic and nylonacrylicof MPs [16, 19 - 21].

Recently, abundance and characteristics of MPs in many species of bivalves such as oysters, mussel, manila clam, scallop, and shellfish have been investigated to evaluate their potential risk to the marine environment [3, 5, 22]. Among marine species, bivalves have been used as biological indicators for monitoring environmental contaminants. MPs accumulation in bivalves has been evaluated for their potential risk to marine ecosystems and human seafood sources [11, 16, 22].

Some studies were focused on determing the occurrence of MPs in oysters cultured in coastal areas including MPs concentration, size, shape, colour and chemical composition of polymer types [12, 13, 16, 22, 23]. It is reported that MPs exist in oyster in high concentrations, calculated by MP items per gram (wet weight of soft tissues) and MP items per oyster. The diversity of MPs with major size < 200 µm and the shape abundance of fibers or fragments with different composition of polymer types were investigated. In Korea, the quantity of MPs ingested by oysters from the coastal environment was 0.43 ± 0.32 particles/g (2.19 ± 1.20 particles/individual) [12]. It is reported in another study that the average abundance of MPs in oysters along the Pearl River Estuary, China ranged from 1.4 to 7.0 items/individual or from 1.5 to 7.2 items tissue/g (wet weight) [13]. Liao *et al*. (2021) found that the average content of MPs in coastal areas of Taiwan varied from 0.63 ± 0.52 items/g to 37.94 ± 19.22 items/g [23]. However, investigations on contamination levels and characteristics of MPs in aquatic organisms in general and marine species in particular in Viet Nam are still limited.

Viet Nam has a strategic location in the center of Southeast Asia with more than 3,000 km of coastline. The recent rapid urbanization and especially tourism activities in a popular tourist destination like Danang can have a remarkable impact on the quality of the coastal marine environment. The Sixth GEF (Global Environment Facility) General Assembly, held in Danang in 2018, showed that Viet Nam was considered as one of the ten worst plastic polluted countries along the coastal hydrosphere, ranking fourth among the top ten countries with mismanagement of plastic waste in the world [24]. It is noteworthy that contamination by microplastics can lead to bioaccumulation of toxic substances for consumers in the food web while aquaculture is a major economic strategy in coastal areas and is the main source of protein for people throughout the country. Among various types of seafood, molluscs are an important commercial product of Viet Nam, playing a great role in the sustainable development of the marine economy with a total production of 300 thousand tons in 2019 [25].

In this context, investigation on the characteristics of pacific oyster *Crassostrea gigas* cultured in Danang bay, Viet Nam was conducted, including abundance, size, shape distribution and polymer types of MPs in pacific oysters. These data may contribute to future studies on the interrelationship between MPs pollution in oysters or bivalves and the marine environment and the assessment of potential risks of MPs in Vietnamese seafood.

2. MATERIALS AND METHODS

2.1. Oyster sampling sites

The pacific oysters (*Crassostrea gigas*) chosen for sampling were collected from two locations (1) and (2) of the pacific farming areas in Danang bay of Viet Nam (Figure 1). At two sites of these farms, oysters are cultured according to the natural farming model. At each location, 30 individuals were collected and transported to the laboratory. All samples were protected by aluminium foil and stored at -20 °C for analysis.

Figure 1. Sampling sites of pacific oysters from Danang bay.

Table 1. Soft tissue weight of cultured oysters from sampling sites.

TT	Sampling code	Length (cm)	Width (cm)	Soft tissue weight (g/individual)
1	OS1	7.5	5.5	9.9701 ± 0.106
2	OS2	8	6.5	14.8681 ± 0.256
3	OS3	8.5	6.5	18.8937 ± 0.213
4	OS4	8.5	6.5	19.3042 ± 0.232
5	OS5	9	6.5	17.8892 ± 0.231
6	OS6	8	5.5	12.5073 ± 0.159
7	OS7	8	6.5	13.8266 ± 0.126
8	OS8	7.5	6	16.7786 ± 0.202

Oyster sample groups are selected with the width of oysters from 5.5 to 6.5 cm and the length from 7.5 to 9 cm. Sampling codes of oysters from the location 1 (OS1, OS2, OS3 and OS4) and location 2 (OS5, OS6, OS7 and OS8) with oyster size and soft tissue weight are presented in Table 1.

2.2. Analytical methods

Microplastics extraction

Eight oyster samples from the freezer were taken out and washed with deionized water to prepare for analysis. The cover of oysters was opened out to collect the soft tissues for microplastic analysis. The wet weight of the soft tissues was determined using an electronic balance in the laboratory (Table 1). The oyster soft tissue was washed with ultrapure water (SG/GERMANY) to remove any remaining peel and weighed with an HR 202i electronic balance, Japan.

Microplastic extraction was performed according to the procedure proposed by Teng *et al*. (2019) and Munno *et al*. (2018) [24 - 25]. Oyster soft tissues were placed in labelled 500 mL beakers (Duran, Germany), followed by adding 180 mL of 10 % KOH and 20 mL of 30 % H_2O_2 to each beaker to digest soft tissues of oyster. The beakers were covered with foil and placed on a hotplate at 60 °C for 48 h in a fume hood and stirred once every 8 hours. When the organic matter was completely removed, the solution became clear and lightly yellow, the decomposition was considered complete. Adding NaI solution (d = 1.85 g/mL, checked by weighing 1 mL of NaI solution on an electronic balance) for gravity settling based on the difference in density. After that, the solution was filtered using a vacuum pump (KNFM, Germany) and a glass filter (Duran, Germany) with glass filter paper (GF/A diameter 47 mm, filter hole size 1.6μm, USA). The filtered samples were placed in a labeled 60 mm glass petri dish and dried at room temperature for microplastic analysis.

Microplastics identifications

In this study, all the oyster samples were identified using a micro-Fourier Transformed Infrared Spectroscope (μ-FT-IR) in reflectance mode ATR. The μ-FT-IR analysis was performed with a Nicolet iN10 MX Infrared Imaging System (Thermo Fisher Scientific, USA) equipped with a highly sensitive Mercury-Cadmium-Telluride detector (MCT detector). Particles of each filtered sample were gently scraped and skillfully transferred on a gold-coated microscope slide before being placed into the sample holder on a motorized stage. The MCT detector was cooled with liquid nitrogen for at least 20 minutes to ensure optimal operating conditions for spectra acquisition (average of 16 scans per pixel). For each scan area, an aperture size of 150 μm x 150 μm with a spectrum collection time of three seconds (corresponding to 16 scan times) was used. Using a motorized gold-coated microscope slide with the scanning mode mentioned above was convenient for analysis of microplastics by the Nicolet iN10 MX device. With this modern technique of scanning spectra and images, microplastic particles were visually identified using a software for the Nicolet iN10 MX device, which gave various parameters such as the name of component, match (%), area (%), length (μm), width (μm) and μFT-IR spectra and corresponding optical images of microplastics detected as polymers or chemical compounds closely similar to polymers. Each sample was scanned from 5 to 10 minutes, depending on the microplastic particles presented and similar chemical composition identified. Microplastics analyzed from each filter were recorded for sampling individual oyster.

The values of length (L) and width (W) (μm) of the microplastic components were used to determine the distribution of microplastic shape with 3 main forms, namely: beads if L = W = 0, fibers if the ratio L:W < 2, and fragments if the ratio L:W ≥ 2 [28, 29]. The sizes of microplastics are grouped from 0 to 750 μm (maximum length) with different dimensions: 0 - 50, 50 - 100, 100 - 150,..., 700 - 750 μm.

Please check the above point again: if L (length) = W (width) = 0, there won't be any particles, how can there be beads?

Polymer types of MPs in the samples were identified by comparing with the database of the identified components, including the spectral library database: HR Aldrich μFT-IR Collection Edition II, HR Polymer Additives and Plasticizers; Hummel Polymer and Additives or some components are identified by name [26, 30]. In this study, the identification of the obtained μFT-IR spectra was given by automatic comparison with the spectral database in the library. Thus, all μFTIR spectra of components in each sample were recorded. The obtained data including spectrum signals and images were automatically analyzed with the Particle Wizard which is an advanced option of the Omnic Picta software. Briefly, the Particle Wizard performed an integrated process to count the number of particles, determine their size (area, length, and width) based on images and identify the nature of polymers after their spectra were compared with the Omnic polymer spectra in the library. However, some of them were not plastic compounds that were omitted in the screening step. Hence, the polymer types of MP particles were classified by screening knowledge and professional skills for microplastic components to arrange into each type of MPs depending on the chemical component name identified by the Nicolet iN10 MX device. All polymer types of MPs were collected to calculate the ratio of each polymer in the polymer mixture. Therefore, the number of MPs and their chemical composition (Nylon, PP, etc.) in oysters were presented.

In addition, a device (Leica S9i Stereomicroscope, Germany) from the University of Science and Technology of Hanoi - Vietnam Academy of Science and Technology was used to record images of the identified microplastics.

Data analysis

All results for each sample were averaged and repeated 3 times. The abundance of microplastics in the oyster sample was expressed as the number of microplastics per gram of wet soft tissue (C_w) and the number of microplastics per individual (C_i), as proposed in the study by Ding *et al*. (2021) [31]:

$$C_w = \frac{MPs_i}{W_i} \text{ (items/g)} \tag{1}$$

$$C_i = \frac{MPs_i}{n_i} \text{ (items/individual)} \tag{2}$$

where: MPs_i is the number of microplastics of individual oyster (items); n_i is the total number of oysters (items); W_i is the total wet soft tissue weight of oysters (g).

The characteristics of microplastics in terms of shape, size and type of polymer are expressed as the percentage of MPs distribution (P(%)) according to Equation (3):

$$P(\%) = \frac{N_{MPs_i} * 100}{\sum N_{MPs_i}} \tag{3}$$

where: N_{MPs} is the number of microplastics in each characteristic as size, shape, and chemical composition of MPs (Nylon, PP, etc.) of oysters; i: oyster in terms of size, shape, chemical composition of MPs (Nylon, PP, etc.).

3. RESULTS AND DISCUSSION

3.1. Abundance of microplastics in pacific oysters

Microplastics were identified in the pacific oysters by the Nicolet iN10 MX Infrared Imaging Microscope. The abundance of MPs in oysters was from 0.32 to 6.96 items per gram of wet tissue, and an average MPs concentration in oysters was about 2.36 ± 2.14 items/g and from 6 to 87 items per individual of sampling codes (OS1, OS2, OS3, OS4, OS5, OS6, OS7, and OS8) at two sampling sites. The average value of MPs in individual oyster was about 33.25 ± 25.93 items, in which OS6 had the highest MPs concentration with 87 items/individual and OS3 had the smallest MPs concentration with 6 items/individual. Most concentrations of MPs ranged from 0.32 to 3.22 items/g in oyster soft tissue at sampling sites. The results for MPs concentration in pacific oysters are shown in Figure 2.

The level of MPs in pacific oysters in Danang is higher than that in France (Atlantic Ocean) 0.47 items/g with the oyster named *Crassostrea gigas*. In constrast, the abundance of MPs in the pacific oyster is significantly lower compared with that in the bivalve *(Mytilus edulis*) in Cananda with 34 - 178 items/individual [3, 4].The number of total MPs changed from 2.1 to 10.5 items/g and from 4.3 to 57.2 items/individual for commercial bivalves from China. In general, the data obtained from this research showed that MPs concentrations per gram and per individual varied and were not significantly different at sampling sites in pacific oyster farms in Danang bay.

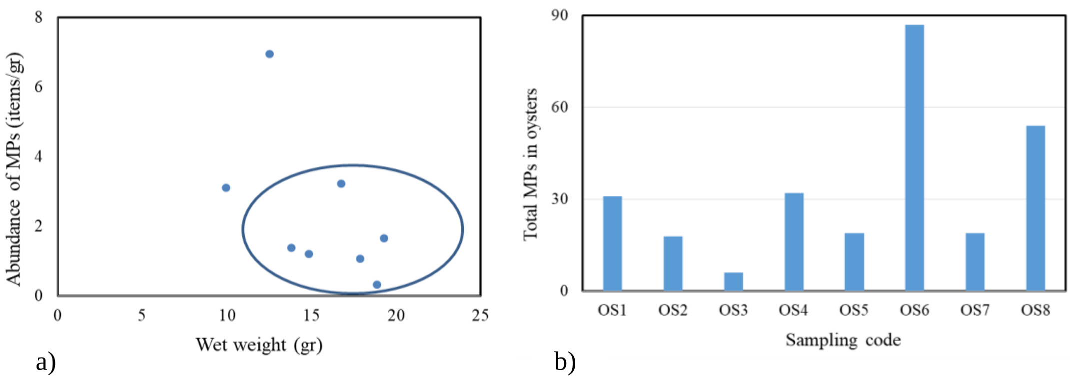


Figure 2. MP abundance in pacific oysters (a) and MPs in individual oyster (b).

In another research on oysters *Saccostrea cucullata* along the Pearl River Estuary, China, C_w was determined to be in the range from 1.4 to 7.0 items/individual and and C_i from 1.5 to 7.2 items/g. These results showed nearly the same value as MPs concentration in this research but the distribution of MPs for each individual oyster was significantly different by comparison [13]. The mussel samples in the United Kingdom showed the C_w and C_i of MPs from 0.7 to 2.9 items/g and from 1.1 to 6.4 items/individual, respectively, which were slightly lower than those in pacific oysters. However, MPs particles detected in individual of the pacific oyster from Danang bay were larger than MPs in mussel [6].

According to the statistical data, the MP abundance in oyster (*Crassostrea gigas*) was 29 and 10 items/g in Neeltje Jansand Rhine estuary, Dutch coast, respectively, which were higher than MPs concentration in this research for the same species of *Crassostrea gigas*. However, the average abundance of microplastics in oysters in China was 0.62 items/g (wet weight) and 2.93

items/individual which are lower than MPs concentration in this research [16]. The average abundance of microplastics was 3.24 ± 1.02 items/g (wet weight), ranging from 0.63 ± 0.52 items/g to 37.94 ± 19.22 items/g (wet weight), determined in oysters in coastal areas of Taiwan [23]. Thus, it was assumed that the existence of MP abundance in oysters was different for the sampling sites and individual oysters.

3.2. Distribution of microplastics in pacific oysters

The size and shape distribution of the microplastics were identified in the soft tissues of oysters selected in this study. They were classified based on the MPs size in the range from 0 to 750 µm into different 12 dimensions. The distribution of MPs shape was presented with the occurrence of three shapes including fragments, fibers and beads according to the length and width classification of the confirmed MPs particles. Moreover, the relation of the size and shape distributions of MPs in pacific oysters was investigated.

Size of MPs in pacific oysters

The proportion of MPs sizes was divided into different categories with dimensions from 0 to 750 µm. Microplastics with the highest C_w and C_i values found in pacific oysters in Danang bay showed the size in the range of 0 - 50 µm (43.98 %), followed by the range of 50 - 100 µm (37.59 %), and different bigger dimensions with a jump of 50 µm (Figure 3). MPs ranged in size from 100 to 150 µm (9.4 %), from 150 to 200 µm (2.26 %), from 200 to 250 µm (2.63 %) and others (4.14 %) including bigger ranges from 250 to 750 µm in seven dimensions with different smaller ratios from 0.38 % to 0.75 %.

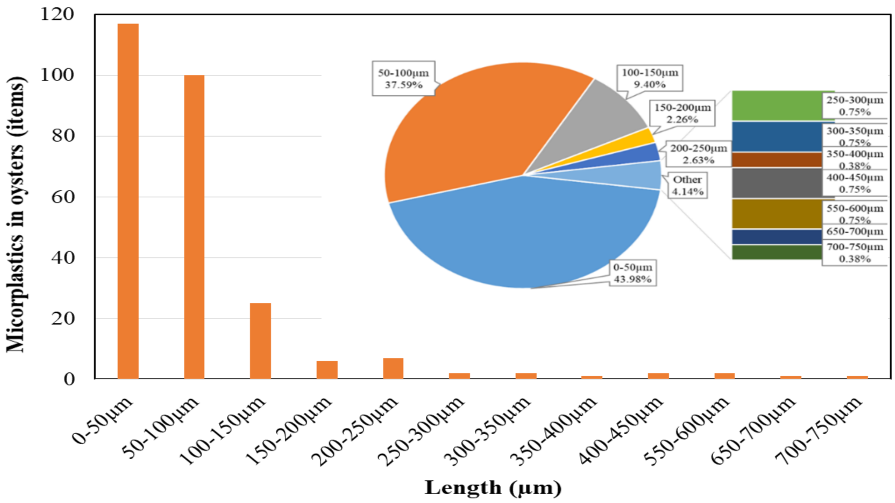


Figure 3. Distribution of microplastics size in oysters.

The size distribution of MPs found in pacific oysters was corresponding to the highest proportion up to 53 % with size < 100 µm in another research on MPs in oysters and 89 % of MPs related to size < 100 µm and 11 % of size > 100 µm for an investigation of MPs in mussels [32]. In comparison with other investigations, the size distribution of MPs in pacific oysters in this study was similar to that in oysters *Saccostrea cucullata* in China in which microplastic sizes ranged from 20 to 5000 µm and about 83.9 % of MPs were less than 100 µm. The most abundant MPs size was below 100 µm in oysters or bivalves, which could be explained that the smaller MPs could be easily ingested into oysters or bivalves in general and accumulated in their tissues [13]. The distribution of MPs size in this study was different compared to the previous research in which the MPs < 500 µm in size were the most common and accounted for 38.57 % of the total MPs. In addition, the existence of larger sizes from 500 to 5000 µm was observed in oysters from different coastal areas of China [16].

Shape of MPs in pacific oysters

The shape distribution of MPs was presented with three types, including fragments, fibers and beads in the soft tissues of pacific oysters (Figure 4a). The dominant proportion of MPs was fragments with 79.32 %, followed by fibers with 20.30 %. Both of them accounted for 99.62 % of the total MPs in oysters at sampling sites. Similarly, the results of this study showed the largest proportion of MPs distribution with the occurrence of fragments and fibers from 82.5 to 97.2 % of total MPs in oysters *Saccostrea cucullata* at different sites. However, the proportion of the fragment was larger than that of the fiber in this study, and three types of MPs shape were detected compared with four shapes of fibers, fragments, pellets and sheets found in oysters *Saccostrea cucullata* from China [13]. In another research, four different shapes of MPs were reported including fibers, fragments, films and pellets, of which the major shape of MPs was fibers with 60.67 %, followed by fragments with 19.95 % in cultured oysters from the coastal areas of China [16].

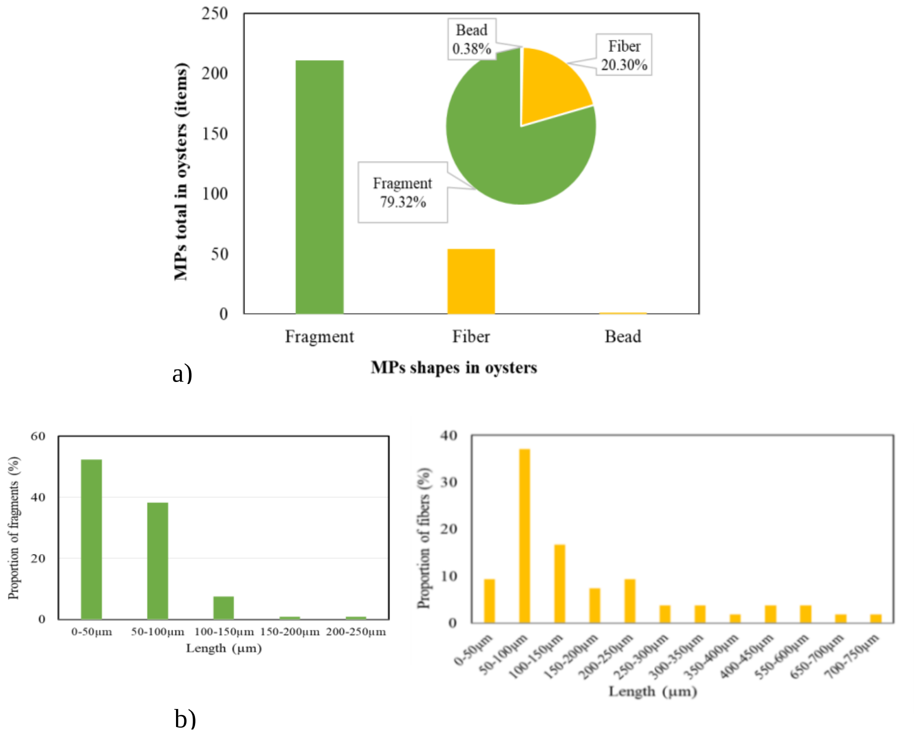


Figure 4. Microplastics shapes (a) and distribution of MPs shape with size in oysters (b).

The abundance of size distribution in pacific oysters with dominant MPs of fragments and fibers was presented, which could be related to the water and natural food quality at sampling sites of the oyster farms. Oysters could uptake pollutants as MPs for feeding from discharging water resources in aquatic ecosystems. It seems that oysters reflected the MPs pollution in water and were considered as a potential bio-monitor for MPs pollution. Fragments and fibers were recorded as the dominant MPs in many researches and they were also detected in different marine creatures such as mussels, shrimps, fishes, and terrestrial birds [4, 6, 13]. Fragment was also found to be the most dominant shape with 76 % of total MPs in a market survey of four bivalve species including oyster (*Crassostrea gigas*), mussel (*Mytilus edulis*), Manila clam (*Tapes philippinarum*), and scallop (*Patinopecten yessoensis*) from South Korea [22].

It was detailed that the fragment and fiber shapes of MPs in oysters accounted for 211 and 54 items, respectively, and the distribution of MPs shapes such as fragment and fiber with different size ranges of MPs was presented (Figures 4a and 4b). The proportions of fragment in oysters in the range of 0 - 50 µm (52.36 %) and 50 - 100 µm (38.21 %) were dominant, followed by the size from 100 to 150 µm (7.55 %) and the remaining two sizes of 150 - 200 µm and 200 - 250 µm. However, the size distribution of the fiber shape of MPs was diversified in the range from 0 to 750 µm and the major fiber size ranged from 50 to 100 µm (37.04 %), followed by a size range of 100 - 150 µm (16.67 %), while the MP sizes of 0 - 50 µm and 200 - 250 µm (9.26 %) and other sizes of MPs with smaller proportions were also detected.

Some microscope images of the top two abundant shapes of MPs, namely fragments and fibers, are shown in Figure 5. It was assumed that these two shapes of MPs were significant and they were considered an environmental problem related to the discharge of MPs into water resources or food management on pacific oyster farms. The results of this research were consistent with the assessment of MPs in oysters of two genera (*Crassostrea* and *Saccostrea*) in coastal areas of Taiwan, whereby over half of the microplastics were smaller than 100 µm, and the most common shape was fragments (67 %), followed by fibers (29 %) [23]. The presence of MPs shapes (fragments and fibers) in pacific oysters from Danang area was a new insight to consider MPs as a pollutant indicator in oysters and bivalves in general in Viet Nam.

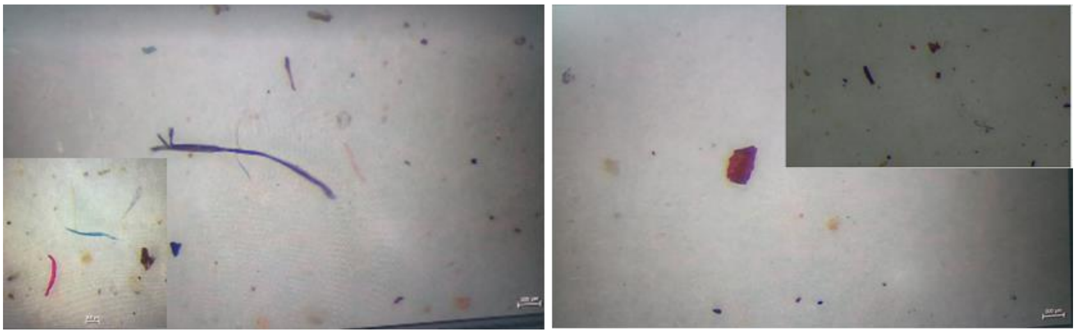


Figure 5. Images of MPs shapes (fragment and fiber) in pacific oysters.

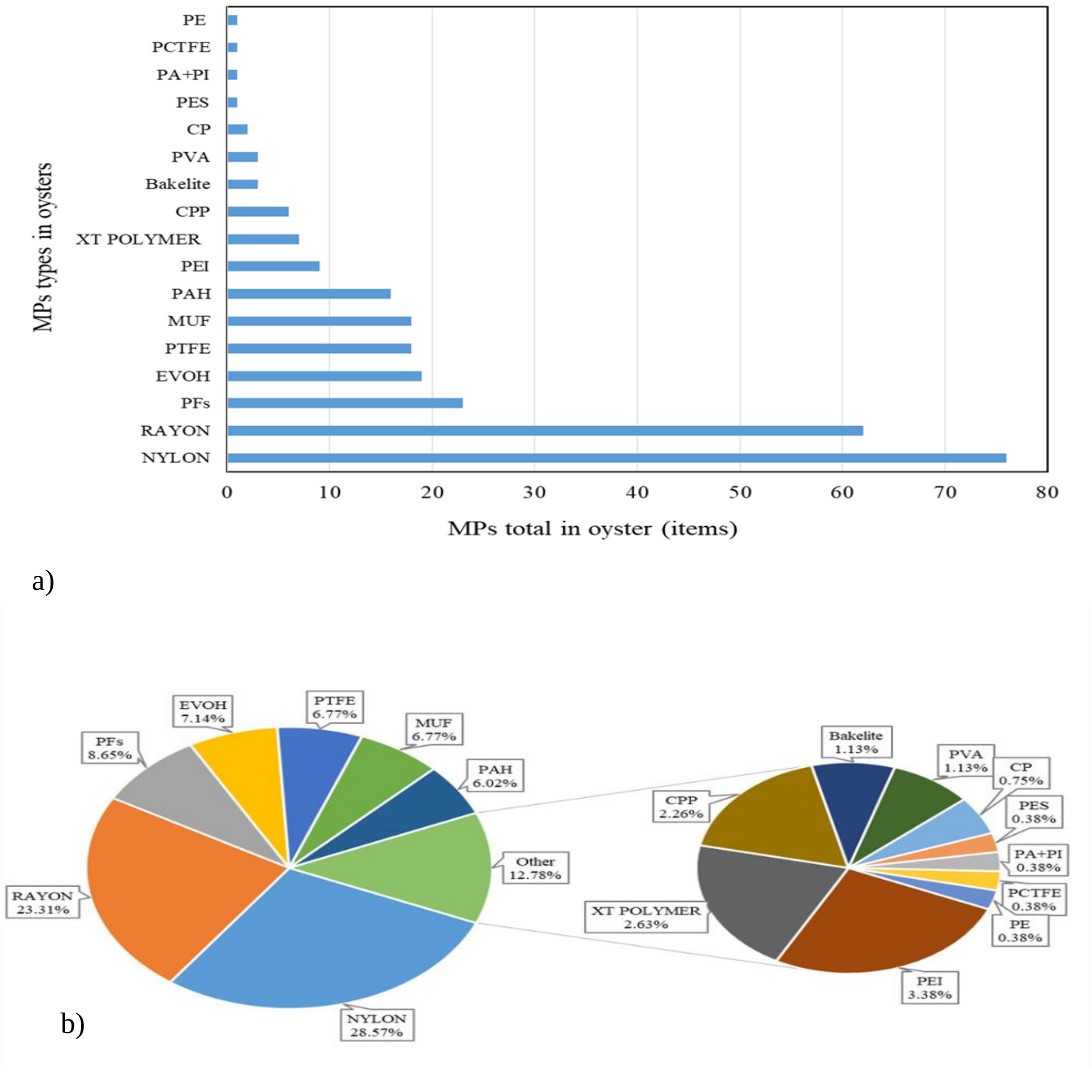
(Recorded on 23rd July, 2021 by Leica S9i Stereomicroscope).

3.3. Chemical composition of microplastics in pacific oysters

The chemical composition screening results showed that in pacific oysters, the total number of MPs particles confirmed as plastic polymers by µFT-IR microscopy was 266 items with 17 types of polymer MPs.

The most common polymers of MPs were Nylon (28.57 %), followed by Rayon (23.31 %), Phenol resin (PFs 8.65 %), Ethylene vinyl alcohol (EVOH 7.14 %), Polytetrafluoroethylene

(PTFE 6.77 %), Melamine-urea-formaldehyde resin (MUF 6.77 %), Polyallyl-amine hydrochloride (PAH 6.02 %), and others (12.78 %) including a smaller division of occurrences such as XT polymer, Polypropylenechlorinated (CPP), Bakelite, Polyvinyl alcohol (PVA), Cellophane (CP), Polyester (PES), Polyamide + imide (PA + PI), Polychlorotrifluoroethylene (PCTFE), and Polyethylene (PE). The polymer types of MPs in pacific oysters in this research are shown in Figure 6 and the infrared spectra of the dominant polymer types in pacific oysters in comparison with the database of the library were presented in Figure 7 by µFT-IR spectra using the Nicolet iN10 MX device. The wavenumber of characterized groups ranged from 650 to 4000 cm^{-1} in the mentioned polymers.



a)

b)

Figure 6. MPs types (a) and polymers proportion of MPs in oysters (b).

Polymer types in pacific oysters of this research were different from those in oysters in coastal areas of Taiwan where the major component was polyethylene terephthalate (PET) with 69.54 % in comparison with the dominant Nylon and Rayon in this investigation [23]. Similarly, it was reported that 18 types of polymer MPs were determined by µFT-IR with polyvinyl chloride (PVC) and Rayon being the highest abundant in four locally cultured bivalve species (scallop *Chlamys farreri*, mussel *Mytilus galloprovincialis*, oyster *Crassostrea gigas*, and clam *Ruditapes philippinarum*) [18]. The occurrence of the most abundant Rayon could be due to the decomposition of clothing or hygiene products into wastewater sources and their direct discharge into the aquatic environment. In addition, Rayon was the highest polymer type in the surface sediment explored and all bivalves such as oysters, mussels, and scallops were cultured in the water column [18, 22].

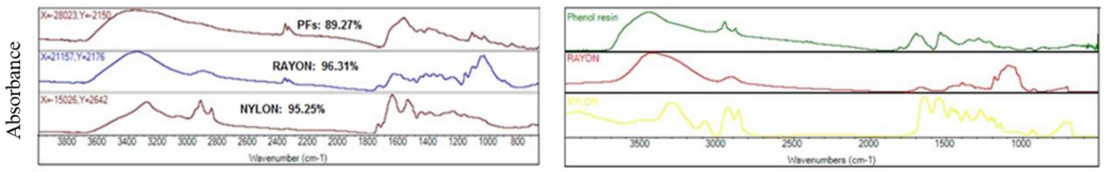
The chemical composition of polymer types of MPs in pacific oysters was investigated, showing that Nylon was the highest with 28.57 %. It was explained that Nylon is used in textiles, clothing, nonwovens, carpets, ropes in large quantities in Viet Nam and the existence of this plastic lasts for a significantly long time in the marine environment around oyster farming sites. Therefore, the relationship between MPs polymer types in pacific oysters and the surrounding environment was significantly influenced by the food chain quality in their growth cycle in cultured farms. All polymer types of MPs in oysters in this study were also identified in previous works with different proportions of the MPs polymer types [16, 18, 23, 33]. Polyethylene (PE), polypropylene (PP), polystyrene (PS; mostly expanded PS), and polyester were the major polymer types, accounting for > 80 % of microplastics in all bivalves, while other types of MPs were determined in smaller proportions [22].

Collected Spectra

ID	Particle/Spectrum Position	CID	Identified Component Name	Match	Area	Length	Width
79	X=-15026,Y=2642	10	NYLON	95.25	0.54	122.1	49
17	X=21157,Y=2176	24	RAYON	96.31	0.13	122.1	100
91	X=-28023,Y=-2150	31	Phenol resin	89.27	0.13	45	27.1

Identified Library Components

CI	Identified Component Name	Component Library Name	Matc	Are	# of	Co
10	NYLON	Synthetic Fibers by Microscope	95.2	0.54	1	
24	RAYON	Synthetic Fibers by Microscope	96.3	0.1	1	
31	Phenol resin	HR Hummel Polymer and Additives	89.27	0.13	1	



The infrared spectra of some polymer types in MPs sample | The corresponding reference spectra from database in the library

Figure 7. The infrared spectra of some polymer types in pacific oysters and database in library by µFT-IR microscopy.

Therefore, the investigation of MPs polymer types varied with the diversity of polymers associated with marine debris types at the sampling sites of coastal, bay areas or beaches such as plastic bottles (indicated by PET and PP), food wrappers, plastic bags, bottles, covers (indicated by PVC, HDPE) or fibrous materials of clothes, ropes (indicated by PP, PE, HDPE, PVC, etc.) or marine debris from wastewater and laundry, fishing or floating village activities (indicated by |Nylon, Rayon, PVC, PEs, EVOH, PTFE, etc.).

4. CONCLUSIONS

In this preliminary research, the abundance and characteristics of MPs in cultured pacific oyster *Crassostrea gigas* from Danang bay, Viet Nam were investigated. The obtained results indicated that the average abundance of MPs in oysters was 2.36 ± 2.14 items/g (wet weight) and 33.25 ± 25.93 items/individual. Additionally, fragments and fibers were the most prevalent shapes of MPs with major sizes of below 100 µm. Among polymeric types of MPs, Nylon (28.57 %) and Rayon (23.31 %) were found to be the most abundant components in oysters from Danang bay.

The high abundance and various polymer types of MPs found in pacific oysters in this study showed the potential risks of MPs. They can affect human health while molluscs have made important contributions to valuable products for the development of sea farming and seafood in Viet Nam. For this reason, further investigations into MPs contamination in different kinds of seafood and marine environmental quality need to be carried out in the future in Viet Nam.

Acknowledgements. The authors acknowledge financial support from Institute of Environmental Technology, Vietnam Academy of Science and Technology for funding the project N°CSCL.12/21-21 and project N° TLTB05.02/21-23.

CRediT authorship contribution statement. Author 1: Methodology, Investigation, Funding acquisition. Author 3: Samples extraction and data analysis. Author 4 and Author 5: Sampling and sample analysis. Author 1, Author 2 and Author 6: Writing and finishing the manuscript.

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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