INVESTIGATION OF MICROPLASTIC CONTAMINATION IN SELECTED MARINE SPECIES FROM THE COASTAL AREA OF QUANG TRI PROVINCE AND ASSESSMENT OF POTENTIAL HUMAN HEALTH RISKS

NGHIÊN CỨU HIỆN TRẠNG VI NHỰA TRONG MỘT SỐ LOÀI HẢI SẢN VÙNG VEN BIỂN TỈNH QUẢNG TRỊ VÀ ĐÁNH GIÁ NGUY CƠ TIỀM ẨN ĐỐI VỚI SỨC KHỎE CON NGƯỜI

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Abstract - This paper presents the results of a study evaluating the current status of microplastic contamination in green tiger prawn (*Penaeus semisulcatus*) and Commerson's anchovy (*Stolephorus commersonnii*) collected from the coastal region of Quang Tri Province, Vietnam. A total of 30 biological samples were analyzed, all of which were obtained from the local coastal fishing port. The concentrations of microplastics detected in *P. semisulcatus* and *S. commersonnii* were 3.89 ± 1.68 particles/g and 2.94 ± 1.27 particles/g, respectively. Microplastics ranged from 100 to 4150 µm, predominantly in fiber form. A total of 17 polymer types were identified. The potential human health risks were assessed as moderately high, with average Health Risk Index (HRI) values of 64.88 and 42.68, and Polymer Hazard Index (PHI) values of 721.3 and 785.5, respectively.

Key words - Microplastics; Marine species; Green tiger prawn; Commerson's anchovy, Human health risk

Tóm tắt - Bài báo trình bày các kết quả nghiên cứu đánh giá hiện trạng vi nhựa trong loài tôm vằn *(Penaeus semisulcatus)* và cá cơm *(Stolephorus commersonnii)* tại vùng ven biển tỉnh Quảng Trị, Việt Nam. Nghiên cứu đã tiến hành phân tích 30 mẫu sinh vật được thu thập tại khu vực cảng đánh bắt vùng ven biển. Nồng độ vi nhựa được tìm thấy trong tôm vằn và cá cơm lần lượt là 3,89 ± 1,68 mảnh/g và 2,94 ± 1,27 mảnh/g. Kích thước của vi nhựa nằm trong khoảng 100-4150 µm, với dạng sợi chiếm ưu thế. Kết quả cho thấy sự đa dạng về chủng loại vi nhựa, với 17 loại polymer được tìm thấy. Nguy cơ tiềm ẩn đến sức khỏe con người của vi nhựa trong tôm vằn và cá cơm được đánh giá ở mức trung bình cao, với chỉ số rủi ro sức khỏe (HRI) trung bình lần lượt là 64,88 và 42,68, chỉ số nguy hại polymer (PHI) trung bình lần lượt là 721,3 và 785,5.

Từ khóa - Vi nhựa; Sinh vật biển; Tôm vằn; Cá cơm; Rủi ro sức khỏe con người

1. Introduction

In recent decades, microplastic pollution has emerged as a global environmental issue, causing particular concern in coastal countries such as Vietnam. Microplastics are plastic particles smaller than 5 mm, originating either from the breakdown of larger plastic products or produced directly for use in various consumer goods. These particles are now ubiquitous in marine environments and are increasingly infiltrating natural food chains.

In Vietnam, numerous recent studies have documented a significant presence of microplastics in marine species. Specifically, a study conducted in Cau Hai Lagoon (Thua Thien Hue Province) revealed that both farmed and wild shrimp were contaminated with microplastics, with average concentrations ranging from 0.5 to 1.1 microplastic particles per gram, and farmed shrimp exhibiting significantly higher contamination levels than wild shrimp [1]. In Da Nang Bay, farmed oysters (Crassostrea gigas) were also found to contain an average of 1.88 microplastic particles per gram [2]. Additionally, another study reported a high density of microplastics in commonly consumed seafood species such as farmed black tiger shrimp, green crab, and sardines [3].

The consumption of seafood contaminated with microplastics may increase the risk of adverse human health effects. Studies have shown that microplastics can cause tissue damage, endocrine disruption, and may accumulate in living organisms, including humans, over extended periods [4]. However, there is still a lack of specific data on the extent of microplastic contamination in local marine areas.

Quang Tri Province is one of the regions in Vietnam with a long coastline, a diverse coastal ecosystem, and abundant marine resources, playing a vital role in the livelihoods of local communities. Alongside rapid socio-economic development and the increasing activities of aquaculture, fisheries, and marine tourism, the risk of environmental pollution - particularly microplastic pollution - has become a growing concern. Therefore, selecting Quang Tri Province as a study area is not only scientifically significant in supplementing experimental data but also has practical value, contributing to the protection of the marine environment and public health.

In this paper, the authors investigate the current status of microplastic contamination in green tiger prawn and anchovy, which are commonly consumed seafood species in Quang Tri Province, and also assess the potential risks to human health associated with the consumption of these species. The results of this study can contribute to the scientific database for public health protection and marine environmental management.

2. Materials and methods

2.1. Sampling locations and methods

Cho Cau Market and Cua Viet Fishing Port were selected as sampling locations, as they are representative of seafood harvesting and consumption activities in Quang Tri Province's coastal areas. Both sites serve as major hubs for seafood trading and harvesting in the region, reflecting the consumption patterns and sources of marine food products. The selection of these areas aimed to provide a comprehensive assessment of microplastic contamination throughout the seafood value chain in the coastal region of Quang Tri Province.

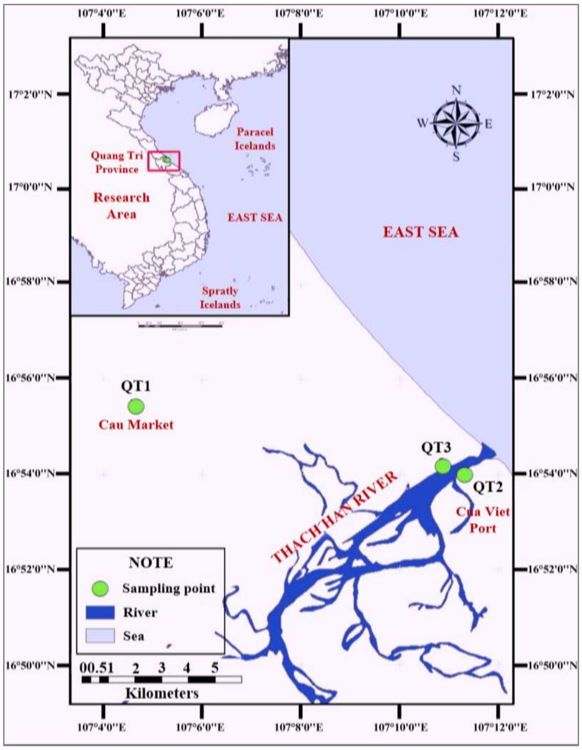

Figure 1. Diagram of sampling locations in Quang Tri province, Vietnam.

Biological samples of two aquatic species - green tiger prawn (*Penaeus semisulcatus*) and Commerson's anchovy (*Stolephorus commersonnii*) - were collected from three sites in Gio Linh District, Quang Tri Province, in April 2025 (see Figure 1).

At least five individuals of each species were collected at each site. Following collection, samples were wrapped in aluminum foil and transported to the laboratory under refrigerated conditions, then stored at -20°C until further analysis.

2.2. Microplastic extraction procedures

The biological samples were processed following the protocols of Thao et al. [5] and Karami et al. [6] for microplastic extraction. Specifically, after natural thawing, the carapace dimensions (length and width) of each specimen were measured using a Vernier caliper to record initial morphological characteristics. Each sample was then carefully dissected, with soft tissues collected and transferred into a 500 mL glass beaker for precise weighing. Soft tissue digestion was performed by adding 180 mL of 10% KOH solution. The mixture was covered with aluminum foil to minimize evaporation and contamination, then incubated at a constant temperature of 60°C for 48 hours using a heating plate.

Subsequently, the digested solution was filtered through a 1.0 µm stainless steel sieve to remove excess KOH. Next, 25 mL of 30% H_2O_2 and 25 mL of Fe(II) solution (containing H_2SO_4) were added, and the mixture was heated at 40°C until it became clear and light yellow. If organic matter remained, additional H_2O_2 was added. When the remaining solution was about 10% of the original volume, density separation was performed sequentially using NaCl solution (d = 1.2 g/mL) and NaI solution (d = 1.8 g/mL). Each solution was used twice, thoroughly mixed, allowed to settle for 120 minutes, and the supernatant was collected by overflow.

The solution containing microplastics was filtered using a vacuum filtration unit with GF/F glass fiber filter paper (47 mm diameter, 0.7 µm pore size). The filter paper was thoroughly rinsed with ultrapure water, placed in a labeled 60 mm petri dish, and air-dried at room temperature in preparation for microplastic analysis.

Each analysis was performed in triplicate, and the results were compiled and expressed as mean values to ensure data accuracy and reliability.

2.3. Microplastic identification

Microplastic identification was conducted using a Micro-FTIR Nicolet iN10 MX infrared microscope (Thermo Fisher Scientific, USA). From each sample, suspected microplastic particles were carefully removed from the filter paper and transferred onto a gold mirror surface for analysis. These particles were measured using ATR (Attenuated Total Reflectance) mode with an MCT (mercury–cadmium–telluride) detector, cooled with liquid nitrogen to ensure high sensitivity.

Infrared spectra were recorded in the range of 4000 to 650 cm^{-1}, with a signal acquisition time of 3 seconds and 16 scans per measurement. After data analysis, the Omnic Picta software generated a report including the number, size, and chemical composition of the particles. Particles with a spectral match of 85% or higher to the reference library were confirmed as microplastics.

2.4. Ensuring and controlling microplastic contamination from the environment

A 70% ethanol solution was used to clean the workspace in order to minimize the risk of microplastic contamination during the analytical process. All equipment used throughout the procedure was made of glass or stainless steel to limit the generation of microplastics from laboratory tools. Distilled water and chemical solutions (Fe(II), H_2O_2, KOH, $ZnCl_2$) were all filtered through 0.45 µm pore size membranes (MCE, Membrane Solutions, USA) prior to use.

In addition, measures to control airborne microplastic contamination in the laboratory were also implemented. Filter papers were placed in open petri dishes and left in the laboratory throughout the sample processing period. Results from these filter papers indicated that no microplastics were detected in the laboratory air, thereby ensuring the integrity of the analytical process.

2.5. Community consultation method

Community consultation in this study refers to the process of direct engagement with residents living in the study area in Quang Tri Province, particularly those who consume local seafood. This consultation enabled the authors to better understand the actual seafood consumption needs and the health status of the local population, serving as a basis for calculating potential health risks.

2.6. Assessment of potential health risks of microplastics to human health

To assess the potential health risks posed by microplastics present in the samples, both the concentration (quantity) and the polymer composition of the detected microplastic particles were considered.

The Health Risk Index (HRI) is an indicator reflecting the hazard level based on microplastic concentration, and is calculated using Equation (1):

$$\mathrm{HRI} = \frac{\mathrm{EDI}}{\mathrm{RfD}} \quad (1)$$

Where EDI (Estimated Daily Intake) is the amount of microplastics consumed daily, calculated as follows:

$$\mathrm{EDI} = \frac{C_{\mathrm{MPs}} \times D_{\mathrm{food\ intake}}}{B_{\mathrm{average\ weight}}} \quad (2)$$

Where CMPs is the concentration of microplastics in seafood (mg/kg), Dfood intake is the average daily seafood consumption (kg/day), and Baverage weight is the average body weight (kg).

RfD (Reference Dose) is the amount of microplastics a person can be exposed to daily over a lifetime without adverse health effects. According to the US EPA, the RfD for polystyrene - a common type of microplastic - is 0.2 mg/kg body weight per meal [7].

If the HRI > 1, the health risk is considered high; otherwise, it is considered low.

The Polymer Hazard Index (PHI) is an indicator reflecting the hazard level based on the types of polymers present in microplastics, and is calculated as follows:

$$\mathrm{PHI} = \sum(P_n \times S_n) \quad (3)$$

Where PHI is the hazard index of polymers in microplastics; P_n is the percentage of each type of polymer identified in mussel samples at each sampling site; and S_n is the hazard score for each polymer, as cited from the study by Lithner et al. [8].

2.7. Data analysis methods

The collected data were processed and statistically analyzed using R-studio software. Parameters such as microplastic density and size (length, area) were presented as mean values with standard deviations (± SD) to reflect the variability of the data.

Additionally, the research data were analyzed using IBM SPSS Statistics version 29.0. The Welch test was chosen to analyze differences in microplastic concentrations between seafood species. Results were considered statistically significant when the p-value was less than 0.05.

3. Research results and discussion

3.1. Results of community consultation

The survey results indicate that the average body weight of adults in Quang Tri province is approximately 63.68 kg per person, and the frequency of seafood consumption among local residents is about 6 times per week. This reflects their eating habits, living conditions, and awareness of both the benefits and potential risks, such as microplastics in food. Males tend to consume seafood more frequently, with the 7–10 times/week group accounting for the highest proportion. In contrast, females are mainly concentrated in the 5–7 and 3–5 times/week groups. Due to page limitations in the article, the authors do not present detailed survey results in the form of analytical charts.

3.2. Microplastic concentration

The analysis of average microplastic fragment concentrations per gram of wet weight in green tiger prawn (*Penaeus semisulcatus*) and anchovy (*Stolephorus commersonnii*) were 3.89 ± 1.68 and 2.94 ± 1.27 microplastic fragments/g wet weight, respectively. This demonstrates that, although both species inhabit aquatic environments, each species has a different capacity to absorb and accumulate microplastics, which may stem from biological characteristics, feeding habits, and their position in the food chain.

Green tiger prawn have a higher capacity to absorb microplastics compared to anchovy due to differences in habitat and feeding behavior (Figure 2). Green tiger prawn are bottom-dwellers, omnivorous, and consume sediments and organic debris - sources that are more likely to be contaminated with microplastics. In contrast, anchovies live near the surface, feed on plankton in less polluted environments, and possess a more selective digestive system, resulting in lower microplastic uptake.

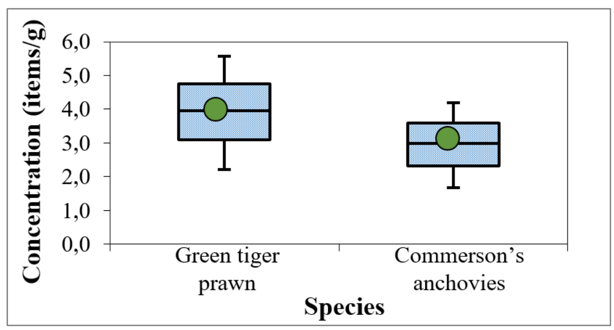

Figure 2. *Microplastic concentrations in green tiger prawn and commerson's anchovies at research sites in Quang Tri province*

According to the study by Ai My et al. on the characteristics of microplastics in green tiger prawn in the Cau Hai Lagoon, Central Vietnam, the average microplastic density recorded was 0.6 ± 0.2 fragments per gram wet weight [1]. This figure is significantly lower than the results in our study area, indicating that microplastic pollution levels vary between coastal regions and can fluctuate considerably depending on environmental conditions.

Based on the findings of Ai My et al., with microplastic concentrations ranging from 0.6 ± 0.2 to 1.0 ± 0.4 fragments/g wet weight in marine fishes along the central coast of Vietnam, the current study's data for anchovy show a notably higher microplastic level (2.94 ± 1.27 fragments/g). This not only exceeds previous values but also highlights the particular risk posed by microplastic accumulation in nearshore waters with high suspended solids and pollutant loads [9].

The Welch test results for differences in microplastic concentrations between the two species yielded a test statistic S of 6.586 with a significance level $p = 0.044$, which is less than the threshold of 0.05. This confirms that the difference between groups is statistically significant. Overall, the uneven distribution of microplastic density among species reflects a close relationship between ecological position, feeding strategy, and exposure to microplastic pollution sources in Vietnam's coastal marine ecosystems.

3.3. Characteristics of microplastics

The study results show that fiber-shaped microplastics overwhelmingly dominate in most of the surveyed species, particularly in anchovy, where the proportion is nearly absolute. This may be related to the filter-feeding mechanism and the near-bottom or coastal habitat of this species.

A representative study by Pizarro-Arias et al. on microplastic pollution in Pleoticus muelleri shrimp in Argentine waters found that fibers were the predominant form among all detected microplastics. Specifically, in the abdominal muscles of shrimp, fibers accounted for the highest proportion, with 87% of samples containing microplastics in fiber form. The authors suggested that the main sources were domestic wastewater containing textile fibers and fishing activities using nylon nets [10].

In anchovy, fiber-shaped microplastics accounted for up to 97.1% of all detected microplastics, indicating a very high level of fiber contamination. This may be related to their plankton-filtering feeding habits and small body size, making them more susceptible to absorbing microfibers suspended in the water column. Green tiger prawn showed a fiber-shaped microplastic proportion of 54.2%, indicating a fairly high level of exposure, consistent with the benthic feeding ecology of this species (Figure 3).

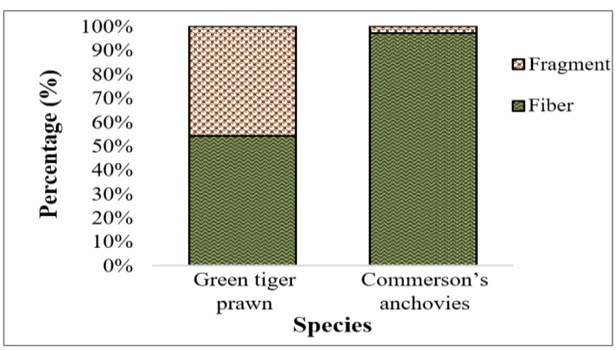

Figure 3. *Distribution of microplastics by shape in green tiger prawn and commerson's anchovies at research sites in Quang Tri province*

In addition, green tiger prawn had the highest proportion of fragment-shaped microplastics, accounting for 45.83% of all detected microplastics (Figure 3). Due to their omnivorous and bottom-dwelling nature, green tiger prawn can absorb microplastics from both food and their surrounding environment, such as sediments or polluted water columns. The prevalence of fragment-shaped microplastics also indicates that these are products of the breakdown of larger plastics eroded in the natural environment.

Microplastic analysis in the two seafood species revealed the presence of microplastic particles across a wide range of sizes, from under 100 µm to over 4150 µm. Green tiger prawn, characterized by a benthic lifestyle and active filtering or digestion of suspended matter, showed a relatively even distribution of microplastics across various size ranges, especially between 100–500 µm, which accounted for about 80% of total detected microplastics. This size range is consistent with their capacity to absorb or ingest particles during feeding and filtering activities (Figure 4).

Anchovy exhibited a more diverse intake of microplastic sizes, particularly in the 201–400 µm group. Anchovy had the highest proportion of microplastics in the 301–400 µm size range (34.29%). This partly reflects their intermediary role in the food chain and prolonged exposure to medium-sized microplastics, which tend to accumulate more in nearshore marine environments (Figure 4).

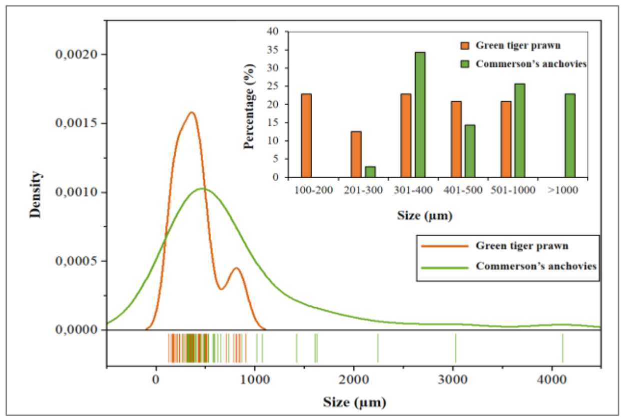

Figure 4. *Size distribution of microplastics in green tiger prawn and commerson's anchovies at research sites in Quang Tri province*

Overall, the findings of this study not only illustrate the occurrence of microplastics in various shapes and sizes but also help clarify the relationship between the biological characteristics of each species and their capacity to accumulate different types of microplastics. These results provide valuable evidence for ecological risk assessments and the development of solutions to control plastic pollution in coastal ecosystems.

3.4. Chemical composition of microplastics

Data from Micro-FTIR infrared spectroscopy enabled precise identification of the chemical composition of microplastics by comparison with standard spectral libraries. Identifying polymer types is a crucial step in assessing pollution levels, as each type has different properties and toxicity, which can have diverse impacts on health and the environment.

In this study, analysis of the two aquatic species revealed the presence of 17 different microplastic polymers. Notably, polyvinyl chloride (PVC) was detected, which is known to contain many toxic additives such as phthalates and vinyl chloride - a carcinogen classified as Group 1 by the International Agency for Research on Cancer (IARC).

An in vivo study on carp showed that PVC microplastics caused liver tissue damage, enteritis, and significantly increased inflammatory cytokines such as

IL-6, IL-8, and TNF-α in molecular assays, while also disrupting immune gene expression and increasing oxidative stress [11]. This demonstrates the high hazard of PVC to aquatic organisms and its potential for far-reaching impacts on global health through the food chain.

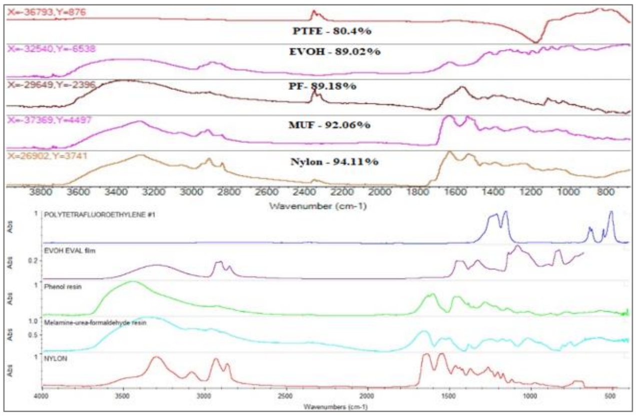

Figure 5. *Fourier transform infrared (FTIR) spectra of polymers (a) and reference spectra (b) in microplastic samples determined in green tiger prawn and commerson's anchovies at research sites in Quang Tri province*

The number of polymers detected in this study exceeded that of many previous studies in Vietnam. For instance, Thao Xuan et al.'s research on bivalves in southern coastal waters identified only 10 polymer types, mainly PET, PA, and CP [5], while Van Manh et al.'s study in Da Nang Bay recorded only 15 types, with nylon as the predominant polymer [2].

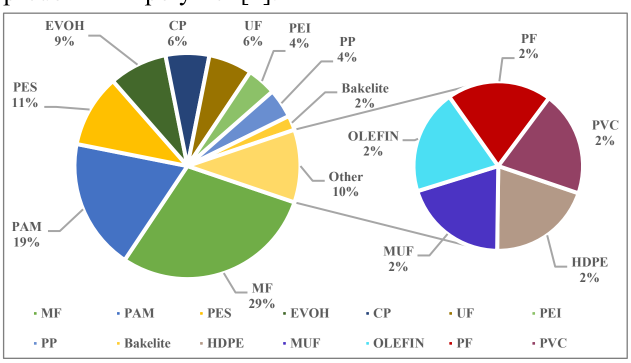

Figure 6. *Distribution of microplastics by species in green tiger prawn*

Microplastic analysis in green tiger prawn revealed considerable diversity in polymer composition, with a total of 14 types identified. Among these, melamine formaldehyde (MF) accounted for the highest proportion (29%), followed by polyacrylamide (PAM) at 19%, PES (11%), EVOH (9%), and both CP and UF at 6%. Other polymers such as PEI, PP, Bakelite, OLEFIN, HDPE, MUF, PF, and PVC appeared at rates ranging from 2–4%, reflecting a wide dispersion and complex origins of microplastics in the living environment of this species (Figure 6).

Compared to the study by Ai My et al. in the Cau Hai Lagoon, which identified only six main polymers (Rayon, PA, PET, PE, PS, and PAA) [1], the number of polymers detected in the present study is significantly higher. This disparity suggests that green tiger prawn in the study area are exposed to a broader range of microplastic pollution sources, reflecting the varied impacts of urban, industrial, and domestic activities specific to the locality.

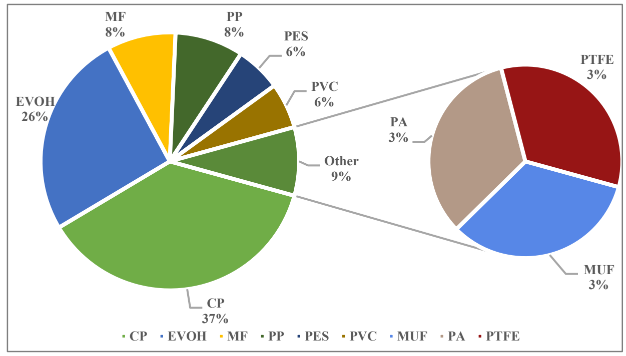

Figure 7. *Distribution of microplastics by species in commerson's anchovies*

In anchovy, up to nine different polymer types were detected, reflecting the diversity of plastic materials and the complexity of microplastic pollution in the marine environment. Common polymers such as cellophane (37%) and EVOH (26%) mainly originate from food packaging and wrapping materials (Figure 7). Notably, the presence of PVC accounted for 6%, indicating the risk of pollution from industrial waste or construction materials directly affecting the marine ecosystem where anchovy live.

The diversity of polymer types found in aquatic species such as green tiger prawn and anchovy reflects a clear correlation between living habits and the specific habitats of each species.

3.5. EDI Value and Health Risk Index (HRI)

Quantifying microplastics is challenging due to the presence of many impurities in the samples. However, based on the thermal stability of polymers and previous studies, microplastics are estimated to account for about 60% of the mass of insoluble material retained on filters. This is a commonly used average value when impurities cannot be completely removed or when specialized analytical equipment is lacking.

Table 1. *EDI and HRI values of green tiger prawn and commerson's anchovies*

No	Species	Average concentration (mg/kg)	EDI (mg/kg/day)	HRI
1	Green tiger prawn	6.356,1302	12.98	64.88
2	Commerson's anchovies	4.181,3602	8.54	42.68

Both green tiger prawn and anchovy show alarming levels of microplastic contamination, with Health Risk Index (HRI) values of 64.88 and 42.68, respectively - far exceeding the safety threshold (HRI > 1). The average microplastic content in green tiger prawn reaches 6,356.1302 mg/kg, indicating a high health risk if consumed regularly. Anchovy also warrants attention, with a microplastic content of 4,181.3602 mg/kg, reflecting a significant level of contamination (Table 1).

Both species demonstrate a clear correlation between microplastic content and health risk, underscoring the necessity of monitoring and controlling microplastic pollution in seafood.

3.6. Polymer Hazard Index (PHI)

***Table 2.** PHI values and hazard levels of green tiger prawn and commerson's anchovies*

No	Species	PHI	Hazard Level
1	Green tiger prawn	721.29	
2	Commerson's anchovies	786.51	

Both green tiger prawn and anchovy have high PHI values, exceeding hazard level III (>100), with scores of 721.29 and 786.51, respectively. This indicates that these species accumulate a large amount of potentially hazardous polymers, reflecting severe plastic pollution in their habitats. Notably, since anchovy and green tiger prawn are common foods in the diet of coastal communities, the presence of these toxic polymers poses a potential threat to human health, even though the alert level is not yet the highest (Table 2).

The PHI values for aquatic species in this study are higher than those reported by Van Manh et al. for mollusks in Da Nang Bay, where the highest PHI was only 220.54 (level III) [12]. On the other hand, the results of this study are lower than those published by Fang et al., who reported PHI values of 3,813–4,478 for bivalve mollusks and fish in Fujian province, China [13].

The hazard level of polymers in the studied seafood species ranges from moderate to high, illustrating differences in microplastic pollution by geographic region and species, and emphasizing the necessity for localized monitoring of microplastic risks in the seafood supply chain.

4. Conclusion

Both green tiger prawn and anchovy exhibited high levels of microplastic contamination, reflecting their biological characteristics and habitat conditions. Green tiger prawn, an omnivorous benthic species, had an average microplastic density of 3.89 ± 1.68 particles/g, with the majority of particles sized 100–500 µm (~80%) and a diverse range of polymers, notably MF (29%) and PAM (19%). Fiber-shaped microplastics accounted for more than 50%, consistent with the species' biological traits and bottom-feeding habits.

Anchovy, a nearshore filter-feeding species, showed a microplastic density of 2.94 ± 1.27 particles/g, with fibers comprising up to 97.1%. The species mainly accumulated microplastics of medium size (201–400 µm), reflecting prolonged exposure in coastal environments. The dominant polymers in anchovy were CP (37%) and EVOH (26%), primarily originating from food packaging and wrapping materials.

In terms of health risks, green tiger prawn had an HRI of 64.88 and anchovy had an HRI of 42.68; both far exceed the safety threshold (HRI > 1), indicating a clear risk if consumed regularly. Regarding polymer hazard (PHI), green tiger prawn reached 721.3 and anchovy 786.5, both surpassing hazard level III but remaining below level IV, yet still at a high alert level.

The simultaneous analysis of both indices highlights an alarming reality: microplastics in seafood not only exist in large quantities but also contain many serious toxins. This underscores the urgent need to reconsider policies for monitoring and controlling microplastic pollution, and calls for coordination among the health, environmental, and food safety sectors to assess and manage long-term risks to public health.

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