MICROPLASTIC CHARACTERISTIC FOUND IN GASTROINTESTINAL TRACT OF PELAGIC AND DEMERSAL FISHES IN TUBAN, EAST JAVA

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ABSTRACT

Regular monitoring of microplastics contamination in marine biota have been concerned in the world, since its tiny size can be swallowed direct or indirectly and lead health problems. Tuban waters is the one of Indonesia's coastal and marine fisheries areas with high risk of microplastic pollution due to their highly anthropogenic activities. We investigated the microplastic in the digestive tracts of pelagic and demersal fishes in Tuban sea waters. Microplastic in fish sample guts were observed under microscope and the type of polymer were examined using FT-IR. This study reveals that number of microplastic in digestive tract of pelagic fishes were higher than demersal fishes. The dominant form was fiber (62%) with black color and dominant size ranging from 100-500 µm (72%). The types of polymers found were polyethylene and polyamide.

Keyword: Demersal Fish, Pelagic Fish, Microplastic, Gastrointestinal Tract

Introduction

Tuban Regency is one of the coastal cities in East Java which has a beach length of ± 65 km. The coastal and marine area in Tuban Regency is the center of the economy, which is often used for marine transportation, nature conservation, marine cultivation, tourism, and fishing settlements. [1]. Moreover, the rapid industrial development in Tuban increasing urbanization that led the adverse impact of the pollution in coastal and marine environment.

A total of 4.8-12.7 million tonnes of plastic have been identified in the oceans [2]. Thus, an estimated 10% of the plastic ends up in the ocean [3]. The four plastic size classes identified were nano-, micro-, meso-, and macro plastic from fishing activities and other anthropogenic plastic waste. Microplastic is a type of plastic waste that is smaller than 5 mm and is grouped into 2 types, namely primary and secondary microplastics [4]. Primary microplastics can be found in cleaning products and pellets which are produced as raw materials for plastic production. Whereas secondary microplastics are produced from the breakdown of larger plastic items. Microplastics from secondary sources are often associated with areas with high population density [5], The total population may generate the high microplastics concentrations in the aquatic systems [6]. Another study in the densely populated coastal area reported that microplastic fragments in sediment of coastal area mostly originated from the breakdown of larger plastic [7]. The discarded larger plastic waste such as carry bags, water mineral bottles, containers, construction materials and toys enter the marine environment will breakdown to be fragments or fiber and contaminate sea water body for very long periods [5][8].

The tiny size of microplastic particle may be ingested by zooplankton and through the food web will contaminated in fish body [9]. Microplastic translocation will occur across the digestive tract and gills and enter the circulatory system. Through blood circulation, microplastics will enter various organs in fish [10]. If plastic particles accumulate in large numbers in the fish's body, microplastics can clog the digestive tract of the fish [11].

In previous studies, as many as 504 demersal and pelagic fish were studied, and 36.5% were found microplastics in their digestive tract [12]. Several types of demersal fish, such as grouper fish (Epinephelus areolatus) and Japanese threadfin bream (Nemipterus japonicus). As well as types of pelagic fish such as herring scad (Alepes vari) and cleftbelly trevally (Atropus atropos) have high economic value, especially at the fish auction place (TPI) in Tuban. [13]. Therefore, according to several previous studies, there is a possibility that these microplastics can be accidentally consumed by various types of fish in Indonesia. In addition, the consumption of microplastics found in the gastrointestinal tract of pelagic and demersal fish has differences in the amount of accumulation [9]. The main objective of this research is to identify the characters of microplastics in the gastrointestinal of pelagic and demersal fishes from the waters of Tuban and have economic value.

Methodology

Study Area and Sampling

This research was conducted in September 2019-March 2020. The fish samples of grouper fish (Epinephelus areolatus), Japanese threadfin bream (Nemipterus japonicus), herring scad (Alepes vari), and cleftbelly trevally (Atropus atropos) were collected from local Fish Market in Tuban. Observation of microplastic in fish gastrointestinal were carried out at Laboratory of Zoology and Animal Engineering Department of Biology, Faculty of Science and Data Analytics, Institut Teknologi Sepuluh Nopember, Surabaya. The FTIR analysis was carried out at the Material Characterization Laboratory, Department of Materials Engineering and Metallurgy, Faculty of Industrial Technology and Systems Engineering, Institut Teknologi Sepuluh Nopember, Surabaya.

Sample Preparation and Extraction

Collection and identification of fish samples

The morphometry of 40 fish samples included total length, standard length, head length and body width were measured, then the species were identified refer to Whitten et al. (1993). The fish samples consist of two species of demersal fishes i.e., grouper fish (Epinephelus areolatus), Japanese threadfin bream (Nemipterus japonicus); and two species of pelagic fishes i.e., herring scad (Alepes vari), and cleftbelly trevally (Atropus atropos), whereas 10 individuals in each species. Fish samples were placed in the cool box with temperature of 4oC prior to examined in the laboratory. Gastrointestinal tract sample of fishes were prepared and preserved with 4% formalin with ratio solution: the tissue volume was 3: 1 [14] [15].

Microplastics analysis in gastrointestinal tract

The preserved gastrointestinal tract was dissected and its content were extracted by diluted in the solution of NaCl [16]. The microplastics were observed under stereo microscope that connected with Camera Optilab Advance 2.2 and Computer. The presence of microplastic particles were analyzed visually based on the morphological characters of shape, color, and size. The microplastic particles are measured using Image Raster software [17]. Observation of microplastic types refers to the results of the morphological identification category of microplastics according to Virsek et al. [18].

Chemical composition analysis of the gastrointestinal tract of fish

Chemical composition analysis uses a special instrument, Fourier Transform Infra-Red (FTIR) Spectroscopy to determine the type of microplastic [19]. The FTIR reading of a carbon-based polymer can easily be drawn from different bond compositions by generating a unique spectrum that differentiates plastic particles from other organic and inorganic particles [15] and can provide a unique infrared spectrum for certain chemical bonds [20].

Data Analysis

The homogeneity of fish body size was analysed using SPSS v.23. [21].

Result and Discussion

Homogeneity of Fish Body size

The homogeneity test showed that total length and total weight of each species samples were homogenous.

Microplastic Content in the Gastrointestinal Tract of Pelagic and Demersal Fish in Tuban Sea Water

The results showed that pelagic and demersal fish obtained from the waters of the Tuban Sea accumulated microplastics in the gastrointestinal tract tissue. This is presumably because the coast of Tuban

Regency has a high potential for plastic pollution, with a coastline length of ± 65 km, various human activities ranging from industry, ports, fisheries (cultivation and fishing), tourism, and settlements indirectly as waste disposal materials [22].

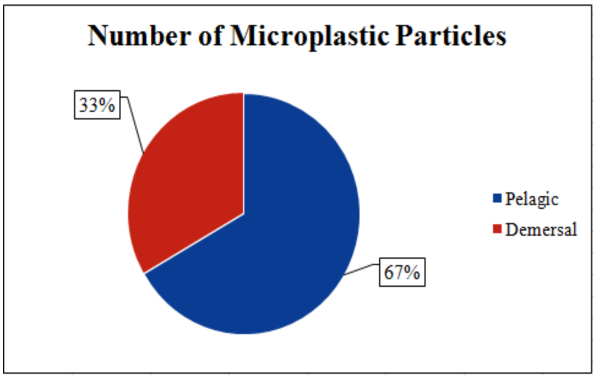

Figure 1. Total Number of Microplastics Found in Pelagic and Demersal Fish Species in Tuban Sea, East Java

Figure 1 exhibits that the percentage of accumulated microplastic particles in gastrointestinal of pelagic fish (67%) was higher than the in demersal fish (33%). This result is similar with the result reported by Rummel et al., whereas the ingestion frequency of microplastics in pelagic feeders significantly higher than demersal fish [23].

The results showed that the microplastics found in pelagic fish species were dominant in fiber and based on the FTIR test, the polymer yield was PE (Polyethylene) which had a lower density (ρ = 0.92 - 0.97 g/cm3) below the density of seawater (ρ = 1.027 g/cm3), causing microplastics to float in the waters and making microplastic consumption more in pelagic fish [24]. PE is the most widely produced polymer [25] and is also widely used for the packaging of products such as food containers and drinking water bottles. PE has also been used for textile fabrics as long and durable fibers [26], where the product can enter the sea through inappropriate wastewater treatment [27].

Physical and Chemical Characteristics of Microplastics in the Gastrointestinal Tract of Pelagic and Demersal Fish in Tuban Sea Waters

Color of Microplastic

The results of visual observations of microplastic color in the gastrointestinal tract of pelagic and demersal fish in the waters of the Tuban Sea found four types of MP colors including black, blue, red, and yellow (Figure 2 and Figure 3). The most dominant microplastic colors found in the gastrointestinal tract of pelagic and demersal fish were black followed by blue, red, and yellow. The black color is caught by the fish because it is the same color as the pellet, and it is associated with some common prey [28].

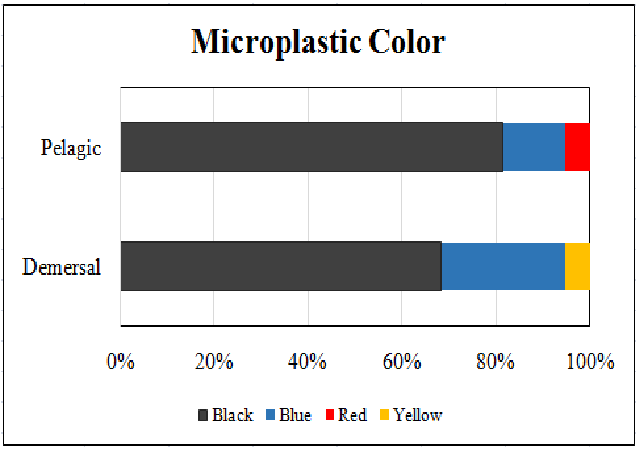

Figure 2. Percentage of Microplastic Color Found in Pelagic and Demersal Fish

Based on the FTIR test results, PE polymers are widely used. The source of this microplastics may be from daily packaging products such as grocery bags, plastic bags, food containers, and beverage bottles, causing the possibility of black, blue, red, and yellow microplastics coming from these products [26]. In addition, the black color is also thought to come from color degradation, where black microplastics are found in the gastrointestinal tract of old fish, basically because of their ability to absorb pollutants [29].

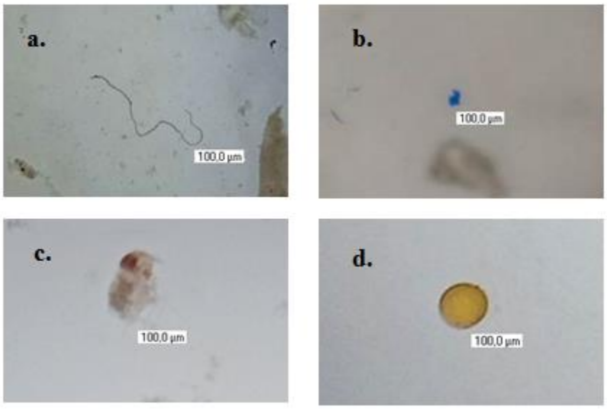

Figure 3. Color Variety of Microplastics Found in Gastrointestinal Tract of Pelagic and Demersal Fish in Tuban Sea Waters. (a) Black Fiber, (b) Blue Fragment, (c) Red Fragment, (d) Yellow Pellet

Shapes of Microplastic

The results showed that the dominant form of microplastic in pelagic fish was fiber (74%) followed by fragments (26%). Whereas, demersal fish were fiber (84%), fragments (11%), and pellets (5%) (Figure 4). The shape of the microplastics is shown in Figure 3. Shape variations in microplastics are caused by degradation or erosion of the particle surface resulting from biological damage, photodegradation, chemical weathering, or physical effects (wave action, wind, weather-UV [5].

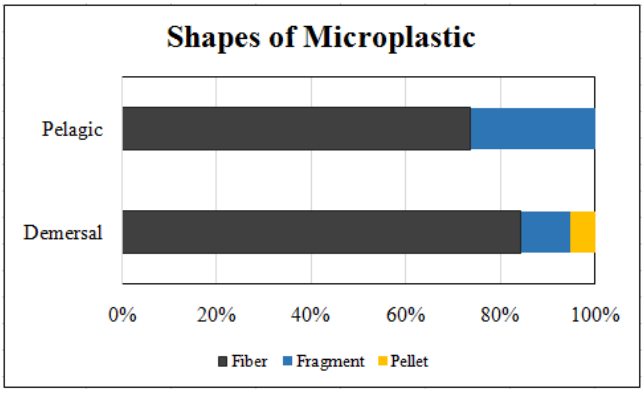

Figure 4. The percentage of Microplastic Shapes Found in the Gastrointestinal tract of Pelagic and Demersal Fish in Tuban Sea Waters

The FTIR test results showed that PA and PE polymers were found in the microplastic fiber. Previous studies have also suggested that the fiber usually consists of polymer acrylic, polyester, or polyamide (PA) [26]. This is due to the cloth washing process can release 1900-700,000 fibers per 6 kg into the environment [30]. The main fiber pollutants come from household waste as a consequence of washing cloth and daily use of personal care products [31] consisting of PE and PA polymers in the manufacturing process [26]. So the dominant form of fiber in this study can be caused by these products. In addition, PA polymers are also often applied as fishing gear used by the fishing industry [32]. Thus, the type of fiber originating from fishermen's activities comes from degraded fishing nets [33]. Primarily, the discovery of the dominant fiber in the gastrointestinal tract of pelagic fish is due to its thin shape and size, which causes the fiber to often be found floating on the surface of the water. [34]. However, the fibers released from the sewerage pipes of the wastewater treatment plant can enter the surface water and eventually accumulate in the sediment [31], causing the microplastic fiber to be found in demersal fish species.

Size of Microplastic

The Figure 5 reveals that microplastics found in the gastrointestinal of tract of pelagic and demersal fish in the waters of the Tuban Sea were in various sizes. According to Nor and Obbard (2014), visually observed microplastic particles were categorized based on ten class sizes: class 1 (<20 µm); class 2 (20-40 µm); class 3 (40-60 µm); class 4 (60-80 µm); class 5; (80-100 µm); class 6 (100-500 µm); class 7 (500-1000 µm); class 8 (1000-2000 µm); class 9 (2000-5000 µm); and class 10 (> 5000 µm).

Figure 5. Various sizes of microplastics found in the gastrointestinal tract of pelagic and demersal fish in Tuban Seawaters

The most microplastic size range found in the gastrointestinal tract of pelagic and demersal fish in the waters of the Tuban Sea is 100-500 µm (0.1-0.5 mm), which is in class 6. Then followed by class 7 with a size of 500-1000 µm (0.5-1 mm) and class 8 (16%) with a size range of 1000-2000 µm (1-2 mm). The percentage difference of each microplastic size found in pelagic and demersal fish can be seen in Figure 6.

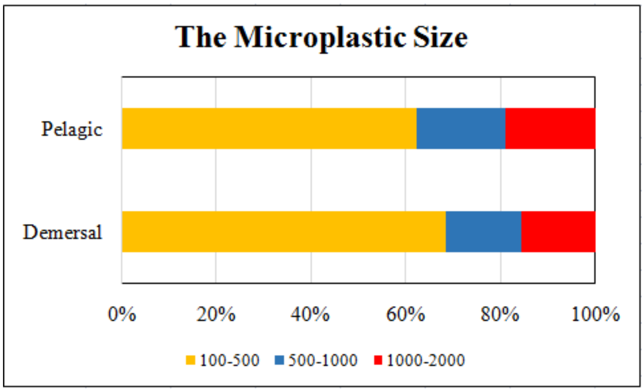

Figure 6. Percentage of Microplastic Size Found in Gastrointestinal Tract of Pelagic and Demersal Fish in Tuban Seawaters

Microplastic size can be affected by retention in fish bodies [35]. The greater the size of the gastrointestinal tract, the longer it is due to the difficulty of the egestion process. The small size of the microplastics also indicates the possible length of the degradation process experienced in the environment caused by erosion, temperature, or photooxidation [29]. In the benthic zone, continuous friction with sediment constantly results in smaller particles that accumulate on the ocean floor [36]. Based on the type of PA polymer detected in the fiber, it is likely that the source of the microplastic would be fishing gear [35].

Polymer type

The type of microplastic polymer was identified through functional group analysis of the sample using Fourier Transform Infrared Spectroscopy (FTIR). The analysis showed that the microplastic black fiber and blue fiber have polymer types of polyethylene (PE) and polyamide (PA). Whereas the type of polymer identified in the blue fragment microplastics, and pellets is polyethylene (PE). These polymers are the most widely produced by the plastics industry and are often found in different marine environments around the world [27].

PE polymers are the main type of plastic observed in the gastrointestinal tracts of fish from fishing grounds, markets, beaches, and oceans [37; 38] and have been identified as the most polluting in aquatic environments due to their durability and various applications in packaging [39]. PE has a low density, so it is often found in pelagic fish [12]. In addition, PE is widely used in daily necessities [40]. PE polymer has a polyethylene density (ρ = 0.92 g / cm3) below the density of seawater (ρ = 1.027 g / cm3), causing the microplastics to float in the water column [24]. However, polyethylene polymers are also found in sediments because they are caused by biofouling [30].

Polyamide (PA) polymer type is the most common variety of thermoplastic polyester known as nylon, which is a useful raw material with high-strength fibers [28]. In addition, the use of polyamide is also applied in the manufacture of bearings, machinery and cooking utensils, fishing nets, and ropes [32].

Conclusion

The gastrointestinal tract of pelagic fishes (A. vari and A.atropos) and demersal fishes (E. areolatus and N. japonicus) from the waters of the Tuban Sea, East Java were contaminated microplastics with a percentage of 67% and 33%, respectively. The visual character of microplastics shows that the dominant color of microplastics is black, with the dominant shape of fiber and the maximum size ranging from 100-500 µm. The polymer types found in 4 of the 57 microplastic particles are polyethylene and polyamide.

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