Analysis of Microplastic Contamination in Vaname Shrimp (*Litopenaeus Vannamei*) with Different Cultivation Methods

Puji Hastuti[1], Asih Fitriana Dewi [2], Defri Yona *[3], Muhammad Mahmudi * [4]
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***Abstract*— Vaname shrimp cultivation is inseparable from the use of plastic. Plastic will fragment into microplastics and pollute the environment. Water sources and cultivation methods are often the source of microplastics entering the cultivation environment. This study aims to determine microplastic pollution in three different cultivation methods, seen from the presence of microplastics in water, sediment, commercial feed, and whiteleg shrimp. Sampling was carried out for three months of December 2024 - February 2025 by testing microplastics in water, sediment, feed, gill organs, and the digestive tract of whiteleg shrimp during one cultivation cycle. The microplastics found amounted to 1,593 particles, 877 particles in water, 561 particles in sediment, 53 particles in feed, and 102 particles in shrimp samples. The microplastics found were in the form of films, fragments, fibers, and pellets with sizes between 10-600 µm. The average abundance of microplastics in water and sediment fluctuates depending on geographical and weather conditions. Microplastics in feed indicate the presence of microplastic sources from the monthly feeding process. Meanwhile, the abundance of microplastics in shrimp accumulates every month. The differences in microplastic abundance in the three methods indicate the presence of microplastic pollution originating from cultivation equipment, commercial feed, and water sources that have been contaminated with microplastics.**

Keywords— *Microplastic, Vaname , Cultivation, Methods*.

I. INTRODUCTION

Human activities are inseparable from the use of plastic materials in everyday [1]. World plastic production continues to increase [2] In 2025 plastic production is estimated to reach 445 million tons. Indonesia is ranked 2nd as the largest contributor of plastic waste in the world,with the amount of plastic waste reaching 14% of the total daily waste pile, which is equivalent to 85.000 tons/year [3]. Piles of plastic waste will undergo a process of breaking down into small particles due to increased temperature, exposure to UV rays and mechanical abrasion, which are commonly referred to as microplastics [4] [5].

Microplastics are plastic fragments measuring 5 mm - 1 µm that are widely found on land and in water [6]. This size has the potential to enter and accumulate in the bodies of living things, such as aquatic biota polluted by plastic waste [6]. The accumulation of microplastics in aquatic biota can directly cause abnormalities in organ performance, such as gills and digestive tracts that affect cell or tissue structure [7]. One of the aquatic biota that can accumulate microplastics in the environment is vaname shrimp (*Litopenaeus vannamei*) [8].

Vaname shrimp is one of the export commodities from aquaculture, with a length of 23 cm and a weight of more than 30 grams [9]. Vaname cultivation requires attention to internal aspects such as the origin and quality of seeds, while external aspects such as water quality, feeding, technology or methods used, and pest and disease control [10]. In Indonesia, vaname shrimp cultivation is carried out using several cultivation methods, such as traditional, semi-intensive and intensive [11] [12]. These three methods are differentiated based on the tools used, stocking density, feed, and cultivation technology from simple to modern [12].

The cultivation methods, used are inseparable from the use of plastic materials, such as ponds made of tarpaulin, water wheels, bird repellents, nets, and fish meal in feed taken from environments contaminated with microplastics [5]. In addition, plastic waste from land carried by river currents and ending up in the sea has the potential for plastic waste pollution in waters, which will be used as a source of water in the cultivation process [13]. The presence of microplastic sources entering the cultivation environment using different methods indicates different abundances of microplastics. Accumulation of microplastics in cultivated biota can

Puji Hastuti, Brawijaya University, Indonesia, E-mail: pujihastuti993@gmail.com
Asih fitriana dewi, IAIN Metro, Indonesia, E-mail: asihfitrianadewi@metrouniv.ac.id

Defri Yona, Brawijaya University, Indonesia, E-mail: defri.yona@ub.ac.id

Muhammad Mahmudi, Brawijaya University, Indonesia, E-mail: mudi@ub.ac.id

occur in the gills and digestive tract, this is related to their eating habits and the availability of microplastic sources in the environment. Accumulation of microplastics in cultivated biota such as vaname shrimp can further have negative effects on humans in the food chain [14]. Microplastics that enter the human body can cause skin irritation, respiratory problems, heart disease, digestive problems, and reproductive problems [15].

In Indonesia, research related to microplastic pollution in the aquaculture environment has begun, such as microplastics found in milkfish ponds in Muara Kamal and Marunda, Jakarta Bay, with the presence of microplastics in sediment reaching 114 MP/g and in water reaching 100 MP/L [16]. Research related to the presence of microplastics in aquaculture biota has also been carried out, for example related to the presence of microplastics in green mussels found at seaweed cultivation locations in Pangkep, with microplastic concentrations reaching 0.3-0.6 MP/g [17]. Then microplastics were also found in white shrimp from ponds in Semarang, with an average of microplastics up to 5 MP/individual [18]. These studies show that microplastics have contaminated the cultivation environment and various types of cultivated commodities such as fish, molluscs and crustaceans.

Research on microplastics in the environment and cultivated biota has been conducted, but research related to microplastic pollution in vaname shrimp with different methods has not been conducted. Therefore, this study is related to microplastic pollution in vaname shrimp with different cultivation methods, seen from the presence of microplastics in water, sediment, commercial feed, and vaname shrimp.

II. METHOD

A. Time and Place of Research

This research was conducted during one cultivation cycle from December 2024 to February 2025 in Purworejo Village, Pasir Sakti District, East Lampung Regency, Lampung Province. Based on the research location (Figure 1) sampling was carried out in rivers, seas and ponds with 3 different cultivation methods. Sample handling was carried out at the Fish Cultivation Laboratory, Fish Reproduction Division, Fish Cultivation Laboratory, Fish Disease and Health Division, Faculty of Fisheries and Marine Sciences (FPIK), Brawijaya University, Malang.

B. Data Collection Methods

Research data collection was conducted through field observation and laboratory analysis. In addition, scientific literature review activities were also conducted to enrich the research results. Sampling was conducted in 5 sampling areas, Way Sekampung River, East Sea of Sumatra, and 3 ponds with different methods. The samples in this study consisted of water samples, sediment samples, commercial feed samples and shrimp samples (gills and digestive tract) at the age of 30-100 days. Determination of the sampling location area was based on the condition of the research site as reviewed from the water source and vaname shrimp cultivation activities. Sampling at each station was carried out 3 times at each location with 3 repetitions. Water sampling using plankton nets by filtering 15 liters of water at each station. Sediment sampling was carried out using an ekman grab and dried using an oven at 100 ºC for ± 4 days until dry, then weighed as much as 150 grams. Commercial feed samples were taken as much as 150 g for each cultivation method. Shrimp samples of 200 grams were separated from the digestive organs and gills for further preparation in the laboratory.

Preparation of sediment and commercial feed samples was carried out by adding 500 ml of NaCl solution while stirring until mixed. The samples were left for 24 hours until 2 layers were formed, then filtered using a 300 mesh filter cloth. The results of the sediment sample filter, feed sample and water sample were each added with 20 ml of 30% H^2O^2 solution. Furthermore, the samples were incubated at room temperature for 24 hours. Then the samples were heated at 90ºC for 30 minutes. After cooling, the sample is then filtered using a 300 mesh filter cloth. The filtering results are rinsed with NaCl and continued with distilled water, then collected in a petri dish for observation. Preparation of the vaname shrimp organ sample was carried out by adding 20 ml of 10% KOH solution or until the sample was submerged to degrade organic matter, and put the sample in an oven at a temperature of 60 ºC degrees for 24 hours. Wait for the solution to turn clear yellow, then the sample was rinsed, filtered and dried before observation. Observation of all samples was carried out using a microscope with a magnification of 40 times. The method of taking and handling samples is based on [19].

C. Research Data Analysis

The observation results obtained are the number of microplastic particles and characteristics such as shape, size, and color in each sample. The number of microplastics found will be calculated as the average abundance of microplastics at each location. The calculation of microplastic abundance is based on the number of particles obtained divided by the volume of filtered water and the dry weight of sediment and feed used [20].

$$C = \frac{n}{v}$$

C : abundance of microplastics (particles/liter)
n : number of microplastic particles
v : volume of filtered water

$$C = \frac{n}{m}$$

C : abundance of microplastics(particles/kg)
n : number of microplastic particles
m : dry weight of sediment or feed

The abundance of microplastics in shrimp was calculated based on microplastics obtained in the gill organs and digestive tract as the accumulation of microplastics in vaname shrimp. Abundance of microplastics in biota using the formula (particles/

gram) [21].

$$C = \frac{\text{number of microplastic particles}}{\text{number of biota}}$$

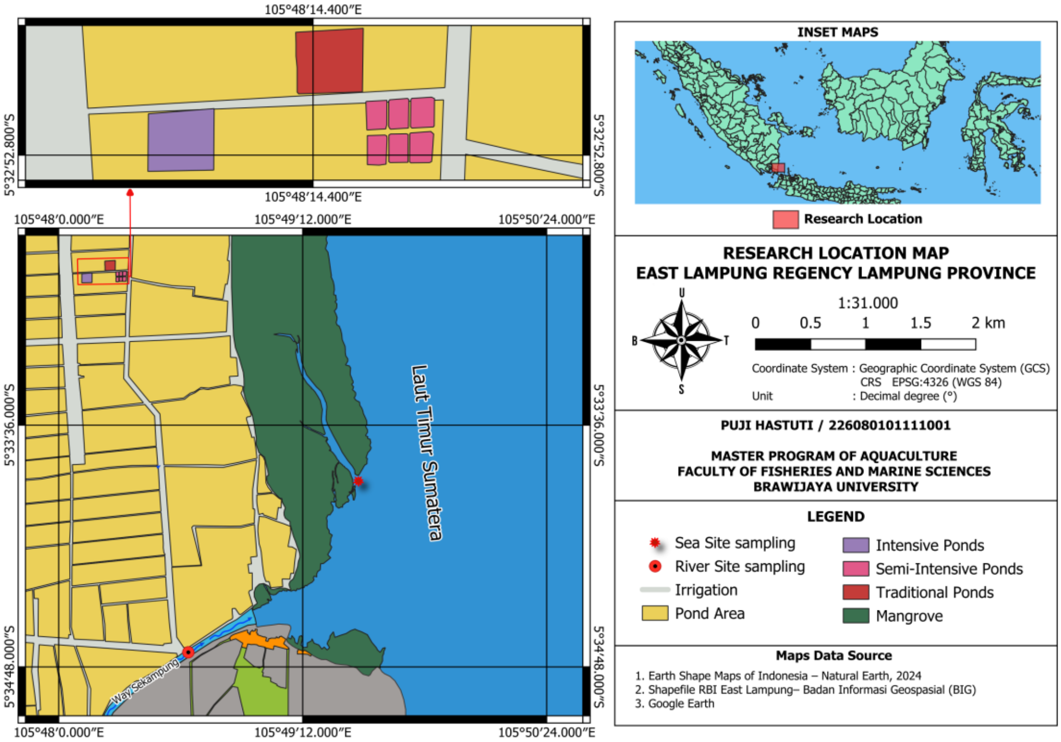


Figure 1. Research Location Map

III. RESULTS AND DISCUSSION

A. Microplastic Identification

Based on the results of the identification of all microplastic samples found amounted to 1.593 particles with 877 particles in water samples, 561 particles in sediment samples, 53 particles in feed samples and 102 particles in shrimp samples. The identification of microplastics can be seen as follows.

Based on its form, the microplastics found are divided into films, fragments, fibers and pellets. Film type microplastics were found in all samples with a size of 10-600 µm. This form of microplastic is a secondary plastic polymer originating from the fragmentation of plastic packaging with a lower density compared to other forms of microplastics, allowing this type of microplastic to float in the water column [22]. The second most commonly found microplastic is in the form of fragmentation with a size ranging from 20-600 µm. Fragmentation type microplastics usually come from household waste and anthropogenic activities [22]. In shrimp farming ponds, the fragment form can come from pond tarpaulins and feed containers that have undergone degradation.

Fragmented microplastics can also come from plastic bags, plastic bottles and pieces of pipe that have undergone degradation through chemical and physical processes with the heat of the sun [23]. Fibers were found abundantly in water and sediment samples at each sampling location, with a size of 20-400 µm. Microplastics in the form of fibers in rivers and seas can come from synthetic fabrics, ship waste, and fishing equipment such as rods and nets [24]. In shrimp ponds, microplastics in the form of fibers can come from ropes used to tie water wheels and bird repellent nets. Pellet forms are often found in water and feed samples with a size of 30-200 µm. Pellets come from primary microplastics that are often used in the manufacture of plastic raw materials made directly by factories or industries [25].

The colors of microplastics found at all sampling locations were black, blue, red, white and clear. The differences in the colors of microplastics are due to the length of time the microplastics are exposed to sunlight so that over time the microplastics will experience oxidation which results in changes in the color of the microplastics [26].

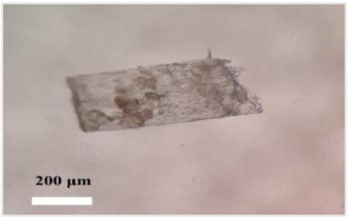
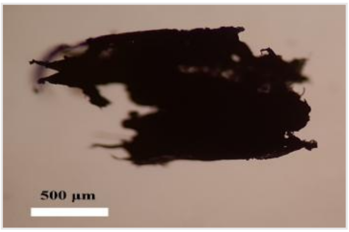
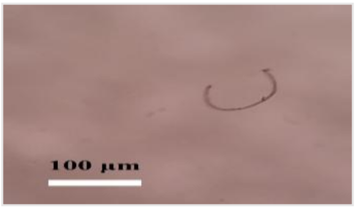
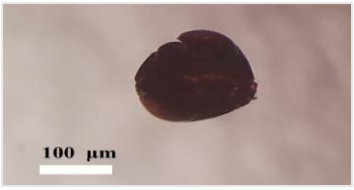
B. Microplastics Content in Water

Basically, microplastics tend to float on the surface due to their low density, so observations of microplastics in water samples can be used as a parameter of microplastic abundance in waters (Figure 2).

Microplastics are widely found in marine waters as one of the water sources in shrimp farming activities that accumulate plastic waste from land, with the highest average value in February of 2.24 particles/liter. In river waters, the highest average abundance occurred in January, namely 1.96 particles/liter. While in aquaculture ponds, the highest average abundance was found in semi-intensive and traditional ponds with microplastic values in January and February of 0.98 particles/liter.

Microplastics in waters can be influenced by geographical factors and sources of pollution from land entering the waters [24]. Differences in the abundance of microplastics in each sampling area are influenced by the weather and water conditions in each month. The rainy season that occurs in January to its peak in February causes the Way Sekampung river area to experience flooding, so that plastic waste from upstream accumulates in the downstream of the river and ends up in the sea.

TABLE 1.
IDENTIFICATION OF MICROPLASTICS

Form	Color	Size	Picture
Film	Blue, Black, White, Clear	20-600 μm	
Fragment	Black, Blue, White, Clear	10-600 μm	
Fiber	Blue,Clear,Red	20-400 μm	
Pellet	Black, Clear	30-200 μm	

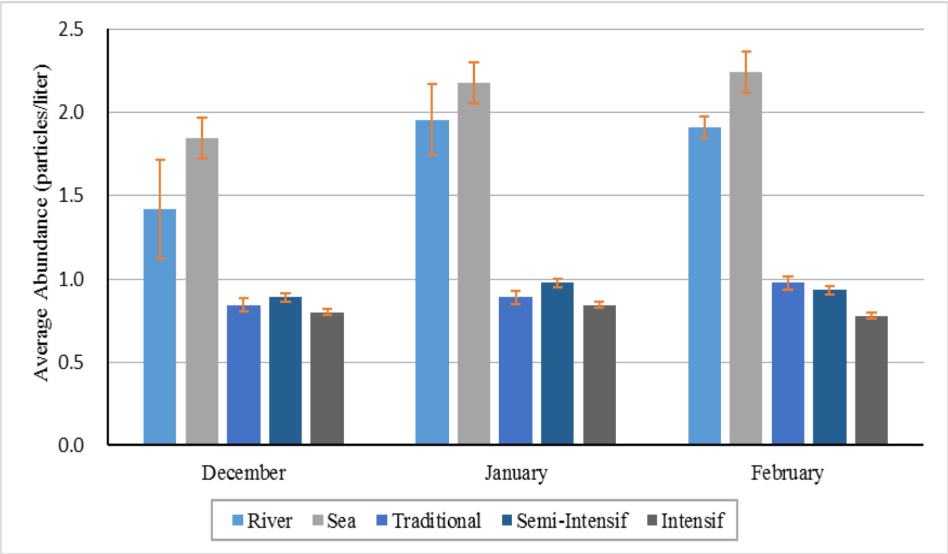


Figure 2. Average abundance of microplastic in water samples

C. Microplastic Content in Sediment

The abundance of microplastics in sediments indicates that microplastic accumulation occurs continuously in aquatic environments. The average abundance of microplastics in sediment can be seen in the (Figure 3).

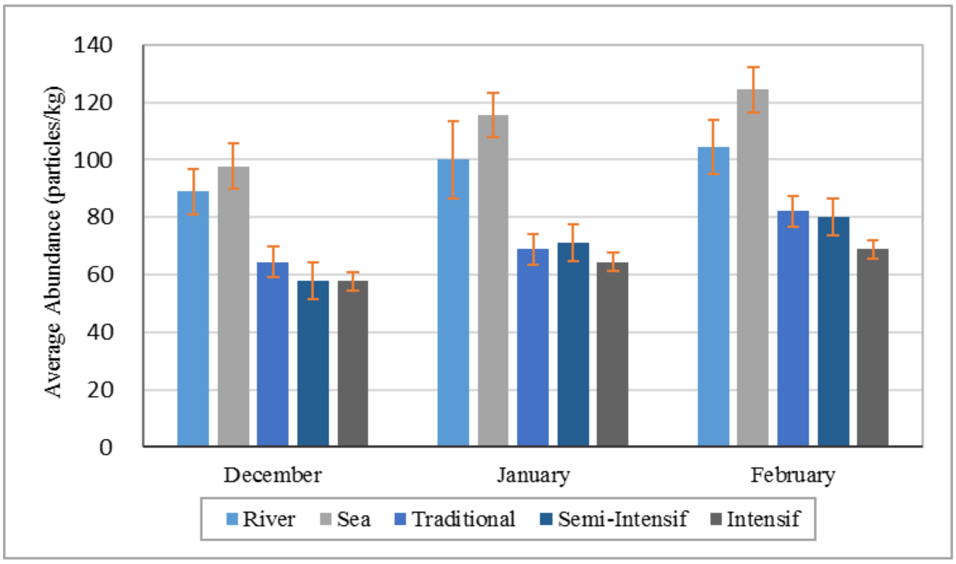


Figure 3. Average abundance of microplastics in sediment samples

Microplastics were found with the highest average abundance value in February. In marine sediments, the highest average abundance was 124.4 particles/kg. In river sediments, the highest average abundance reached 104.4 particles/kg. While in shrimp ponds with three different methods, the highest microplastics were found in traditional ponds with a value of 82.2 particles/kg.

The high microplastic content in sediments indicates that there are many sources of pollution and can have an impact on the biota living in these waters [27].

Microplastics in sediments will be difficult to decompose, allowing them to be consumed by organisms such as macrobenthos, crustaceans, and molluscs [28]. In all sampling areas, the sediment obtained was mud. Soft sediments such as mud will more easily capture microplastic particles than rocky or sandy sediments [29].

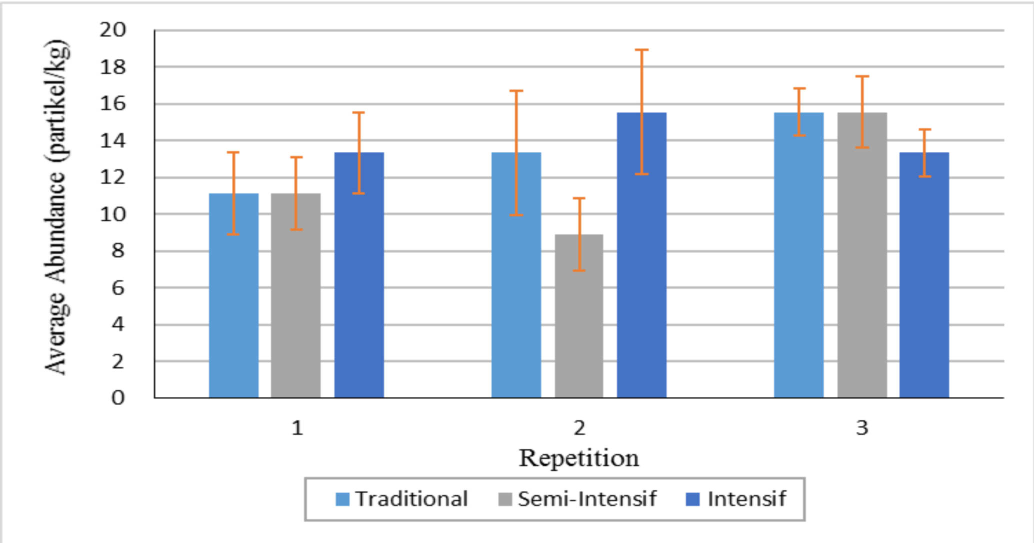


Figure 4. Average abundance of microplastics in shrimp feed samples

D. Microplastics Content in Shrimp Feed

Fish meal and fish oil used as feed ingredients are increasingly threatened by contamination of pollutants in the form of microplastics [30]. Feed is one of the sources of microplastic entry into the vaname shrimp cultivation environment. In this study, the average abundance of microplastics in commercial feed (Figure 4) used during one shrimp cultivation cycle ranged from 8.9-15.6 particles/kg. Microplastics can enter commercial feed through fishmeal made from marine fish that have been contaminated with microplastics [5]. In general, commercial fishmeal used as a feed raw material can contain up to 124 particles/kg, this concentration is higher than that of trash fish as the raw material [31].

E. Microplastic In Vaname Shrimp

Microplastics found in the gills and digestive tract of shrimp indicate the entry of microplastics into the bodies of biota cultivated
in waters polluted by plastic. The average abundance of microplastics in shrimp organs (Figure 5) showed an increase every month, the highest abundance in shrimp cultivated in semi-intensive ponds with average abundance values of 6.0, 7.2 and 8.2 particles/gram. The lowest averange abundance was found in intensive ponds with values of 4.7, 5.6 and 5.7 particles/gram. while in traditional ponds the average abundance reached 5.3, 6.7 and 7,1 particles/gram. The difference in microplastic abundance in the three ponds with different cultivation methods can be caused by the water source, feed and equipment used [5].

Microplastics floating in the water column or in the sediment as a habitat for vaname shrimp can accumulate in the shrimp's body during the breathing process and the foraging process. When eating, it accidentally enters through the mouth and accumulates in the digestive tract. This can happen because the shape of the microplastic is almost the same as the type of food [32]. Most research results state that the presence of microplastics in the digestive tract is considered a place where microplastics accumulate [33]. The entry of microplastics into the body of whiteleg shrimp can also be through the transfer of particles to an organism, one of which is plankton. The transfer of microplastic particles occurs if whiteleg shrimp consume natural food (plankton) that has been contaminated with microplastics [8]

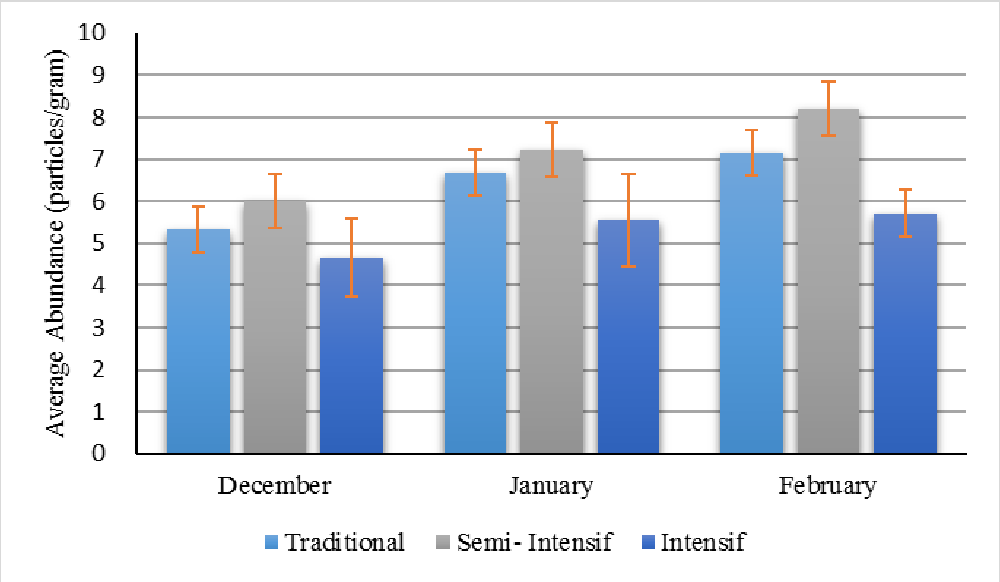


Figure 5. Average abundance of microplastics in shrimp vaname samples

F. Microplastics In Vaname Shrimp Cultivation With Different Methods

The abundance of microplastics found in the gills and digestive tract (Figure 5) indicates
microplastic contamination in cultivation activities. Microplastics in shrimp cultivation activities can come from plastic equipment, commercial feed used and water sources as one of the sources of life in aquaculture activities. In vaname shrimp cultivation, the use of plastic equipment starts from the seeding process to the harvest process [34]. Table 2 shows the plastic equipment found in vaname shrimp ponds with three different methods, so that the presence of microplastics in the cultivation environment both in water, sediment and shrimp as biota can come from the cultivation equipment used. The use of these plastic materials allows plastic fragments to enter the maintenance media as microplastics. In cultivation activities, plastic equipment must be properly maintained to avoid the release of microplastic fragments from the tools used [5]. In addition, the abundance of microplastics in water samples and sediment samples (Figures 2 and 3) in the Way Sekampung River and the Laut Timur Sumatera, proves the presence of microplastic sources in the main water sources for cultivation activities.

In intensive ponds, the use of plastic materials is the most complex, but the results of microplastics found in water, sediment and shrimp are inversely proportional, because the plastic material in the intensive method uses plastic with stronger materials and the incoming water source is well filtered. One of them is the use of HDPE (*High Density Polyethylene*) plastic which is resistant to water seepage and UV rays [35]. The abundance of microplastics with the semi-intensive method is much higher compared to other methods. This can be caused by the use of cultivation equipment such as mulch that is easily broken and can only be used 3-4 times a cycle depending on weather and climate conditions. Global warming, climate change, and extreme weather events can accelerate the degradation of plastic into microplastics [36]. In traditional ponds, the highest abundance of microplastics is found in the sediment

(Figure 3), because microplastics that enter the pond do not undergo routine filtering and siphoning rocesses, therefore microplastics enter together with organic materials from cultivation residues. Microplastics that settle in the sediment and occur continuously will cause accumulation of microplastics in deeper sediment layers [24].

TABLE 2.
TOOLS USED IN THREE DIFFERENT METHODS

Tools	Traditional	Semi-Intensive	Intensive
HDPE/Mulch		✓	✓
Water Wheel & Float	✓	✓	✓
Bird Repellent		✓	✓
Commercial Feed	✓	✓	✓
Bucket	✓	✓	✓
Net	✓	✓	✓
Anco		✓	✓
Water Barrel		✓	✓
Auto Feeder			✓
Paralon	✓	✓	✓
Water Filter	✓	✓	✓

IV. CONCLUSION

The microplastics found amounted to 1,593 particles, 877 particles in the air, 561 particles in the sediment, 53 particles in the feed and 102 particles in the shrimp. The microplastics found had 4 different shapes with sizes between 10-600 μm. The abundance of microplastics in the waters and sediment fluctuated influenced by geographical and weather conditions. The highest abundance in sea water occurred in February with 2.24 particles/liter, reporting the highest in river water occurred in January with 1.96 particles/liter. The highest abundance in pond water occurred in January and February with 0.98 particles/liter in semi-intensive and intensive ponds. In marine sediments, the highest average was reported at 124.4 particles/kg. In river sediments, the highest average was reported at 104.4 particles/kg. Shrimp ponds with three different methods, the highest microplastics in sediment were found in traditional ponds with a value of 82.2 particles/kg. The average abundance of microplastics in commercial feed during one shrimp cultivation cycle ranged from 8.9-15.6 particles/kg. The abundance of microplastics in shrimp accumulates every month, the highest abundance value occurs in semi-intensive ponds in February with 8.2 particles/gram. The discovery of microplastics at all sampling locations both in rivers, seas, commercial feed and three ponds with different methods indicates the presence of microplastic contamination in the cultivation environment.

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