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The Effect of Polyvinyl Chloride (PVC) Microplastic Exposure in Feed on The Growth Performance and Survival of Catin Fish (*Pangasius hypophthalmus*)

Pengaruh Paparan Mikroplastik Polyvinyl Chloride (PVC) Pada Pakan Terhadap Performa Pertumbuhan dan Kelangsungan Hidup Ikan Patin (*Pangasius hypophthalmus*)

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Abstract

This study aims to analyze the effect of exposure to polyvinyl chloride (PVC) microplastics on the growth and survival rate of catfish (Pangasius hypophthalmus). Microplastics were administered through feed with four treatments: P1 (control, no microplastics), P2 (0.01 mg/0.75 g feed), P3 (0.1 mg/0.75 g feed), and P4 (1 mg/0.75 g feed), each with three replicates in a completely randomized design. The results showed that increased microplastic concentrations, particularly in treatment P4, significantly reduced the growth rate of catfish, although survival rates did not differ significantly among treatments. These findings indicate that high-dose microplastic exposure has the potential to inhibit the growth performance of farmed fish..

Keywords: Microplastic, Polyvinly chloride, Catfish, Freshwater

Abstrak

Penelitian ini bertujuan untuk menganalisis pengaruh paparan mikroplastik polivinil klorida (PVC) terhadap pertumbuhan dan tingkat kelangsungan hidup ikan lele (*Pangasius hypophthalmus*). Mikroplastik diberikan melalui pakan dengan empat perlakuan: P1 (kontrol, tanpa mikroplastik), P2 (0,01 mg/0,75 g pakan), P3 (0,1 mg/0,75 g pakan), dan P4 (1 mg/0,75 g pakan), masing-masing dengan tiga ulangan dalam rancangan acak lengkap. Hasil menunjukkan bahwa peningkatan konsentrasi mikroplastik, terutama pada perlakuan P4, secara signifikan menurunkan laju pertumbuhan ikan lele, meskipun tingkat kelangsungan hidup tidak berbeda nyata antarperlakuan. Temuan ini mengindikasikan bahwa paparan mikroplastik dosis tinggi berpotensi menghambat performa pertumbuhan ikan budidaya.

Kata kunci : Mikroplastik, Polyvinly chloride, Ikan Patin, Air Tawar

1. Introduction

Indonesia is the world's largest contributor of plastic pollutants to the ocean after China with a size of 1.29 million metric tons of plastic/year. The high use of plastic in various human life activities has the potential to increase the number of microplastics in the aquatic environment. Plastics are generally persistent and durable but oxidative degradation caused by long-term exposure to ultraviolet radiation and physical abrasion can break down plastic debris into smaller particles measuring micrometers to nanometers called microplastics (Hasibuan *et al.* 2020).

Plastic pollution has been reported in every ocean and sea on Earth and is widely recognized as a global threat to aquatic life. When plastic particles are smaller than 5 micrometers, they can be ingested by various aquatic organisms. Ingested microplastics can cause harm through physical damage to the digestive tract such as the intestines. Consumption of microplastics can also be harmful to the health of various organisms because the indigestible particles will fill the stomach and reduce hunger, causing false satiety (Critchell & Hoogenboom, 2018).

Microplastics are generally defined as plastics smaller than 5 mm in size, and can be found in various environments and aquatic and terrestrial biota. Microplastics consist of two types, namely primary and secondary microplastics. Primary microplastics are types of microplastics that come from raw materials for making plastic or from beauty products that are micro-sized, while secondary microplastics come from the fragmentation of large plastic products into small pieces through photooxidation, mechanical, chemical, or biological interactions (Nurdiana & Trivantira, 2021).

Microplastic forms are categorized into 4 forms, namely fiber, film, fragment and foam. Microplastics categorized as fiber can come from land such as leftover laundry or from fishing gear used by fishermen. Microplastics in the form of films can come from human activities such as the use of plastic bags, plastic wrappers, and plastic bottles that are not recycled properly.

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Fragments are a form of microplastic that can come from the use of hard plastic items such as household appliances. The difference between the fragment and film forms is that the film looks transparent while the fragment is not transparent. Meanwhile, microplastics in the form of foam can come from ship coatings with the characteristic of having a hollow structure (Hanif *et al.* 2021).

The presence of microplastics in waters can be consumed by aquatic biota such as fish. Microplastics in the body tissues of aquatic biota can disrupt the digestive system. Other impacts that arise include reducing growth rates, inhibiting enzyme production, reducing steroid hormone levels, affecting reproduction, and can cause greater exposure to toxic plastic additives. The chemical content of plastic will also be absorbed into the bodies of aquatic biota, so that if consumed by humans, toxic transfer will occur (Tuhumury & Ritonga, 2020).

Catfish is one of the most widely cultivated fish in Indonesia and has high economic value. In addition, catfish itself has 13 species spread across Indonesian waters. In the catfish cultivation system, fish cultivation activities are certainly susceptible to the use of materials containing plastic such as the use of PVC pipes. Polyvinyl chloride (PVC) is a pipe made of plastic and several other vinyl combinations. Generally, the use of PVC pipes in cultivation is used to flow water into cultivation ponds. Throughout the world, more than 50% of PVC produced is used as a construction material. This is because PVC is relatively cheap, durable, and easy to assemble (Hanggara & Amiruddin, 2017).

The refore, this study was conducted to analyze the effect of exposure to polyvinyl chloride microplastics mixed in feed on the growth and survival of catfish (*Pangasius hypophthalmus*), where polyvinyl chloride is often used in fish farming and is found in waters, both rivers and lakes, which are sources of water.

2. Materials and Methods

2.1. Time and Place

This research was conducted for 45 days, in June 2024 - July 2024 which took place at the Fish Reproduction and Production Laboratory and Fish Nutrition and Feed Laboratory, Aquaculture Study Program, Department of Fisheries and Marine Sciences, Faculty of Agriculture, University of Mataram.

2.2. Research Procedure

a. Preparation of Research Containers

The first thing to do is to prepare the cultivation container. The container that will be used in this study is a 45 L container as many as 12 pieces. The container that will be used is first cleaned using detergent and a sponge, then rinsed using fresh water, after being washed the container is then dried in the sun. After the container is dry, the next step is to add sterilized water. The water used is fresh water that has been left overnight. Fresh water is the living medium of catfish.

b. Preparation of Test Animals

The test animal is a catfish (Pangasius hypophthalmus) with 8-10 cm seeds which are used as test animals for research. This test animal was obtained at the Lingsar Fish Seed Center Installation, in Lingsar Village, Lingsar District, West Lombok Regency. After being acclimatized, the fish were then put into a maintenance container with a density of catfish seeds of 1 per 2 liters of water, so that each container contains 15 fish.

c. Microplastic Manufacturing Process

Polyvinyl chloride microplastics come from water PVC pipes. PVC pipes are prepared in advance as many as 2 lengths, the pipes are then cut into small pieces using a grinder in a large bucket. The pipe cutting process which aims to produce PVC powder is carried out in a large bucket which aims to keep the PVC powder from flying during cutting. The PVC powder from the cutting results will later be mixed into the pellet feed that will be given to the test biota.

d. Mixing Feed and Microplastics

The type of microplastic used in this study is Polyviny Chloride (PVC) which will be mixed with feed and then given to the test biota. Before being mixed, the feed will first be ground using a flouring machine. After the feed is ground, the feed will be mixed with microplastics at a predetermined dose. In the process of mixing feed with microplastics, a little water is added to make it easier for the microplastics to blend with the feed. In addition to using water as an adhesive, there is an additional ingredient as a fish feed adhesive, namely CMC (Carboxyl Methyl Cellulose). CMC is part of the composition of drinks, namely acting as a thickening agent and acting as a binder. Fish pellet feed that has been ground into flour is then given CMC at a dose of 1%, and PVC powder and pellet feed are put in a large bucket. Then mixed evenly by hand, while adding water until it is ensured to be evenly mixed. The next stage, the mixture of these ingredients is put into the feed making machine and the pellet feed is waited for to come out through the machine outlet. After the feed is finished, the feed is then dried in the sun until dry. The test feed was given three times a day, at 08.00, 13.00 and 17.00 WITA. The test fish were fed ad satiation, where the feed was given until the fish did not respond to the feed.

e. Water change and siphoning

The siphoning process is a process carried out to remove feces (fish waste) and uneaten fish food remains. This process is carried out by preparing the necessary tools such as a small hose and a 5-liter jar as a container for siphoning water. The upper end of the small hose is inserted into the maintenance container. The lower end of the hose is sucked using the mouth which aims to draw water so that it can flow out into the jar container, after the water and dirt are sucked out of the maintenance container. Furthermore, the hose is directed to the part where there is dirt and food remains. Siphoning is carried out every 3 days, along with changing the maintenance water.

Water changes are the process of removing/reducing and adding new water that has gone through a sedimentation process in a large bucket with a capacity of 80 liters. New water that will be put into the maintenance container must go through a sedimentation process for 24 hours or until it is certain that there is no chlorine odor that could poison the biota being maintained. Water changes are carried out by reducing the volume of water by 10%. The first thing to do is to reduce the water in the maintenance container using a large hose, the method is almost the same as the siphoning process by sucking the water in the maintenance container. After the water in the container is reduced, then add new water using the help of a water pump connected to a large hose to the maintenance container.

2.3. Research Parameters

a. Specific Growth Rate

The specific weight growth rate is calculated using the formula according to Mukhlis *et al.* (2017) as follows:

$$SGR = (Wt / W0)^{1/t} - 1) \times 100\%$$

Information:
SGR : Specific growth rate (% day).
Wt : Average weight of test animals at the end of the study (gr).
W0 : Average weight of test animals at the beginning of the study (gr).
T : Length of observation period (days).

b. Absolute Growth of Body Weight

Absolute growth of body weight in fish can be known based on the calculation of fish biomass at the end of the study which is calculated using the Septimesy *et al.* (2016) as follows:

$$Wm = Wt - W0$$

Information:
Wm : Absolute Weight Increase.
Wt : Final Weight.
W0 : Initial Weight.

c. Absolute Growth of Body Length

The absolute growth of body length in fish can be known based on the measurement of fish length at the end of the study which is calculated using the formula of Sinaga et al. (2021) as follows:

$$Lm = Lt - L0$$

Information:
Lm : Absolute length of fish (cm).
Lt : Length of fish at the end of maintenance (cm).
L0 : Length of fish at the beginning of maintenance (cm).

d. Survival rate

The survival rate is defined as the number of living biota divided by the number of biota stocked during the research process (Suryaningsih *et al.* 2018) as follows:

$$SR = (Nt / N0) \times 100\%$$

Information:
SR : Fish survival rate (%).
N0 : Number of fish at the start of the study (tails).
Nt : Number of fish at the end of the study (tails).

e. Feed Convertion Ratio

$$FCR \equiv \frac{F}{(Wt + D) - Wo}$$

Information:
F : Total feed used (gr).
Wt : Total final weight of maintenance (gr).
Wo : Total initial weight of maintenance (gr).
D : Total weight of dead fish / mortality (gr).

2.5. Data Analysis

The research data will be tested using a completely randomized design (CRD) which will then be analyzed using the F test (ANOVA). This test is conducted to determine the effect of treatment (independent variable) on the response of the measured parameters. If the test value is significantly different, it will be continued by using the BNT (Smallest Real Difference) test to determine which treatment gives the best results with a level of 0.05 (95% confidence interval).

3. Results and Discussion

a. Absolute Length Growth

Absolute length growth is the overall length growth of fish in each container at the end of 45 days of maintenance. The absolute length value based on the research results obtained a value in treatment P1 of 3.7 cm, P2 of 2.9 cm, P3 of 2.5 cm, and P4 of 2.4 cm. The highest value was obtained in treatment P1 while the lowest value was obtained in treatment P4.

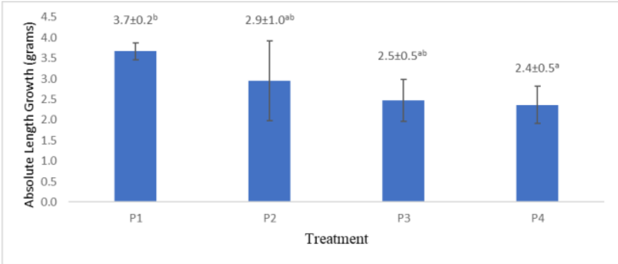

Figure 1. Absolute length growth data

This shows that in P1 control without giving microplastics, catfish experienced the highest increase in length growth, while the lowest growth was in the P4 treatment which is thought to be due to the presence of microplastics with the highest dose which causes catfish to experience damage in their ability to absorb feed properly for growth, but the feed eaten is used to survive or treat damaged organs caused by microplastics. This is in accordance with the statement of Hermawan *et al.* (2022) microplastics that accumulate in the digestive tract of fish, causing damage to internal organs and blockage of the digestive tract and microplastics in the long term can cause significant intestinal changes, structural and functional changes in the intestines. Fish will not get the right food for growth. This is reinforced by Azizah *et al.* (2020) fish that accidentally eat microplastics will accumulate in the digestive tract which has the potential to injure and block their digestive tract and harmful compounds in microplastics can cause harmful biological effects such as decreased gill and intestinal function. In addition, according to Horton et al. (2018) microplastic particles measuring <5 micrometers cause fish to experience oxidative stress and inflammation in the liver. If plastic particles become nano-sized, they have the potential to enter the blood and brain, causing brain damage and behavioral changes. Therefore, it has serious consequences for fish life.

b. Specific Length Growth

The specific length growth rate is a parameter to determine the growth rate per day for 45 days of maintenance. Based on the results of the research that has been done, where the specific length values obtained in treatments P1, P2, P3 showed a greater increase in length growth, compared to treatment P4. The highest values were obtained in succession in P1 with a value of 0,57%, P2 of 0,45%, P3 of 0,39%, while the lowest value was obtained from P4 with a value of 0,38%.

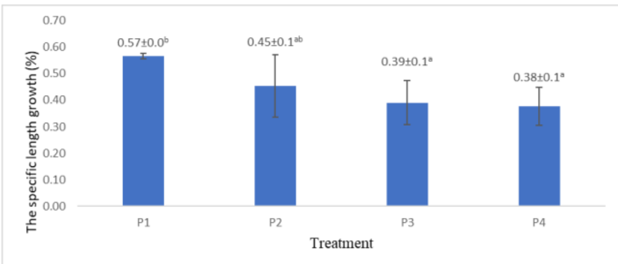

Figure 2. Specific length growth data

Based on these values, it is suspected that the P4 treatment experienced growth disorders caused by the presence of a mixture of microplastics in the P4 feed. Microplastics contain substances that are harmful to catfish if consumed. This is in accordance with the statement of Al-Fatih, (2021) that the entry of microplastics into the body of biota can potentially cause damage to organ function, reduced fish growth rates, decreased immune systems, and potentially death in fish that have been contaminated with microplastics.

c. Absolute Weight Growth Rate

Absolute weight is the total growth rate of fish biomass during maintenance expressed in grams. Based on the results of the study for 45 days, the absolute weight growth value in P1 was 276.5 gr, P2 was 249.8 gr, P3 was 204.2 and the absolute weight growth value in P4 was 198.2 gr.

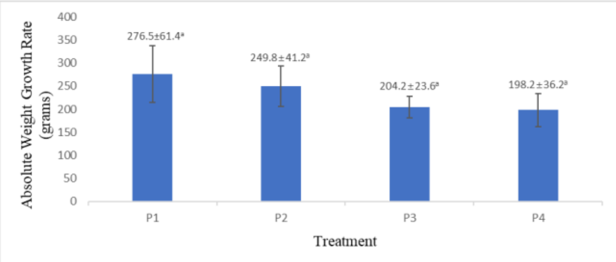

Figure 3. Absolute weight data

The highest absolute weight value was obtained in treatment P1 and the lowest was obtained in treatment P4 which was caused by the presence of microplastic content with a high percentage, this is thought to cause catfish to experience digestive system disorders and the ability to absorb food consumed so that the utilization of feed as weight growth in fish slows down. This is in accordance with the statement of Puspita *et al.* (2023) the presence of microplastic content in fish will have an impact on digestive disorders, growth, and metabolism. Microplastics will be one of the causes of environmental changes that can cause stress in fish. Fish that are stressed or experiencing environmental pressure will try to restore their homeostatic conditions. Homeostasis is an environmental condition in the fish's body that remains balanced. If this condition is not achieved, the fish will experience health problems, behavioral changes and become weak.

d. Specific Weight

Specific weight is a parameter to determine the rate of weight growth per day during maintenance. Based on the research that has been done, the highest specific weight value was obtained in the treatment without microplastics, namely P1, which was 6.14 grams, while the specific weight value in the treatment containing microplastics was P2, which was 5.55 grams, P3, which was 4.54 grams, and the lowest in the P4 treatment, which was 4.40 grams.

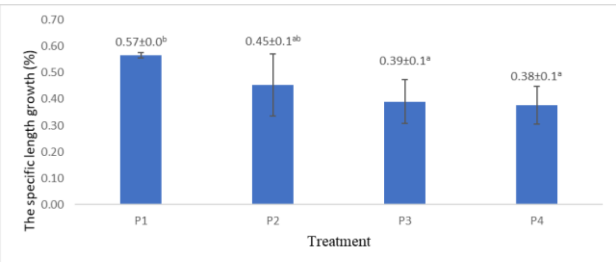

Figure 4. Specific weight data

It is suspected that due to the highest dose of microplastics in P4 compared to other treatments, the catfish in P4 did not experience the same growth as the P1 treatment. This is in accordance with the statement of Naidoo & Glassom, (2019) that growth will be negatively affected by the addition of microplastics to fish feed. Fish also experience smaller growth and microplastic consumption places an additional energy burden on fish and decreases energy reserves. The energy that is usually used for growth is actually used for vital maintenance such as adjusting body functions from microplastics and their additives. In addition, the use of feed for growth is diverted to overcome stress and inflammation.

e. Feed Convertion Ratio (FCR)

Feed conversion ratio is a useful parameter to determine the amount of feed needed to produce one kilogram of meat in fish farming or the amount of feed converted into meat. Based on the research results, the FCR value at P1 was 1,48, P2 was 1,84, P3 was 1,93 and P4 was 2,04.

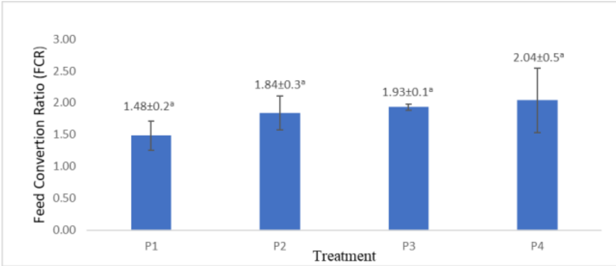

Figure 5. Feed convertion ratio data

The FCR value at P1 is low, because the feed given is of good quality and the optimal utilization of feed is carried out by catfish for its growth, while the highest FCR value is at P4 with a value of 2.04, the highest FCR value at P4 is thought to be due to the presence of microplastics in catfish feed which causes the feed to be of poor quality to be given to fish. This is in accordance with the statement of Aryani *et al.* (2023) that feed quality is influenced by the digestibility or absorption of fish to the feed consumed. The smaller the feed conversion value, the better the feed quality, but if the feed conversion value is high, the fish feed is not good. According to Verma & Prakash, (2022) microplastics contained in feed are then eaten by fish causing harm to fish species. Absorption of microplastics by fish can accumulate in the digestive tract, causing hunger due to a false sense of fullness. The effect that even occurs is perforation of the digestive tract. So that the physical and physiological consequences of these microplastics on fish are not beneficial for fish life.

The feed consumed by catfish will be used as energy in the fish's body, the energy will be used first to survive. If the energy needs to maintain its life are met, catfish will use the remaining energy for its growth. This is in accordance with the statement of Supriyan *et al.* (2020) growth is a biological process that will take place in the fish's body, growth will occur if the amount of food consumed by the fish exceeds the body's maintenance needs. The lower the feed conversion value, the less is needed to produce 1 kg of fish meat. This means that the more efficient the feed is converted into meat. The greater the growth in fish body weight at the same level of feed consumption will result in a smaller conversion value so that the better the feed's utility. The better the quality of the feed, the lower the feed conversion achieved, whether the quality of the feed is good or not is determined by the balance of the feed nutrients that are in accordance with the needs of the fish.

f. Survival Rate

Fish survival is one of the factors that greatly influences the success of a fish farming business. Patin fish survival is the average percentage of the total number of fish that survive at the end of maintenance from the number of fish that were stocked at the beginning of maintenance. The results of the survival rate calculation obtained during 45 days of maintenance in treatment P1 were 95%, P2 was 88%, P3 was 84% and the survival rate value in P4 was 82%.

The highest survival rate value was obtained in the P1 treatment, while the lowest was in the P4 treatment. Factors that can affect the survival rate of catfish include the ability to adapt to the environment. In addition, the percentage of the survival rate value of the P4 treatment was low, it is suspected that there was exposure to microplastics which had a higher dose of microplastics compared to the P1 treatment without microplastics, P2 and P3 had microplastic content but had no effect. The percentage of the survival rate value of the P1 treatment was relatively high, this was because P1 was given feed without a mixture of microplastics. This is in accordance with the statement of Saomadia *et al.* (2024) microplastics contain hazardous materials because they contain chemicals so that if consumed by fish it will cause damage to the fish's organs so that the fish's immune system becomes increasingly reduced. Fish that have been exposed to microplastics can experience stress and cause death, therefore (SR) in fish becomes lower.

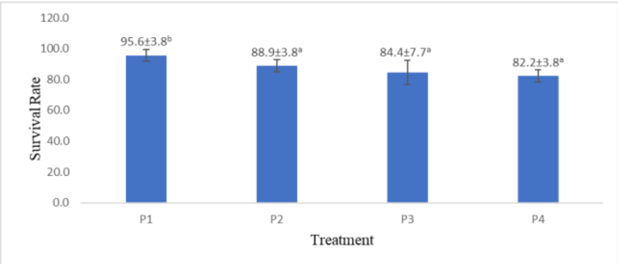

Figure 6. Survival rate data

The survival rate of catfish in this study that was exposed to microplastics through a mixture of feed and without microplastic exposure showed the same value in the optimal range. In catfish cultivation, the optimal survival rate range is normally obtained at 70-100%. This is in accordance with the statement of Arsad *et al.* (2017) survival rate is categorized as good if the SR value is> 70%, for the medium SR category 50-60%, and in the low category the SR value is <50%.

g. Water Quality

Water quality is one of the important parameters in every fisheries cultivation system, be it freshwater cultivation or marine cultivation. Water is a living medium for aquatic organisms and is an important factor to consider in order to provide support for the life of the organisms in it. This is in accordance with the statement of Scabra & Setyowati, (2019) water is the main medium for the life and growth of fish and the organisms that live in it. Fish can live well in a cultivation medium that suits their needs. In optimal conditions, fish can grow optimally. In less than optimal conditions, fish adapt more so that their growth is not optimal.

Temperature is a factor that affects the metabolic rate and solubility of gas in water. This temperature requirement affects the physiological performance of hormones and enzymes secreted by fish. Based on research that has been conducted, the temperature value in water is between 27.5 ºC– 29.7ºC, this value is still considered optimal for catfish cultivation. This is in accordance with the statement of Adi *et al.* (2023) the optimal temperature for catfish maintenance is 27-31°C so that the temperature range is thought to be quite optimal for growth. Higher temperatures will increase the metabolic rate of fish, but respiration that occurs is faster, reducing the concentration of oxygen in the water which can cause stress and even death in fish.

The degree of acidity or pH is one of the water quality parameters used to determine the acidity or alkalinity of water. Based on research that has been conducted, the pH value in the maintenance container is between 6.5-8.4. This value is still in the optimal category for the growth of catfish or maintenance of catfish. This is in accordance with the statement of Adi *et al.* (2023) the effect of pH on fish growth, at pH 4.0-6.5 and pH 9.0-11.0 fish growth is slow, pH 6.5-9.0 optimum fish growth, while pH <4.0 and pH> 11.0 cause death in fish. So the optimal pH range for maintaining catfish is 6.5-8.5. According to Supriyan *et al.* (2020) the optimal pH of water during maintenance of catfish (Pangasius hypophthalmus) ranges from 6.5-7.5. Acidic pH disrupts the fish's metabolic process, fish appetite will decrease and fish are susceptible to disease, and alkaline pH causes an increase in ammonia content which can interfere with fish life.

Dissolved oxygen (DO) is one of the water quality parameters that needs to be considered in fish farming activities. Dissolved oxygen is oxygen in dissolved form in water. Fish cannot take oxygen directly from the air. Based on research that has been conducted, the dissolved oxygen value is between 4.4-6.7 mg/L, this value is still considered optimal in maintaining catfish. Dissolved oxygen that is less than optimal can cause catfish to experience stress and a lack of appetite in catfish which disrupts fish growth. This is in accordance with the statement of Adi *et al.* (2023) the optimal dissolved oxygen for maintaining catfish is 3-8 mg/L, so dissolved oxygen is thought to be quite optimal for the growth of catfish. Low dissolved oxygen content causes decreased appetite, which will then affect the growth rate of fish. According to Asis *et al.* (2017) the level of fish oxygen consumption varies depending on temperature, dissolved oxygen concentration, fish size, activity level, time after feeding, and so on. Metabolic rates also vary between species and are limited by the low oxygen content available. In general, small fish will consume more oxygen per body weight than large fish of the same species. Dissolved oxygen is needed by all organisms for respiration, metabolic processes or exchange of substances which then produce energy for growth and reproduction as well as for the oxidation of organic and inorganic materials in aerobic processes. The ideal dissolved oxygen content in water for fish farming should not be less than 3 mg/L because it can cause the death of aquatic organisms.

Ammonia is a colorless liquid, has a very sharp odor and is easily dissolved in water. Based on the research that has been done, the ammonia value was obtained at 0.01-0.1 mg/L, this value is still included in the concentration that can be tolerated by catfish because during maintenance, water quality is one of the parameters that holds the key to success in cultivation. The siphoning and water replacement process is a method to keep the ammonia value within the normal range, so that during the research the catfish can run well. This is in accordance with the statement of Noprianto *et al.* (2022) ammonia consists of two forms, namely ammonium (NH_4^+) and non-ionized ammonia (NH_3). The total amount of these two fractions is usually called total ammonia or ammonia. The ammonia content produced in catfish maintenance during maintenance ranges from 0.0008-0.0013 mg/L. The ammonia value produced during maintenance is still within the normal range for maintenance catfish. This is reinforced by Anusuya et al. (2017) that ammonia greatly affects the dynamics of dissolved oxygen in water, because 4.6 mg of oxygen is needed to oxidize 1.0 mg of ammonia. Ammonia levels between 3 and 4 mg/L can be toxic to fish. Ammonia concentrations of more than 0.2 mg/L are not good for fish farming. Ammonia concentrations that are safe for freshwater fish are less than 0.05 mg/L.

4. Conclusion

The conclusion of the study shows that the addition of microplastics to the P4 treatment feed (1 mg/L 0.75 g of feed) that the addition of microplastics to the feed showed a significant effect on the growth performance of catfish, namely on absolute length growth which showed a significantly different effect on the P4 treatment, while the specific length showed a significantly different effect starting from the P3 treatment (0.1 mg/L 0.75 g of feed) to the P4 treatment (1 mg/L 0.75 g of feed). The survival rate in the P4 treatment showed the lowest value compared to other treatments, but was still within the optimal range of 82%.

Table 1.
Average water quality measurement

	Parameter			
	Temperature (°C)	pH	DO (mg/L)	Amonnia (mg/L)
optimal	25-27,5	6,5-8,4	4,4- 6,7	0,01-O,1
	27-31	6,5-8,5	3-8	>0,1

Sumber: [(1)](Adi *et al.* 2023), [(2)](Adi *et al.* 2023), [(3)](Adi *et al.* 2023) & [(4)](Wahyuningsih *et al.* 2020)

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