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Survival rate and growth performance of tilapia (*Oreochromis niloticus*) exposed in polyvinyl chloride microplastics

Bagus Dwi Hari Setyono[1,*], Wiwin Iky Soenarky[1], Zaenal Abidin[1], Rangga Idris Affandi[1]

[1]*Aquaculture Study Program, Faculty of Agriculture, University of Mataram, Mataram, Indonesia*

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ABSTRACT

Plastic is one of the materials most widely used by humans. The more plastic that is used, the more plastic waste is released into environment and will polute water areas in various sizes, both macroplastics and microplastics. Microplastic are classified as plastic particles whose diameter is less than 5 millimeters. One type of microplastic that has an adverse impact on the life of aquatic organisms is polyvinyl chloride (PVC). The aim of this research was to determine the effect of PVC microplastic exposure on the survival rate and growth performance of tilapia, *Oreochromis niloticus*. This study was conducted in a completely randomized design (CRD) consisting of four treatments with three replications. The treatments were as follows: MP_0 = No addition of microplastics (control); MP_1 = Addition of 5 mg/L microplastics; MP_2 = Addition of 15 mg/L microplastics; MP_3 = Addition of 20 mg/L microplastics. The results showed that exposure to polyvinyl chloride microplastics on the survival rate and growth performance of tilapia through water made a real difference to Survival Rate (SR), absolute weight growth, absolute length growth, Specific Growth Rate (SGR), Feed Convension Ratio (FCR) and the abundance of polyvinyl chloride microplastics in fish gut.

Introduction

Plastic is one of the materials most widely used by humans (Al-Fatih, 2021). People really enjoy using plastic, both in daily activities and in the commercial sector without realizing the long-term impacts it caused. Plastic produced by humans are ultimately thrown into the environment. The more plastic that is used, the more plastic waste will be released into the environment and will ultimately enter into water areas in various sizes, both macroplastic and microplastic.

Microplastic are plastic particles whose diameter is less than 5 millimeters (Alam and Rachmawati, 2020). Microplastic pose a risk to aquatic biota and ecosystems, according to the statement Haque and Fan (2023), because the shape is the same as food, microplastic can be easily ingested by aquatic organisms such as fish, invertebrates, birds and coastal animals. The biological effects of microplastic ingestion by aquatic organisms include disturbances in oxidative balance, energy metabolism, antioxidant capacity, DNA structure, immunological, neurological and histological disorders. Direct and indirect consumption of contaminated microplastic can result in biological responses such as inflammation, weight loss, and death caused by bioaccumulation (Benson *et al.*, 2022).

One type of microplastic that has an adverse impact on the life of organisms in waters is polyvinyl chloride (PVC) (Nosova and Uspenskaya, 2023). The impact of polyvinyl chloride (PVC) microplastic on aquatic organisms is related to chemicals from the environment that attach to the microplastic and make it as a vector (Issac and Kandasubramanian, 2021). Research conducted by Ziani *et al.* (2023), shows the potential effects of microplastic at the tissue and cellular levels. Polyvinyl chloride (PVC) microplastic, if ingested by aquatic biota, can cause cell inflammation (Li *et al.*, 2021).

* Corresponding author.
Email address: bagus.setyono@unram.ac.id

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The negative impact that microplastic have on aquatic organisms has begun to be realized. Currently, only a few studies have focused on the impact of microplastic in freshwater areas, most of which focus only on marine areas without paying attention to research for freshwater areas, so research on microplastic on freshwater aquatic organisms is very necessary, especially on tilapia (*Oreochromis niloticus*).

Tilapia is a freshwater fish that is widely consumed by Indonesians and is often found on the market in the form of processed or fresh fish (Salsabila and Suprapto, 2018). Tilapia is one of the fishery commodities that is very popular with the society to fulfill their animal protein needs (Mulyani *et al*., 2014). Tilapia production has been recorded to increase from year to year. In 2018, tilapia production was 1.16 million tons, then in 2022 it increased to 1.35 million tons (Kementerian Kelautan dan Perikanan, 2019; Kusumanti *et al*., 2023). In the cultivation process, tilapia requires water quality requirements that must be clean, not too turbid and not contaminated with toxic chemicals, especially those originating from microplastic which have huge consequences for both the survival of the tilapia and the humans who consume the fish. During the cultivation process, the particular activities or materials that might be a main source of microplastic contamination to tilapia is water and feed.

Based on the impact and potential dangers of microplastic on aquatic organisms, especially tilapia, it is necessary to conduct research on the effect of polyvinyl chloride (PVC) microplastic exposed on tilapia. The aim of this research is to determine the effect of polyvinyl chloride microplastic exposed on the survival rate and growth performance of tilapia, so it is hoped that a solution will emerge that can deal with this microplastic problem.

Materials and Methods

Location and time of research

This research was carried out for 30 days from June to July 2023, which took place at the Fish Production and Reproduction Laboratory. Observations on the abundance of microplastic in fish gut were carried out at the Fish Health Laboratory, Aquaculture Study Program, Faculty of Agriculture, University of Mataram.

Fish collection and maintenance

Twelve containers are prepared with a size of 45 liters. Twelve containers were used with 4 treatments and 3 replications. The container is washed using soap and then dried. Next, the container is filled with 30 liters of water. A total of one hundred eighty tilapia with an average weight of 0.9 grams were purchased from the Lingsar Fish Seed Center, West Lombok Regency. Before rearing, the tilapia are acclimatized for 2 weeks by keeping them in a tarpaulin pond which has new environmental conditions. Adaptation is carried out until the fish no longer die in a row. All equipment as well as water used in the procedure are free from plastic contamination.

Preparation of microplastic

The type of microplastic used comes from PVC pipes (PVC, PT. Wavin Trading Indonesia, Indonesia) which are crushed using a grinder to micro size. Then sifted using a flour sieve (Sieve, CV. Vamial Chem, Indonesia) with mesh 80. The sifted microplastic were stored in a container.

Experimental design

This study was conducted in a completely randomized design (CRD) consisting of four treatments with three replications. Exposure of microplastic is carried out before the seeds are put in containers. After that, the seeds were put in at a stocking density of 1 fish per 2 liters in containers with a capacity of 30 liters/container, so that 15 fish were kept in each experimental unit, then the microplastics were spread according to the predetermined concentration. Determination of the dose of microplastics in tilapia refers to research by Hidayatullah (2021). The method of providing exposure to microplastics is through water. The treatments were as follows:

- MP_0 = No addition of microplastics (control)
- MP_1 = Addition of 5 mg/L microplastics
- MP_2 = Addition of 15 mg/L microplastics
- MP_3 = Addition of 20 mg/L microplastics

If the container looks dirty, the water will be replaced to maintain good growth of fish seeds. After each siphon, they are given another exposure of microplastics at the same concentration according to the concentration of each experiment. The commercial diet (HI-PRO-VITE 781-1, PT. Central Proteina Prima, Indonesia) was used in this study. It gave twice a day with the ad satiation method in the morning and evening.

Survival rate

Survival rate is one of the main parameters used in this study. According to Setyono *et al.* (2023) survival can be calculated using the formula:

$$SR = \frac{Nt}{No} \times 100\%$$

Description:
SR = Survival rate (%)
Nt = Number of fish at the end of experiment
No = Number of fish at the start of experiment

Absolute weight growth

Absolute weight growth can be determined by weighing the fish at the start of the study and then on the last day of the study. Absolute weight growth is determined using the formula according to Aulia *et al.* (2024) as follows:

$$W = Wt - Wo$$

Description:
W = Absolute weight growth (g)
Wt = Final fish weight (g)
Wo = Initial fish weight (g)

Absolute length growth

Absolute length growth can be determined by measure the fish length at the start of the study and then on the last day of the study. Absolute length growth is determined using the formula according to Jabaruddin *et al.* (2023) as follows:

$$L = Lt - Lo$$

Description:
L = Absolute length growth (cm)
Lt = Final fish length (cm)
Lo = Initial fish length (cm)

Specific growth rate

Specific growth rate is a parameter used to determine the growth rate in percentage of weight gain per day. The specific growth rate can be determined using the formula according to Setyo *et al.* (2023), namely:

$$SGR = \frac{\ln Wt - \ln Wo}{t} \times 100\%$$

Description:
SGR = Specific growth rate (% per day)
Wt = Final fish weight (g)
Wo = Initial fish weight (g)
t = Maintenance time (days)

Feed conversion ratio

The feed conversion ratio is the ratio between the amount of feed given and the fish meat produced. The FCR calculation uses the formula (Anggraini *et al.*, 2023):

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

Description:
FCR = Feed conversion ratio
Wt = Total fish weight at the end of experiment (g)
Wo = Total fish weight at initial experiment (g)
D = Total weight of fish that died during experiment (g)
F = Total amount of feed given (g)

Abundance of microplastics in the gut

Sampling was carried out by taking fish from container and then dissecting them. Then the gut were taken and placed into an Erlenmeyer flask and 30% H_2O_2 solution was added until the sample was submerged. After that, it was covered using aluminum foil and incubated at room temperature for 24 hours. The destruction process is continued by placing the sample into waterbath at 70ºC for 24 hours until it turns clear. Next, the gut was filtered using filter paper (Whatman No. 41, Whatman plc, United Kingdom). Microplastics were observed and counted using a microscope (Olympus CX33, Olympus Corporation, Japan) with 10x magnification (Yona *et al.*, 2021; Yona *et al.*, 2022). Based on research conducted by Boerger *et al.* (2010), obtained a formula to calculate the abundance of microplastics found in fish intestinal organs, as follows:

$$\text{Abundance} = \frac{\text{Total of Microplastics (pcs)}}{\text{Total of Fish}}$$

Water quality

Water quality measurements are carried out regularly, such as measuring temperature, pH, dissolved oxygen, ammonia, nitrate and nitrite. Water quality measurements are carried out once a week, checking twice a day, namely in the morning and evening.

Data analysis

Data analysis was performed using SPSS software (SPSS version 25 for Windows). Results are presented as mean and standard error. The difference between the control and treatments were analyzed using a one-way analysis of variance (ANOVA) followed by the Duncan multiple range test. The significant differences were considered when $P<0.05$. Meanwhile, the results of the water quality parameters obtained will be analyzed descriptively.

Results

Survival rate

Tilapia survival rate can be determined by counting the number of fish stocked at the start of the study and the number of fish alive at the end of the study. The survival rate results obtained on average ranged from 37.8%-73.3% can be seen in Figure 1.

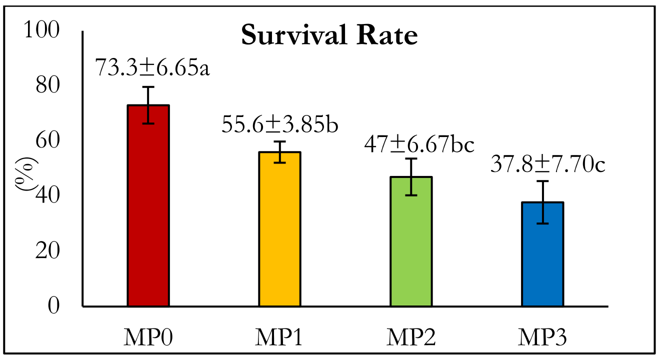


Figure 1. Survival rate (%) of *O. niloticus.*

The results of the ANOVA test at the 0.05 level showed that the survival rate of tilapia at different microplastic doses had a significant effect (P<0.05). The highest survival rate parameters for tilapia were based on the results of further analysis (Duncan's test), specifically the MP_0 treatment was very significantly different from MP_1, MP_2 and MP_3, but MP_1, MP_2 and MP_3 were significantly different.

Absolute weight growth

The results of the absolute weight growth of tilapia (*O. niloticus*) were known by weighing them on day 0 and at the end of the 30th day of the study, the average absolute weight growth of tilapia was found to be around 3.57-10.94 g as seen in Figure 2.

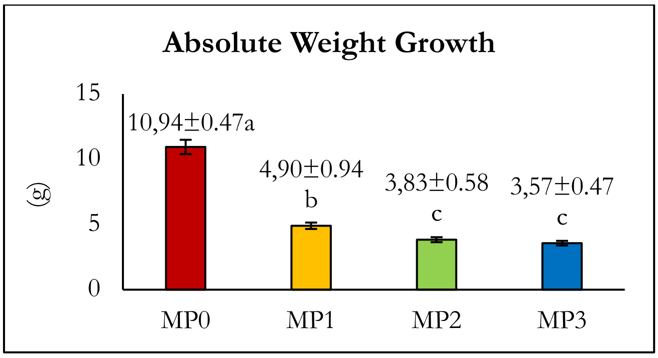


Figure 2. Absolute weight growth (g) of *O. niloticus*.

The results of the ANOVA test at the 0.05 level showed that the absolute weight growth of tilapia with different doses of polyvinyl chloride had a significant effect (P<0.05). The absolute weight growth parameters of tilapia based on the results of the Duncan Test in the MP_0 treatment were significantly different from MP_1, MP_2 and MP_3, while MP_2 and MP_3 were not significantly different, but were significantly different from MP_1 and MP_0.

Absolute length growth

The results of the absolute length growth of tilapia (*O. niloticus*) were known by taking measurements on day 0 and at the end of the 30th day of the study, namely that the average absolute length growth of tilapia was found to be around 1.04-1.83 cm as seen in Figure 3.

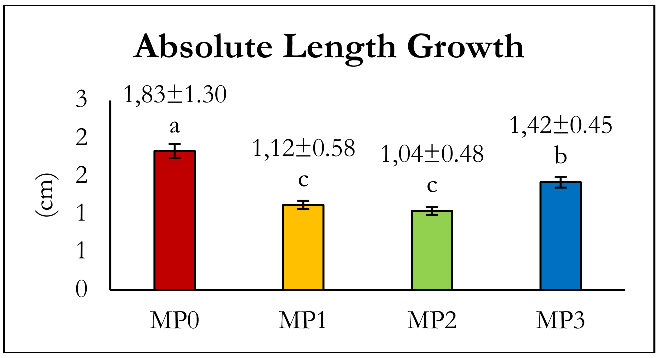


Figure 3. Absolute length growth (cm) of *O. niloticus*.

The results of the ANOVA test at the 0.05 level showed that the absolute length growth of tilapia with different doses of polyvinyl chloride had a significant effect (P<0.05). The absolute length growth parameters of tilapia based on the results of the Duncan Test in the MP_0 treatment were significantly different from MP_1, MP_2 and MP_3, while MP_1 and MP_2 were not significantly different, but were significantly different from MP_0 and MP_3.

Specific growth rate

The results of the specific growth rate show that the percentage of daily weight gain of fish at the beginning of the study, namely day 0 and at the end of the study, namely on day 30, ranged from 2.14-4.40%/day as seen in Figure 4.

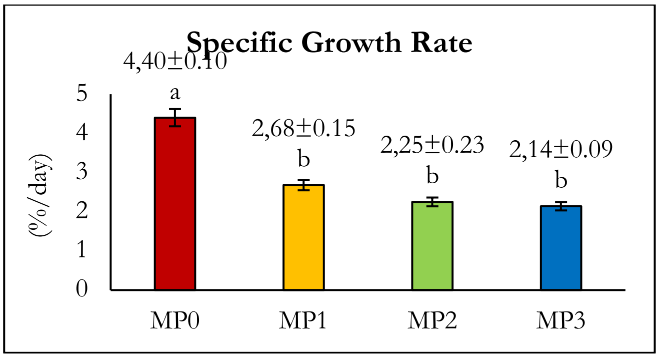


Figure 4. Specific growth rate (%/day) of *O. niloticus*.

The results of the ANOVA test at the 0.05 level showed that the specific growth rate of tilapia at different doses of polyvinyl chloride had a significant effect (P<0.05). The specific growth rate parameters of tilapia based on the results of further analysis (Duncan Test) showed that the MP_0 treatment was significantly different from MP_1, MP_2 and MP_3, while MP_1, MP_2 and MP_3 were not significantly different.

Feed conversion ratio

The results of the feed conversion ratio for tilapia during 30 days of rearing were found to be an average of around 1.61-2.01 which can be seen in Figure 5.

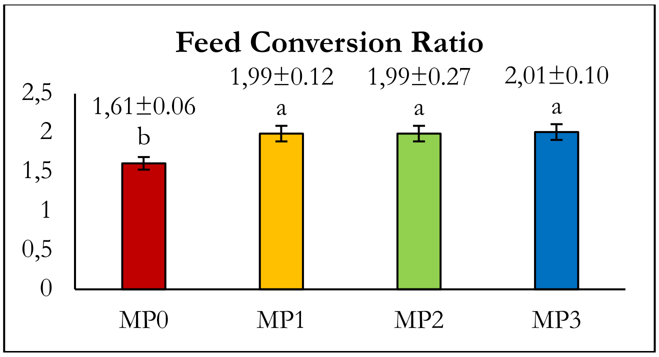


Figure 5. Feed conversion ratio of *O. niloticus*.

The results of the ANOVA test at the 0.05 level showed that the feed conversion ratio value for tilapia at different doses of polyvinyl chloride had a significant effect (P<0.05). The feed conversion ratio parameter for tilapia was the lowest in the MP_0

Depik Jurnal Ilmu-Ilmu Perairan, Pesisir dan Perikanan
Volume 13, Number 3, Page 516-524

treatment. In the results of the further analysis (Duncan Test) the MP_0 treatment was significantly different from MP_1, MP_2 and MP_3, while MP_1, MP_2 and MP_3 were not significantly different.

Abundance of microplastics in the gut

Measurement of the abundance of microplastics in the tilapia gut was carried out surgically at the end of the study by taking the tilapia gut. Then the abundance of microplastics was calculated. The results of the abundance of polyvinyl chloride microplastics range from 42.0-76.6 particles/individual which can be seen in Figure 6. The results of the identification of polyvinyl chloride microplastics can be seen in Table 1.

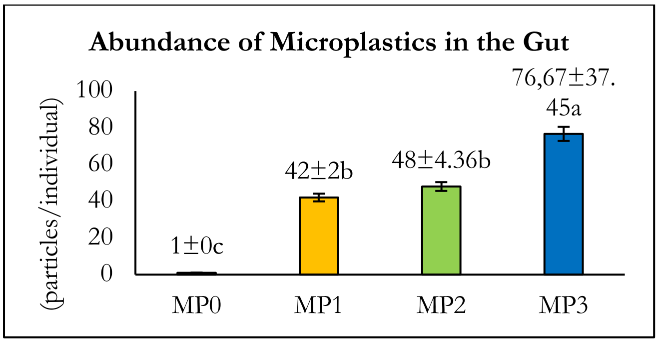
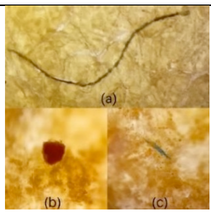
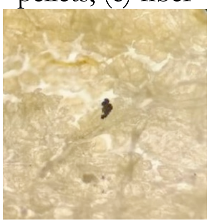


Figure 6. Abundance of microplastics in the gut of *O. niloticus*.

Table 1. Identification of Microplastics in the Gut of *O. niloticus*.

Treatment	Organ	Organ Weight (g)	Microplastics
MP_0	Gut	0.9	 (a) fiber, (b) pellets, (c) fiber
MP_1	Gut	0.25	 Polyvinyl Chloride
MP_2	Gut	0.39	 Polyvinyl Chloride
MP_3	Gut	0.42	 Polyvinyl Chloride

Based on Figure 6, the results of the ANOVA test at the 0.05 level show that administering different doses of polyvinyl chloride has a significant effect ($P<0.05$) on the abundance of microplastics in the gut of tilapia. Microplastic abundance parameters in the gut of tilapia were lowest in the MP_0 treatment. In the results of the further analysis (Duncan Test) the MP_0 treatment was significantly different from MP_1, MP_2 and MP_3, while MP_1 and MP_2 were not significantly different but were significantly different from MP_3.

Water quality

Water quality has a very important role in supporting the life and growth of tilapia. Water quality parameters observed during the study can be seen in Table 2.

Table 2. Water Quality During Research.

Parameter	Obtained Range	Ideal Range	References
Temperature (°C)	26-28.1	26-30	Mila and Mistina (2023)
pH	6.6-7.8	6-8	Safsafubun *et al.* (2023)
DO (ppm)	4-6.2	4-10	Adi and Suryana (2023)
Ammonia (ppm)	0.15-1.5	<1.5	Djaelani *et al.* (2023)
Nitrate (ppm)	0-25	<50	Maldino *et al.* (2023)
Nitrite (ppm)	0.25-1	<1	Hadiroseyani *et al.* (2023)

Based on Table 2, it can be seen that the temperature during the study ranged from 26-28.1°C. The pH during the study ranged from 6.6-7.8. Dissolved oxygen (DO) content during the study ranged from 4-6.2 ppm. Ammonia (NH_3) during the study ranged from 0.15-1.5 ppm. Nitrate (NO_3^-) during the study ranged from 0-25 ppm. Nitrite (NO_2^-) during the study ranged from 0.25-1 ppm.

Discussion

The average survival rate results for tilapia ranged from 37.8-73.3%. It is known that the survival rate in the MP_3 with a microplastic dose of 20 mg/L got the lowest result, 37.8%, while in the MP_0 the highest result was 73.3%. This is because microplastics have the property of attracting chemical compounds in the environment, some of which are toxic. When a fish's body accidentally consumes microplastics, the microplastics will enter the digestive system and accumulated in the digestive organs. The mixture of chemicals as toxins in microplastics is in the digestive system, so that the digestive tract will absorb these substances directly throughout the body, causing a reduction in hormone levels and resulting in death. Meanwhile, the MP_0 treatment had good environmental conditions and was able to utilize comercial feed and there are no microplastics that inhibit the working process of enzymes in fish. This is in accordance with the opinion of Zientika *et al.* (2021) who say that if microplastics accumulate in large quantities, they can damage and disrupt the function of vital organs, such as the digestive tract, can reduce growth rates, inhibit enzyme production, reduce steroid hormone levels, and affect reproduction. Moreover, assuming that the synthetic mixture contained in microplastics has dangerous properties, it can cause damage to the fish's body. According to Wright *et al.* (2013), the direct impact of microplastics if they enter an organism's body can disrupt the working system of the digestive tract and even cause death.

Based on the results of research that has been carried out, the MP_3 with a microplastic dose of 20 mg/L had the lowest absolute weight growth results, 3.57 g, while the MP_0 (without microplastic administration) had the highest results, 10.94 g. This is because the tilapia in the MP_3 experienced contamination through the digestive tract, namely the intestines, because the microplastics were swallowed and entered the fish's body. Fish that directly mistake microplastics as food stick to fish food such as moss, so that they indirectly enter the fish's body because microplastics accumulate in fish food, so that the result of ingesting microplastics that do not provide nutritional intake for fish will cause false satiety which results in fish experience starvation and decrease in fish weight. Based on research by Yona *et al.* (2020), microplastics found in the digestive system occur because microplastics are swallowed and enter the fish's body. Microplastics directly enter the bodies of tilapia, possibly because they mistake the microplastics for food such as pellets or stick to fish food such as moss. Plastic particles that accumulate in large quantities in fish bodies can block the fish's digestive tract, disrupt digestive processes, or hinder the absorption process (Browne *et al.*, 2013; Wright *et al.*, 2013). Firmani (2021) also stated that toxic microplastics will pass through the hepatic portal vein and flow to the liver. If the capillaries exceed the permissible limits and if this happens without stopping, there is a risk of liver damage and decrease in the weight of the fish.

Based on the results of research that has been carried out, the MP_2 with a microplastic dose of 15 mg/L had the lowest absolute length growth results, 1.04 cm, while the MP_0 (without microplastic administration) had the highest results, 1.83 cm. This is because the tilapia in the MP_2 treatment experienced contamination through the digestive tract, namely the intestines, because the microplastics were swallowed and entered the fish's body. Fish that directly fed on microplastics as food indirectly enter the fish's body because microplastics accumulate in fish food, so that the result of ingesting microplastics that do not provide nutritional intake for fish will cause false satiety which results in fish experience starvation and a decrease in fish length growth. Assas *et al.* (2020) said the effect of eating microplastics is that it inhibits the digestive system, causes a false feeling of fullness in fish, makes fish hungry and slows down the growth rate of fish in length. Plastic particles that accumulate in large quantities in fish bodies can block the fish's digestive tract, disrupt digestive processes, or hinder the absorption process (Browne *et al.*, 2013; Wright *et al.*, 2013; Akbar *et al.*, 2023). Microplastics that cannot be hydrolyzed by digestive enzymes can be dangerous if they continue to accumulate for a long time in the fish's digestive tract. Retention of microplastics that are not hydrolyzed can clog the digestive tract, triggering a false feeling of fullness. The impact is reduced appetite in fish and even physical damage to the villi or epithelium of the digestive tract (Barboza *et al.*, 2019).

The average specific growth rate results for tilapia were ranging from an average of 2.14-4.40%/day. It is known that the specific growth rate in the MP_3 treatment with a microplastic dose of 20 mg/L obtained the lowest results, 2.14%/day. while the MP_0 (control) got the highest results of 4.40%/day. The good growth rate of tilapia in MP_0 is due to internal and external factors. Internal factors, for example, the food provided can be utilized properly so that it can help in the process of creating new tissue from protein deficiency. An external factor, for example, is good water quality. Meanwhile, MP_3 experienced a decrease in growth rate because the energy used for growth was used to restore body organs damaged by the impact of microplastics so that the fish used this energy to continue to restore their body organs to work normally. This is in accordance with research by Hidayat *et al.* (2013) who stated that fish growth is influenced by the protein content of the feed consumed, because protein has the ability to form new tissue for growth and replace tissue that lacks protein, so that the growth rate of tilapia decreases with increasing doses of microplastics. Wang *et al.* (2020) explained that the decrease in the specific growth rate was caused by energy that should have been used for development being diverted to repairing organs damaged by microplastics. This is also supported by Yin *et al.* (2018), where the reduction in body development is caused by fish consuming microplastics because the fish's energy must be diverted to maintain organ function so that it continues to work normally and keep the fish alive.

The average feed conversion ratio results for tilapia in the MP_3 with a microplastic dose of 20 mg/L got the highest result, precisely 2.01, and MP_0 got the lowest result, 1.61. A low feed conversion ratio value indicates that the feed eaten is used well by the fish for its development and a low feed coefficient value also indicates that the feed eaten is used better in the body. Meanwhile, the feed conversion ratio value is high because the feed eaten by the fish is not converted into meat, but is immediately thrown away during the metabolic process because it is caused by the negative impact of microplastics on the tilapia's body. This is in accordance with the statement by Browne *et al.* (2013) that microplastics that enter the body can have a bad impact on fish, the presence of microplastics in the fish's body can reduce the health of fish and has the potential to be toxic to fish, namely in the form of physical and chemical toxicity because microplastics can absorb addictive substances and other monomers that are toxic. Putra *et al.* (2020) stated that the high feed conversion ratio is caused by the fish being underutilized, so the nutrients in the feed are not maximally absorbed by the body and are only wasted through feces so that the growth rate obtained is relatively low.

Based on the results of microscope observations of each sample for each treatment, different numbers of microplastic particles were obtained. The results of the observations showed that a picture of polyvinyl chloride microplastic at 10x magnification showed a black color, a type of polyethylene polymer. In the MP_0 (without administration of microplastics) the average abundance of microplastic particles was 1 particle/individual, including polypropylene and polyethylene, the shapes can be seen in Table 1 (a) fiber (long black fiber), (b) pellet (red), (c) fiber (blue), while MP_1, MP_2, and MP_3 microplastics are obtained from polyvinyl chloride (PVC) as treatment. This microplastic is in the form of a film, for MP_1 the average is around 42 particles/individual, for MP_2 the average is around 48 particles/individual, for MP_3 the average is around 76.67 particles/individual. The MP_3 obtained the highest number of microplastic particles, this does not depend on the weight and length of the fish, because the abundance of microplastic particles in the intestines of tilapia can increase as the fish's body size increases, but there is also an abundance of microplastics in fish that are much smaller. This is in accordance with the statement of Boerger *et al.* (2010) that quantitatively, the average number of microplastics ingested by fish can increase with increasing fish size. However, according to research by Bessa *et al.* (2018), the highest average number of microplastics is found in fish species with much smaller in length and weight.

The results of water quality measurements for all parameters are generally still within the normal range and support the growth of tilapia. The temperature check results obtained during the research were still within the optimum range for tilapia cultivation, namely around 26°C to 28.1°C. This is in accordance with the research results of Mila and Mistina (2023) that tilapia grows optimally at temperatures of 26°C to 30°C. The pH value obtained during the research was still in the optimum range, namely around 6.6-7.8. If the pH value is too high, it can cause an increase in ammonia levels in the water, while a pH value that is too low can disrupt the reproduction and growth of tilapia. These results are in accordance with research by Safsafubun *et al.* (2023) that the appropriate pH for tilapia is around 6-8. The results of dissolved oxygen or DO measurements during the research were still within the optimum range for tilapia, namely around 4-6.2 ppm. Low DO values can disrupt the development of tilapia. Adi and Suryana (2023) stated that a good DO value for tilapia is 4-10 ppm. The ammonia levels obtained during the research ranged from 0.15-1.5 ppm. The increase in ammonia levels is caused by a lot of feces being excreted by the fish and settling in the rearing container. This can occur because the feed is not converted into meat by the fish but is directly thrown away as feces. This is in accordance with the statement of Widanarni *et al.* (2012) that the disposal of unused food and fish waste at the bottom of the water can oxidize the ammonia content. The results of ammonia measurements in this study are classified as safe because according to Djaelani *et al.* (2023) which states that the ammonia value that can be tolerated and is good for the survival of tilapia is <1.5

ppm. Nitrate measurement results range from 0-25 ppm. The increase in nitrate was caused by the high value of ammonia nitrified by organisms, as stated by Fadillah *et al*. (2022) that nitrifying microscopic organisms can oxidize ammonia to nitrite and nitrate. The nitrates in this study were classified as safe and in accordance with those shown by Maldino *et al*. (2023) that the ideal nitrate level for tilapia is <50 ppm. Nitrite measurement results range from 0.25-1 ppm. The high nitrite value is caused by feces that produces ammonia and the absence of organisms that can oxidize nitrite to nitrate, as stated by Dhiba *et al*. (2019) that nitrite concentrations are affected by microorganisms that do not use nitrite to convert it to nitrate. According to Hadiroseyani *et al*. (2023) that the ideal nitrite level for tilapia is <1 ppm.

Conclusion

Exposure to polyvinyl chloride microplastics on the survival rate and growth performance of tilapia through water made a real difference to Survival Rate (SR), absolute weight growth, absolute length growth, Specific Growth Rate (SGR), Feed Convension Ratio (FCR) and the abundance of polyvinyl chloride microplastics in fish gut.

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