PAKISTAN JOURNAL OF ZOOLOGICAL SCIENCES

IJSMART PUBLISHING COMPANY

RESEARCH ARTICLE

# Effects of Polyvinyl Chloride Microplastics on the Growth Rate, Liver Enzyme, and Serum Metabolites of *Cirrhinus mrigala*

**Anam Saeed[1,2,#], Maryam Riasat[2], Ayesha Zahid[2,#], Faiza Maqsood[2], Tahira Ghafoor[2], Muneeb Ul Rehman[2], Rida younas[2], Naureen Rana[1]**

[1] College of Biological Resource and Food Engineering, Qujing Normal University, Qujing 655011, China.

[2] Department of Zoology, Faculty of Engineering and Applied Sciences, Riphah International University, Faisalabad Campus, Faisalabad, 38000, Pakistan.

*Correspondence: chhuanhuan@163.com

**Article Info**

**Academic Editor: Muhammad Naeem**

Received: 20, October, 2025
Accepted: 25, November, 2025
Published: 24 December, 2025

**Citation:** Saeed, A., Riasat, M., Zahid, A., Maqsood, F., Ghafoor, T., Rehman, M. U., Younas, R., Rana, N., & Naeem, M. (2025). Effects of polyvinyl chloride microplastics on the growth rate, liver enzyme, and serum metabolites of Cirrhinus mrigala. *PAKISTAN JOURNAL OF ZOOLOGICAL SCIENCES, 1*(3), 1–8.



**Abstract** Polyvinyl chloride microplastics have become one of the most harmful aquatic pollutants, and their potential toxicity to fish has become one of the major issues. The target of our research was to determine the effects of polyvinyl chloride microplastics on the *Cirrhinus mrigala* growth pattern and serum metabolites like glucose, protein, and lipid profiles. To assess the effect of polyvinyl chloride on *Cirrhinus mrigala*, we use four containers marked as T0, T1, T2, and T3. An equal number of fingerlings was placed in each container. T0 used as control, in which we used no microplastics. While 50, 100, and 150 mg/L of microplastics were used in T1, T2, and T3, respectively. The research was performed under the complete randomized design (CRD). After 4 weeks of growth, the result was measured, and the result was analyzed by one-way ANOVA. After a specific time, the growth was compared. The fingerlings in T3 had a smaller length than those in other containers due to a high amount of PVC microplastics. The noticeable changes in the liver include loss of cell shape, damaged liver cells, and deposition of fat in parenchyma cells. The serum metabolites parameter was measured by LFT. Serum metabolite parameters such as ALT, AST, ALP, protein, bilirubin, and GGT were significantly elevated as PVC quantity increased. The results of this study revealed that a higher concentration of PVC microplastics could have negative impacts on the growth and liver of fish, which may ultimately endanger the food web.

**Keywords**: Global concern, histopathology, microplastics, plastic usage, serum metabolites, aquatic toxicity.

## Introduction

A plastic particle less than 5mm is a microplastic, became most widespread environmental pollutant and aquatic pollutant. The plastics are divided into different classes depending on their size: mega plastics (50 cm), macro plastics (larger than 5 mm), and microplastics (less than 5 mm). In the diversity of microplastics, polyvinyl chloride (PVC) became more noticeable due to its differe use in industrial and consumer products, coupled with its persistence and potential toxicity in aquatic environments. When plastic pollution interacts with ultraviolet light, plastics break into small fragments [4]. Microplastics take years to decompose and are found everywhere easily, especially in aquatic ecosystems, making it easy to be ingested by fish**.** The most important source of microplastics is humans. Every day, humans dump microplastics in nature in different forms, like shopping bags, shampoo, or toothpaste [11].

According to past reports, most of the plastic items were not properly discarded. In medical emergencies, everyone uses gloves and a mask, but does not discard them properly [19]. The most important part of an aquatic ecosystem is fish, which are most sensitive to microplastics [2]. *Cirrhinus mrigala,* commonly known as mrigal carp, is commercially important in South Asia and plays a critical role in the local economy. Any effect on *Cirrhinus mrigala* can directly affect the food web and economy [11]. As a bottom-dwelling omnivore*, C. Mrigala* is particularly susceptible to ingesting microplastics that settle in sediments or are suspended in the water column. Aquaculture produces a significant percentage of the fish production annually. Aquatic ecosystems and terrestrial ecosystems are connected; consequently, modification in one system affects the other. PVC microplastics are often mistaken for food particles by fish. These microplastics facilitate the toxic chemical absorb which are eaten by fish during prey [16].

Many studies show that ingestion of microplastics can lead to impaired fish growth, change metabolism, and weaken the immune system and liver function, which shows the need for toxicology assessments [5][13]. Sometimes, PVC releases some chemicals like BPA, which disrupt the functions of endocrine compounds, sometimes known as endocrine disrupting compound (EDC). Endocrine compounds control the hormonal regulation. Due to disruption of endocrine compounds, the normal function of hormones is disrupted, which causes a reduction in fertility and alters the sex hormone levels [12]. Microplastics show significant variation in growth, intestine, liver, reproduction, immunity, and metabolism [7]. The most affected part of the fish is the liver [20]. The other factors to assess the effect of microplastics are serum metabolites, which include glucose, protein, and lipid profile [1].

Interaction with microplastics causes a severe lung inflammation, causing a change in cell shape and ultimately stops the detoxification [8]. There is very little knowledge about the effect of polyvinyl chloride microplastics on freshwater fishes, especially *Cirrhinus mrigala*. The PVC microplastics are a great threat to the aquatic ecosystem because they can cause severe growth problems, liver damage, and disturb the metabolic process. We can fill this gap by knowing the effects of PVC microplastics on freshwater fishes, especially *Cirrhinus mrigala.* We did this study to evaluate the effects of PVC microplastics on the growth performance of *Cirrhinus mrigala*, to assess the histopathological changes in the liver tissues of *C. Mrigala* exposed to PVC microplastics, and to analyze the impact of PVC microplastics on serum metabolite profiles in *C. Mrigala.*

# Materials and Methods

Fingerlings (5-7 cm) of *Cirrhinus mrigala* were collected from the Faisalabad fish hatchery. To acclimatize in a laboratory setting, fish were placed in glass aquariums and raised for four weeks with continual aeration. Four groups of similar glass aquariums, each with ten fish, were distributed. One air stone aerator is used in every aquarium [6]. Every tank has an air stone for oxygen. Air stone powered by electricity. Clean water is used in an aquarium. Fish were fed by commercially prepared feed every day. Every day, uneaten food and dead fish are removed from the water [3].

## Sample Preparation

Fishes are treated with polyvinyl chloride with different concentrations in different aquariums. PVC was bought from the chemical market in Faisalabad. Four different aquariums are marked as To, T1, T2, and T3. Each aquarium was treated with a different concentration. In T0, only food is given, in T1, 50 mg/L is used, in T2, 100 mg/L, and in T3 125mg/L PVC is used. PVC is measured on the scale and mixed with the respective aquarium water to make a soluble solution.

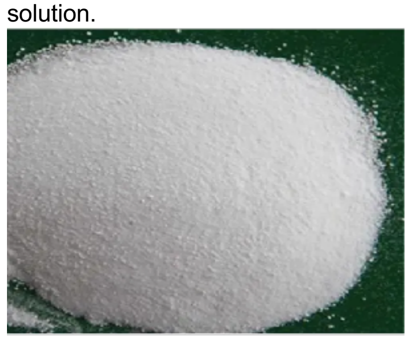

**Figure 1.** Polyvinyl chloride powder

## Growth Performance

Various growth measurements, including absolute weight gain (ABG), absolute length growth (ALG), condition factor, weight gain (WG), specific growth rate (SGR), and survival rate, can be used to evaluate fish growth performance. CF was calculated by dividing *Cirrhinus mrigala*'s total length by its body weight. Length was measured with a measuring tape, and body weight was determined using an electronic balance.

$$CF=\frac{Total\ length(\ L)}{Body\ weight(w)}$$

Weight gain measured by the electron balance. For the initial weight, we measured the weight of five fish from each aquarium before giving any chemicals. For the final weight, we measured the weight of the same five fish (that were taken for initial weight) after completing the trial period.

Wight gain% $=\frac{Final\ weight - Initial\ weight}{Initial\ weight} X100$

For absolute weight gain, we measured how much weight gain the fishes. For the initial weight, we measured the weight before giving any chemicals. For the final weight, we measured the weight after completing the trial period.

Absolute weight gain = Final weight – Initial weight

For absolute length gain, we measured how much length gain by fishes. For initial length, we measured the length of five fish from the same aquarium with a measuring tape. For the final length, we measured the same fish after completing the trial period.

Absolute length gain = Final length – Initial length

To examine the particular growth rate, the initial and end weights were assessed during 7 days, and statistical data were collected to see whether there was a difference in growth rate between the control and trial groups of fish.

Wight gain %$=\frac{In(Final\ weight - Initial\ weight)}{Experimental\ duration\ in\ days} X10$

For survival rate, we check the number of fish before giving any chemical. After completing the trial period, record the number of fish. If any fish died in this period, record it in your record book. The formula to calculate the survival rate is:

Survival rate$=\frac{Final\ number\ of\ fishes}{Initial\ number\ of\ fishes} X100$

## Liver Function Analysis

At the end of the trial period, fish were taken from each aquarium, a sample was taken by using a syringe up to 1 ml of blood, and transferred to a heparin tube (EDTA). The parameters are measured by the spectrophotometer. Heparin acts as an anticoagulant agent. Liver analysis by liver function test, such as ALT, ASP, AST, bilirubin, protein, and GGT. Liver function test like ALT, ASP, AST, bilirubin, protein, and GGT, were performed on the Microlab 300 with the QEC diagnostic kit.

## Statistical Analysis

The researchers used One-Way Analysis of Variance, also known as ANOVA, as the primary method of assessing the results after the end of the 4-week trial period. ANOVA was used to determine if the changes in growth and liver health were "statistically significant," or if the changes were too large to be explained by chance. The F-value is the ratio of the variance between the different treatment groups and the variance within the different treatment groups. For example, the very high F-value of Triglycerides, which was 1423, showed a large variation in lipid levels directly proportional to the PVC dosage. The sum of Squares (Sum sq) was calculated for each parameter, e.g., Avg. weight was 19.1, to determine the total variation of the data points from the mean.

The p-value is essential in validating the hypothesis. For instance, in most cases, if the p-value is below 0.05, the results are said to be significant. In this study, the parameters, such as Weight, SGR, ALT, and AST, had a p-value of 0, indicating that the results are extremely significant. If the p-value is 0, as in the case of the parameters Glucose and Protein in the table, it means that the probability of the PVC treatment not affecting the parameter is zero. For the parameter Uric Acid, the p-value is 0.65, which is way beyond 0.05. This shows that the PVC treatment had an effect on the parameter, although it was not significant.

# Results

The experiment analyzes the physical changes in the liver, liver growth, and serum metabolites. The key parameters that are analyzed: physical changes, including weight and length, liver assessment, which includes enzymes and serum metabolites, which include glucose, total protein, and other relevant biochemical markers. These biomarkers were selected based on their established sensitivity to xenobiotic exposure and their role in reflecting liver functional status. All these markers assess the stress, any changes in liver or serum metabolites. The result was assessed based on the following parameters:

- pH, temperature, and dissolved oxygen were measured every week
- For growth rate, weight gain, specific growth rate, total length gain, CF, and survival rate were measured.
- The liver parameters, i.e., ALT, AST, ALP, bilirubin, and GGT.
- The serum metabolites include total protein, globulin, albumin, cholesterol, triglyceride, and uric acid.

The serum metabolites include total protein, globulin, albumin, cholesterol, triglyceride, and uric acid. The growth was measured in relation to weight, length, SGR, condition factor, and survival rate. The weight was measured with the help of an electric weighing machine. Every week, the weight of each treatment fish was measured, and at the end of the week, the average of each week was calculated. The length was measured with inching tape. Every week, the length of each treatment fish was measured, and at the end of the week, the average of each week was calculated.

SGR, or sustainable growth rate, was measured by subtracting the final weight from the initial weight. It gave us the weight which fishes sustained during this period. The condition factor reflects the nutritional status and well-being of fish based on the fish's length and weight. A higher CF value reflects the fatter fish, and a lower CF value reflects the skinny fish. The survival rate is measured by calculating the deaths of fish in each treatment.

The Specific Growth Rate (SGR) was calculated to determine the relative growth efficiency of the fish during the experimental period. Survival rate was determined by monitoring daily mortalities and recording the number of live fish at the end of the experiment. Provides a percentage increase in weight per day. The condition factor (K) is an indicator of the overall health and well-being of the fish. It helps assess the robustness and nutritional status of the fish under different treatments. Survival rate was determined by monitoring daily mortalities and recording the number of live fish at the end of the experiment. This parameter indicates the suitability of the rearing environment and the stress level imposed by the treatments. The T0 treatment group exhibited higher average weight and weight gain values than the T3 treatment group. When T1 is subjected to a 50 mg/L concentration of PVC microplastics, it experiences the least amount of weight gain compared to T0. T2 was treated to a 100 mg/L dose of PVC microplastics and experienced the least amount of weight gain as compared to T0. When T3 was subjected to a higher concentration of PVC microplastics (150 mg/L), it experienced the least amount of weight gain compared to the other experimental groups.

The T0 treatment group exhibited a higher average length, which is 7.4cm. When T1 is subjected to a concentration of 50 mg/L PVC microplastics, it experiences the least amount of length compared to T0, which is 7.1cm. T2 was subjected to a concentration of 100 mg/L PVC microplastics and gained the least amount of length, as compared to T0, which was recorded at 7.025cm. When T3 was subjected to a higher concentration of PVC microplastics (150 mg/L), it gained the least length compared to the other experimental groups, which was 6.8cm. As we discuss the length gain, the least length gain was recorded in T3, which was just 0.9cm, while the control group, or T0, gained the maximum length, which was 1.45 cm. It shows the pattern, as we increase the concentration of the microplastics, the length decreases. It may be due to oxidative stress, which causes less ingestion of food and changes in the hormones.

The T0 treatment group exhibited higher condition factor values than the T3 treatment group. When T1 is subjected to a concentration of 50 mg/L PVC microplastics, it experiences the lowest value of condition factor compared to T0. T2 was subjected to a concentration of 100 mg/L PVC microplastics and gained the lowest value of condition factor as compared to T0. When T3 was subjected to a higher concentration of PVC microplastics (150 mg/L), it showed the lowest value of condition factor compared to the other experimental groups. The T0 treatment group exhibited the highest SGR values compared to the T3 treatment group. When T1 is subjected to a concentration of 50 mg/L PVC microplastics, it experiences the lowest value of SGR compared to T0. T2 was subjected to a concentration of 100 mg/L PVC microplastics and gained the least value SGR as compared to T0. When T3 was subjected to a higher concentration of PVC microplastics (150 mg/L), it showed the least value of SGR compared to the other experimental groups.

The periodic increase in AST value in *Cirrhinus mrigala*. The control groups, T1 and T2, showed the normal AST values. However, the T3 showed abnormal AST values. The average value shown in T0 is 27.16 U/L, while the AST in T1 and T2 was 34.76 U/L and 45.46 U/L. T3 showed the highest value of AST, which was 54.16 U/L. As the AST may be found in other organs, its increase may not significantly assess the health of the liver. The ALP in the control group was under control. As we increased the concentration of PVC, ALP values increased but remained under normal values. The maximum value was seen in T3, which had a mean of 36.8 mg/dL, while the minimum value was seen in the control group, which had a mean of 16.1 mg/dL.

As the concentration of PVC increases, the value of bilirubin increases gradually. The control group bilirubin and T1 were normal. But as we approach T2, its value is slightly increased from the normal value. In T3, the bilirubin values were higher than in the other treatments. The highest value was seen in T3, which was exposed to 150 mg/L of PVC microplastics. The lowest value was seen in the control group. The least values of total protein of *Cirrhinus mrigala* in treatment T0, in contrast to T1, which was subjected to a dose of 50 mg/L of PVC microplastics, exhibit a higher value of total protein when compared to T0. The T2 with a dose of 100 mg/l of PVC microplastics demonstrates a higher total protein value than both treatments, T0 and T1. Furthermore, the concentration of the 150 mg/L PVC microplastics exhibits the highest value among the entire experimental group.

The least values of albumin of *Cirrhinus mrigala* in treatment T0, in contrast to T1, which was subjected to a dose of 50 mg/L of PVC microplastics, exhibit a higher value of albumin when compared to T0. The T2 with a dose of 100 mg/L of PVC microplastics demonstrates a higher albumin value than both treatments, T0 and T1. Furthermore, the concentration of the 150 mg/L PVC microplastics exhibits the highest value among the entire experimental group. The control group, T1, and T2 showed the normal AST values. However, the T3 showed abnormal ALT values. As the ALT is found primarily in the liver, its increase has a direct effect on the liver, which can damage the liver. The least values of globulin of *Cirrhinus mrigala* in treatment T0, in contrast to T1, which was subjected to a dose of 50 mg/L of PVC microplastics, exhibit a higher value of globulin when compared to T0. The T2 with a dose of 100 mg/L of PVC microplastics demonstrates a higher globulin value than both treatments T0 and T1. Furthermore, the concentration of the 150 mg/L PVC microplastics exhibits the highest value among the entire experimental group. The least values of triglyceride of *Cirrhinus mrigala* in treatment T1, in contrast to T2, which was subjected to a dose of 100 mg/L of PVC microplastics, exhibit a higher value of triglyceride when compared to T0 and T1. The T3 with a dose of 150 mg/L of PVC microplastics demonstrates the highest triglyceride value among treatments.

The maximum value of triglycerides was recorded in T3, which was 470 mg/dL, while the minimum triglyceride seen in T1, which was subjected to 100 mg/L of PVC microplastics, was 125 mg/dL. The T3 with a dose of 150 mg/L of PVC microplastics demonstrates the highest glucose value compared to treatments T0, T1, and T2. The least values of glucose of *Cirrhinus mrigala* in treatment T0, in contrast to T1, which was subjected to a dose of 50 mg/L of PVC microplastics, exhibit a higher value of glucose when compared to T0. The T2 with a dose of 100 mg/L of PVC microplastics demonstrates a higher glucose value than both treatments T0 and T1. Furthermore, the concentration of the 150 mg/L PVC microplastics exhibits the highest value among the entire experimental group. The maximum glucose value recorded into, which was 215 mg/dL, while the least value of glucose recorded in T0 was 121 mg/dL.

The least values of uric acid of *Cirrhinus mrigala* in treatment T2 and T3, in contrast T1, which was subjected to a dose of 50 mg/L of PVC microplastics, exhibits the highest value of uric acid when compared to T0. The T2 with a dose of 100 mg/L of PVC microplastics demonstrates a lower uric acid value than both treatments T0 and T1. Furthermore, the concentration of 150 mg/L PVC microplastics exhibits the lowest value among the entire experimental group. The least values of cholesterol of *Cirrhinus mrigala* in treatment T1, in contrast to T2, which was subjected to a dose of 100 mg/L of PVC microplastics, exhibit a higher value of cholesterol when compared to T0 and T1.

**Table 1:** *Mean comparison values of the effect of different concentrations of polyvinyl chloride microplastics on the average weight, weight gain, CF, SGR, ALT, AST, ALP, bilirubin, total protein, albumin, triglyceride, glucose, cholesterol, and uric acid of Cirrhinus mrigala*

| | **Treatment** | | | |
|---|---|---|---|---|
| **Parameter** | **T1** | **T2** | **T3** | **T4** |
| **Mean (weight)** | 7.25 | 6.6 | 6.35 | 5.225 |
| **Mean (length)** | 7.4 | 7.1 | 7.025 | 6.8 |
| **Mean (CF)** | 1.79 | 1.63 | 1.525 | 1.452 |
| **Mean (SGR)** | 1.9 | 1.28 | 1.17 | 0.81 |
| **Mean (ALT)** | 27.76 | 27.53 | 36.1 | 53.83 |
| **Mean (AST)** | 27.16 | 34.76 | 45.46 | 54.16 |
| **Mean (ALP)** | 16.1 | 17.76 | 27.83 | 36 |
| **Mean (bilirubin)** | 0.3 | 0.4 | 1.27 | 1.39 |
| **Mean (protein)** | 3.9 | 5.1 | 8.4 | 9.3 |
| **Mean (albumin)** | 1.4 | 1.9 | 3.6 | 4.1 |
| **Mean (globulin)** | 2.5 | 3.2 | 4.8 | 5.5 |
| **Mean (triglyceride)** | 182 | 125 | 350 | 470 |
| **Mean (glucose)** | 121 | 129 | 185 | 215 |
| **Mean (cholestrol)** | 180 | 173 | 303 | 389 |
| **Mean (uric acid)** | 7.7 | 7.8 | .7.6 | 7.6 |

The survival rate of all groups T0 to T3 remains consistent when subjecting to varying concentrations of PVC microplastics for four weeks. T3, subjected to a higher level of microplastics at 150 mg/L, did not affect the survival probability of *Cirrhinus mrigala*. The most interesting thing in this study is that no fish died due to ingestion of PVC microplastics, but it affects their lifestyle and other factors. To evaluate the effectiveness of the treatment methods, we utilize the analysis of variance ANOVA technique. The p-value reflects the importance of treatment in the analysis of the variable table.

**Table 2:** *Analysis of Variance of different doses of polyvinyl chloride* ***microplastics*** *on the average weight, CF, SGR, ALT, AST, ALP, bilirubin, protein, albumin, globulin, triglyceride, cholesterol, glucose, and uric acid of Cirrhinus mrigala*

| | **Treatment** | | | | **Residual** | |
|---|---|---|---|---|---|---|
| | Sum sq | df | F | PR | Sum sq | df |
| Avg. weight | 19.1 | 3 | 66.5 | 0 | 3.0 | 32 |
| CF | 0.939 | 3 | 22.9 | 0 | 0.23 | 32 |
| SGR | 8.29 | 3 | 437.1 | 0 | 0.20 | 32 |
| ALT | 1683 | 3 | 44.08 | 0 | 101 | 8 |
| AST | 839 | 3 | 31.6 | 0 | 70.6 | 8 |
| ALP | 1266 | 3 | 14.2 | 0.001 | 237 | 8 |
| bilirubin | 1856 | 3 | 16.73 | 0.001 | 295 | 8 |
| protein | 55.9 | 3 | 125 | 0 | 1.18 | 8 |
| albumin | 15.51 | 3 | 142 | 0 | 0.291 | 8 |
| golbulin | 14.97 | 3 | 332 | 0 | 0.12 | 8 |
| triglyceride | 222134 | 3 | 416 | 0 | 1423 | 8 |
| cholestrol | 91798 | 3 | 586 | 0 | 417 | 8 |
| glucose | 16613 | 3 | 49 | 0 | 892 | 8 |
| Uric acid | 0.26 | 3 | 0.571 | 0.65 | 1.24 | 8 |

# Discussion

Due to their durability and ability to resist decay, microplastics are a significant pollutant and have become a global problem. As larger pieces of plastic degrade into smaller particles, they will continue to be an issue for aquatic ecosystems. Microplastic particles can be found in various sizes and shapes, as well as different chemical compositions. For example, polyvinyl chloride (PVC) microplastics can be found in a broad range of consumer and industrial goods (pharmaceuticals and personal care products), so there is a high chance of exposure through the manufacturing process. When ingested by fish, microplastics can build up in their intestinal tracts, causing blockage, limited ability to absorb nutrients, altered metabolism, and immune function [17].

The effects of PVC Microplastics on Cirrhinus mrigala growth and liver functioning were evaluated in this study by placing fish into 4 different concentration levels of PVC microplastic (50 mg/L, 100 mg/L, and 150 mg/L) in 4 separate glass aquaria under controlled laboratory conditions. A control aquarium was also included. The water temperature, pH, and dissolved oxygen levels were recorded throughout the course of the experiment [18]. The results were recorded linearly, demonstrating that as dosages increased, the animals had less growth performance. The highest average weight was found with no tetrahydrofuran in the control group (i.e., 7.25 g), while the lowest average weight was found with 75% tetrahydrofuran in T3 (i.e., 5.25 g). The average weights for T1 and T2 were between 6.6 g and 6.35 g, respectively, showing moderate decreases. In addition, the specific growth rates were highest for T0 (1.8) and lowest for T3 (0.81), indicating that higher concentrations of PVC significantly hindered growth. Decreasing the rate of growth from PVC ingestion may be due to food being diverted into the stomach due to the presence of indigestible particles, leading to starvation, oxidative damage from the degraded contaminants, or metabolic disruption of the animal's normal processes due to the presence of the contaminant, including altering the animal's normal lipid profile [15].

Analysis of liver enzymes indicated that the fish were under a significant amount of stress due to exposure. T3 had an increase in ALT, AST, and ALP levels as compared to the control, which demonstrates damage to hepatocytes and changes to the permeability of their membranes. The increases in bilirubin and GGT levels indicate possible biliary dysfunction and potential destruction of red blood cells as well. Other studies on hepatic toxicity induced by microplastic exposure revealed that polyethylene microplastics resulted in similar levels of hepatic toxicity [17], and PVC nanoplastics caused hepatic toxicity under thermal stress. In Cirrhinus mrigala, it was confirmed through experimentation that increased contamination by PVC microplastics caused systemic biochemical changes (increased levels of total protein, albumin, globulin, triglycerides, glucose, and uric acid) due to stress and metabolic imbalance [10]. Growth and liver functionality were also found to be affected by increased concentrations of PVC microplastics.

# Conclusion

Research results indicate that as levels of PVC microplastics increase, so too do harmful impacts to fish, particularly the species studied (Cirrhinus mrigala). In this study, as microplastic concentration increased from 50 to 150 mg/l, there were progressive reductions in growth performance, which was evidenced by reductions in weight (between 62% and 70%) and length (between 6.6% and 12%) relative to controls. On the other hand, concentrations of the laboratory values (ALP, AST, ALT, GGT, and total protein) also increased, but these increases were much greater than those seen in control fish, and so the results are strongly suggestive of the negative impact of microplastics on fish health. The results of this investigation provide a strong basis for establishing the necessity of understanding and addressing microplastic pollution in aquatic habitats to protect fishery resources and develop sustainable aquaculture.

While there were some valuable contributions made by this research, it had some limitations. The duration of exposure was limited to only 28 days. Thus, it only provides us with information on the short-term, but does not cover chronic or long-term exposures. The study was also conducted under controlled laboratory conditions using four aquaria (control, 50 mg/L, 100 mg/L, 150 mg/L) and therefore may not accurately represent the complexity of natural aquatic ecosystems. A wider range of concentrations could be used to better define toxicity thresholds and dose-response relationships. In addition, the research only used the fingerlings of Cirrhinus mrigala, and therefore, this will limit the generalisability of the findings to other life stages or species, because of the expected interspecies variability in microplastics.

Future research will require lengthy exposure trials to determine the effects of microplastic pollution on the health of fish, including their growth rate, liver condition, and death rate. Additionally, future research will require assessing many different non-lethal effects on these fish (including their behaviour, reproduction, immune system suppression, and oxidative stress) after being exposed to microplastics for a long period of time. Future studies will also need to expand their scope in order to create findings that are ecologically relevant by examining a larger number of different species and conducting studies under real-world conditions. It will also be important for future research to evaluate various ways to reduce microplastic pollution and preserve biodiversity in aquatic environments, such as through improved waste management, reduced use of disposable plastics, increased efficiency of water treatment processes, and the enactment of new regulations for reducing microplastic pollution.

# Author Contributions

Anam Saeed played a key role in developing the research concept, designing the experimental setup, and establishing PVC microplastic exposure concentrations. She conducted in vivo experiments on Cirrhinus mrigala, managed aquarium conditions, feeding strategies, and sampling timelines. Additionally, she drafted the initial version of the manuscript. Maryam Riasat and Ayesha Zahid were involved in biochemical assays such as ALT, AST, ALP, bilirubin, and serum metabolite studies utilizing spectrophotometric techniques. Faiza Maqsood and Tahira Ghafoor supported the handling of the fish, executing morphometric studies, assessing growth performance, and maintaining experimental records. Muneeb Ul Rehman and Rida Younas worked together in collecting blood samples, processing those samples, and ensuring quality control in laboratory processes. Naureen Rana contributed to the statistical analysis, interpretation of findings, and preparation of tables

# Conflicts of Interest

The author(s) declare(s) that there is no conflict of interest regarding the publication of this paper.

# Acknowledgment

This work was supported by Riphah International University, Faisalabad Campus.

## Data Availability

Data will be made available on request

# References

[1] Yan, J., & Li, F. (2023). Effects of sediment dredging on freshwater systems: A comprehensive review. ***ENVIRONMENTAL SCIENCE AND POLLUTION RESEARCH, 30***, 119612–119626. https://doi.org/10.1007/s11356-023-30244-1

[2] Menezes, M., Teixeira de Mello, F., Ziegler, L., Wanderley, B., Gutiérrez, J. M., & Deo Dias, J. (2024). Revealing the hidden threats: Genotoxic effects of microplastics on freshwater fish. ***AQUATIC TOXICOLOGY, 276***, 107089. https://doi.org/10.1016/j.aquatox.2024.107089

[3] Manam, V. K. (2023). Fish feed nutrition and its management in aquaculture. ***INTERNATIONAL JOURNAL OF FISHERIES AND AQUATIC STUDIES, 11***(2), 58–61. https://doi.org/10.22271/fish.2023.v11.i2a.2791

[4] Andrady, A. L., (2011). Microplastics in the marine environment.*Marine Pollution Bulletin, 62* (8), 1596–1605. https://doi.org/10.1016/j.marpolbul.2011.05.030

[5] Barboza, L. G. A., Vieira, L. R., Branco, V., Figueiredo, N., Carvalho, F., Carvalho, C., & Guilhermino, L., (2020). Microplastics cause neurotoxicity, oxidative damage and energy-related changes and interact with the bioaccumulation of mercury in the European seabass, Dicentrarchus labrax (Linnaeus, 1758). *Aquatic Toxicology*, *219(7)*, 105377. https://doi.org/10.1016/j.aquatox.2017.12.008.

[6] Boyd, C. E., D'Abramo, L. R., Glencross, B. D., Huyben, D. C., Juarez, L. M., Lockwood, G. S., McNevin, A. A., Tacon, A. G. J., Teletchea, F., Tomasso, J. R., Tucker, C. S., & Valenti, W. C., (2018). Achieving sustainable aquaculture: Historical and current perspectives and future needs and challenges. *Journal of the World Aquaculture Society*, *51*(3), 578–633. https://doi.org/10.1111/jwas.12714.

[7] Chamas, A., Moon, H., Zheng, J., Qiu, Y., Tabassum, T., Jang, J. H., & Suh, S., (2020). Degradation rates of plastics in the environment.*ACS Sustainable Chemistry & Engineering*, *8* (9), 3494–3511. https://doi.org/10.1021/acssuschemeng.9b06635.

[8] Chen, Q., Gundlach, M., Yang, S., Jiang, J., Velki, M., Yin, D., & Hollert, H., (2022). Quantitative investigation of the mechanisms of microplastics and nanoplastics toward zebrafish larvae locomotor activity. *Science of the Total Environment*, *806* (2), 150611. https://doi.org/10.1016/j.scitotenv.2017.01.156.

[9] Choi, J. S., Jung, Y, J., Hong, N., Hong, S, H., & Park, J. W. (2018). Toxocological effects of irregularly shaped and spherical microplastics in a marine teleost, the medake. *Marine pollution bulltin, 129*(1), 231-240. https://doi.org/10.1016/j.marpolbul.2018.02.039.

[10] D'Avignon, G., Gregory-Eaves, I., & Ricciardi, A. (2023). Combined effects of microplastics and warming reduce growth

and predatory performance in an invasive fish.Science of the Total Environment, 858(1), 159742. https://doi.org/10.1002/lno.12417.

[11] El Bilali, H., Strassner, C., & Ben Hassen, T. (2021). Sustainable agri-food systems: Environment, economy, society, and policy. *SUSTAINABILITY, 13*(11), 6260. https://doi.org/10.3390/su13116260.

[12] Gado, A. R., Soliman, M. M., El-Maddawy, Z. K., Soliman, N. K., El-Mahdy, M. M., & Aboubakr, M. (2023). Ingestion of Polyvinylchloride Powder Particles Induces Oxidative Stress and Hepatic Histopathological Changes in Oreochromis niloticus (Nile Tilapia). A Preliminary Study. Sustainability, 15(8), 6494. https://doi.org/10.3390/su15086494.

[13] Jiang, J., (2018). Occurrence of microplastics and its pollution in the environment: *A review.Sustainable Production and Consumption*, *13(5)*, 16–23. https://doi.org/10.1016/j.spc.2017.11.003

[14] Jovancic, B. (2017). Ingestion of microplastic by fish and its potential consequences from a physical persepectve. *Intergrated environmental assessment and management. 13(*3*)*, 510-515. https://doi.org/10.1002/ieam.1913.

[15] Kalina, M., & Tilly, E. (2020). We are already sick: Infexxtion waste Management and inequality in the time of Covid-19, a Reflection from Blantyre, Malawai. *Human organization, 79*(3), 187-196. https://doi.org/10.5334/wwwj.54

[16] Pitt, J. A., Kozal, J. S., Jayasundara, N., Massarsky, A., Trevisan, R., Geitner, N., & Di Giulio, R. T., (2018). Uptake, tissue distribution, and toxicity of polystyrene nanoparticles in developing zebrafish *(Danio rerio*) . *Aquatic Toxicology*, *194(1)*, 185–194. https://doi.org/10.1016/j.aquatox.2017.11.017.

[17] Sayed, A. E. D. H., Soliman, H. A., & Hamed, M. (2022). Polyethylene microplastics increases the tissue damage caused by 4-nonylphenol in the common carp (Cyprinus carpio) juvenile. *Frontiers in Marine Science, 9*(34), 1041003. https://doi.org/10.3389/fmars.2022.1041003

[18] Siddiqui, S., & Al-Khedhairy, A. A. (2024). Behavioral and molecular effects of micro and nanoplastics across three plastic types in fish: Weathered microfibers induce a similar response to nanosized particles. *Frontiers in Toxicology, 2(1)*, 1490223. https://doi.org/10.3389/ftox.2024.1490223.

[19] Wang, J., Li, Y., Lu, L., Zheng, M., Zhang, X., Tian, H., & Yan, C., (2022). Polystyrene microplastics cause tissue damages, sex-specific reproductive disruption and transgenerational effects in marine medaka (Oryzias melastigma).*Environmental Pollution, 292* (1), 118304. https://doi.org/10.1016/j.envpol.2019.113024.

[20] Zhang, K., Shi, H., Peng, J., Wang, Y., Xiong, X., Wu, C., & Lam, P. K. S., (2021). Microplastic pollution in China's inland water systems: A review of findings, methods, characteristics, effects, and management.*Science of the Total Environment*, *630(1)*, 1641-1653.

https://doi.org/10.1016/j.scitotenv.2018.02.300

## Disclaimer / Publisher's Note