



The Effects of Different Water Treatments on the Growth, and Health of Ornamental Fishes Raised under the Water Conditions

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Authors' contributions

This work was carried out in collaboration between both authors. Author NM formal analysis, data curation, writing an original draft, conceptualization, methodology. Author RS formal analysis, data curation, project administration, supervision, review, and editing. Both authors read and approved the final manuscript.

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ABSTRACT

In freshwater fish culture, water quality poses a serious hazard to survival and growth. To understand this high-risk factor associated with the poor water quality in the aquarium system, the hematological, histological, immunological, antioxidant, and growth performance of *C. auratus*, *C. carpio*, and *P. hypophthalmus* in the aquarium with different water treatment efficiencies and one without water filtration were compared. The experiment was conducted for approximately 120 days using water treatments: 1. PF, 2. BF, 3. PBF, 4. PBUVF, 5. WoF. Results showed that Fish health concerning turbidity (98%) was significantly reduced during post-filtration (PF, BF, PBF, and PB-UV-

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F) ($p < 0.05$). In experimental tanks, water-treated fish showed improved growth and a 90% survival rate ($p < 0.05$). In pot and bamboo filters, the hematological parameters such as RBC (93%, 94%, and 93%), WBC (79%, 18%, and 91%), and MCHC (93%, 45%, and 90%) were in the optimum levels during post filtration experiment. The immune response (IgM, C3, C4, NOS, and LSZ) of enzyme activities in the gut and liver of aquarium fishes and antioxidant parameters in the gut and liver (ABTS, CAT, GR, SOD, and LPO) were also the low-risk level where the water treatments in the aquarium tanks. In conclusion, our findings show that installing filtration systems in freshwater fish culture has helped to successfully regulate the fish health and water quality of aquariums and ensure their proper maintenance.

Keywords: Water turbidity; fish health and growth; filtration system; removal efficiency.

1. INTRODUCTION

A recent assessment found that iridescent shark catfish (*Pangasianodon hypophthalmus*) produce 2% of the 112 million tonnes of aquaculture products made worldwide [1]. The yearly harvests of the species are typically between 10 and 15 T/Ha, and they can grow up to 1 to 1.5 kg in a year. According to the National Fisheries Development Board, pangasius was thought to be cultivated in an area of about 40,000 ha by 2008. Over time, this species' culture in India has developed and spread to many states' fish producers. Currently, production is thought to be between 400,000 and 425,000 metric tons per year (GAA Goal, 2016 statistics).

Insufficient amounts of clean water frequently result in increased pond stocking rates and levels, which in turn cause a decline in water quality, including turbidity, dissolved oxygen, pH, and ammonia [2]. This negatively affects fish growth and health, leading to long-term stress makes them more vulnerable to disease. According to Bondad-Reantoso et al. [3], regularly restocking ponds with fish of questionable health condition to offset mortality rates may ultimately lead to a repeat of sub-clinical infections [4,5].

Also, increased suspended sediment levels can harm fish physiologically by causing damage to their tissues and organs or by reducing light penetration and visual clarity in the water. These consequences can range from behavioral abnormalities to fish death [6]. The majority of direct consequences result from the scouring and abrasive action of suspended particles, which harms gill tissues to impede breathing, decreasing growth or mortality or reducing resistance to infection [7-10].

Fish kept in aquariums can get both infectious and non-infectious diseases. Various biological entities, including bacteria, viruses, fungi, and protozoa are sources of infectious diseases.

These organisms proliferate and spread to other fish in the tanks. Non-infectious diseases are not spread and can be caused by several issues, like inadequate nutrition and contaminated water. In addition to fin rot, white spots, and local infections from traumatic injuries, bacterial illnesses were also frequently detected in the ornamental fish species kept in aquariums [11-13].

In ponds, tanks, cages, etc., catfish are produced intensively with high yield owing to their rapid growth, omnivorous feeding, and high feed conversion efficiency [14]. Still, *Pangasius* culture is threatened by disease, harsh feeding, and declining water quality because of heavy stocking, rigorous feeding, and declining water quality [15]. Although this species is very productive and has significant economic value, little is known about its physiology and biochemistry, as standards for health monitoring are currently being developed. Physiological and metabolic conditions of animals, including fish, can be diagnosed using biochemistry and blood components. In pangas species, previous researches have examined the probiotics; different dietary proteins and nucleotides sourced [16,17-19], hematological and clinical parameters of stress study [20], infection [21], and use of immunostimulants [22]. Due to a lack of physiological and biochemical data, it is difficult to assess a species' health and manage its diseases. Therefore, this investigation was carried out to investigate the culture of Goldfish (*C. auratus*), Koi carp (*C. carpio*), and Iridescent shark catfish (*P. hypophthalmus*) in different water treatments (PF- Pot filter, BF- Bamboo filter, PBF- Pot and Bamboo filter, PB-UVF- Pot, Bamboo and UV filter, and WoF- Without filtration system) and its effects on growth performance, hematological parameters, and histological changes as well as to analyze the antioxidant and immunological parameters of fish tissue samples.

2. MATERIALS AND METHODS

2.1 Experimental Setup and Tank Installations

A 120-day experiment was done at the Aquarium Trade Centre at Kongunadu Arts and Science College, Coimbatore, Tamil Nadu, India. The study involved different water treatment systems including pot, bamboo, and UV filters for Goldfish, Koi carp, and iridescent shark catfish. The reared tank water was discharged to biofilters, which adjusted the flow with motors. The water percolated down to an inlet funnel with an electrically driven aerator, and filtered water was pumped out through the outlet. The water was then recycled at a rate of 3m/3 hours. To increase the organic content, 3 grams of pelleted commercial fish feed was added to the rearing tank. The results were compared with and without a filtration system for 16 weeks. The experimental setup detailed explanation in the previous journal [23].

2.2 Turbidity

The water samples were collected once every 15 days for 16 weeks of the experiment at three different treatment (TI, TII, and T III) samples. The turbidity helps to determine the EPA guidelines and is measured using a spectrophotometer. Results were expressed as Nephelometric Turbidity Unit (NTU) and turbidity removal percentage as follows equation (1):

$$\text{Turbidity removal efficiency} = \frac{\text{TBF}-\text{TAF}}{\text{TBF}} \times 100 \quad (1)$$

2.3 Growth Performances

Growth performance were collected at the end of the experiment, and the total weights were calculated for the control and experimental tanks. The following equations (2) were used to compute weight gain (WG), specific growth rate (SGR), and feed conversion ratio (FCR) [24].

$$\text{WG} = \text{final weight (g)} - \text{initial weight (g)} / \text{initial weight (g)} \times 100;$$

$$\text{FCR} = \text{feed intake/weight gain and consumption (g)};$$

$$\text{SGR (\%)} = [(\text{final weight}) - (\text{initial weight})/120 \text{ days}] \times 100.$$

$$\text{SR} = \text{Final number of fish in the tank/Initial number of fish in the tank} \times 100 \quad \dots\dots (2)$$

2.4 Fish Sampling

Each initial tank's fish was chosen at random and sedated with MS-222 (60 mg/L). Using syringes, 1 mL of whole blood was taken from the caudal vein and collected in an EDTA tube. Following that, the kidney, liver, and gut of each fish were surgically removed through vivisection, promptly flash-frozen, and preserved at -80 °C. A total of 10 times of distilled water was added to the tissues to dilute them, before centrifugation for 5 minutes at 4°C (5000 r/min) and storage at 4°C for the supernatants.

2.5 Histological Examination

After a 24-hour fixation in 10% buffered formalin, the intestinal samples were cleaned with 0.9% NaCl solution. After being cleaned in Xylene, the fixed samples were put in paraffin wax. Iwashita et al. [25] stated that after making thin cross-sectional slices (5 µm), the samples were stained with hematoxylin and eosin (H&E). An Olympus light microscope, a Zeiss Cyber-Shot on-board camera, and Adobe Photoshop were used for the analysis and photography of the histology slides. In the end, the degree of histological alterations (degeneration, necrosis, and mucosal abscission) brought on by experimental diets was assessed using a semi-quantitative scoring method.

2.6 Hematological Analysis

Hematology characteristics were determined using whole blood samples from fish. A Neubauer counting chamber [26] was used to count red blood cells (RBC) and white blood cells (WBC). A Sahli's haemoglobinometer [27] was used to determine the hemoglobin (Hb) content. Hematocrit (Ht) levels were determined using the Wintrobe tube method [28]. MCV, MCH, and MCHC was measured with an automatic hematology analyzer (Sysmex 2100) 30 min, after the sample collection.

2.7 Immunological Activities

The immunological characteristics were measured using homogenized liver and intestinal supernatant samples. Complement C3, C4, Nitric Oxide Synthase (NOS), and immunoglobulin M (IgM); Lysozyme (LSZ) activity was determined using the ELISA test kit according to the protocol of Yu et al. [29].

2.8 Antioxidant Activities

Antioxidant ability - Superoxide dismutase (SOD) activity, Total Antioxidant Capacity (T-AOC) activity, Catalase (CAT) activity, Glutathione Reductases (GR) activity, and Lipid peroxidation (LPO) were determined using the method according to the protocol of Feng et al. [30].

2.9 Statistical Analysis

SPSS statistics (IBM – SPSS software 2020) was used to analyze the experimental data using one-way ANOVA followed by the Duncan test, and a P value < 0.05 was considered statistically significant. The data visualization graphics were created by Origin Pro 8.5 software (Origin Lab Corporation). Statistical analyses were conducted using three replicates and expressed as means ± standard errors.

3. RESULTS

3.1 Removal Efficiency of Turbidity

Table 1 displays the descriptive statistics of turbidity metrics in the research groups throughout 120 days using the filter system. The turbidity was significantly higher in the WoF system when compared to the filtration system ($p < 0.05$). On the 120th day, the turbidity was TI: 9.15 ± 0.14 ; TII: 6.15 ± 0.05 ; TIII: 7.00 ± 0.05 in the without filtration system but with filtration treatment, PF - TI: 0.14 ± 0.00 ; TII: 0.15 ± 0 ; TIII: 0.15 ± 0.00 , BF - TI: 0.22 ± 0.00 ; TII: 0.20 ± 0.00 ; TIII: 0.21 ± 0.00 , PBF - TI: 0.12 ± 0.00 ; TII: 0.12 ± 0.00 ; T III: 0.12 ± 0.00 , and the PB-UVF - TI: 0.12 ± 0.00 ; TII: 0.12 ± 0.00 ; T III: 0.12 ± 0.00 . The filtration system maintains the turbidity level in the < 5 NTU as per the EPA guidelines.

Table 1. The mean±SE of water turbidity analysis with the different treatments of WoF, PF, BF, PBF, and PB-UV-F for 120 days during the culture period of *Crassius auratus*, *Cyprinus carpio*, *Pangasianodon hypophthalmus*

Days	Samples	WoF	PF	BF	PBF	PB-UVF
15	T-I	0.32 ± 0.00^a	0.17 ± 0.01^c	0.23 ± 0.00^b	0.18 ± 0.00^c	0.12 ± 0.00^d
	T-II	0.43 ± 0.01^a	0.15 ± 0.00^c	0.23 ± 0.00^b	0.14 ± 0.01^c	0.12 ± 0.00^c
	T-III	0.21 ± 0.00^a	0.14 ± 0.00^c	0.25 ± 0.00^a	0.13 ± 0.00^c	0.13 ± 0.00^c
30	T-I	0.59 ± 0.01^a	0.16 ± 0.00^c	0.23 ± 0.00^a	0.13 ± 0.00^{cd}	0.12 ± 0.00^d
	T-II	0.24 ± 0.02^a	0.15 ± 0.00^b	0.21 ± 0.00^a	0.13 ± 0.00^b	0.12 ± 0.00^b
	T-III	0.25 ± 0.02^a	0.14 ± 0.00^b	0.23 ± 0.00^b	0.13 ± 0.00^b	0.12 ± 0.00^b
45	T-I	0.90 ± 0.03^a	0.15 ± 0.00^{bc}	0.23 ± 0.00^b	0.12 ± 0.00^c	0.13 ± 0.00^c
	T-II	3.85 ± 0.06^a	0.15 ± 0.00^b	0.21 ± 0.00^b	0.13 ± 0.00^b	0.12 ± 0.00^d
	T-III	5.71 ± 0.05^a	0.15 ± 0.00^b	0.23 ± 0.00^b	0.13 ± 0.00^b	0.13 ± 0.00^b
60	T-I	4.68 ± 0.11^a	0.15 ± 0.00^b	0.21 ± 0.00^b	0.11 ± 0.00^b	0.13 ± 0.01^b
	T-II	4.52 ± 0.20^a	0.15 ± 0.00^b	0.21 ± 0^b	0.12 ± 0.00^b	0.13 ± 0.00^b
	T-III	5.89 ± 0.09^a	0.14 ± 0.00^b	0.22 ± 0.00^b	0.12 ± 0.00^b	0.12 ± 0.00^b
75	T-I	6.46 ± 0.02^a	0.15 ± 0.00^c	0.21 ± 0.00^b	0.13 ± 0.00^c	0.13 ± 0.01^c
	T-II	4.67 ± 0.23^a	0.15 ± 0.00^b	0.22 ± 0.00^b	0.12 ± 0.00^b	0.13 ± 0.00^b
	T-III	6.24 ± 0.06^a	0.15 ± 0.00^b	0.21 ± 0.00^b	0.12 ± 0.00^b	0.12 ± 0.00^b
90	T-I	7.53 ± 0.12^a	0.15 ± 0.00^b	0.21 ± 0.00^b	0.12 ± 0.00^b	0.11 ± 0.00^b
	T-II	5.47 ± 0.90^a	0.15 ± 0.00^b	0.22 ± 0.00^b	0.12 ± 0.01^b	0.12 ± 0.00^b
	T-III	6.40 ± 0.06^a	0.15 ± 0.00^b	0.22 ± 0.00^b	0.13 ± 0.01^b	0.12 ± 0.00^b
105	T-I	8.68 ± 0.13^a	0.15 ± 0.00^b	0.2 ± 0.00^b	0.13 ± 0.00^b	0.13 ± 0.00^b
	T-II	5.53 ± 0.01^a	0.14 ± 0.00^c	0.21 ± 0.00^b	0.13 ± 0.00^c	0.12 ± 0.00^c
	T-III	6.62 ± 0.05^a	0.15 ± 0.00^b	0.22 ± 0.00^b	0.13 ± 0.01^b	0.11 ± 0.00^b
120	T-I	9.15 ± 0.14^a	0.14 ± 0.00^b	0.22 ± 0.00^b	0.12 ± 0.00^b	0.12 ± 0.00^b
	T-II	6.15 ± 0.05^a	0.15 ± 0^b	0.20 ± 0.00^b	0.12 ± 0.00^b	0.12 ± 0.00^b
	T-III	7.00 ± 0.05^a	0.15 ± 0.00^b	0.21 ± 0.00^b	0.12 ± 0.00^b	0.12 ± 0.00^b

Each value is represented in Mean ± SE (n=3). Different superscripts are significant differences between the filtration system ($p < 0.05$).

PF (Pot filter), BF (Bamboo filter), PBF (Pot and Bamboo filter), PBUV F (Pot, Bamboo and UV filter)

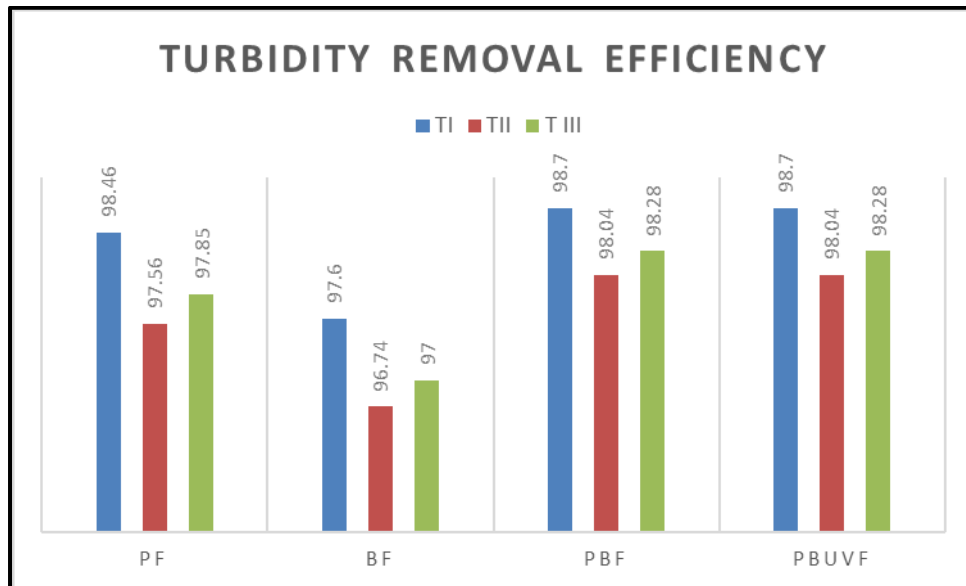


Fig. 1. The removal efficiency of turbidity in different filtration system

The efficacy of turbidity removal was also found to be adversely affected by the combination of the bamboo and pot filtering system. The highest turbidity removal percentage (98%) and lowest turbidity value (0.12 NTU) were achieved while utilizing the PBF and PBUVF filtering systems. The turbidity in the water was efficiently eliminated by the PBF and PBUV F filters, compared to the PF and BF filters (Fig. 1).

3.2 Growth Performance and Survival

Results of the overall production of three different species of ornamental fishes in both WoF and with filtration treatments are summarized in Table 2. The average size of the three different species harvested in the Without filtration system. The average growth was 0.12g/day and the final weight gain of the three different treatments PBF shows significantly higher when compared to the other filters. The survival rate was numerically lower than that of fish without a filtration system. The feed conservation ratio increased significantly when fishes were cultured in the PBF system. Between the five experimental groups, when fish were with a filtration system the growth, Feed conservation ratio, and survival rate were significantly higher than without a filtration system in the experimental setup.

3.3 Histological Study

The basic gill structure, which includes the primary and secondary lamellae, is depicted in

the PB-UVF (Fig. 2: e, e1, e2) in all three fish samples (TI, TII, and T III) and has a filtration system. The secondary lamellae were bound by squamous epithelial cells. Hyperplasia of secondary lamellae is shown in Fig. 2a (Circle). Fig. 2 (a, a1, a2, b1, b2, c2, d1- star) shows the close view of interlamellar hyperplasia with almost total fusion of secondary lamellae. Telangiectasia of secondary lamellae is shown in Fig. 2c1. Eosinophilic infiltrate (Fig. 2c- Arrow) and edema in the gill in primary lamellae was shown in Fig. 2 (a2-Hexagonal).

A single layer of mesothelial cells and a thin fibrous capsule envelop the cultured fish liver samples and normal hepatocytes of fish shown in the filtering system (Fig. 3d2 & e2). The liver alterations were found in the with and without-filtration system cultured fishes. Dilation and congestion in sinusoids are shown in Fig. 3 (a, a1, a2; Triangle, b1; Hexagonal). Hepatopancreas damage is characterized by loss of contact between hepatocytes (Fig. 3b & c; Circle). Melano-macrophage aggregation and cellular degenerations are shown in Fig. 3b2, b3; Arrow.

The normal histological structure of the glomerulus, renal tubules, and bowman's capsules are shown in Fig. 4 (e, e1, & e2). Detached epithelial cells from the basal lamina and dilated tubules are observed in Fig. 4 (a, a1, a2, b, c, c2, d, & d1; Star and Arrow).

Table 2. The growth performance of *C. auratus*, *C. carpio*, and *P. hypophthalmus* with the different treatments of WoF, PF, BF, PBF, and PB-UV-F

Growth Performance	Treatments	WoF	WF			
			PF	BF	PBF	PB-UV-F
IW	TI	2.73±0.21	2.16±0.02	2.17±0.01	2.20±0.01	2.08±0.01
	TII	5.32±0.77	2.18±0.01	2.19±0.02	2.46±0.06	2.14±0.01
	TIII	19.2±1.52	19±0.06	18.85±0.02	19.27±0.04	19.02±0.01
FW	TI	2.91±0.29	3.02±0.02	3.21±0.07	3.13±0.09	2.99±0.03
	TII	6.22±0.77	3.08±0.04	2.89±0.03	3.28±0.11	2.70±0.04
	TIII	20±1.51	20.01±0.04	19.8±0.05	20.43±0.04	19.89±0.04
WG	TI	4.79±0.67 ^d	39.2±1.09 ^c	44.8±0.86 ^a	42.09±3.95 ^b	43.7±1.06 ^a
	TII	3.79±0.81 ^e	41.5±2.19 ^a	31.75±1.08 ^c	33.09±2.43 ^b	26.3±1.48 ^d
	TIII	2.09±0.42 ^e	4.88±0.27 ^c	4.93±0.19 ^b	5.93±0.10 ^a	4.54±0.12 ^d
SGR	TI	0.09±0.01 ^d	0.70±0.01 ^c	0.80±0.01 ^a	0.09±0.01 ^b	0.75±0.02 ^b
	TII	0.16±0.18 ^e	0.75±0.03 ^a	0.57±0.02 ^c	0.16±0.18 ^b	0.46±0.02 ^d
	TIII	0.32±0.05 ^c	0.77±0.04 ^a	0.77±0.02 ^a	0.32±0.05 ^c	0.71±0.01 ^b
FCR	TI	0.12±0.01 ^a	0.009±0.00 ^b	0.009±0.00 ^b	0.013±0.00 ^b	0.01±0.00 ^b
	TII	0.17±0.03 ^c	0.011±0.00 ^a	0.015±0.00 ^a	0.01±0.001 ^c	0.01±0.00 ^b
	TIII	0.32±0.07 ^c	0.12±0.00 ^d	0.11±0.00 ^d	1.10±0.32 ^a	0.34±0.21 ^b

Each value is represented in Mean ± SE (n=3). Different superscripts are significant differences between the filtration system (p<0.05)

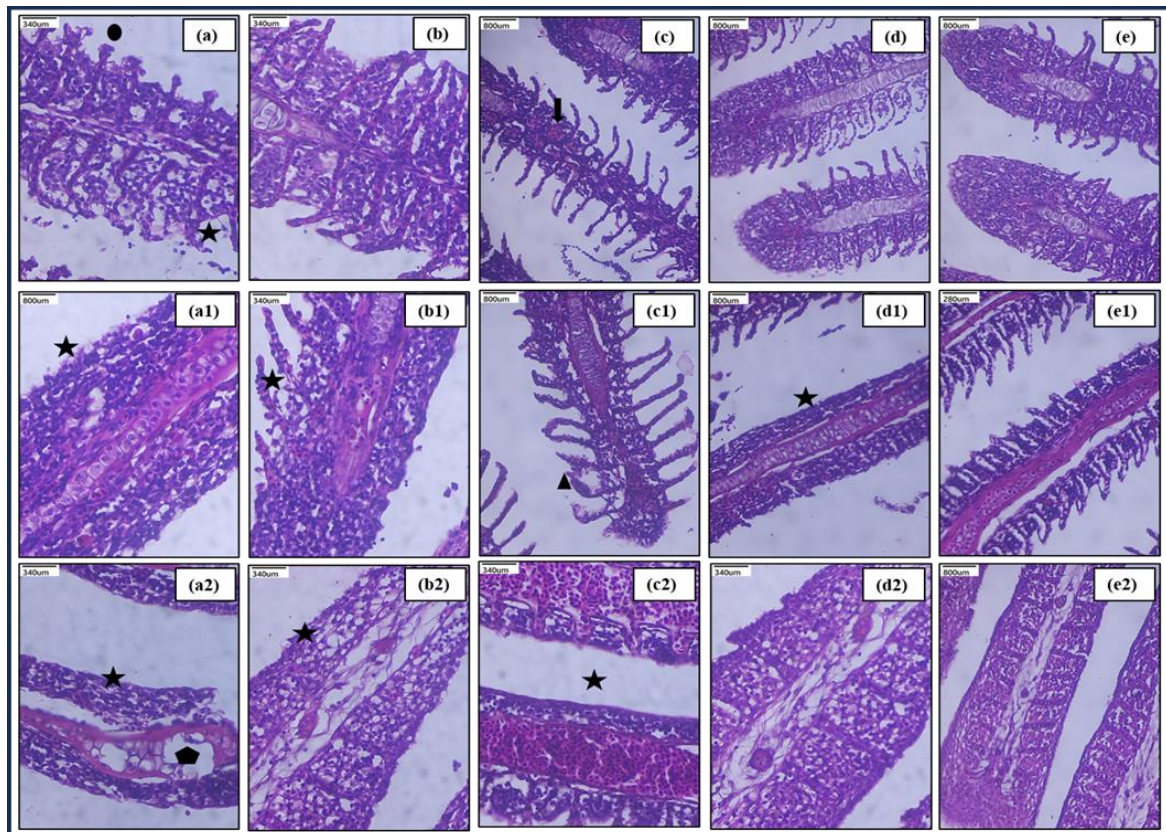


Fig. 2. Histological observation of fish gill in WoF, PF, BF, PBF, and PB-UV-F treatments
 (a) Histological study of treatment I fish gill in WoF, (b) PF, (c) BF, (d) PBF, (e) PB-UVF; (a1), Treatment II WoF, (b1) PF, (c1) BF, (d1) PBF, (e1) PB-UVF; (a2) Treatment III WoF, (b2) PF, (c2) BF, (d2) PBF, (e2) PB-UVF

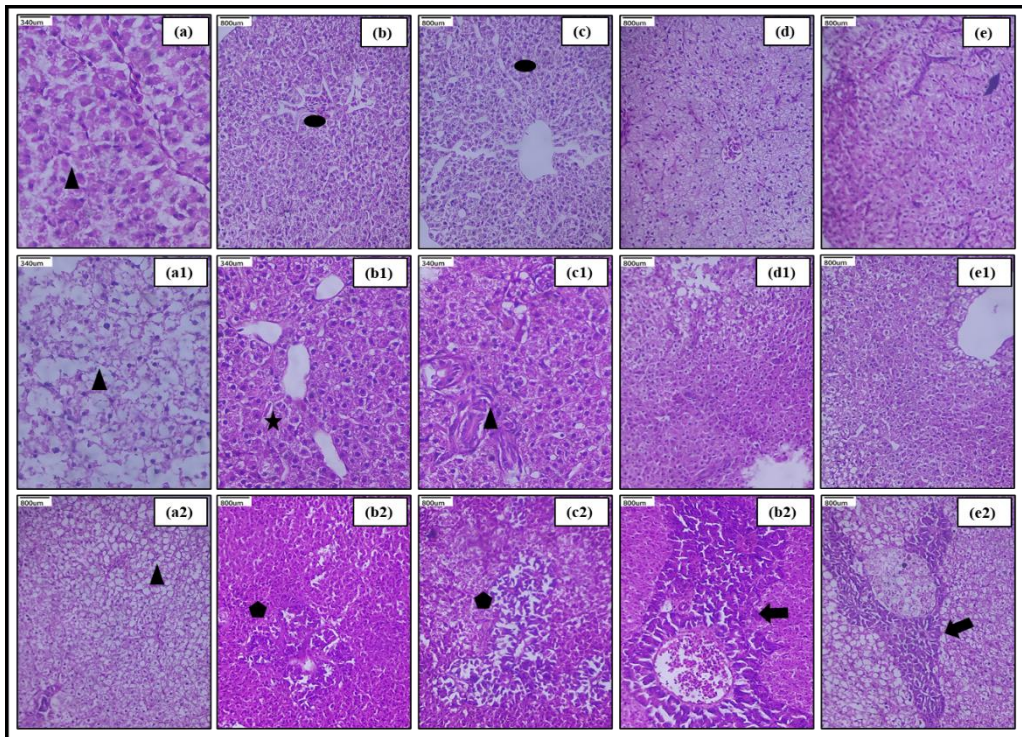


Fig. 3. Histological observation of fish liver in WoF, PF, BF, PBF, and PB-UV-F treatments
 (a) Histological study of treatment I fish liver in WoF, (b) PF, (c) BF, (d) PBF, (e) PB-UVF; (a1), Treatment II WoF, (b1) PF, (c1) BF, (d1) PBF, (e1) PB-UVF; (a2) Treatment III WoF, (b2) PF, (c2) BF, (d2) PBF, (e2) PB-UVF

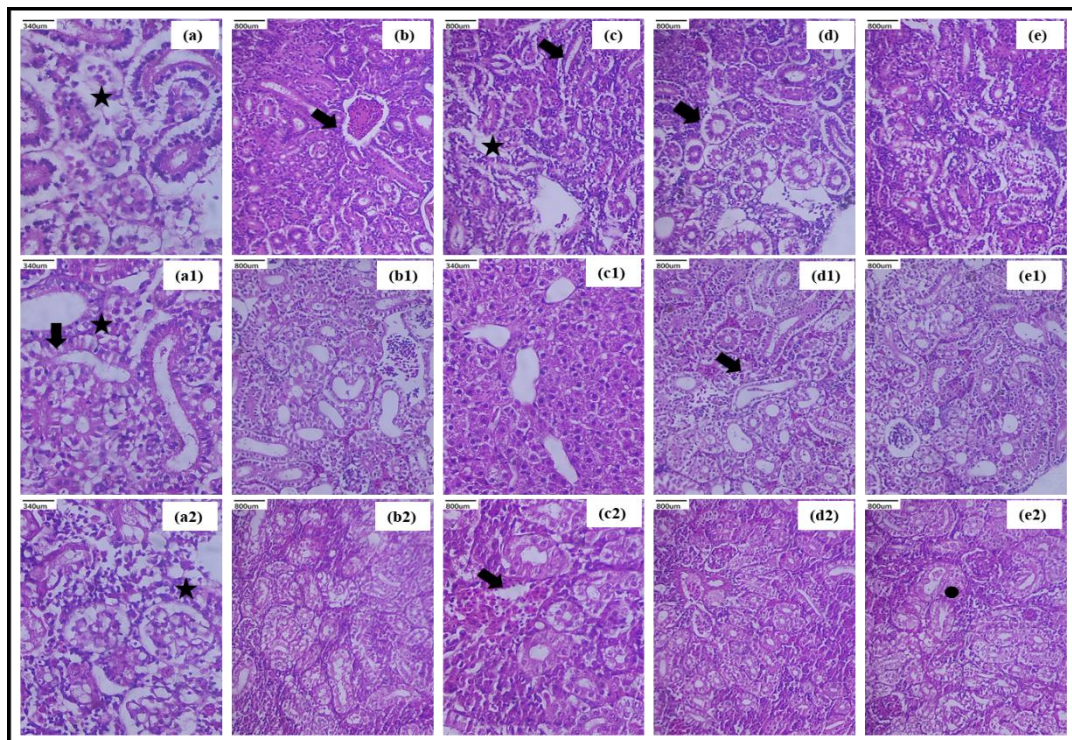


Fig. 4. Histological observation of fish kidney in WoF, PF, BF, PBF, and PB-UV-F treatments
 (a) Histological study of treatment I fish gill in WoF, (b) PF, (c) BF, (d) PBF, (e) PB-UVF; (a1), Treatment II WoF, (b1) PF, (c1) BF, (d1) PBF, (e1) PB-UVF; (a2) Treatment III WoF, (b2) PF, (c2) BF, (d2) PBF, (e2) PB-UVF

3.4 Hematological Analysis

The hematological parameters (RBC count, WBC count, Hb, and Ht; MCV, MCH, and MCHC) of *C. auratus*, *C. carpio*, *P. hypophthalmus* in different filtrations are demonstrated in Table 3. PF, BF, PBF, PB-UVF, and WoF treatment groups were analyzed in the filtration treatment group, Hb, MCHC, and MCH significantly differed from the WoF treatment. The RBC content was higher in the fish kept in filtration tanks as compared to the without filtration tanks. The RBC content was significantly higher in the PBF followed by the PF and PBUVF. The group of fish kept in the filters showed significantly different WBC and Hb in all the filtration tanks (PF, BF, PBF, and PBUVF) as compared to those without filtration tanks. The WBC showed insignificant variation among the T1, T2, and T3 and the filters.

Significant Hb content was found in fish kept in a filtration system over 120 days. The entire treatment group showed significantly higher Hb content as compared to the without filtration tanks. The highest no of Hb was recorded in the T1 (PF) tank, TII (PBUVF) tank, T III (BF) tank.

3.5 Antioxidant Indices

Each experimental group measured antioxidant enzymes (SOD, CAT, ABTS, GR, and LPO) in its liver and gut according to its treatment (WoF, PF, BF, PBF, and PB-UV-F) (Table 4). There was a significant difference between the WoF treatment and the other treatment groups in GR and CAT activities in liver and gut samples ($p > 0.05$). There is a significant increase in PBF in ABTS compared to the other treatments. WoF, PF, PBF, and PB-UVF are significantly lower when compared to the BF treatment.

3.6 Immunological Indices

In immune enzyme activities of fish liver and gut samples are shown in Table 5, LSZ: The with-filtration (PF, BF, PBF, and PBUVF) fish gut and liver samples were significantly different when compared to the without-filtration fish samples ($p > 0.05$). C3: Gut was increased dramatically in PBF compared to the other treatment groups; Liver was significantly reduced in WoF, PF, BF, and PB-UVF ($p > 0.05$). C4: Gut and liver samples of T1, TII, and T III showed significantly higher PF when compared to the other treatments. Compared to the other treatments, PBF significantly increased IgM and Nos ($P > 0.05$).

Table 3. The effects of hematological parameters on the culture of *P. hypophthalmus* in different filtration treatments

Blood parameters	Treatments	WoF	WF			
			PF	BF	PBF	PB-UV-F
RBC	T1	1.09±0.00 ^b	1.15±0.01 ^a	1.12±0.01 ^{ab}	1.19±0.02 ^a	1.14±0.00 ^{ab}
	TII	1.06±0.01 ^b	1.16±0.01 ^{ab}	1.08±0.00 ^{ab}	1.12±0.02 ^a	1.12±0.01 ^a
	TIII	1.06±0.02 ^b	1.08±0.01 ^{ab}	1.10±0.01 ^{ab}	1.13±0.01 ^a	1.12±0.01 ^a
WBC	T1	6.82±0.01 ^c	8.52±0.01 ^a	8.51±0.05 ^a	8.58±0.02 ^a	8.40±0.02 ^b
	TII	3.03±0.01 ^d	10.78±0.37 ^c	10.88±0.29 ^c	16.1±0.11 ^a	11.95±0.25 ^b
	TIII	7.52±0.01 ^d	8.17±0.00 ^b	8.04±0.02 ^c	8.24±0.02 ^a	8.15±0.02 ^b
Hb	T1	7.11±0.00 ^c	11.88±0.02 ^a	10.52±0.17 ^b	11.7±0.00 ^a	11.72±0.11 ^a
	TII	5.26±0.14 ^d	11.46±0.15 ^b	11.31±0.09 ^b	11.46±0.20 ^c	11.98±0.24 ^a
	TIII	17.1±1.14 ^b	16.09±0.15 ^c	18.40±0.19 ^a	18.3±0.11 ^a	15.43±0.18 ^d
Ht	T1	10.8±0.2 ^c	29.13±0.31 ^a	22.2±0.63 ^b	30.7±0.37 ^a	22.3±1.24 ^b
	TII	10.13±0.07 ^c	16.23±0.37 ^{ab}	17±0.25 ^b	14.6±0.25 ^{ab}	18.7±0.40 ^a
	TIII	17.3±0.11 ^b	17.19±0.55 ^b	17.1±0.35 ^b	18.6±0.12 ^a	18.3±0.41 ^{ab}
MCH	T1	39.2±0.17 ^c	57.5±1.01 ^b	63.1±0.75 ^a	62.5±0.65 ^a	62.6±0.55 ^a
	TII	53.16±0.12 ^b	82.8±0.52 ^a	84.2±2.49 ^a	83.8±0.33 ^a	86.7±3.87 ^a
	TIII	11.16±0.14 ^d	66.6±1.45 ^a	64±1.73 ^a	16.4±0.14 ^c	56±1.51 ^b
MCV	T1	101.36±0.31 ^c	115.1±2.6 ^b	101.6±5.23 ^c	151.2±0.52 ^a	114±3.21 ^b
	TII	90.6±0.2 ^d	151.6±6.96 ^a	132±7.23 ^b	127.4±0.20 ^b	112.3±1.20 ^c
	TIII	62.26±0.23 ^b	85.6±0.88 ^a	85±2.30 ^a	71.53±0.08 ^{ab}	76±13.5 ^{ab}
MCHC	T1	59.63±0.14 ^b	63±0.7 ^a	55.23±0.29 ^c	63.7±0.37 ^a	57.3±1.23 ^c
	TII	48.26±0.12 ^d	112.63±2.24 ^a	114.3±1.7 ^a	107±0.40 ^b	88.2±0.02 ^c
	TIII	68.26±0.12 ^d	83±3.05 ^{ab}	85.33±2.18 ^a	75.6±0.25 ^c	79.15±0.25 ^{bc}

Each value is represented in Mean ± SE (n=3). Different superscripts are mentioned as the significant differences between the filtration system ($p < 0.05$)

4. DISCUSSION

4.1 Effect of Different Filtration Treatments on Growth Performance

Among the fish treated with WoF, the survival rate was significantly higher for 120 days of the experimental period. As reported by Attramadal et al. [31,32,33,34], marine fish larvae treated with FTS had lower survival rates than larvae treated with RAS, which supported the hypothesis that *C. auratus*, *C. carpio*, *P. hypophthalmus* juveniles reared in PF, BF, PBF, PB-UV-F will show a higher weight gain and survival compared to the WoF treatment. In rainbow trout culture, the recommended nitrate level was 75 mg l⁻¹ [35] where there are no growth effects, however some harmful effects on overall wellness.

This research noted that higher turbidity caused the growth effects on the culture of *C. auratus*, *C. carpio*, *P. hypophthalmus*. Growth in this study has fallen under low water changes, which an increase in organic material and excessive sediment loads may have caused.

4.2 Effect of Different Filtration Treatments on Hematological Parameters

A pathologic reflector of the entire body is the blood. The various biological and hematological

responses of aquatic animals directly reflect the various stressors like transport, excess crowding, and pollution. Therefore, research on changes in fish's hematological characteristics can offer useful information in identifying stress, environmental contamination, and pathology [36]. In the present study, hematological parameters are notably increased when compared to the WoF treatment. The existence of anemia is due to the reduction of hemoglobin percentage and the total erythrocyte count. In environmental stress, Hb seems to be the best blood indicator. De Almeida-val [37] reports the low oxygen levels by altering several physiological and biochemical parameters.

4.3 Effect of Different Filtration Treatments on Histology

Gill's health is a crucial sign of the well-being and health of fish in farming practices [38]. Fish gills are an ideal indicator of the interaction between them and their environment because of the thin, highly sensitive respiratory epithelium that covers the lamellae of the gills (Strzyzewska et al., 2016). Along with being an essential immune tissue, the gills also regulate processes like gas exchange, acid-base balance, nitrogenous waste excretion, ion and osmoregulation, and home hormone metabolism [39]. Better gill and liver health in this experiment was seen in the PF, BF, PBF, and PB-UVF compared to the WoF treatment.

Table 4. The effects of antioxidant parameters on the culture of *C. auratus*, *C. carpio*, and *P. hypophthalmus* in different treatments WoF, PF, BF, PBF, and PB-UV-F

Antioxidant parameters	Sample	Treatment	WoF	WF			
				PF	BF	PB-F	PB-UV-F
ABTS	Gut	TI	7.43±2.17 ^b	7.13±0.02 ^c	7.11±0.03 ^c	10.63±3.59 ^a	6.89±0.05 ^d
		TII	17.1±2.72 ^a	5.3±0.12 ^c	5.22±0.13 ^c	13.54±2.59 ^b	5.14±0.02 ^c
		TIII	21.19±1.94 ^b	11.52±0.01 ^e	11.9±0.02 ^d	22.91±1.94 ^a	12.6±0.18 ^c
	Liver	TI	6.23±1.84 ^b	6.15±0.02 ^{cd}	6.10±0.00 ^d	9.32±2.35 ^a	6.17±0.01 ^c
		TII	17.4±4.78 ^a	6.17±0.01 ^c	6.12±0.02 ^c	11.54±2.3 ^b	5.47±0.00 ^d
		TIII	24.24±2.76 ^b	15.71±0.14 ^c	16.0±0.49 ^c	28.71±2.89 ^c	16.2±0.27 ^a
CAT	Gut	TI	0.24±0.02 ^a	0.15±0.02 ^b	0.23±0.01 ^a	0.22±0.01 ^a	0.25±0.02 ^a
		TII	0.2±0.01 ^a	0.17±0.01 ^b	0.17±0.01 ^a	0.2±0.01 ^{ab}	0.21±0.01 ^a
		TIII	0.25±0.00 ^b	0.12±0.01 ^c	0.17±0.01 ^b	0.19±0.00 ^b	0.26±0.01 ^a
	Liver	TI	0.24±0.01 ^{ab}	0.17±0.0 ^{bc}	0.24±0.02 ^a	0.17±0.01 ^c	0.26±0.01 ^a
		TII	0.17±0.01 ^b	0.16±0.00 ^b	0.22±0.00 ^a	0.2±0.01 ^a	0.24±0.01 ^a
		TIII	0.31±0.00 ^a	0.14±0.01 ^d	0.16±0.02 ^{cd}	0.22±0.03 ^{bc}	0.22±0.00 ^b
GR	Gut	TI	60.2±9.35 ^a	49±0.20 ^b	43.5±1 ^c	42.6±9.62 ^c	38.8±0.17 ^d
		TII	68.3±8.49 ^b	50.87±0.20 ^c	50.4±0.28 ^c	81.2±15.6 ^a	44.4±0.15 ^d
		TIII	31.2±3.49 ^a	22.3±0.15 ^c	22.5±0.2 ^{bc}	16.9±2.79 ^c	22.8±0.05 ^b
	Liver	TI	64.7±10.23 ^b	40.5±0.23 ^c	39.08±0.04 ^a	93.8±6.07 ^c	35.5±0.23 ^d
		TII	38.1±6.68 ^b	31.1±0.02 ^c	30.75±0.29 ^c	21.3±2.94 ^d	40.2±0.20 ^a
		TIII	34.9±10.23 ^a	29.2±0.13 ^b	22.43±0.29 ^c	12.2±3.4 ^d	22.3±0.09 ^c
LPO	Gut	TI	1.01±0.37 ^c	1.13±0.01 ^b	1.25±0.02 ^a	0.65±0.2 ^d	1.16±0.02

Antioxidant parameters	Sample	Treatment	WoF	WF			
				PF	BF	PB-F	PB-UV-F
SOD	Liver	TII	0.66±0.22 ^b	0.47±0.01 ^d	0.51±0.02 ^{cd}	0.97±0.26 ^a	0.55±0.02 ^c
		TIII	0.6±0.12 ^a	0.61±0.00 ^a	0.58±0.00 ^a	0.21±0.05 ^b	0.61±0.01 ^a
		TI	0.87±0.24 ^{ab}	0.75±0.02 ^b	0.88±0.05 ^a	0.42±0.08 ^c	0.77±0.01 ^b
	Gut	TII	1.07±0.37 ^a	0.95±0.03 ^a	0.81±0.01 ^b	0.31±0.00 ^c	0.76±0.01 ^b
		TIII	0.51±0.15 ^a	0.46±0.01 ^b	0.47±0.01 ^b	0.41±0.00 ^c	0.46±0.01 ^b
		TI	59.4±11.7 ^a	46.07±0.49 ^b	44.18±0.05 ^c	58.8±12.5 ^a	41.13±0.03 ^d
		TII	49.15±3.65 ^a	48.5±0.23 ^a	48.9±0.09 ^a	41.7±5.39 ^b	47.7±0.86 ^a
		TIII	70.08±11.1 ^d	75.6±0.15 ^a	71.8±0.18 ^b	67.4±7.09 ^e	71.05±0.03 ^c
		TI	79.9±6.06 ^a	71.03±0.46 ^b	67.4±1.33 ^c	26.8±3.45 ^e	61.7±0.38 ^d
	Liver	TII	59.6±5.26 ^a	49.3±0.13 ^c	46.4±0.32 ^d	57.7±6.4 ^b	47±0 ^d
		TIII	57.14±8.08 ^{ab}	67.4±1.33 ^{ab}	54.3±0.08 ^b	57.7±8.96 ^a	56.1±0.02 ^{ab}

Each value is represented in Mean ± SE (n=3). Different superscripts are mentioned as the significant differences between the filtration system (p<0.05).

Table 5. The effects of immunological parameters on the culture of *C. auratus*, *C. carpio*, and *P. hypophthalmus* in different treatments WoF, PF, BF, PBF and PB-UV-F

Immunological parameters	Sample	Treatment	WoF	WF			
				PF	BF	PB-F	PB-UV-F
LSZ	Gut	TI	122±1.85 ^a	86±1.52 ^b	75.6±2.40 ^c	85±2.30 ^b	84.6±2.02 ^b
		TII	209±5.50 ^a	125.6±2.84 ^c	117±1.52 ^c	160±2.88 ^b	123±1 ^c
		TIII	228±4.05 ^a	153.6±1.45 ^c	136±2.51 ^d	182±4.04 ^b	126±1.15 ^e
	Liver	TI	91±3.05 ^a	73.6±1.45 ^b	73.3±1.20 ^b	71±3.78 ^b	87±0 ^a
		TII	91.6±1.76 ^a	86±2.51 ^b	74.6±0.66 ^c	72.3±1.85 ^c	71.3±0.33 ^c
		TIII	122±2.02 ^a	93.3±1.85 ^b	90.6±3.75 ^b	93.3±2.33 ^b	86±2.51 ^b
C3	Gut	TI	0.52±0.02 ^c	0.46±0.01 ^d	0.36±0.01 ^e	0.72±0.01 ^b	1.22±0.00 ^a
		TII	0.68±0.05 ^b	0.73±0.01 ^b	0.70±0.00 ^b	0.84±0.02 ^a	0.42±0.00 ^c
		TIII	1.05±0.02 ^c	1.12±0.02 ^b	0.97±0.01 ^d	1.22±0.01 ^a	0.85±0.02 ^e
	Liver	TI	0.29±0.02 ^d	0.54±0.02 ^b	0.51±0.01 ^c	0.54±0.02 ^b	0.61±0.01 ^a
		TII	0.47±0.01 ^c	0.65±0.03 ^a	0.63±0.01 ^{ab}	0.58±0.01 ^b	0.64±0.00 ^a
		TIII	0.84±0.01 ^c	1.38±0.05 ^b	0.65±0.00 ^d	1.60±0.01 ^a	0.56±0.01 ^e
C4	Gut	TI	0.41±0.01 ^d	0.46±0.01 ^c	0.48±0.01 ^c	0.64±0.02 ^a	0.53±0.01 ^b
		TII	0.44±0.02 ^d	0.83±0.02 ^b	0.88±0.00 ^b	0.93±0.01 ^a	0.71±0.00 ^c
		TIII	0.63±0.01 ^c	1.14±0.02 ^{ab}	0.92±0.00 ^{abc}	1.05±0.02 ^a	0.72±0.01 ^{bc}
	Liver	TI	0.37±0.02 ^b	0.52±0.02 ^a	0.56±0.00 ^a	0.51±0.01 ^a	0.56±0.01 ^a
		TII	0.39±0.04 ^d	0.62±0.01 ^b	0.55±0.00 ^{bc}	0.64±0.01 ^a	0.52±0.00 ^c
		TIII	0.54±0.02 ^c	1.05±0.02 ^a	0.88±0.00 ^b	1.04±0.01 ^a	0.93±0.01 ^b
IgM	Gut	TI	0.18±0.01 ^b	0.69±0.10 ^a	0.64±0.02 ^a	0.68±0.01 ^a	0.74±0.01 ^a
		TII	0.32±0.00 ^d	0.63±0.02 ^b	0.55±0.00 ^c	0.74±0.02 ^a	0.53±0.03 ^c
		TIII	0.32±0.00 ^e	1.04±0.00 ^c	0.92±0.02 ^d	1.26±0.02 ^a	1.10±0.00 ^b
	Liver	TI	0.22±0.01 ^d	0.66±0.00 ^b	0.56±0.01 ^c	0.74±0.01 ^a	0.65±0.00 ^b
		TII	0.24±0.01 ^d	0.59±0.02 ^b	0.46±0.01 ^c	0.78±0.00 ^a	0.48±0.02 ^c
		TIII	0.34±0.01 ^e	1.13±0.02 ^b	0.95±0.02 ^d	1.33±0.02 ^a	1.04±0.03 ^c
Nos	Gut	TI	0.55±0.02 ^d	1.17±0.01 ^{bc}	1.22±0.00 ^b	1.85±0.03 ^a	1.14±0.02 ^c
		TII	0.36±0.01 ^c	1.25±0.01 ^a	1.15±0.01 ^b	1.25±0.01 ^a	1.16±0.02 ^b
		TIII	1.82±0.02 ^c	1.96±0.02 ^b	1.45±0 ^e	2.33±0.02 ^a	1.64±0.01 ^d
	Liver	TI	0.57±0.01 ^c	1.22±0.00 ^b	1.24±0.01 ^b	1.31±0.02 ^a	1.25±0.01 ^b
		TII	0.45±0.01 ^d	1.33±0.00 ^a	1.13±0.01 ^b	1.33±0.02 ^a	1.07±0.01 ^c
		TIII	1.32±0.01 ^b	2.18±0.05 ^a	1.22±0.00 ^{bc}	2.25±0.02 ^a	1.16±0.02 ^c

Each value is represented in Mean ± SE (n=3). Different superscripts are mentioned as the significant differences between the filtration system (p<0.05)

4.4 Effect of Different Treatments on Immunological Parameters

SOD, T-AOC, CAT, GR, and MDA are among the enzymes and antioxidants that prevent oxygen

toxicity [30]. The antioxidant power of SOD protects active cells from damage and aging, lowers inflammation, and boosts immunity [40]. It is possible to measure T-AOC effectiveness by the body's antioxidant defense system.

GR plays a role in preserving the equilibrium of the cellular redox status since it is the most prevalent intracellular non-protein thiol [30]. The CAT enzyme eliminates free radicals by breaking down H_2O_2 into H_2O and O_2 [41]. Animals produce MDA as a byproduct of unbalanced lipid peroxidation, an abnormal antioxidant system. MDA damages organisms and hurts cells [42]. In the current study, compared with the WoF; CAT, LPO, and GR levels are significantly raised in the liver. While SOD and ABTS were attenuated in the gut and liver. After different water treatments (PF, BF, PBF, and PB-UVF), the levels of antioxidant parameters of fish tissue samples were seen significantly better to compare the WoF treatment, and the results are shown in Table 4.

4.5 Effect of Different Filtration Treatments on Immunological Parameters

Sakai [43] reported that fish mostly utilize generic and innate immunity when harmful organisms enter or alter their living environment. Several immune components are widely accepted in fish immunity, including C3, C4, IgM, NOS, LSZ, AKP, GOP, GTP, TNF-IL-1IL IL-2, and IL-6, which might indicate a fish's response to environment stress [44,45,46]. Ekdahl et al. [47] stated, a humoral immune response can be aided by the macromolecule complement C3 and C4. They are primarily made by hepatocytes and can engage in the immune response through a variety of routes when triggered. They can destroy bacteria and viruses by dissolving immunoglobulin complexes and promoting inflammatory responses, in addition to their direct role in dissolving and neutralizing viruses. Considering that complement activity is down-regulated under some stress conditions, complement activity can be used to measure fish immunological capacity [48]. A fish's health and immunological condition can also be determined by IgM and NOS [49]. C3, C4, IgM, and NOS levels in PF, BF, PBF, and PB-UVF were significantly higher, and liver and gut LSZ levels were significantly lower than the WoF. Following ammonia stress, C4, IgM, and NOS levels decreased in all experimental groups, although immune enzyme levels were significantly greater in the C/N 20 treatments than in the control groups [29].

5. CONCLUSION

In conclusion, our results suggest that the different filtration treatments have positive effects

on water quality, growth performance, immune response, antioxidant capacity, hematological parameters, and histological observation in aquarium management of *C. auratus*, *C. carpio*, *P. hyphopthalmomus* digestion and absorption performance of cultured animals with pot, bamboo, and UV-based filtration system. Recommended this filtration system helps to purify the water using the natural materials.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

ETHICAL APPROVAL

Fish tests were carried out according to the guidelines set forth by the Animal Ethics Council for the use of animals in research in India. Every effort was made to minimize the number of fish used and their agony.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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