Uttar Pradesh Journal of Zoology

Volume 44, Issue 22, Page 168-183, 2023; Article no.UPJOZ.2928
ISSN: 0256-971X (P)

Enhancing Water Quality Management in Ornamental Fish Aquariums with Pot and Bamboo Filter Systems

Navaneethan M. [a] and Raja S. [a*]

[a] *Department of Zoology, Kongunadu Arts and Science College, Coimbatore, Tamil Nadu, India.*

Authors' contributions

This work was carried out in collaboration between both authors. Author NM to conduct experiments, data curation and analysis, writing- original draft preparation. Author RS did the conceptualization and draft editorial work. Both authors read and approved the final manuscript.

Article Information

DOI: 10.56557/UPJOZ/2023/v44i223731

Editor(s):
(1) Dr. Ana Cláudia Correia Coelho, University of Trás-os-Montes and Alto Douro, Portugal.
Reviewers:
(1) H. K. S. de Zoysa, Rajarata University of Sri Lanka, Sri Lanka.
(2) Wahyu Pamungkas, Research Center for Fishery National Research and Innovation Agency, Indonesia.

Original Research Article

Received: 26/08/2023
Accepted: 30/10/2023
Published: 03/11/2023

ABSTRACT

The filtration of aquarium wastewater composed of a pot and bamboo is constructed for the purification of microbial activities and to reduce turbidity. The aquarium wastewater is treated with sand to reduce BOD and COD; the usage of coconut husk and vetiver act to decrease the turbidity, nitrite, and pH while raising DO level. Initially, sand was sieved to produce 12 size ranges between 180 and 2000 m. The effectiveness of each range in removing turbidity, BOD, and COD through sand beds 4 or 5 cm deep were tested. The critical size (300 & 425 m) at which no solid particles could penetrate through the sand bed was observed at 3 and 4 cm in depth, respectively. Moreover, the flow of solids through sand filter beds had all particles smaller than 180 m removed from them. A 2 cm bed of sand allowed 0.2-0.5% of solids to flow through, and a 4 cm bed allowed 0.07-0.1 %. Both fine and coarse sand layers are supported by a layer of gravel. In the column approach, the thickness and flow rate of each layer were fixed. The thickness of the layers of sand and charcoal were fixed at 4 cm and 6 cm, respectively. The findings of the column analysis, the combined filter

**Corresponding author: Email: rajaselvaraju12@kongunaducollege.ac.in, rajaselvaraju12@gmail.com;*

showed decreases in turbidity by 48%, COD by 52%, BOD by 30%, and increasing DO by 48%, respectively. The results reveal that absorbing nutrients can serve as bio-filters to create better conditions for fish growth. The final weight, length, and SGR of fishes in the three aquariums were significantly different after seven weeks of trial, the treated aquarium showed the highest value than the control.

Keywords: Coconut husk; sand bed; turbidity; COD; BOD; SGR.

1. INTRODUCTION

Ornamental fish culture is a growing industry and is a considerable profit to the entrepreneur. Goldfish species are often referred to as 'living jewels,' and their attractive coloration and fascinating behavior [42]. The important qualities of ornamental fish are coloration and patterns, acceptance of artificial feed, resilience to captive conditions, and compatibility with members of the same or different species [50]. Many of the ornamental fish species possess these attributes and are of small size that can be easily accommodated in the aquarium [37] goldfish possess high appetites and actively release products of catabolism in the water through their feces as well as gills, causing water quality problems that require frequent cleaning [4]. Any delay in this process is reflected in water becoming cloudy and increasing the vulnerability of the fish to health problems. Nitrogenous can be removed from fish production using mechanical, physicochemical, or biological techniques [30,71,72]. Biological procedures, which follow natural breakdown paths in under-regulated settings, are more reliable, sustainable, inexpensive, and efficient means of nitrogenous component elimination [1,2,28,71]. Biological filtration helps in dealing with this problem by neutralizing the toxic waste in the products for nourishment [17,18].

Bio-filter performance is dependent on a variety of factors, including the surface area of media used for bacterial enhancement, concentrations of dissolved oxygen in the system, and the amount of organic matter such as temperature, pH, alkalinity, and salinity [8]. Because bacterial nitrification is known to be highly sensitive and susceptible to their environment, biological filters are made of non-corroding material with broad surface areas where nitrifying bacteria can attach [12]. When compared to a bio-filter with a low surface area per unit volume, a bio-filter with a higher surface area per unit volume is more efficient and economical. The installation of bio-filters in modern re-circulating aquaculture systems is expected to account for 10-30% of the total cost [43]. The high cost of industrial media should make RAS technology not easy to employ in developing countries [6].

Plastic filtration media replaced with natural filtration media could be one of the conceivable options for lowering the use of plastic in filtration systems while also meeting the growing need for bio-filters for intensive aquaculture, particularly in developing nations. In biological chambers, a variety of natural filtering media have been investigated for efficiency. Current studies have shown that biofiltration medium manufactured locally from available materials i.e., wood, shells, charcoal, coconut shells, husks, and gravels can be used for bio-flock and gas filter systems [10,52,56].

Vetiver (*Chrysopogon zizanioides* (L) Roberty), a medicinally significant perennial plant known to reduce soil erosion, can withstand a wide range of pH and hazardous metal levels [23]. Vetiver is a hydrophilic terrestrial plant with physiological properties such as the ability to absorb dissolved nutrients such as N and P, reduce BOD, COD, TSS, oil spill, accumulation of heavy metals, batik production wastewater, tofu production wastewater, and a high tolerance to herbicides and pesticides [15,16,55, 62,63,64,59].

Several technologies are available for wastewater treatment. The biological filter is one of the best filtration systems and is eco-friendly for aquariums. One of the most essential features of the aquarium ecosystem is the biological filter, which can also remove ammonia from circulation water. Slow sand filters contain biological activities. Sand beds are used in a variety of ways to treat waste. However, many technologies are available to maintain water quality. They're normally considered for large-scale treatment plants, but the essential chemistry for the latter methodology can be used on a lower scale. However, the performance of nitrification of these natural materials in RAS under controlled conditions has not been studied. The aim to develop a simple, low-cost technology for reducing ammonia from the aquarium ecosystem using locally available materials is the main motivation of this research, instead of employing the preceding procedures, the three pots, and bamboo one of the earliest water purifying technologies, were tested. It is a good technology for reducing BOD, COD, NO_3, NH_3, and other contaminants.

2. MATERIALS AND METHODS

2.1 Experimental Setup and Tank Installations

The fish were purchased from the Aquarium trade center in Coimbatore - Tamil Nadu, India. The experiment was carried out for 120 days with no water exchange at the aquaculture unit's (94 x 39 x 37.5 cm) 135-liter fiberglass tanks. The waste generation is varied among the fish species, hence during experiments different species of fish were used to assess the filter efficiency in the pot and bamboo recirculating system. The experiment was conducted with three distinct treatments and three duplicate samples. A total of 3 g of pelleted commercial fish feed (Taiyo. fish grower feed, 1.5 mm) with approximately 30% crude protein, 2.0% crude fat, 5.0% crude fiber, and 9.0% ash were added into each rearing tank on day one of the experiment to raise the organic content within the system. The filtering procedures used pot and bamboo filters, and the water was recirculated via these two separate filters. The experiment's outcomes were compared with and without a filtration system period of 16 weeks. The three different aquarium tanks followed by the three different cultures of ornamental fish, *Carassius auratus* [38,39] -Treatment tank I, *Cyprinus rubrofuscus* [34] –Treatment tank II, and *Pangasianodon hypophthalmus* (Sauvage, 1878) -Treatment tank III follows as respectively, purpose for its comparison of growth and other parameters.

2.2 Pot and Bamboo Filter

The pot filter is usually manufactured from locally accessible and affordable materials, such as clay. Both the first and second pots measured 24 cm in height; and 21 cm in width and the storage pot is 32 cm in height and 21 cm in width. On top and middle of the pot composed of a 6 cm fine sand layer of 0.15 mm grain size, a 4 cm gravel layer of 10 mm grain size, and a 4 cm charcoal layer of 0.5 mm grain size; the bamboo filtration system consists of tender coconut coir 5 cm, vetiver 5 cm and cotton 3 cm and the storage tank contain aerator, plants, heater its shown in [Table 1]. The water was discharged to each biofilter through a ½' PVC pipe drawn with the help of the motors. The flow of the water was adjusted with the help of a regulator. The inflow of water to each biofilter was found to be 500 ml/min. Then the water percolated down and reached the mouth of the inlet funnel which was equipped with an electrically driven aerator and finally by the action of airflow, the filtered water came out through the outlet. Then the stored water is drawn with the help of the motors and reaches the fish tanks (Fig. 1). The sand, charcoal, gravel, coir, and vetiver should be replaced; at the very least, they should be changed every two or three months.

2.3 Analysis of the Sampling Schedule and Water Quality

Water samples were collected fifteen days after being treated with and without a filtration system. The 120 mL of samples were carried out from 10:00 to 11:00 am, the sampling tap of each biofilter for inflow and outlet of the filters for outflow, and the water samples were collected on each sampling date in labeled polythene bottles for physicochemical analysis and kept refrigerated until analysis.

Samples were analyzed weekly and twice during the 120-day experimental period. The dissolved oxygen (DO) was measured weekly using Azide modification [68]. The Spectrophotometry technique was used to analyze ammonia (NH3) and nitrate (NO3-) following APHA [5]. Sawyer and McCarty [9] measured the chemical oxygen demand (COD) and biological oxygen demand (BOD) of wastewater. Every other week, COD, nitrate, nitrite, and ammonia are measured.

2.4 Removal Rate

The progressive mass of the analyte (i.e., g per day removal) was divided by the entire volume of the bioreactor to calculate removal rates (g of analyte removed m^3 bioreactor volume d-1) (L x W x D; $2.21m^3$). By dividing the difference between the influent and effluent loads (i.e., the load removed) by the influent load for specific test dates, removal efficiencies (%) were calculated.

2.5 Scanning Electron Microscopy (SEM)

The dry sludge samples were examined by SEM for surface analysis (ZEISS Model). The crosssection of samples without metal caps was placed on a carbon tape and observed, applying a potential of 10.00 kV and amplified 5.00 K×.

2.6 Growth Performances

At the end of the experiment, they were then collected, and the total weights were measured to control and experimental tanks. Weight gain (WG), Specific growth rate (SGR), feed conversion ratio (FCR), and Survival rate (SR) were calculated as per the following equations: [41].

Weight gain (WG) = final weight (g) -initial weight (g);

Food conversion ratio (FCR) = feed intake/weight gain and consumption (g);

Specific growth rate (SGR) (%): [(In (final weight) -In (initial weight))/50 days] × 100,

Where: In = Napierian logarithm;

Survival rates (SR) = final number of fish in the tank/ initial number of fish in the tank × 100.

2.7 Statistical Analysis

All statistical analyses were carried out using an analysis of variance as implemented in IBM SPSS Statistics version 20 with a significance level set at $p < 0.05$. The full ANOVA model used the mean of DO, pH, ammonia, nitrite, nitrate, BOD, and COD were measured as response variables. A significant difference among treatment pairs was determined for each response variable through the effect test as implemented in IBM.

3. RESULTS AND DISCUSSION

Complex ecosystems of aquatic environments with many elements affecting the quality of water. Several of these serve vital roles in aquaculture [51,52,53]. Dissolved oxygen (DO), temperature, pH, suspended particles, ammonia, nitrite, and carbon dioxide (CO_2) are the most essential components influencing fish development performance is alkalinity also critical for the causes of nitrifying processes [13]. Figs. 1 and 2 illustrate the results of this experiment's water quality criteria.

In the present study, the pH of the three different treatments without a recirculation system was followed at 7.75±0.01, 7.69±0.01, and 7.69±0.03 (Fig. 2a). Using the filtration system helps to reduce the level of pH in the aquarium water to 7.58, 7.51, and 7.5 (treatment I, II, and III). In this present experiment, with filtration systems, the three different treatments' pH levels were 7.36±0.02, 7.36±0.02, and 7.33±0.01. Fig 4a shows the reduction percentage after using the filtration system was seen to be 2.19%, 2.34%, and 2.47 % (treatment I, II, and III). pH was stable around and ranged from 7.3 ± 0 to 8.1 ± 0.5.

Nitrification is very sensitive to pH, and this process declines significantly at pH values below 6.8 [64]. Alkalinity is therefore used to balance and maintain the pH in re-circulating aquaculture. In a perlite media trickling bio-filter startup cycle, nitrification as assessed by ammonia conversion to nitrate was substantially faster at pH 8.5 than at pH 7.5 or 6.5. The pH range for aquaculture systems is 6.5 to 8.5, while hydroponic systems should be between 5.5 and 6.5 [67]. The system pH values reported in this study are ideal for nitrification and fish development [25].

Ammonia is the most common nitrogenous waste product in fish, accounting for 60 % to 80% of nitrogenous excretion [29,56]. Contamination of intensive culture water with ammonia and nitrite nitrogen has become a major stressor in the aquaculture industry [16]. Adding microbial flock enhanced the survival rate of *Opsariichthys kaopingensis* under ammonia stress. Bacterial challenge tests are routinely used to examine fish immunity and health along the feeding trail [36]. In the aquatic environment, poor water quality encourages the growth of harmful microorganisms that can be transmitted to aquatic species [7,20,73]. Organic waste from both fresh and marine farming activities has been successfully treated using a biological filter system [20,26,47]. The filter technique is used to remove feed residues quickly. According to the traditional bio-filter design, any wasted feed or feed residue should be removed as quickly as possible and as much as possible recycled. Practically eliminated Recycling of food web with the rapid disposal of unutilized feed ingredients. Much effort has been done in recent decades to improve the water efficiency of quality treatment systems [71,27], as well as to improve the energy efficiency and oxygen efficiency uptake [69].

Analyses of the untreated aquarium treatment wastewater samples revealed greater ammonia levels above the Environmental Production Agency (EPA). The ammonia levels for treatment I, treatment II and treatment III samples were 0.077±0.001, 0.072±0.001, and 0.063±0.002 mg/L (Fig 2b). The values obtained following treatment with filter, on the other hand (Fig. 3b). The ammonia levels in the three water samples were dramatically reduced to acceptable levels (0.005 mg/L). Using filters, the ammonia in treatment I waste was reduced to 48.07%, in treatment II to 18.05 %, and in treatment III 20 % wastewater (Fig. 4b).

The ammonia levels in the three water samples were dramatically reduced to acceptable levels (0.005 mg/L). The reduction efficiencies, expressed in terms of percentage waste removal, were discovered. Robert and William [49] found that in channel catfish, excretion of ammonia at pH 6 increased, whereas it decreased with increased pH. Saha et al. [54] and Scott et al. [57,58] indicated that ammonia excretion increased with increasing pH (alkalinity), while growth decreased. Guangjun Wang et al. [68] further found that ammoniacal nitrogen and nitrite-nitrogen levels in aquaculture water of *C.auratus* were effectively reduced when the C/N ratio was greater than 15:1 in biofloc technology. The concentrations of TAN detected were the consequence of two processes: TAN removal in bio-filters and excretion of TAN from the fish. Because the fish were given equivalent fixed amounts over a set time, the contribution is deemed to be equal in all trials [11]. The calculated TAN removal ranged from 0.11±0.03 g N $m^{-2}d^{-1}$ to 0.30±0.02 g N $m^{-2}d^{-1}$ [43]. In this study ammonia removal rates ranged from treatment I is 0.029 g N m^{-2} d^{-1} and treatment II is 0.01 g N m^{-2} d^{-1}.

Dissolved oxygen (DO) is one of the important parameters in water quality management, and it's needed for the survival of fish and other aquatic organisms. An increase of DO 5.27 ± 0.4 mg/L in one week to 6.70 ± 0.1 in eight weeks was observed [43]. Researchers have noticed a substantial effect of dissolved oxygen (DO) concentration on ammonia-oxidizing bacteria (AOB) whereby *Nitrosomonas europaea* dominates the microbial community when DO is below 0.24 mg/L [74]. *Nitrosomonas oligotropha* were found to be optimally predominant at 8.5 mg/L DO [35]. Nitrification in fixed-bed biofilters has been reported to stop at dissolved oxygen below 40% saturation [24]. In this current study, the raw treatment I, II, and III wastewater tested failed to meet the EPA's minimal standard level. Filters are effective in bringing the low DO values of the three effluents to acceptable levels, which has a direct impact on water quality because low DO in water is linked to pollution. The present study also observed values within the recommended ranges [75,76].

In this current study, the raw treatment I, II, and III wastewater tested failed to meet the EPA's minimal standard level. The treatment I, II, and III wastewater samples yielded values of 6.66±0.01, 6.3±0.11, and 6±0.005 mg/L, respectively (Fig. 2c). However, employing the filter to treat treatment I, II and III wastewater yielded substantially better results 7.24±0.02, 7.15±0.02 and 7.27±0.04 (Fig 3c). Filters are effective in bringing the low DO values of the three effluents to acceptable levels, which has a direct impact on water quality because low DO in water is linked to pollution. The increasing percentage of the DO is 4.58%, 11.42% and 13.5% (Fig 4c). The current study observed values within the recommended ranges.

Nitrate reduction percentages of the three different treatments are 21.8%, 14.78% and 18%. Throughout the 99-day testing period, the de-nitrification tank combined with the tilapia RAS performed well in terms of nitrate removal, with a nitrate removal efficiency of 85.17%. The fish were found to be unaffected by the reused water from the de-nitrification tank, and water exchange could be kept to a minimum [48]. Re-circulating nitrogen removal systems such as tricking filter and sand filter has been created to remove contaminants and preserve water quality in a closed aquaculture system [40,67].

The effect of the filter on nitrate in the Treatment I, II and III aquarium wastewater samples is shown in (Fig. 2d & 4d). In all the treatments, the filters were found to lower the nitrate levels in treatments I, II and III. The nitrate in treatments I, II, and III was lowered by the filter from 7.11, 7.03 and 7.01 mg/L. Nitrate reduction percentages of the three different treatments are 21.8%, 14.78% and 18% (Fig. 4d).

According to Al-Hafedh et al. [33], NO_2 concentrations in aquaculture systems should be kept below 0.5 mg/L to minimize NO_2 toxicity to fish. However, at a high stocking density of 220 fish/m3 and a low RR of 50%, the effects of the without filtration system on the nitrite in treatments I, II, and III were found in the

0.058±0.001, 0.057±0.001, and 0.05±0.001 (Fig 2e). The *Canna glauca* trench had the highest de-nitrification rate, with 42-48% NO_2-N and NO_3-N eliminated in the 200% RR. Some of this loss could be due to plant uptake, but because the *C. glauca* trench had gravel rather than hydroponics culture, there were likely sufficient conditions for de-nitrification in anoxic settings in the gravel [65,66]. In this present study, on the other hand with a filtration system the treatments are respectively maintained nitrite level in the water and the filter effectively reduce the nitrite level in after using the recirculation system.

The effects of the without filtration system on the nitrite in treatments I, II, and III were found in the 0.058±0.001, 0.057±0.001, and 0.05±0.001 (Fig. 2e). In this present study, on the other hand with a filtration system the treatments are respectively maintained nitrite level in the water followed by 0.047±0.004, 0.043±0.003, and 0.044±0.004 (Fig. 4e) and the filter effectively reduce the nitrite level in after using the recirculation system, Fig. (4e) shows the reduction percentage level was seen likewise 41.46%, 31.57% and 25%.

The Chemical Oxygen Demand (COD) indicates the amount of oxygen supplied by the highest oxidizing agent to neutralize the organic material and inorganic nutrients, such as Ammonia or Nitrate, present in water. Biochemical Oxygen Demand (BOD) indicates the amount of dissolved oxygen required for aerobic-organism metabolism of organic material in wastewater. Before treatment, the BOD for the measured without filtration treatment I, II and III wastewater samples in the aquarium were 21±1.52, 13.43±0.24 and 16.33±0.88 mg/L, respectively (Fig. 2f). The treatment of I, II and III wastewater samples with filters resulted in considerably improved values of 11.6±0.33, 10±0.57 and 12±0.57 mg/L, respectively (Fig. 4f). As a result, the effectiveness of the filter system for treatment I, II and III wastewaters were between 23.52 %, 23.97% and 25.41% (Fig. 4g). While the COD levels for treatment I, II and III wastewaters were 67.6±0.97, 75.3±2.02, and 81.06±0.29 mg/L, respectively (Fig. 2g). Filters for the three water samples yielded findings of 65±0.32, 64±0.57 and 63±1.15 mg/L for treated treatments I, II, and III (Fig. 4g). The reduction percentage of the three treatments is likewise 8.5%, 13.87% and 14.86% (Fig. 4f).

The Chemical Oxygen Demand (COD) indicates the amount of oxygen supplied by the highest oxidizing agent to neutralize the organic material and inorganic nutrients, such as Ammonia or Nitrate, present in water. Biochemical Oxygen Demand (BOD) indicates the amount of dissolved oxygen required for aerobic-organism metabolism of organic material in wastewater. [14] found the analyses before and after filtration of the industrial and kitchen wastewater. The BOD and COD values are tested before and after the filtration. It decreased after filtration using the pot and bamboo filter.

Fig. 4 presents the SEM image of biological sludges viewed at 5.00 k × magnification. The porous structure of the surface can be seen by SEM of samples. The SEM examination of the dehydrated biological sludge samples showed granular-shaped porous material with various sizes main in organic material in the after-filtration samples (Fig. 3: a1, b1 and c1) and biological sludge samples didn't show porous materials in the before filtration samples (Fig. 3: a, b & c).

The final weight, length, and SGR of fishes in the three aquariums were significantly different after seven weeks of trial. Present study there was no mortality, and the treated aquarium showed the highest value, followed than the control aquariums. All fish specimens showed positive signs of growth and normal behaviour expected of healthy specimens. Galkina et al. [22] have also noticed faster growth of grass carp when integrated with duckweed than compared sustainability to the other feed materials. Common carp, catfish, and tilapia were the most active users of fresh duckweed [21]. According to Fasakin et al. [19] duckweed can contribute up to 30 percent of the total feed without significantly affecting growth performance. Evidence presented suggested that duckweed could be efficiently assimilated into the biomass of tilapia and carp [50].

In the experiment, the fish gained less weight and their specific growth rate (SGR). The rate of survival, the food consumption rate, and the growth of the fishes were less compared to control (Table 1). Before filtration treatments I, II and III the survival rate like vise 60%, 60% and 70% was observed. After filtration treatment the survival rate was shown in 100% in the three treatments. Treatment I, II and III have a specific growth rate of 0.09%, 0.16% and 0.32% in before filtration and after filtration has 0.77%, 0.67% and 0.11% of SGR.

Table 1. Ornamental fish's growth performance of three different treatments with and without a filtration system

Growth performance	Treatment I (*Carassius auratus*)		Treatment II (*Cyprinus rubrofuscus*)		Treatment III (*Pangasianodon hypophthalmus*)	
	Without filtration	With filtration	Without filtration	With filtration	Without filtration	With filtration
IW (g)	2.73±0.021	2.20±0.011	5.32±0.77	2.46±0.06	19.28±1.52	19.27±0.04
FW (g)	2.91±0.21	3.13±0.09	6.22±0.77	3.28±0.11	20.28±1.51	20.42±0.042
FCR (%)	0.12±0.01	0.013±0.00	0.17±0.03	0.01±0.001	0.32±0.07	1.10±0.32
WG (%)	4.79±0.67	42.09±3.95	3.79±0.81	33.09±2.43	2.09±0.42	5.93±0.10
SGR (%)	0.09±0.01	0.77±0.07	0.16±0.18	0.67±0.058	0.32±0.05	0.11±0.01
SR (%)	60%	100%	60%	100%	70%	100%

Treatment I - Goldfish; Treatment II- Koi carp; Treatment III - Iridescent shark cat fish; IW- Initial weight; FW - Final weight; FCR- Feed Conservation ratio; WG - Weight gain; SGR- Survival Growth Rate; SR - Survival Rate. Values show Mean ± SE

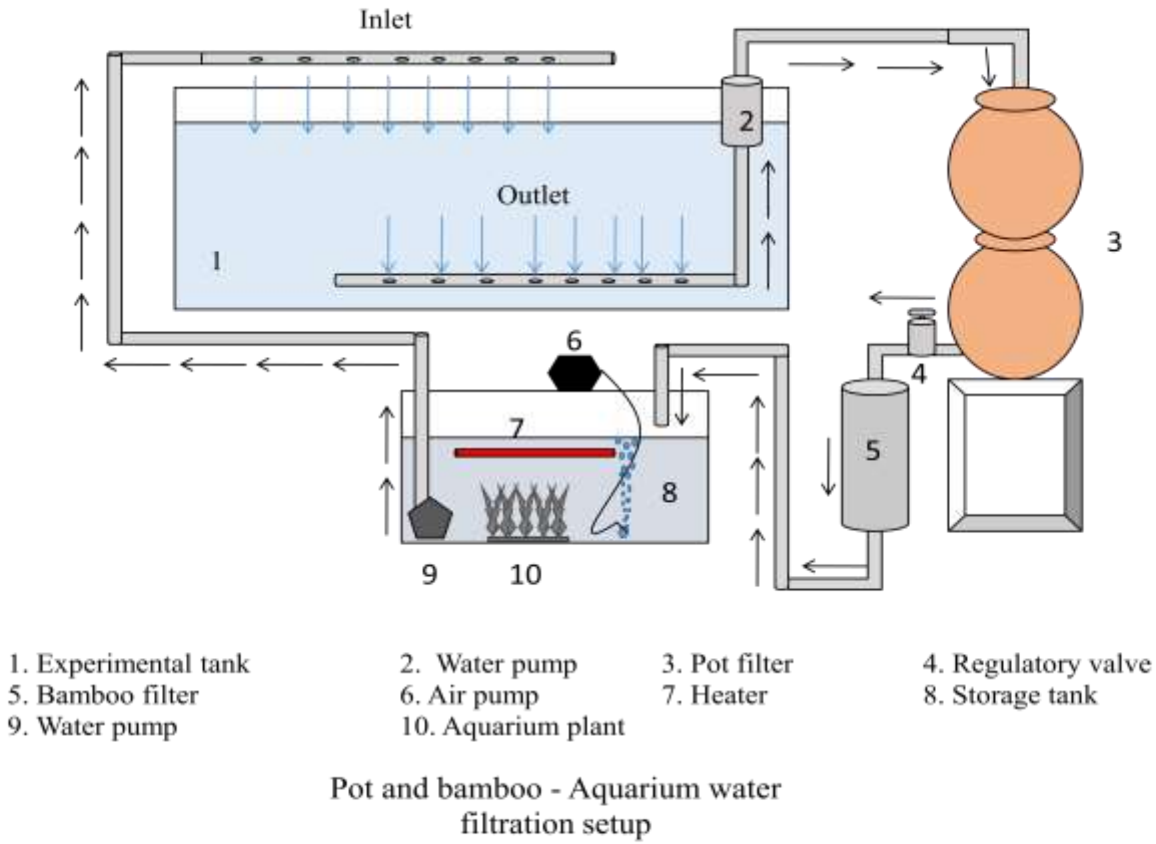

Fig. 1. This diagram shows the mechanism of the aquarium water filtration system.

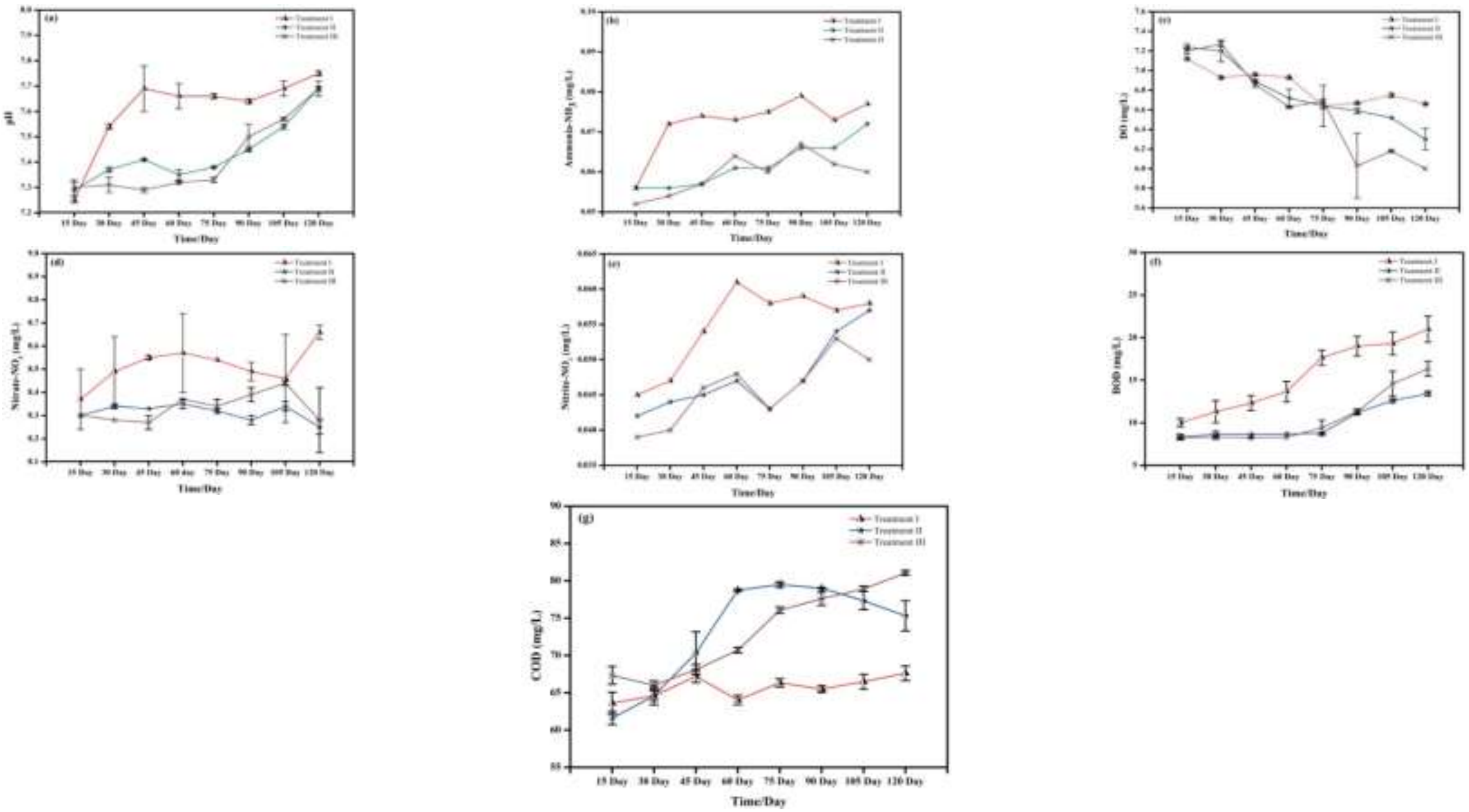

Fig. 2. Physico-chemical analysis before the filtration system for 120 days in during culture period of *Cyprinus rubrofuscus*, *Pangasianodon hypophthalmus* and *Carassius auratus.* Each value is represented in Mean±SD (n=3)

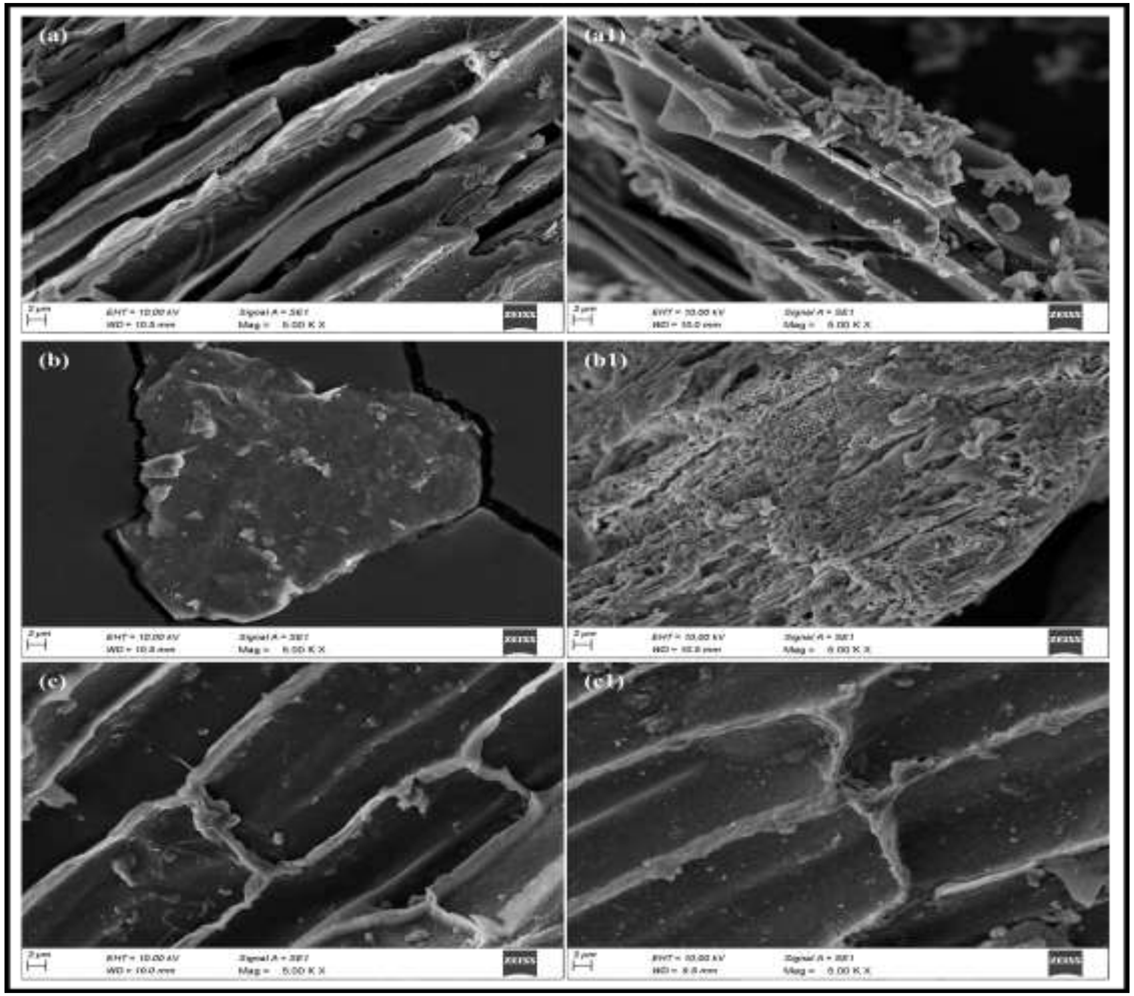

Fig. 3. analysis of the filtration materials: a) Before filtration - Sand sample; a1) After filtration - Sand sample; b) Before filtration - Charcoal sample; b1) After filtration - Charcoal sample; c) Before filtration - Vetiver sample; c1) after filtration - Vetiver sample

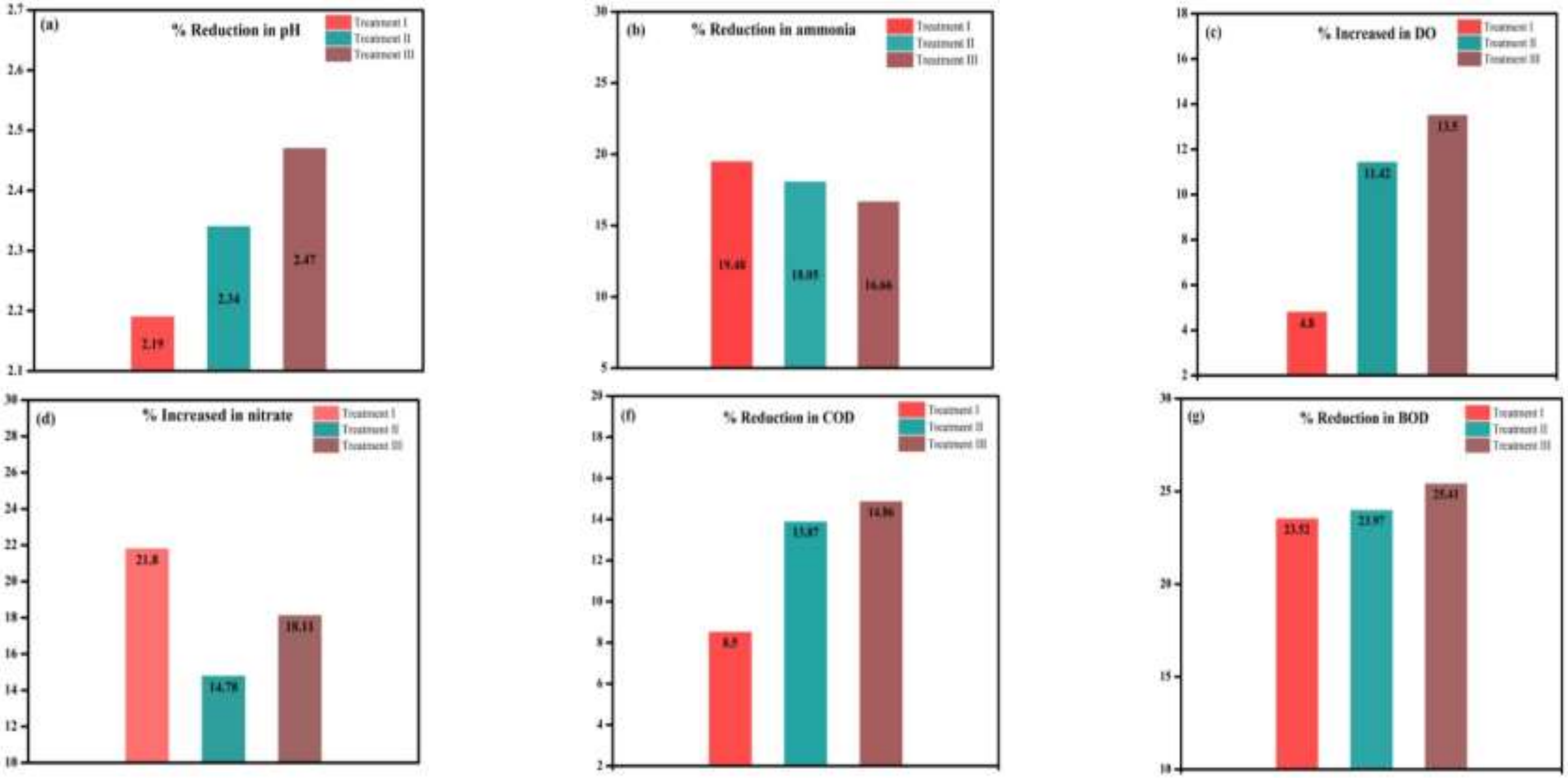

Fig. 4. The reduction percentage (mg/L) of the experimental water after using the aquatic filtration system. Each value is represented in Mean±SD (n=3)

The most expensive product in fish production is feed, accounting for around 45 % of the total cost [3]. Many efforts have been made to identify pathways to reduce feed costs in assessing the dietary supplement for fish production [3]. Products extracted from *Aspilia mossambicensis* and *Azadirachta indica* leaf have been tested [31]. Extracts of Carica papaya as a dietary supplement could enhance gonadal development and improve growth [32].

According to Ki Won Shin et al. [60], as the level of ammonia rises, the growth performance of *S.Schlegelii*, such as daily gain, daily weight gain, condition factor, and hepatosomatic index, Decreases. The concentration of ammonia exposure and temperature were both modified by growth indicators. There are many different varieties of biofilters, each with its own set of benefits and drawbacks, as well as specialized application regions. For eliminating dissolved wastes from re-circulating aquaculture systems, FSBs are an efficient, relatively small, and cost-competitive technology [44,45,4670]. Particularly in cool or cold-water applications that require consistently low levels of TAN and nitrite [61]. In this study after using the pot and bamboo filtration system the ammonia and nitrite level was reduced, eliminating dissolved wastes and its helps to the growth of fishes.

4. CONCLUSION

The purpose of this experiment was to study the reusability of pot and bamboo filtration water treated with sand and vetiver. NH_3, NO_3, and NO_2 levels were higher at the beginning of the experiment. The results showed that high denitrification efficiency was achieved in the pot and bamboo filtration system. It is a cost-effective, eco-friendly option for purifying water. As a future scope of research, more samples of water can be tested to further improve the quality of pot and bamboo filters. The fish growth and survival rate also improved after the filtration system of water. Emphasis on monitoring and measuring other facets to ascertain the purity of the water, such as microplastics, and microbial growth, and to enhance fish coloration by feed additives with effective waste management can be performed.

ACKNOWLEDGEMENTS

The experiments conducted and facilities were provided by the Kongunadu Arts and Science College, Tamil Nadu, India

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Ahn YH. Sustainable nitrogen elimination biotechnologies: A review. Process Biochemistry. 2006;41:1709-1721.
2. Al-Khalaifah HS, Amer SA, Al-Sadek DMM, Khalil AA, Zaki EM, El-Araby DA. Optimizing the growth, health, reproductive performance, and gonadal histology of broodstock fantail goldfish (*Carassius auratus*) by Dietary Cacao Bean Meal. Animals. 2020;10:1808.
3. Amer SA, Ahmed SA, Ibrahim RE, Al-Gabri NA, Osman A, Sitohy M. Impact of partial substitution of fish meal by methylated soy protein isolates on the nutritional, immunological, and health aspects of Nile tilapia, *Oreochromis niloticus* fingerlings. Aquaculture. 2020;518: 734871.
4. Andrews C. Guide to fancy goldfish, Fishkeeper's Guides; Interpet Publishing: Dorking, UK; 2002.
5. APHA. Standard methods for the examination of the water and wastewater, 22nd edn. American Public Health Association, Washington, DC. Aquaculture systems. Aquacultural Engineering. 1998; 34:389-402.
6. Betanzo-Torres EA, Pĩnar-´Alvarez M, de los ´A, Sandoval-Herazo LC, Molina-Navarro A, Rodríguez-Montoro I, Gonz´alez-Moreno RH. Factors that limit the adoption of biofloc technology in aquaculture production in Mexico. Water. 2020;12: 2775.
7. Bhateria R, Jain D. Water quality assessment of lake water: A review. Sustain. Water in juvenile rainbow trout, *Oncorhynchus mykiss*. Aquaculture Toxicology. 2016;59:71-82.
8. Chen M, Chen Y, Dong S, Lan S, Zhou H, Tan Z, Li X. Mixed nitrifying bacteria culture under different temperature dropping strategies: nitrification performance, activity, and community. Chemosphere. 2018;195:800-809.
9. Sawyer CN, McCarty PL. Chemistry for environmental engineering (3rd ed.). New York: McGraw-Hill Book Co; 1978.
10. Cruz C, Cai M, Johnson K, Patelke M, Saftner D, Teasley R. Performance evaluation of alternative biofilter media

amendments. In: Geo-Congress 2020: Geo-Systems, Sustainability, Geoenvironmental Engineering, and Unsaturated Soil Mechanics. American Society of Civil Engineers Reston. VA. 2020;284-291.

11. Dalsgaard J, Larson BK, Pefersen PB. Nitrogen waste from rainbow trout (*Oncorhynchus mykiss*) with a particular focus on urea. Aquacultural Engineering. 2015;65:2-9.
12. DeLong DP, Losordo T. How to Start a Biofilter. Southern Regional Aquaculture Center. SRAC Publication. 2012;4502.
13. Ebeling JM, Timmons MB. Recirculating aquaculture systems. In: James, T. (Ed.), aquaculture production systems. John Wiley & Sons, Inc., Hoboken, New Jersey. U.S. 2012;245-277.
14. Efeovbokhan VE, Olurotimi OO, Yusuf EO, Abtan OG, Alagbe EE. Production of clay filters for wastewater treatment. Journal of Physics: Conference series. 2019;1378-032028.
15. Effendi H, Delis PC, Krisanti M, Hariyadi S. The performance of nile tilapia (*Oreochromis niloticus*) and vetiver grass (*Vetiveria zizanioides*) concurrently cultivated in aquaponic system. Advances in Environmental Biology. 2015;(24):382-388.
16. Tovar M, Moreno C, Mánuel-Vez MP, García-Vargas M. Environmental impacts of intensive aquaculture in marine waters. Water Research. 2000;34(1):334-342.
17. Estim A. Water Quality Management in a Marine Fish Hatchery System. Ph.D. Dissertation, Universiti Malaysia Sabah, Kota Kinabalu, Malaysia; 2010.
18. Estim A, Saufie S, Mustafa S. Water quality remediation using aquaponics sub-systems as biological and mechanical filters in aquaculture. Journal of Water Processing Engineering. 2019;30: 100566.
19. Fasakin EA, Balogum AM, Fasuru BE. Use of duckweed, *Spirodela polyrrhiza* L. Schleiden, as a protein feedstuff in practical diets for tilapia, *Oreochromis niloticus* L. Aquaculture Research. 1999;30:313-318.
20. Foysal MJ, Fotedar R, Gupta SK, Chaklader MR. Biological ball filters regulate bacterial communities in the marron (*Cherax cainii*) culture system. Letters Applied Microbiology. 2019;68:455-463.
21. Gaigher IG, Short R. An evaluation of duckweed (Lemnaceae) as a candidate for aquaculture in South Africa. In Aquaculture Report Series. No. 15; Wamsley, R.D., Wan, J.G., Eds.; CSIRO: Canberra, Australia. 1986;15:81-90.
22. Galkina NV, Abdullaev DA, Zacharova VL. Biological and feed features of duckweeds. Uzbekistan Biological Journal. 1965;3:44-47.
23. Gautam M, Agrawal M. Phytoremediation of metals using vetiver (*Chrysopogon zizanioides* (L.) Roberty) grown under different levels of red mud in sludge amended soil. Journal of Geochemical Exploration. 2017;182(B):218-227.
24. Pedersen LF, Suhr KI, Dalsgaard J, Pedersen PB, Arvin E. Effects of feed loading on nitrogen balances and fish performance in replicated recirculating aquaculture systems. Aquaculture. 2012; (29):237-245.
25. Guerrero RD, Fernandez PR. Aquaculture and water quality management in the Philippines. In: Water Policy in the Philippines. Springer, Philippines. 2018;143-162.
26. Gutierrez-wing MT, Malone RF. Biological filters in aquaculture: Trends and research directions for freshwater and marine applications. Aquacultural Engineering. 2006;34:163-171.
27. Hadas I, Mozes N. The concept of the maga-flow air driven super-intensive aquaculture system. In: Proceedings of the Fifth International Conference on Recirculating Aquaculture, Virginia Tech, Roanoke. VA. 2004;535-537.
28. Halling-Sørensen B, Jorgensen SE. The removal of nitrogen compounds from wastewater. Elsevier publishers, Amsterdam Netherlands. 1993;449.
29. Handy RD, Poxton MG. Nitrogen pollution in mariculture: Toxicity and excretion of nitrogenous compounds by marine fish. Reviews in Fish Biology and fisheries. 1993;1:3(3):205-41.
30. Kaleta J, Puszkarewicz A, Papciak D. Removal of iron, manganese and nitrogen compounds from underground waters with diverse physical and chemical characteristics. Environmental Protection Engineering. 2007;33(3):5.
31. Kapinga IB, Limbu SM, Madalla NA, Kimaro WH, Mabiki FP, Lamtane HA, Tamatamah RA. Dietary *Aspilia mossambicensis* and *Azadirachta indica*

supplementation alter gonadal characteristics and histology of juvenile Nile tilapia (*Oreochromis niloticus*). Aquaculture Research. 2019;50:573-580.

32. Kareem ZH, Abdelhadi YM, Christianus A, Karim M, Romano N. Effects of some dietary crude plant extracts on the growth and gonadal maturity of Nile tilapia (*Oreochromis niloticus*) and their resistance to *Streptococcus agalactiae* infection. Fish Physiology and Biochemistry. 2016;42:757-769.
33. Al-Hafedh YS, Alam A, Alam MA. Performance of plastic biofilter media with different configuration in a water recirculation system for the culture of Nile tilapia (*Oreochromis niloticus*). Aquacultural Engineering. 2003;29(3):139-154.
34. Lacepède BGE. Histoire Naturelle des Poissons. Plassan, Paris. 1803; 5: i–lxiv, 1–803, i–lxvii, pls 1-21.
35. Langone M, Yan J, Haaijer SCM, Op den Camp HJM, Jetten M, Andreottola G. Coexistence of nitrifying, anammox and denitrifying bacteria in a sequencing batch reactor. Frontier. Microbiology. 2014;5:28.
36. Li MY, Zhu XM, Tian JX, Liu M, Wang GQ. Dietary flavonoids from *Allium mongolicum* regal promote growth, and improves immune, antioxidant status, immune related signaling molecules and disease resistance in juvenile northern snakehead fish (*Channaargus*). Aquaculture. 2019;501:473-408.
37. Lim LC, Wong CC. Use of the rotifer, *Brachionus calyciflorus* Pallas, in freshwater ornamental fish larviculture. Hydrobiologia. 1997;358:269-273.
38. Linnaeus C. Systema naturae per regna tria naturae, secundum classes, ordines, genera, species, cum characteribus, differentiis, synonymis, locis. Tomus I. Editio decima, reformata. Holmiae [= Stockholm]: L. Salvii. 1758;824.
39. Malone RF, Beecher LE. Use of floating bead filters to recondition recirculating waters in warm water aquaculture production systems. Aquacultural Engineering. 2000;22:57-73.
40. Malone RF, Pfeiffer TJ. Rating fixed film nitrifying biofilters used in recirculating aquaculture systems. Aquacultural Engineering. 2006;34:389-402.
41. Espinal CA, Matulić D. Recirculating aquaculture technologies. Aquaponics Food Production Systems. 2019;35-76.
42. Meade JW. Allowable ammonia for fish culture. Progress Fish-Culture. 1985; 47:135-145.
43. Mnyoro MS, Munubi RN, Pedersen LF, Chenyambuga SW. Evaluation of biofilter performance with alternative local media in pilot scale recirculating aquaculture systems. Journal of Cleaner Production. 2022;366:132929.
44. Nam TK, Timmons MB, Montemagno CD, Tsukuda SM. Biofilm characteristics as affected by sand size and location in fluidized bed vessels. Aquacultural Engineering. 2000;22:213-224.
45. Ng C. The ornamental fish trade in Malaysia. UTAR Agricultural Science Journal. 2016;2(4):7-18.
46. O'Rourke PD. The economics of recirculating aquaculture systems. In: Proceeding of the 1st International Conference on Recirculating Aquaculture. Virginia Polytechnic Institute and State University, Roanoke, Virginia, USA. 1996;1-19.
47. Permatasari R, Rinanti A, Ratnaningsih R. Treating domestic effluent wastewater treatment by aerobic biofilter with bio balls medium. IOP Conf. Ser. Earth Environmental Science. 2018;106: 12048.
48. Pungrasmi W, Playchoom C, Powtongsook S. Optimization and evaluation of a bottom substrate denitrification tank for nitrate removal from a recirculating aquaculture system. Journal of Environmental Science. 2013;25(8):1557-1564.
49. Robert JS, Lewis WM. Influence of pH and ammonia salts on ammonia toxicity and water balance in young channel catfish. Transactions of the American Fisheries Society. 1986;115(6):891-899.
50. Robinette HR, Brunson MW, Day EJ. Use of duckweed in diets of channel catfish. Proc. Annu. Conf.-Southeast. Assoc. Fish Wildlife Agencies. 1980;34:108-114.
51. Verma DK, Singh S, Maurya NK, Kumar P. Important water quality parameters in aquaculture: An overview. Agriculture and Environment. 2022;3(3):24-29.
52. Hlordzi V, Kuebutornye FKA, Afriyie G, Abarike ED, Lu Y, Chi S, Anokyewaa MA. The use of Bacillus species in maintenance of water quality in aquaculture: A review. Aquaculture Reports. 2020;18:100503.
53. Safer M. Aquatic invaders of the pacific Northwest: Carassius auratus n Goldfish); Washington Department of Fish and

Wildlife Fish: Olympia, WA, USA. 2014;423.
54. Saha N, Kharbuli ZY, Bhattacharjee A, Goswami C, Häussinger D. Effect of alkalinity (pH 10) on ureogenesis in the air-breathing walking catfish, *Clarias batrachus*. Comparative Biochemistry and Physiology Part A: Molecular & Integrative Physiology 1. 2002;132(2):353-64.
55. Saliling WJB, Westerman PW, Losordo TM. Wood chips and wheat straw as alternative biofilter media for denitrification reactors treating aquaculture and other wastewaters with high nitrate concentrations. Aquacultural Engineering. 2007;37:222-233.
56. Salin D., Williot P. Acute toxicity of ammonia to Siberian sturgeon, *Acipenser baeri*. Williot, Ed. Acipenser, Cemagref Publ. 1991;53-67.
57. Scott DM, Lucas MC, Wilson RW. The effect of high pH on iron balance, nitrogen excretion and behavior in freshwater fish from a eutrophic lake: a laboratory and field study. Aquatic Toxicology 1. 2005;73(1):31-43.
58. Seroja R, Effendi H, Hariyadi S. Tofu wastewater treatment using vetiver grass (*Vetiveria zizanioides*) and zeliac. Applied Water Science. 2018;8:2.
59. Sharma D, Taylor-Edmonds L, Andrews RC. Comparative assessment of ceramic media for drinking water biofiltration. Water Research. 2018;128:1-9.
60. Shin KW, Kim SH, Kim JH, Hwang SD, Kang JC. Toxic effects of ammonia exposure on growth performance, hematological parameters, and plasma components in rockfish, *Sebastes schleglii*, during thermal stress. Fisheries and Aquatic Sciences. 2016;19:44.
61. Summerfelt ST. Design and management of conventional fluidized-sand biofilters. Aquacultural Engineering. 2006;34:275-302.
62. Tambunan JAM, Effendi H, Krisanti M. Phytomerediating batik wastewater using Vetiver *Chryspogon zizanioides* (L). Polish Journal of Environmental Studies. 2018;27(3):1281-1288.
63. Terjesen BF, Summerfelt ST, Nerland S, Ulgenes Y, Fjæra SO, Reiten BKM., Selset R, Kolarevic J, Brunsvik P, Bæverfjord G, Takle H, Kittelsen AH, Åsgård T. Design, dimensioning, and performance of a research facility for studies on the requirements of fish in RAS environments. Aquacultural Engineering. 2013;54:49-63.
64. Tomaszewski M, Cema G, Ziembi´nska-Buczy´nska A. Influence of temperature and pH on the anammox process: A review and meta-analysis. Chemosphere. 2017;182:203-214.
65. Trang NTD, Konnerup D, Brix H. Effects of recirculation rates on water quality and *Oreochromis niloticus* growth in aquaponic systems. Journal of Aqua Engineering. 2017;S0144-8609(16):30104-2.
66. Truong P, Van T, Pinners E. Vetiver system applications. Technical Reference Manual. The Vetiver Network International. 2011;127.
67. Tyson RV, Simonne EH, White JM, Lamb EM. Reconciling water quality parameters impacting nitrification in aquaponics: the pH levels. Proceedings of the Florida State Horticultural Society. 2004;117:79-83.
68. Wang G, Yu E, Xie J, Yu D, Li Z, Luo W, Qiu L, Zheng Z. Effects of C/N ratio on water quality zero-water exchange tanks and the bio floc supplementation in feed on the growth performance of crucian carp, *Carassius auratus.* Aquaculture. 2015; 443:98-104.
69. Watten BJ. Aeration and oxygenation. In: Timmons M.B. and Losordo T.M. (Ed.) Aquaculture Water Reuse Systems: Engineering Design and Management,Elsevier, Amsterdam, The Netherlands. 1994;173-208.
70. Weaver DE. Design and operations of fine media fluidized bed biofilters for meeting oligotrophic water requirements. Aquacultural Engineering. 2006;34:303-310.
71. Wheaton FW, Hochheimer JN, Kaiser GE, Komes MJ, Libey GS, Easter C. Nitrification filter principles. In: Timmons M.B. and Losordo T. (Ed.), Aquaculture Water Reuse Systems: Engineering Design and Management. Elsevier, Amesterdam, The Netherland. 1994;101-126.
72. Wingler LW. Die bestimmmung des in wasser gelosten sauerstoffen. Berichte der deutschen chemischen. Gesellschaft. 1888;21:2843-2855.
73. Yildiz HY, Robaina L, Pirhonen J, Mente E, Domínguez D, Parisi G. Fish welfare in aquaponic systems: Its relation to water quality with an emphasis on feed and faces - A review. Water. 2017; 9:1-17.

74. Zhang X, Zheng S, Wang R. Effect of dissolved oxygen concentration (microaerobic and aerobic) on community structure and activity of culturable heterotrophic nitrifying bacteria in activated sludge. Chemical Ecology. 2020;36:953-966.
75. Zhu G, Peng Y, Li B, Guo J, Yang Q, Wang S. Biological removal of nitrogen from wastewater. In: Whitacre, D.M. (Ed.), Reviews of Environmental Contamination and Toxicology. Reviews of Environmental Contamination and Toxicology. 2008;192. Springer, New York, NY.
76. Zubrowska-Sudol M, Walczak J. Enhancing combined biological nitrogen and phosphorus removal from wastewater by applying mechanically disintegrated excess sludge. Water Research. 2015;76:10-18.
