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Impact of Zeolite to Maintain Water Quality and Increasing the Growth of Mono-sex Male Nile Tilapia Cultured in Concrete Ponds

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ABSTRACT

The expansion of intensive aquaculture to decrease the gap between fish productivity and consumption negatively affects the water quality and fish productivity. Therefore, the current research aims to use zeolite to maintain water quality while increasing the growth of mono-sex male Nile tilapia in concrete ponds. 270 tilapia fingerlings were placed in a pond with a 10.8 m^3 volume of water. Zeolite was used at a constant rate of 5 kg/m^3 in different cases (Tr1: Zeolite was put at the bed of the pond, Tr2: Zeolite was put inside a net bag suspended inside the pond, Tr3: Zeolite was put in a plastic tank outside the pond, Tr4: Zeolite was put in an industrial channel outside the pond) in addition to control case (without putting zeolite). Three replicates for each treatment, the experiment was conducted within 140 days. The findings revealed that water quality was effectively maintained, and fish growth performance improved by adding zeolite (5 kg/m^3 water) across different cases (Tr1, Tr2, Tr3, and Tr4) compared to the control case. Furthermore, employing zeolite in Tr1 (placing it at the pond bed) demonstrated the most effective water quality maintenance and growth performance enhancement among the various zeolite application cases. Therefore, it is recommended, under similar conditions, to apply zeolite at a rate of 5 kg/m^3 by situating it in the pond bed. Additionally, further research is warranted to determine the optimal zeolite dosage for diverse aquaculture conditions.

Keywords: Zeolite - Water Quality - Growth Performance - Nile Tilapia.

INTRODUCTION

In Egypt, rapid development has happened in the form of fish farming activity (Ali, 2021), and it's shown the biggest growth among the different fisheries. Therefore, aquaculture is the viable optimal option to decrease the gap between fish productivity and consumption (Soliman and Yacout, 2016). Aquaculture contributes 80% of the fish production in 2020 compared to 15% in 1995 (GAFRD 2020). Even though the aquaculture sector has witnessed amazing success, it has created challenges in environmental issues and food security (Abdel-Meguid et al., 2005; Soliman and Yacout, 2016). Water quality is very important in aquaculture because fish productivity depends mainly on the water characteristics (chemical, physical, and biological). Ideal water quality differs from one type to another; therefore, constantly monitored to ensure the fish survive and grow (Zain, et al., 2018; 2019). Fish stocking densities and aquaculture systems are limited by several factors the most important are dissolved oxygen and ammonia concentrations (Santhosh and Singh 2007). High oxygen levels are the most important factors that positively affect fish growth. Fish growth and productivity are higher in culture ponds with higher concentrations of dissolved oxygen (Bartholomew, 2010), while oxygen depletion in water leads to reduced growth (Bhatnagar and Garg, 2000). Aeration is one method of supplying dissolved oxygen to culture systems, as it is the most important factor controlling growth. Therefore, the conservation of the quantity of dissolved oxygen is critical to successful fish production (Middleton and Reeder, 2003). Ammonia nitrogen resulting from the decay of fish waste and uneaten food (El-Gendy et al., 2015), is the main contamination in aquaculture systems that can have negative effects on the health and growth of fish and it is toxic to it. The ammonia concentrations between 0.2 mg/l to 0.5 mg/l can be lethal (Bhatnagar and Devi 2019). Therefore, it is necessary for ammonia removal to improve water quality in aquaculture systems.

With the increasing population, aquaculture will continue to expand, which means more efficient technologies must be adopted to increase production. Using natural zeolitic minerals is a promising solution for achieving sustainability in aquaculture (Abdel-Rahim, 2017). Zeolites are a group of micro-porous hydrous crystalline aluminosilicates, which are used in numerous applications due to their distinct properties, including ion exchange, adsorption, and desorption (Ghasemi, *et al.,* 2018). There are major benefits for natural zeolite in aquaculture. Including, acting as an adsorbent to remove nitrogenous compounds especially ammonia in addition to some pollutants, improving aeration by increasing pond oxygen, and being used as a food additive to increase the growth factor (Yildirim *et al.,* 2009; Danapas and Alton 2011). The use of a specific dose of zeolite is an obstacle in large-scale aquaculture (Ghasemi *et al.,* 2018). Zeolite dosage depends on several factors which are; water quality, fish stocking density, protein content in the feed, and food continuity (Abdel-Rahim, 2017). Zeolites types especially clinoptilolite, improve water quality, growth performance of fish, indicators, and health (Peyghan and Azary, 2002; Obradovic *et al.,* 2006; Eya *et al.,* 2008; Yildırım *et al.,* 2009). Previous studies of freshwater fish (Farhangi and Rostami-Charati, 2012; Ghiasi and Jasour 2012; Zain, *et al.,* 2018) found that adding zeolite to fish feeds or adding zeolite to the water improved growth performance and their survival rate.

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In addition, the final weight for fish with adding zeolite was higher compared to the control (without adding zeolite). Also, Ghiasi and Jasour (2012); Zain, *et al.*, (2019) found that the final weights of tilapia and Angelfish with adding zeolite were higher compared to the control (without adding zeolite). Obradovč *et al.*, (2006) suggested that using natural zeolite has improved fish growth in rainbow trout ponds, while Danabas and Altun (2011) no differences were observed in water quality and fish growth of rainbow trout after adding zeolite at different concentrations. This research aims to detect the effect of using zeolite at a constant amount (5 kg/m^3) in different cases on maintaining water quality, thus reducing water exchange rates and consumption, in addition to improving the growth performance indicators of mono-sex male Nile tilapia to raise its productivity in concrete ponds.

MATERIALS AND METHODS

Study area

The research was performed in an El Qanater El-khairiya Research Station affiliated with the National Water Research Center (NWRC), Qalyubia Governorate, Egypt.

Experimental design

Fifteen concrete ponds were used. The volume of each pond was 10.8 m^3 of water having the dimensions; (3m length x 3m width x 1.2m depth). The ponds were supplied with continuous aeration by an air compressor, which is one method of supplying oxygen to the culture systems. The experiment was designed from five treatments, four treatments using different zeolite arrangement cases at a rate of 5 kg/m^3 as shown in Fig. 1 (Tr1: Zeolite was put at the bed of the pond, Tr2: Zeolite was put inside a net bag suspended inside the pond, Tr3: Zeolite was putting in a plastic tank outside the pond, Tr4: Zeolite was putting in an industrial channel (P.V.C pipes) outside the pond, in addition to control case (Cont.): without putting zeolite. Three replicates for each treatment were conducted. Yemeni zeolite was used with chemical compositions as shown in the table (1). Water exchange rates of ponds by 50% each month, in addition to compensating for the daily loss of water by evaporation from the free surface. The experiment lasted for 20 weeks (140 days) starting from the 5th of June until the 23rd of October 2022. Fingerlings of Nile tilapia, average initial weight of 2.8 ± 0.01 g in all treatments, were acquired from a commercial farm and transported in oxygenated plastic bags to the experimental unit and stocked in the reception ponds for 2 weeks to adapt them to the experiment conditions. Fish were randomly distributed to 25 fingerlings/m^3 (270 fingerlings/pond). Nile tilapia was fed on a diet of 30% protein for 6 days/week at a feeding rate of 3%, twice times daily at 8.00 am and at 3.00 pm. Fish feeding rates were adjusted every 2 weeks after measuring the biomass of each treatment.

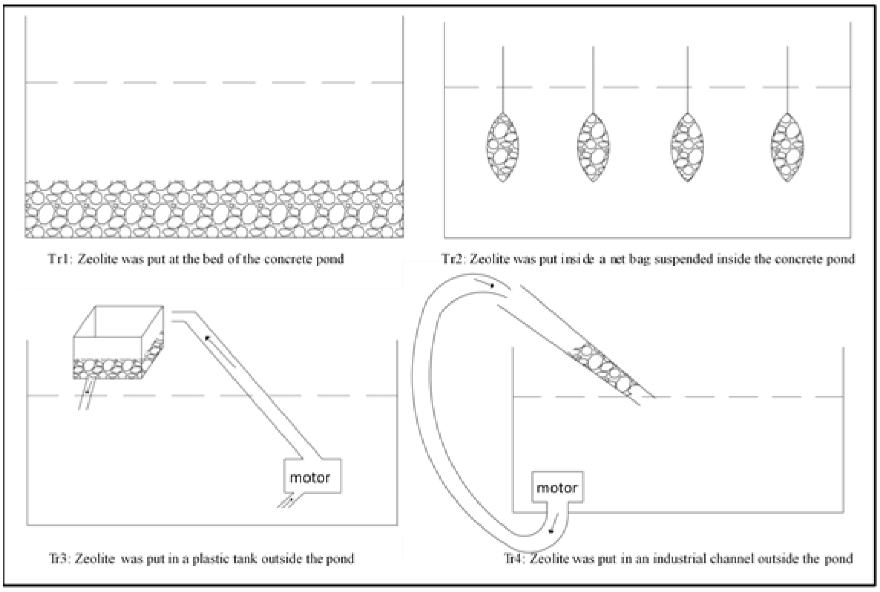

Fig. 1. Cases of zeolites used in the experiment ponds

Table 1. Chemical composition (%) of Yemeni zeolite

Elements	Percentage (%)
SiO_2 (Silicon Oxide)	68.34
Al_2O_3 (Aluminium Oxide)	11.82
Fe_2O_3 (Iron III Oxide)	2.12
CaO (Calcium Oxide)	1.61
MgO (Magnesium Oxide)	0.64
Na_2O (Sodium Oxide)	1.13
K_2O (Potassium Oxide)	2.35
TiO (Titanium Oxide)	2.03
Loss of ignition	9.15

Water quality

It is imperative to ensure that the water quality is at its optimal levels during the process of raising fish in ponds. Therefore, water quality standards in experimental concrete ponds were examined to observe any changes that might have occurred as a result of different zeolite arrangement cases throughout the trial period. In this research, water quality standards were used within what is considered suitable a range for the culture of Nile tilapia, according to, (Riche and Garling 2003; Bhatnagar *et al*., 2004; Stone and Thomforde 2004; Kausar and Salim 2006; Santhosh and Singh 2007; OATA, 2008; Bhatnagar and Singh 2010). Physical parameters were measured daily for Water temperature, Dissolved Oxygen (DO), pH, Electrical Conductivity (EC), and transparency. Those parameters were monitored daily by the thermometer model Thermo-Orion, the combined electrode connected to a pH meter, and the combined electrode connected to a (DO) meter, digital electrical conductivity meter, and Secchi disk respectively. The chemical water quality in the ponds was monitored every 2 weeks between 08:00 am. and 10:00 am. Water samples were collected every 2 weeks by water column in a 500 ml polyethylene bottle. Samples were analyzed in the laboratories of the NWRC. Ammonium (NH_4^+), Nitrite (NO_2^-), Nitrate (NO_3^-), and Phosphate (PO_4^{3-}) were determined spectrophotometrically according to the international standard criteria (APHA, 2017).

Growth performance

The fish populations in ponds were collected every 2 weeks for growth monitoring whereas 10% of the pond population was used as the sample size according to (Knud-Hansen 1997). Every two weeks, fish were removed from ponds using a seine. Growth performance parameters were measured for 30 random fish from each pond. The fish were returned to the pond after measurement. Growth performance parameters were determined according to (Carlos, 1988) through the following equations:

- Weight gain (WG) (g) = Final weight (FW) (g) – Initial weight (IW) (g).
- Average daily weight gain (ADWG) (g/day) = WG (g) / times (days).
- Specific growth rate (SGR) (%/day) = {ln FW (g) - ln IW (g)}/ times (days) x 100.
- Condition factor (CF) was measured according to (Okgerman, 2005). CF = WL^{-3} x 100. Where: CF is a condition factor, W is weight (g), and L is length (cm).
- Survival rate (SR) (%) was determined by (Fish stocked - dead fish/ Fish stocked) ×100

At the end of the experiment (140 days), water was removed from ponds. Fish were harvested from the ponds, weighed, and counted. Gross yield (kg /m^3) was calculated for the weighted sum of the harvested fish.

Statistical analysis

Data analysis was performed through Microsoft EXCEL 2019. SPSS program version 20 with One-way ANOVA was used for data statistical analysis. The differences between the mean of treatments were compared, and differences were considered statistically significant at $P \leq 0.05$.

RESULTS AND DISCUSSION

Water quality

The mean values of the water quality monitored throughout the trial period in concrete ponds cultured with mono-sex male Nile tilapia for each of the different zeolite arrangement cases at a rate of 5 kg/m^3 compared with the control are shown in Table (2).

Table 2. Impact of zeolite (5 kg/m^3 water) in different arrangement cases on water quality (Mean ±SD) of mono-sex male Nile tilapia, in ponds

Parameters	Ctrl	Zeolite (5 kg/m^3 water) in different arrangement cases			
		Tr1	Tr2	Tr3	Tr4
Temperature (°C)	25.91±0.95	25.69±0.93	25.56±0.84	25.59±0.81	25.69±0.94
DO (mg/l)	4.82±0.54	5.81±0.27	5.37±0.23	5.27±0.26	5.15±0.22
pH	7.94±0.12	8.13±0.23	8.08±0.25	8.06±0.19	8.04±0.16
EC (µS/cm)	399.2±20.1	374.1±12.9	381.2±15.4	385.9±18.4	390.5±18.3
Secchi disk (cm)	35.9±12.9	43.8±9.7	41.3±7.1	41.2±7.9	40.4±8.2
NH_4-N (mg/l)	0.097±0.03	0.029±0.01	0.039±0.01	0.043±0.01	0.049±0.01
NO_3-N (mg/l)	5.93±3.48	2.92±1.08	4.21±1.52	4.27±1.64	4.53±1.85
NO_2-N (mg/l)	0.11±0.03	0.06±0.01	0.08±0.03	0.09±0.03	0.10±0.03
PO_4-P (mg/l)	1.11±0.43	0.69±0.21	0.84±0.27	0.86±0.28	0.87±0.28

Tr1: Zeolite was put on the bed of the concrete pond.
Tr2: Zeolite was put inside a net bag suspended inside the concrete pond.
Tr3: Zeolite was put in a plastic tank outside the concrete pond.
Tr4: Zeolite was put in an industrial channel (PVC pipes) outside the concrete pond.
Ctrl.: without putting zeolite in the concrete pond.

Averaged water temperature values in the ponds ranged between 25.56 and 25.91 °C in different arrangement cases. The average temperature for control, Tr1, Tr2, Tr3, and Tr4 were 25.91, 25.69, 25.56, 25.59, and 25.69 °C respectively, and they were within the optimal growth limits for Tilapia according to (Kausar and Salim 2006; Ngugi *et al.,* 2007; Yıldırım *et al.,* 2009). The mean dissolved oxygen concentrations in the all-experimental ponds ranged from 4.83 mg/l to 5.80 mg/l during the experiment period. The average DO values for the different zeolite arrangement cases were recorded, Tr1 (5.81), Tr2 (5.37), Tr3 (5.27), and Tr4 (5.15) higher than control which a (4.82). It is suitable to support high fish production and the preferred for the optimum growth of tilapia, according to (Riche and Garling 2003; Bhatnagar *et al.,* 2004; Bhatnagar and Singh 2010). The lower DO value of control could be attributed to relatively high ammonia concentration compared to zeolite arrangement cases, this interpretation was consistent with (Mokhtari-Hosseini *et al.,* 2016) mentioned that ammonia present can lead to the consumption of oxygen in the water. Average pH values obtained were 7.94, 8.13, 8.08, 8.06, and 8.04 in control, Tr1, Tr2, Tr3, and Tr4 respectively, and within the optimal range for tilapia growth. Those results agree with studies of (BFAR 1992; Wurts and Durborow 1992; Bhatnagar *et al.,* 2004). They recommended that the optimum pH level in ponds should be ranged between 6.5 - 9. Also, these pH values agree with the optimal absorption of ammonia by natural zeolites, according to (Huang *et al.,* 2010; Zhang *et al.,* 2011; Mazloomi and Jalali, 2016). Mean of EC values for control, Tr1, Tr2, Tr3, and Tr4 were 394.2, 374.1, 381.2, 385.9, and 390.5 µS/cm, respectively and they were within optimum conductivity to high production of fish (100–2000 µS/cm) according to (Stone and Thomforde 2004; Stone *et al.,* 2013). The average transparency values for the different zeolite arrangement cases Tr1, Tr2, Tr3, and Tr4, were recorded at 43.8, 40.9, 40.8, and 40.1 cm, which is slightly higher than the control (35.9). The means of ammonia concentrations in the different zeolite arrangement cases were found as 0.029, 0.039, 0.043, and 0.049 mg/l in Tr1, Tr2, Tr3, and Tr4 respectively. The result was similar to (Danabas and Altun, 2011; Ghiasi and Jasour, 2012), and within the optimum for tilapia growth (0.02–0.05 mg/l) according to

(BFAR, 1992; TNAU, 2008). Zeolite replaces sodium ions with ammonium ions and prevents a rise in its level, thus maintaining the ammonia balance away from toxic ammonia (Ghiasi and Jasour, 2012). Control treatment (0.097 mg/l) was relatively higher than different zeolite arrangement cases possibly resulting from feed addition and nitrogenous excretory leading to the accumulation of ammonia, this explanation is consistent with (Azim et al., 2002), who verified the effect of feeding on increasing ammonia concentration in the feeding-only treatment. Thus, the addition of zeolite led to a reduction in the ammonia concentration levels in water compared to the control. Average nitrate concentrations in control, Tr1, Tr2, Tr3, and Tr4 were recorded as 5.93, 2.92, 4.21, 4.27, and 5.53 mg/l respectively. The nitrate concentration was within the recommended according to (Santhosh and Singh 2007). The lowest concentration of nitrate was recorded with Tr1 and the highest concentration with control thus, adding zeolite decreased the level of nitrate in water which is consistent with (Gangadhar *et al.*, 2016). The nitrite concentration was under the values according to (AFCD, 2009) who stated that the nitrite concentration must be lower than 0.2 mg/l. The lowest nitrite concentration of was recorded with the Tr1 while the highest concentration was recorded with the control. Averages of orthophosphate (PO_4-P) for control, Tr1, Tr2, Tr3, and Tr4 were 1.11, 0.69, 0.84, 0.86, and 0.87 respectively. The lowest concentration of orthophosphate was recorded with Tr1 while the highest concentration was with control. The results prove that the phosphorus removal by zeolite increases with increasing pH. This was consistent with the results obtained by (Zain, *et al.,* 2019).

Statistical analysis was done to clarify the significant variation in the impact of zeolite (5 kg/m^3 water) in different arrangement cases on water quality of mono-sex male Nile tilapia, cultured in concrete ponds, as shown in Table (3).

Table 3. The significant variation for the impact of zeolite (5 kg/m3 water) in different arrangement cases on water quality of fish in ponds

Parameters	Ctrl-Tr1	Ctrl-Tr2	Ctrl-Tr3	Ctrl-Tr4	Tr1-Tr2	Tr1-Tr3	Tr1-Tr4	Tr2-Tr3	Tr2-Tr4	Tr3-Tr4
Temperature (°C)	0.325^{ns}	0.114^{ns}	0.152^{ns}	0.325^{ns}	0.547^{ns}	0.651^{ns}	1.000^{ns}	0.880^{ns}	0.547^{ns}	0.651^{ns}
DO (mg/l)	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*	0.000^{*}	0.202^{ns}	0.107^{ns}	0.143^{ns}
pH	0.000*	0.003*	0.015*	0.034*	0.391^{ns}	0.146^{ns}	0.076^{ns}	0.549^{ns}	0.357^{ns}	0.747^{ns}
EC (µS/cm)	0.000*	0.000*	0.002*	0.042*	0.049*	0.006*	0.000^{*}	0.260^{ns}	0.029^{ns}	0.282^{ns}
Secchi disk (cm)	0.001*	0.022*	0.025*	0.058*	0.286^{ns}	0.263^{ns}	0.142^{ns}	0.958^{ns}	0.686^{ns}	0.725^{ns}
NH_4-N (mg/l)	0.000*	0.000*	0.000*	0.000*	0.023*	0.002*	0.000*	0.362^{ns}	0.047^{ns}	0.277^{ns}
NO_3-N (mg/l)	0.000*	0.001*	0.001*	0.007*	0.013*	0.009*	0.002*	0.905^{ns}	0.533^{ns}	0.615^{ns}
NO_2-N (mg/l)	0.000*	0.000*	0.000*	0.005*	0.000*	0.000*	0.000*	0.518^{ns}	0.024^{ns}	0.104^{ns}
PO_4-P (mg/l)	0.000*	0.000*	0.001*	0.002*	0.047*	0.027*	0.020*	0.815^{ns}	0.723^{ns}	0.904^{ns}

ns: not significant, *P< 0.05.

The average values of NH_4-N, NO_3-N, NO_2-N, PO_4-P, DO and EC for Tr1, Tr2, Tr3, and Tr4 showed significant variation ($p < 0.05$) compared to control. Also, Tr1 showed significant variation compared to Tr2, Tr3, and Tr4, but there was no significant variation between Tr2, Tr3, and Tr4. The average values of pH and transparency for Tr1, Tr2, Tr3, and Tr4 showed significant variation ($p < 0.05$) compared to the control, but there was no significant variation ($p < 0.05$) between Tr1, Tr2, Tr3, and Tr4. Temperature is no significant variation ($p < 0.05$) between the treatments and control and between the treatments and each other.

The results in Tables (2) and (3), clear that the water quality during the trial period was within the range considered suitable for the culture of mono-sex male Nile tilapia. Improvement in water quality was obtained by adding Zeolite (5 kg/m^3 water) in different cases (Tr1, Tr2, Tr3, and Tr4 respectively) better than the control. Tr1 case (Zeolite put on the bed of the concrete pond) was the best among the different zeolite cases.

Growth performance

Growth performance was defined in terms of weight gain (WG), specific growth rate (SGR), average daily weight gain (ADWG), condition factor (CF), and survival rate (SR) for the trial period of 140 days as shown in Table (4) and were analyzed statistically as shown in the table (5).

At the experiment`s start, the average weight ranged from 2.76 to 2.82 g for control and zeolite (5 kg/m^3 water) in different arrangement cases. The growth performance rates varied with the different treatments during the trial period until its end. WG and ADWG of zeolite cases, Tr1 (130.66, 0.93), Tr2 (123.00, 0.88), Tr3 (119.62, 0.85), and Tr4 (115.88, 0.83) were recorded higher than the control (87.36, 0.62). These results are consistent with Ghiasi and Jasour (2012) who reported that the final weight of Angelfish (freshwater fish) with adding zeolite was higher compared to the control (without adding zeolite). The highest WG and ADWG were recorded with the Tr1 case and there was a significant difference (P<0.05) compared to zeolite arrangement cases (Tr2, Tr3, and Tr4) and control, and between the cases and each other. In the present research, the average SGR in experimental ponds of tilapia fish cultured within 140 days ranged from 2.49 to 2.76 %/day. At the same time, the average CF in experimental ponds ranged from 1.13 to 1.30. The SGR and CF in all cases of zeolite arrangement improved significantly (P<0.05) compared with the control. The highest SGR and CF were recorded by adding the Tr1 case and it was a significant difference (P<0.05) compared to zeolite arrangement cases (Tr2, Tr3, and Tr4) but, there is no significant variation between Tr2, Tr3, and Tr4. In a previous study, Abo-State *et al.*, (2009), reported an SGR of 3.308–3.513 %/day in cultured tilapia within 70 days under approximately similar values in water quality of the current research. Also, Saeed *et al.,* (2015) obtained higher mean CF, ranging from 1.56 to 1.67. Survival rate (SR) of cases Tr1(98.15 %), Tr2 (95.19 %), Tr3 (94.44 %), and Tr4 (93.33 %) showed significantly different (P<0.05) highest than control (84.44 %), these results are accordance with those obtained by (Osman *et al.,* 2008; Saeed *et al.,* 2015). The highest SR was recorded with the Tr1 case and there was a significant difference (P<0.05) compared to zeolite arrangement cases (Tr2, Tr3, and Tr4) and control, and between the cases and each other.

Table 4. Impact of zeolite (5 kg/m^3 water) in different arrangement cases on growth rates of mono-sex male Nile tilapia, in ponds

Growth rates parameters	Ctrl.	Zeolite (5 kg/m^3 water) in different arrangement cases			
		Tr1	Tr2	Tr3	Tr4
Initial Weight (IW) (g)	2.76±0.11	2.82±0.08	2.78±0.08	2.80±0.07	2.80±0.10
Final Weight (FW) (g)	90.12±1.31	133.48±1.29	125.78±3.21	122.42±1.14	118.68±2.15
Weight Gain (WG) (g)	87.36±1.33	130.66±1.24	123.00±3.22	119.62±1.08	115.88±2.17
ADWG (g/day)	0.62±0.009	0.93±0.009	0.88±0.023	0.85±0.008	0.83±0.015
SGR (%/day)	2.49±0.03	2.76±0.02	2.72±0.03	2.70±0.01	2.68±0.03
Condition factor (CF)	1.13±0.03	1.30±0.06	1.22±0.02	1.22±0.3	1.21± 0.03
Survival rate (SR) (%)	84.44±0.37	98.15±0.37	95.19±0.74	94.44±0.37	93.33±0.37

Tr1: Zeolite was put on the bed of the concrete pond.
Tr2: Zeolite was put inside a net bag suspended inside the concrete pond.
Tr3: Zeolite was put in a plastic tank outside the concrete pond.
Tr4: Zeolite was put in an industrial channel (PVC pipes) outside the concrete pond.
Ctrl.: without putting zeolite in the concrete pond.

Table 5. The significant variation for the impact of zeolite (5 kg/m^3 water) in different arrangement cases on growth rates of fish in ponds

Parameters	Ctrl-Tr1	Ctrl-Tr2	Ctrl-Tr3	Ctrl-Tr4	Tr1-Tr2	Tr1-Tr3	Tr1-Tr4	Tr2-Tr3	Tr2-Tr4	Tr3-Tr4
FW (g)	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*	0.014*	0.000*	0.007*
WG (g)	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*	0.014*	0.000*	0.007*
ADWG (g/day)	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*	0.014*	0.000*	0.007*
SGR (%/day)	0.000*	0.000*	0.000*	0.000*	0.050*	0.002*	0.000*	0.149^{ns}	0.060^{ns}	0.190^{ns}
CF	0.000*	0.001*	0.001*	0.002*	0.003*	0.002*	0.001*	0.931^{ns}	0.667^{ns}	0.731^{ns}
SR (%)	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*	0.042*	0.001*	0.016*

ns: not significant, *P< 0.05.

From the results in Tables (4) and (5), the highest growth performance of FW, WG, ADWG, SGR, and CF was recorded by the Tr1 case while the lowest growth performance was recorded by the control. According to these results, it can be concluded that adding zeolite in Tr1 (Zeolite put at the bed of the concrete pond) is the best arrangement cases for improving growth performance by increasing fish body weight. These findings are consistent with Saeed *et al.,* (2015) who showed that adding zeolite to fish ponds helps achieve better fish production and improving water quality. Also, Obradovč *et al.,* (2006), and Zain *et al.,* (2018) reported that using zeolite and good management resulted in improved water condition and growth performance in freshwater fish.

Fish production

It can be concluded from Table (6) that the total production (kg/pond) and net production (kg/ m^3) of mono-sex male Nile tilapia in this experiment provided a picture of cases of different zeolite inside and outside the ponds compared to control. The total production and net production in the different arrangement cases of zeolites were Tr1(35.37 kg/pond, 3.27 kg/m^3), Tr2 (32.33 kg/pond, 2.99 kg/m^3), Tr3 (31.22 kg/pond, 2.89 kg/m^3), Tr4 (29.91 kg/pond, 2.77 kg/m^3) is higher than the control (20.54 kg/pond, 1.90 kg/m^3). Tr1 case (zeolite put at the bed of the concrete pond) was the best among the different zeolite cases for both total production and net production. The higher harvest weights in the Tr1, Tr2, Tr3, and Tr4 zeolite-treated ponds than those in the control ponds may be due to the good water quality in ponds treated with zeolite. The results in this research are consistent with (Xia *et al.,* 2009) who noticed that natural zeolite promotes prevent disease and promotes growth and survivability. Also, Boyd, (1998) reported that fish ponds with good water quality are expected to give higher productivity of fish than ponds with poor water quality.

Table 6. Impact of zeolite (5 kg/m^3 water) in different arrangement cases on total production (kg/pond) and net production (kg/m3) of fish in ponds

Parameters	Ctrl.	Zeolite (5 kg/m^3 water) in different arrangement cases			
		Tr1	Tr2	Tr3	Tr4
The volume of water used at the beginning of the trial (m^3)	10.8	10.8	10.8	10.8	10.8
The volume of water added to replace evaporation losses (m^3)	6.3	6.3	6.3	6.3	6.3
The volume of renewable water/ 4 months (m^3)	21.6	21.6	21.6	21.6	21.6
Total volume of water used during the trial period (m^3)	38.7	38.7	38.7	38.7	38.7
Total of fish production (kg/ pond)	20.54±0.09	35.37±0.13	32.33±0.25	31.22±0.12	29.91±0.12
Net of fish production (kg/ m^3)	1.90±0.01	3.27±0.01	2.99±0.02	2.89±0.01	2.77±0.01

Tr1: Zeolite was put on the bed of the concrete pond.
Tr2: Zeolite was put inside a net bag suspended inside the concrete pond.
Tr3: Zeolite was put in a plastic tank outside the concrete pond.
Tr4: Zeolite was put in an industrial channel (PVC pipes) outside the concrete pond.
Ctrl.: without putting zeolite in the concrete pond.

Total production (kg/pond) and net production (kg/m^3) were significantly ($P < 0.05$) the best at different arrangement cases (Tr1, Tr2, Tr3, and Tr4) compared to control. Also, significant variation ($p < 0.05$) was found between cases of different zeolites inside and outside the ponds as shown in the table (7).

Table 7. The significant variation for the impact of zeolite (5 kg/m^3 water) in different arrangement cases on total production (kg/pond) and net production (kg/m^3) of fish in ponds

Parameters	Ctrl-Tr1	Ctrl-Tr2	Ctrl-Tr3	Ctrl-Tr4	Tr1-Tr2	Tr1-Tr3	Tr1-Tr4	Tr2-Tr3	Tr2-Tr4	Tr3-Tr4
Total of fish production (kg/ pond)	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*
Net of fish production (kg/ m^3)	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*

ns: not significant, *P< 0.05.

CONCLUSION AND RECOMMENDATIONS

Through the results of current research, it is clear that water quality during the trial period was within the suitable range for the culture of mono-sex male Nile tilapia. Also, it is shown that high dissolved oxygen concentrations, high temperatures, and lower ammonia in the different zeolite cases, tend to enhance fish growth. The findings revealed that water quality was effectively maintained, and fish growth performance improved by adding zeolite (5 kg/m3 water) across different cases (Tr1, Tr2, Tr3, and Tr4) compared to the control case. Furthermore, employing zeolite in Tr1 (placing it at the pond bed) demonstrated the most effective water quality maintenance and growth performance enhancement among the various zeolite application cases. Therefore, it is recommended, under similar conditions, to apply zeolite at a rate of 5 kg/m3 by situating it in the pond bed. Additionally, further research is warranted to determine the optimal zeolite dosage for diverse aquaculture conditions.

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تأثير الزيوليت في الحفاظ على جودة المياه وزيادة نمو ذكور البلطي النيلي أحادي الجنس المستزرع في الأحواض الخرسانية

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الملخص

إن التوسع في تربية الأحياء المائية المكثفة لتقليص الفجوة بين إنتاجية الأسماك واستهلاكها يؤثر سلبا على نوعية المياه وإنتاجية الأسماك. لذلك، يهدف البحث الحالي إلى استخدام الزيوليت للمحافظة على نوعية المياه مع زيادة نمو ذكور البلطي النيلي أحادي الجنس في الأحواض الخرسانية. تم وضع 270 إصبعية بلطي في أحواض حجم كل منها 10.8 م3 من الماء. تم استخدام الزيوليت بمعدل ثابت 5 كجم/م3 في حالات مختلفة (Tr1: وضع الزيوليت في قاع الحوض، Tr2: وضع الزيوليت داخل كيس شبكي معلق داخل الحوض، Tr3: وضع الزيوليت في خزان بلاستيك خارج الحوض، Tr4: تم وضع الزيوليت في قناة صناعية خارج الحوض، بالإضافة إلى حالة الكنترول (بدون وضع الزيوليت). ثلاث مكررات لكل معاملة وأجريت التجربة خلال 140 يوماً. أظهرت النتائج أنه تم الحفاظ على جودة المياه بشكل فعال، وتحسن أداء نمو الأسماك بإضافة الزيوليت (5 كجم/ م3 ماء) في الحالات المختلفة (Tr1، Tr2، Tr3، و Tr4) مقارنة بحالة الكنترول. علاوة على ذلك، أظهر استخدام الزيوليت في حالة Tr1 (وضعه في قاع الحوض) أكثر فعالية في الحفاظ على نوعية المياه وتحسين أداء النمو بين حالات تطبيق الزيوليت المختلفة. ولذلك، يوصي، في ظل ظروف مماثلة، بتطبيق الزيوليت بمعدل 5 كجم/ م3 عن طريق وضعه في قاع الحوض. بالإضافة إلى ذلك، هناك ما يبرر إجراء مزيد من البحوث لتحديد جرعة الزيوليت الأمثل لظروف تربية الأحياء المائية المتنوعة.

الكلمات الدالة: الزيوليت، جودة المياه، أداء النمو، البلطي النيلي.