

## Using the natural zeolite (clinoptilolite) in removing ammonia, heavy metals and improving water quality in fish ponds

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### ABSTRACT:

The progressive build-up of toxic wastes, such as ammonia and heavy metals, is a problem of intensive fish culture systems. This study was conducted to determine the effects of the natural zeolite (clinoptilolite) in removing ammonia and heavy metals. Twelve cement ponds (each 2m<sup>3</sup>) were used to carry out three experimental zeolite treatments with the following concentrations: 1kg/1000L, 2kg/1000L, and 3kg /1000L) with three replications, in addition to 0 concentration for the control. The clinoptilolite was placed in mesh bags (25x20 cm). Twenty mono-sex male Nile tilapia, *O. niloticus*, fingerlings, with an average initial weight of 21.10, 20.43, 22.70 and 22.40g for control, T1, T2 and T3, respectively, were stocked in each tank. The results revealed that application of zeolite significantly ( $P<0.05$ ) decreased all the inorganic dissolved nitrogen. The average concentrations of unionized ammonia (NH<sub>3</sub>) were 0.52, 0.39, 0.21 and 0.04 mg/l for Control, T1, T2, and T3 during the whole experimental period, whereas the concentrations of nitrate (NO<sub>3</sub>-N) were 1.31, 0.91, 0.88 and 0.61 mg/l, respectively. The concentrations of nitrite (NO<sub>2</sub>-N) were 0.36, 0.31, 0.19 and 0.11 mg/l during the whole experimentation. Zeolite had the ability to take up heavy metals; Cd, Cu, Fe, Mn, Pb and Zn. Heavy metals concentration values in ponds' water showed significant differences ( $P<0.05$ ) for the control as well as the three treatments, where control ponds had the highest total mean concentrations of all metals (5.771 mg/l) compared to T1 (4.827 mg/l), T2 (4.083 mg/l) and T3 (3.562mg/l), respectively. Heavy metals accumulation in musculature of *O. niloticus* in different treatments was investigated. All metals showed significant ( $P<0.05$ ) differences among different treatments.

**Keywords:** Zeolite; Ammonia; Heavy Metals; Water Quality; Fish Growth; *O. Niloticus*; Fingerlings.

### INTRODUCTION

The word "Zeolite" is derived from the two Greek words, "zeein": "lithos" meaning "boiling": "stones", due to the ability of the mineral to froth when heated to about 200°C (Polat *et al.*, 2004). Zeolite is a cation exchanger which serves both as a sink for dissolved cations and as a source of nutrients such as NH<sub>4</sub><sup>+</sup> (Allen *et al.*, 1993). (Hey 1930) concluded that natural zeolite is a class of crystalline, porous, hydrated aluminosilicates frameworks with loosely bonded alkaline or alkaline earth metals with important physicochemical characteristics. It can be used in many applications as cation exchange and molecular sieving (Dyer, 1988).

As reported by Ramalho (1997), the ion exchange process is widely used in wastewater treatment since it is able to achieve complete demineralization through simultaneous cation and anion exchange.

Using zeolites to improve water quality is widely documented, especially in freshwater aquaculture. However, the ability of zeolites to improve water quality in brackish and marine aquaculture was significantly limited due to the high content of Na, Ca, Mg, and other cations (Boyd CE, 1995). Heavy metals

removal by natural zeolites has been considered in recent years (Gholikandi *et al.*, 2012). (Ouki *et al.*, (1993) reported an increase in exchange capacity of chabazite by 19 times and of clinoptilolite by 21 times after contacting with salt solutions. Adsorption capacity towards heavy metal (Cd<sup>2+</sup>) was also seen to increase, with uptake that is higher by 46% for pretreated chabazite over its natural counterpart. (Leppert (1990) showed that CRRs (Clinoptilolite-Rich Rocks) can possibly be used for Pb removal from wastewater and subsequently disposed of as non-hazardous waste. (Moralı N. (2006) also indicated that the removal efficiency of zeolite for other heavy metals such as cadmium, chrome, copper, nickel, zinc, iron, and lead was 90, 90, 90, 75, 85, 70, and 95%, respectively. The CEC of the natural zeolite for some heavy metals may amount to: (Fe<sup>2+</sup> 1.0meq/g - Zn<sup>2+</sup> 1.1meq/g - Ni<sup>2+</sup> 1.0meq/g - Cd<sup>2+</sup> 1.0meq/g - Pb<sup>2+</sup> 1.2meq/g - Cu<sup>2+</sup> 1.0meq/g zeolite). Ammonia-selective ion exchange using synthetic and natural zeolites have been used successfully to remove ammonia from aquaculture waters in the laboratory (Johnson and Sieburth, 1974; Teo *et al.*, 1989; Bergero *et al.*, 1994; Ferreira *et al.*, 1995). Zeolites have been also used on a pilot scale in the culture of different fish species (Bruin *et al.*, 1981) reported that by

adding the zeolite, ammonium concentration in the treated aquarium was lower than that of the control test for most of the experiments. (Demir A, (2002) indicated that the greater the initial concentration of ammonia, the lesser the NH<sub>3</sub>- removal efficiency is. Ammonia removal efficiency in freshwater is better than marine water. (Rafie and Saad (2006) concluded that the use of 10 g zeolite in a small cotton bag as a bed medium to plant lettuce seedlings in a recirculating aquaponic system could improve water quality parameters by lowering the concentration of total ammonia-N. According to (Obradovic et al. (2006), adding 60 kg of this zeolite to a pool resulted in a remarkable decrease in the total water hardness, nitrates and ammonia. (Saltali, K.Sari, (2007) reported 75% ammonium removal at pH 7 and nearly 79% at pH 8 for Turkish (Yildizeli) zeolite. (Ergun et al. (2008) mentioned that ammonia excretion rates were investigated as a function of zeolite dosage in rainbow trout dietary. A diet with 2.5% natural zeolite decreased ammonia discharge by 24% compared to the control group. (Yusof et al. (2010) indicated that there have been many studies of natural zeolites – particularly clinoptilolite – for removing ammonium from wastewater. The results of these studies do not provide much useful information concerning the use of zeolites in aquaculture, because TAN concentrations in wastewater are much greater than in waters of aquaculture. (Farhangi and Hajmoradloo (2011) Concluded that in lethal concentration of ammonia, application of 15 g L<sup>-1</sup> zeolite prevented the mortality rate in rainbow trout fish. Use of a surfactant modified natural clinoptilolite for removal of nitrogenous anions from a recirculated aquaculture system was also reported. (Farhangi and Rostami-Charati (2012) reported that in lethal concentration of ammonia, application of 15 and 12 g L<sup>-1</sup> of the zeolite could prevent the mortality rate in beluga and Persian sturgeon, respectively. In another study, natural clinoptilolite zeolite was used to reduce ammonia and hardness level of water for rearing freshwater aquarium fish angel. According to (Ghiasi and Jasour (2012), adding 10 g L<sup>-1</sup> zeolite was an optimum dose for improvement of water quality in angel culture. Natural clinoptilolite zeolite was applied to reduce ammonia lethal concentration in rainbow trout culture. (Motesarezad et al. (2015) illustrated that the effect of different levels of clinoptilolite zeolite and nitrifying bacteria was investigated on nitrogenous compounds absorption in a closed system of carp breeding. (Öz et al. (2017)

pointed out that the effect of natural Zeolite Clinoptilolite on aquarium water conditions indicated that zeolite put inside a net bag reduced ammonia content in fish tanks by 72%, while zeolite put directly in aquarium reduced ammonia by 33% compared with control. Although the zeolite removal efficiency of ammonia in saltwater is relatively less than that in freshwater, the highest efficiency and lowest cost, compared to other materials in the same class such as activated carbon, are still remarkable (Xue et al., 2018).

But in Egypt so far, zeolite has not been used in the field of fish farming as in East Asian and European countries, but its use was limited to the treatment of well water in modern land and an attempt to reduce the high concentrations of salts in it.

The aim of the research: Evaluation of the efficiency of zeolite in removing ammonia and heavy metals and its effect on improving water quality in fish ponds. Improving the quality of the Egyptian fish product and increasing its competitiveness in global markets

## MATERIALS AND METHODS

This study has been done in a private farm at Abo Shabana (agriculture drainage water Tollumbat 7) in Riyadh City, Kafr El-Sheikh governorate, Egypt.

Zeolites are crystalline granules (sedimentary rocks) whose chemical composition can be illustrated as table (1).

### Ponds preparation and Experimental fish:

The current experiment was conducted using twelve cement ponds to represent four treatments; control and three zeolite treatments where 3- 5 mm- zeolite was added at a rate of (1kg/1000L) to the T2 , (2kg/1000L) to the T3 and (3kg /1000L) to the T4. clinoptilolite put into net bags (50x20 cm) which are 3000 g capacity and made from cloth. It was waited for accumulation of matters demanded binding (ammonium, nitrate, and nitrite), first 30 days after beginning of the experiment and then, clinoptilolite put into pond water covering the ponds floor. The experimental ponds were equal in water volume (2m<sup>3</sup>) and dimensions (1x2 m<sup>3</sup>) with the same average water depth of 100 cm. The source of irrigation was drain channel of tollombat 7 and the water was changed every 4 days (under constant aeration, temperature = 28°C and pH = 8.2).

Experimental ponds were stocked with monosex male Nile tilapia, *O. niloticus*,

fingerlings at an average initial length of 12.20, 11.70, 12.40 and 11.90cm and an average initial weight of 21.10, 20.43, 22.70 and 22.40g for control and three zeolite treatments, respectively.

Nile tilapia were fed on a commercial diet containing 30% crude protein for six days/week at a daily feeding rate of 3% of an average fish-body weight twice, once at 9.00 am and the other at 3.00pm during the experimental period in each pond. The trial lasted for 16 weeks. It started on the 15th of July and harvesting was done on the 15<sup>th</sup> of November 2018 in which the following cultural practices were done. Fish were fed on a 35% - floating protein ratio at a rate of 3%- from the fish weight

### Sampling:

Water sediments were collected monthly and fish samples biweekly from each pond. Water samples were taken from different places at each site by a PVC tube column sampler at half meter- depth from the water surface. The samples at each site were mixed in a plastic bucket and a sample of 1 liter was placed in a polyethylene bottle, kept refrigerated and transferred cold to the laboratory for analysis. Sampling of bottom sediments (from the upper 10 cm surface layer) was taken using Peterson grab as described by (Boyd and Tucker (1992) and was kept in cleaned plastic bags. The wet sediment samples were dried by air

### Laboratory Analysis.

#### Water quality parameter

Hydrogen ion concentration (pH) was measured with pH meter (Model 25, Fisher Scientific). Total dissolved solids (TDS as g/l) were determined using salinity-conductivity meter (model, YSI EC 300). Temperature and dissolved oxygen were measured by using a digital oxygen meter (Model YSI 55). The concentration of total hardness (mg/l as CaCO<sub>3</sub>), total ammonia (NH<sub>4</sub>-N+NH<sub>3</sub>-N), unionized ammonia (NH<sub>3</sub>-N), nitrite (NO<sub>2</sub>-N) and nitrate (NO<sub>3</sub>-N) was measured by methods described in Boyd and Tucker (1992). Transparency (cm) was measured by using a Secchi Disc of 20cm diameter. Heavy metals were extracted with conc. HNO<sub>3</sub> and HCl were preserved in a refrigerator till being analyzed for Fe, Zn, Mn, Cu, Cd and Pb concentration as µg/l (EPA. 1992). Measuring conductivity is a quick and easy way to estimate the amount of total dissolved solids (TDS) in natural waters, since most of these

solids dissolve to form ions. Whereas total dissolved solids can include organic as well as inorganic molecules, conductivity depends only upon dissolved ions. For water used for agricultural and irrigation purposes the values for EC and TDS are related to each other and can be converted with an accuracy of about 10% using the following equation: TDS (mg/l) = 640 × EC (ds/m or ms/cm).

#### Heavy Metals residues in fish.

At the end of the experiment, (20 fish from each pond) of examination, musculature were collected separately and metals were extracted by HNO<sub>3</sub> and HCl according to the methods described in Sediment samples were extracted with HNO<sub>3</sub>, HCl acid and H<sub>2</sub>O<sub>2</sub> according to EPA (1996). Atomic Absorption Spectrophotometer (Model Thermo Electron Corporation) instrument was used to detect metals concentrations which were expressed as µg/g dry wt in both sediments and fish samples. The degree of metal removal (%) (Removal efficiency or Purification rate %) from the investigated treatments was calculated by the following general mathematical equation; where, CI and CT are concentrations (mg/L) in control and zeolite treatments, respectively. the meaning of this part is not clear. The using natural zeolite was calculated by the following mathematical formula;

$$\text{Uptake} = (C_0 - C/C_0) 100\%$$

Where C<sub>0</sub> and C are the initial and final concentration (mg L<sup>-1</sup>).

#### Growth performance parameters

Total fish samples (20 fish from each pond) were taken biweekly during the experimental period. Body measurements (body weight in g and body length in cm) were conducted at biweekly intervals. Throughout the whole experimental period, growth parameters were calculated as follows:

Daily weight gain (DWG) was calculated using the formula:

$$\text{DWG} = [\text{Average W}_2 \text{ (g)} - \text{Average W}_1 \text{ (g)}] / t$$

Where W<sub>1</sub> and W<sub>2</sub> = the initial and final fish weight, while t is the experimental period in days.

Specific growth rate (SGR) was calculated according to Jauncey and Rose (1982) as:

$$\text{SGR} = (\text{Ln W}_2 - \text{Ln W}_1 \times 100) / t \text{ where, } w_1 = \text{first fish weight in grams, } w_2 = \text{final fish weight in grams, } t = \text{period in day.}$$

Fish condition factor (K) was calculated according to Schreck and Moyle (1990) as:

$K = (Wt/L^3) \times 100$  where, Wt is the total gutted weight of the fish (g), and L is the total length (cm).

### Statistical Analysis

Statistical analysis was carried out by using SPSS statistical package

Program version 20. One-way ANOVA was used for data analysis And the comparison between groups was done using Duncan's test

## RESULTS AND DISCUSSIONS

### Water Quality Parameters of Fish Ponds

The obtained results of water quality parameters of the experimental ponds during the experimental period (120 days) as averages are summarized in Table 2

In general, water temperature averages were 27.50, 28.20, 27.90 and 28.40 °C during the whole experiment period in the four treatments Cont. T1, T2, T3, and T4, respectively. Water temperature did not show very significant differences ( $P < 0.05$ ) among zeolite treatments throughout the experimental period. In general, it is already known that the optimal temperature for feed intake, growth and spawning of the Nile tilapia is 25 - 28 °C (Boyd, 1998)

From table (2), the data of dissolved oxygen (DO) in experimental ponds for all treatments were relatively good for Nile tilapia culture and had averages of 4.41, 4.67, 4.59 and 4.70 mg/l for T1, T2, T3 and T4, respectively. DO of T4 showed higher value (4.70) than other treatments while control showed a relatively low one. The suitable levels of DO concentration for tilapia as a warm water species are 5.0 to 15.0 mg/l or higher to maintain good health and feed conversion (Boyd, 1998).

### Water pH data:

Application of zeolite caused significant differences ( $P < 0.05$ ) Increase in water pH (8.10 in T2 and 8.24 in T3 and 7.92 in T4) was compared with control ponds (T1, 7.51). This may be attributed to the fact that zeolites, in general, are weakly acidic in nature and sodium-form exchangers are selective for hydrogen, which leads to high pH values when the exchanger is equilibrated with relatively dilute electrolyte solutions (Leinonen and Lehto, 2001). Both carbonate and nitrate ions are attracted by the negative charge

within zeolites (Mumpton, 1999). The desirable pH range for most fish species is 7-9 (Boyd 1998).

Meanwhile, the values of the total alkalinity [ $CaCO_3 + Ca(HCO_3)_2$ ] showed significant differences ( $P < 0.05$ ). A decrease in control with a total mean of (392.96 mg/l), while these values increased by increasing zeolite levels in water of T1 and T2 and T3 (413.55, 402.63, 407.23), respectively.

On the other hand, the total hardness ( $Ca^{+2} + Mg^{+2}$ ) also showed significant differences ( $P < 0.05$ ) decrease in control with a total mean of (284.36 mg/l), while such values increased by increasing zeolite levels in water in T3 and T4 (305.14, 309.98 and 311.66 mg/l) for T2, T3 and T4, respectively. On his part, Barker *et al.* (2009) indicated that the desirable range of alkalinity is 50-300 mg l<sup>-1</sup>, but fish survive in waters up to 400 mg l<sup>-1</sup>. This may be referred to the adsorption activity of zeolite for removing positive ions ( $Ca^{++}$ ,  $Mg^{++}$  and/or  $Fe^{++}$ ) from water, which was compatible with the interpretation of (Mumpton, 1999). Also, zeolite can be used for the fixation of phosphates, cleanup of sewerage, and both heavy metal, and ammonium ion removal (Kocakusak *et al.*, 2001). Obradović *et al.* (2006)

The average values of seechi disk readings showed significant differences ( $P < 0.05$ ), increased with increasing the proportion of zeolite in the fish diet as shown in Table 1. T4 recorded the highest value at 26.50 cm, followed by T3, T2 and control T1 at 22.20, 19.90 and 19.10 cm, respectively. Due to its absorption/ adsorption properties and its ability to gain and lose water reversibly (Kocakusak *et al.*, 2001; Xia *et al.*, 2009), zeolite can adsorb the suspended and organic matters and play a role in leaching the water of ponds

From table (2) that zeolite proved itself as reliable corrector of environmental conditions in removing ammonia  $NH_3$  from water and decreasing other water parameters. Accordingly, the results revealed that all parameters of water quality for zeolite treatments were in the suitable ranges and good for tilapia culture than control.

### Nitrogen compound

Application of zeolite significant differences ( $P < 0.05$ ) decreased all the inorganic dissolved nitrogen (Table 3).

The average concentration of unionized ammonia ( $NH_3$ ) was 0.52, 0.39, 0.21 and 0.04 mg/l for Cont T1, T2, T3 and T4, respectively. The concentrations of nitrite ( $NO_2-N$ ) were

0.36, 0.31, 0.19 and 0.11 mg/l during the whole experimental period whereas the concentrations of nitrate (NO<sub>3</sub>-N) were 1.31, 0.91 0.88 and 0.61 mg/l. In this context, Kamal *et al.* (2008) recorded similar data for nitrite (0.02 - 0.03 mg/L). Zeolite preference for larger cations, including NH<sub>4</sub><sup>+</sup>, was exploited for removing NH<sub>4</sub>-N from municipal sewage effluent and has been extended to agriculture and aquaculture applications (Mumpton and Fishman, 1977). It is clear that adding zeolite to water ponds decreases the nitrogen components (Table 1) in water by ion exchange activity and also inside fish body by metabolism activation.

A direct relationship between the mass of zeolite and total ammonia removal was evident (Burgess *et al.*, 2004). The desirable ranges are 0.2-2.0 mg/l for total NH<sub>4</sub>-N, <0.3 mg/l for NO<sub>2</sub>-N and 0.2-10 mg/l for NO<sub>3</sub>- N in fish ponds (Boyd, 1998).

### Heavy Metals.

#### Water

Metals concentration values showed significant differences ( $P < 0.05$ ) for the four treatments (Table 4), where control ponds (T1) had the highest total mean concentrations of all metals (5.771 mg/l) compared to T2 (4.827 mg/l) T3 (4.083 mg/l) and T4 (3.562 mg/L).

Hamed *et al.* (2013) attributed the increase of metals content in water to the decomposition of organic matter in sediments and release of metals to the overlying water. Also, Cu showed the highest accumulated metal in different sites, while Zn was the lowest one.

Natural zeolite, clinoptilolite has the ability to take up heavy metals; Cd, Cu, Fe, Mn, Pb and Zn (Barloková and Jilavsky, 2010). Thus, application of zeolite (clinoptilolite) decreased heavy metals in pond's water and was more effective in T4 this complies with studies which showed that natural zeolites were able to remove cationic heavy metal elements from industrial wastewater.

Moreover, Kocakusak *et al.* (2001) mentioned that zeolites application in wastes increased both heavy metals and ammonium ions removal. Metal ions' removal efficiencies for tested pond's water treated with zeolite are shown in Table 3.

In which, zeolites had selectivity chelated Cd, Pb, Mn and Zn. In the two treatments the selectivity of ions was: Cd > Pb > Mn > Zn > Fe > Cu. The difference in selectivity might be

attributed to ion-exchange processes. Also, data demonstrated the preference of zeolite for Cd and Pb compared to other metals. Similar results were recorded by Shaheen *et al.* (2012) who described more interactions of Pb<sup>2+</sup> and Cd<sup>2+</sup> competing for ion exchange sites in natural zeolite clinoptilolite.

Means with the same letter in each column are not significantly different ( $P \geq 0.05$ ). Zeolite, clinoptilolite as a bulking material has the ability to increase the porosity of the substrate and, as a result, to improve the composting process and the biodegradability of the organic matter. The net negative charge in zeolite is balanced by the positive cations (sodium, potassium, or calcium). These cations are exchangeable with certain cations in solutions such as lead, cadmium, zinc, and manganese (Barrer, *et al.* 1978) and make zeolite suitable for removing undesirable heavy metal ions from industrial effluent waters.

#### Fish:

Metals accumulation in musculature of *O. niloticus* in different treatments are shown in Table 4.

All metals showed significant differences ( $P < 0.05$ ) among different treatments. It was observed that the concentrations of all studied metals in fish reared in T2, T3 and T4 were lower than those reared in control ponds (T1). This may be explained by the assumption that dissolved metals are adsorbed on zeolite (Shaheen *et al.*, 2012). Thus, to decrease metals bioaccumulation in fish. Adding natural clinoptilolite has also reduced water and tissue bioaccumulation of cadmium in Prussian carp (*Carassius gibelio*)

The effect of natural zeolites on the removal of cadmium from water of freshwater cichlid fish, Mozambique tilapia (*O. mossambicus*) ponds was investigated. It was found that the addition of 4 g/L zeolite reduced the concentration of cadmium in water remarkably and eliminated it from fish body, which ultimately improved fish hematological parameters. It was concluded that Cd<sup>2+</sup> ions can bind with the easily exchangeable extra framework Na<sup>+</sup> ion of zeolite resulting lesser free Cd<sup>2+</sup> ions that lead to a lower chance of metal uptake by fish (James 2000)

In study (Noegrohati, 2006), it was found that the abundance of heavy metals in different tissue/organs showed that liver had a high tendency to accumulate heavy metals than musculature. This may be explained as liver is the main target organ for detoxification and

excretion of toxicants besides gills, being the key interface for the uptake of water borne metal from water

### Growth Parameters.

Fish Growth can be simply monitored by measuring the increase of fish weight and length traits Table (6).

Condition factor as an index of growth provides a measure of fatness "plumpness" or "robustness" of fish and food conversion efficiency. Condition factor is frequently assumed to reflect not only characteristics of fish such as health, reproductive state and growth, but also characteristics of the environment such as water quality (Schreck and Moyle, 1990).

Concerning the values of condition factor (k) of *O. niloticus* (Table 5) for different treatments; they were 1.49, 1.49, 1.50 and 1.51 respectively. Control ponds (T1), T2, T3 and T4 where T4 had the highest ( $P < 0.01$ ) K value compared with Fish in control.

Final body weight followed were control ponds T1, T2, T3 and T4 (150.10, 151.30, 152.80g and 155.60 gm), respectively. They showed the highest final body weight followed by T4. Average fish final length at the end of the experimental period was found to follow the same order of final body weight, being 20.70, 21.30, 21.60 and 22.85 cm, respectively (Table 5).

Regarding the survival rate of Nile tilapia, it was improved by adding zeolite in the pond bottom. The highest value of survival (96.4%) was obtained by adding zeolite in the pond bottom (T4), while the lowest (92.9%) was observed for control T1.

These results are in accordance with those obtained by Osman *et al.* (2008), who found a strong correlation between body weight and body length for tilapia. The fluctuations in fish growth (length and weight) are affected by different factors such as feeding regime (Saeed and Abdel-Mageed, 2011) and environmental conditions

On the other hand, the highest averages daily gain and SGR were recorded at T3, (1.44 and 1.47%/day, respectively) followed by T4 (1.59 and 1.58%/day, respectively), while the lowest values 1.15 and 1.41%/day, respectively, were found in control ponds. The good conditions of water quality in T3 and T4 (treated with zeolite) may be the reason for higher harvest weights than those reared in control ponds. The data in the present study

matches the conclusions of Xia *et al.* (2009) who reported that natural zeolite helps to prevent the occurrence of disease and enables to promote growth and survival

Khodanazary *et al.* (2013). Reported that incorporation of 5% clinoptilolite zeolite in the diet of common carp exhibited positive effects on dry matter, protein apparent digestibility coefficients and growth performance Improvement of growth and nutritional parameters was observed using Iranian natural clinoptilolite with different dosages of 4, 10 and 15 g L in rearing freshwater aquarium fish, angel (*Pterophyllum scalare*) (Ghiasi and Jasour 2012).

### CONCLUSION

Application of zeolite in fish ponds improved fish health, disease resistance, water quality parameters, growth parameters and decreased heavy metals accumulation in water, sediment and in organs. However, proximate chemical composition of fish musculature did not significantly vary. Application of zeolite scattered on the pond bottom increased significantly the efficiency of improving pond quality than that put in the bag.

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**Table 1:** Chemical composition of Yemen natural zeolite used in the present study.

Elements	Percentage (%)
SiO <sub>2</sub> (Silicon Oxide)	71.10
Al <sub>2</sub> O <sub>3</sub> (Aluminum Oxide)	13.12
Fe <sub>2</sub> O <sub>3</sub> (Iron III Oxide)	0.91
TiO (Titanium Oxide)	0.01
CaO (Calcium Oxide)	1.54
MgO (Magnesium Oxide)	0.99
K <sub>2</sub> O (Potassium Oxide)	2.40
Na <sub>2</sub> O (Sodium Oxide)	0.90
Al <sub>2</sub> O <sub>3</sub> (Aluminum Oxide)	13.12
Fe <sub>2</sub> O <sub>3</sub> (Iron III Oxide)	0.91

**Table 2:** water quality parameters in different treatments during the experimental period based on) means± SE)

Parameters of water	Treatments			
	Control.T1	T2	T3	T4
Temperature(c)	27.50±0.14 <sup>b</sup>	28.20±0.05 <sup>a</sup>	27.90±0.06 <sup>b</sup>	28.40±0.06 <sup>a</sup>
Dissolved O <sub>2</sub> (mg/l)	4.41±0.12 <sup>c</sup>	4.67±0.17 <sup>a</sup>	4.59±0.15 <sup>b</sup>	4.70±0.12 <sup>a</sup>
PH	7.51±0.012 <sup>d</sup>	8.10 ±0.011 <sup>b</sup>	8.24. ±0.014 <sup>a</sup>	7.92.±0.29 <sup>c</sup>
Total alkalinity (mg/l)	392.96±1.88 <sup>d</sup>	413.55±2.33 <sup>a</sup>	402.63±1.96 <sup>c</sup>	407.23±1.88 <sup>b</sup>
Total hardness (mg/l)	284.36±1.69 <sup>d</sup>	305.14±1.33 <sup>c</sup>	309.98±1.22 <sup>b</sup>	311.66±1.7 <sup>a</sup>
Turbidity	19.10±0.05	19.90±0.06 <sup>c</sup>	22.20±0.07 <sup>b</sup>	26.50±0.07 <sup>a</sup>

**Table 3:** Nitrogen compound concentration (mg/L) in water of different treatments Means± SE).

Parameters of water	Treatments						
	Control T1	T2	Rate of Removal%	T3	Rate of Removal %	T4	Rate of Removal %
NH <sub>3</sub> -N (mg/L)	0.52±0.05 <sup>a</sup>	0.39±0.03 <sup>b</sup>	25 %	0.21±0.01 <sup>a</sup>	59.3%	0.04±0.02 <sup>a</sup>	92.6
NO <sub>2</sub> (mg/L)	0.36±0.043 <sup>a</sup>	0.31±0.038 <sup>ab</sup>	13.8%	0.19±0.038 <sup>b</sup>	27.7%	0.11±0.037 <sup>c</sup>	69.4%
NO <sub>3</sub> (mg/L)	1.31±0.002 <sup>a</sup>	0.91±0.001 <sup>b</sup>	30.5%	0.88±0.001 <sup>c</sup>	32.8%	0.61±0.006 <sup>d</sup>	53.4%

**Table 4:** Heavy metals concentration (mg/L) in water of different treatments (Means± SE).

heavy metals	Treatments.						
	Control T1	T2	Rate of Removal %	T3	Rate of Removal %	T4	Rate of Removal %
Cu	2.23±.26 <sup>a</sup>	1.98 ±0.30 <sup>b</sup>	11.2%	1.72 ± 1.29 <sup>c</sup>	22.8%	1.47±0.80 <sup>d</sup>	34.1%
Pb	1.46 ± 0.19 <sup>a</sup>	1.22 ±0.21 <sup>b</sup>	16.4%	0.921 ± 0.21 <sup>c</sup>	36.9%	0.845±0.70 <sup>d</sup>	42.1%
Fe	1.12 ± 0.42 <sup>a</sup>	0.977 ± 0.39 <sup>b</sup>	12.7%	0.906 ± 0.38 <sup>c</sup>	19.1%	0.899±0.70 <sup>d</sup>	19.7%
Mn	0.632 ± 0.29 <sup>a</sup>	0.377 ± 0.40 <sup>b</sup>	40.3%	0.322 ± 0.38 <sup>c</sup>	49.1%	0.274±0.22 <sup>d</sup>	56.6%
Cd	0.210 ± 0.30 <sup>a</sup>	0.196 ± 0.26 <sup>b</sup>	6.6%	0.180 ± 0.28 <sup>c</sup>	14.2%	0.151±0.037 <sup>d</sup>	28.1%
Zn	0.119 ±0.78 <sup>a</sup>	0.077 ± 0.32 <sup>b</sup>	35.2%	0.054 ±0.29 <sup>c</sup>	54.6%	0.049±0.71 <sup>d</sup>	58.8%
Total	5.771	4.827		4.038		3.562	

**Table 5:** Means± SE of heavy metals concentration (µg/g dry wt.) in musculature of *O. niloticus* in different treatments

Heavy Metals	Treatments			
	Control T1	T2	T3	T4
Cu	249.61±0.46 <sup>a</sup>	178.78±0.48 <sup>b</sup>	133.88±0.48 <sup>c</sup>	128.71±0.70 <sup>d</sup>
pb	206.26±0.63 <sup>a</sup>	155.06±0.60 <sup>b</sup>	98.36±0.61 <sup>c</sup>	91.05±0.79 <sup>d</sup>
Fe	46.34±0.10 <sup>a</sup>	33.18±0.11 <sup>b</sup>	31.8±0.11 <sup>c</sup>	31.06±0.49 <sup>c</sup>
Mn	19.12±0.14 <sup>a</sup>	14.36±0.09 <sup>b</sup>	12.9±0.10 <sup>c</sup>	11.2±0.12 <sup>d</sup>
Cd	8.29±0.02 <sup>a</sup>	6.49±0.02 <sup>b</sup>	6.31±0.02 <sup>b</sup>	5.23±0.04 <sup>c</sup>
Zn	8.19±0.03 <sup>a</sup>	6.61±0.03 <sup>b</sup>	5.53±0.03 <sup>b</sup>	4.19±0.06 <sup>c</sup>

**Table 6:** growth parameters of *O. niloticus* in different treatments. It and higher profits. ( Means± SE)

Parameters	Treatments			
	Control T1	T2	T3	T4
Condition factor (K)	1.49±0.11 <sup>b</sup>	1.49±0.12 <sup>b</sup>	1.50±0.11 <sup>a</sup>	1.51±0.10 <sup>a</sup>
Initial weight (gm)	21.10±0.62 <sup>b</sup>	20.43±0.59 <sup>c</sup>	22.70±0.60 <sup>a</sup>	22.40±0.59 <sup>a</sup>
Final weight(gm)	150.10±1.63 <sup>c</sup>	151.30±1.80 <sup>b</sup>	152.80±1.52 <sup>b</sup>	155.60±1.81 <sup>a</sup>
Initial length (cm)	12.20±0.80 <sup>a</sup>	11.70±0.89 <sup>b</sup>	12.40±0.126 <sup>a</sup>	11.90±0.86 <sup>ab</sup>
Final length (cm)	20.70±1.77 <sup>c</sup>	21.30±1.70 <sup>b</sup>	21.60±1.91 <sup>a</sup>	21.85±1.82 <sup>a</sup>
DWG, g/fish	1.15±0.032 <sup>b</sup>	1.16±0.033 <sup>b</sup>	1.44±0.042 <sup>a</sup>	1.59±0.034 <sup>a</sup>
SGR, %/d	1.41±0.059 <sup>b</sup>	1.42±0.054 <sup>b</sup>	1.47±0.028 <sup>a</sup>	1.58±0.027 <sup>a</sup>
Survival rate %	92.9 ±0.11 <sup>c</sup>	94.4 ±0.11 <sup>b</sup>	94.7 ±0.11 <sup>b</sup>	96.1 ±0.11 <sup>a</sup>

**Figure 1:** Commercial natural zeolite, clinoptilolite, granules (3-5mm)

### استخدام الزيوليت الطبيعي (كلينوبتيولايت) في إزالة الأمونيا والمعادن الثقيلة وتحسين جودة الماء وأداء النمو في أحواض الأسماك

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#### الملخص العربي:

يعتبر تراكم النفايات السامة مثل الأمونيا والمعادن الثقيلة هما المشكلتين الرئيسيتين في أنظمة الاستزراع السمكي وفي هذه الدراسة تمت دراسة إمكانية تحسين جودة الاستزراع السمكي باستخدام الزيوليت الطبيعي وهو عبارة عن سيليكات الألومنيوم المائية حيث يسمح الإطار الداخلي له بتبادل الأيونات بينه وبين البيئة المائية. أجريت هذه الدراسة بإحدى المزارع الخاصة التي تعتمد علي استخدام ماء الصرف الزراعي بمنطقة الرياض بمحافظة كفرالشيخ لتحديد تأثير الزيوليت الطبيعي (كلينوبتيولايت) في إزالة الأمونيا والمعادن الثقيلة وتحسين جودة الماء في أحواض الأسماك حيث تم استخدام اثني عشر حوضاً اسمنتياً بطول (2متر وعرض 1متر وارتفاع عمود الماء 1متر) تمثل أربع معاملات تجريبية ثلاث مكررات لكل معاملة (كنترول بدون معاملات) المعاملة الثانية (1 كجم زيوليت /1000 لتر) الثانية (2 كجم زيوليت /1000 لتر) الرابعة (3 كجم زيوليت /1000 لتر) وتم وضع الزيوليت في شبك معلقه في عمود الماء في أول التجربة ثم نثره علي قاع الحوض بعد ذلك وكانت فاعليته أفضل. وتم استخدام إصبعيات البلطي النيل وحيد الجنس بمتوسط وزن ابتدائي 21.10,20.43,22.70,22.40 للكمترول والمعاملة الأولى والثانية والثالثة علي التوالي وأظهرت النتائج مايلي: أن اضافة الزيوليت أدت الي انخفاض معنوي في تركيزات كل من الأمونيا الغير متأينة والنيترت والنترات. كما أن الزيوليت لديه القدره علي امتصاص المعادن الثقيلة مثل الكاديوم والنحاس والحديد والمنجنيز والزنك وأظهرت قيم تركيزات المعادن الثقيلة اختلافات معنوية كبيرة مقارنة بالكنترول وتراكم المعادن الثقيلة في عضلات الأسماك حيث لوحظ أنها أقل من الكنترول. ويفسر ذلك بأن الزيوليت يعمل كمخل جزيئي بالإضافة لخاصية التبادل الأيوني لنا فهو لديه قدرة كبيرة على الحد من التركيزات العالية للمعادن الثقيلة .

الكلمات الاسترشادية: التلوث البيئي، الفضلات، المخلفات السامة، الاصبغيات، البلطي النيل، نمو الأسماك.