Effect of Single Strength Magnetic Field on Some Physicochemical Water Parameters and Performance of *Oreochromis niloticus*

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Abstract:
This study was carried out to investigate the effect of magnetic field on some physicochemical water parameters including (temperature, pH, dissolved oxygen, nitrogenous substances with organic matter, salinity, electrical conductivity, chloride, total hardness, calcium (Ca^2), and magnesium (Mg^{+2}), lead and iron) ; as well as performance and some mineral contents of *Oreochromis niloticus*. 240 out of 300 apparent healthy *Oreochromis niloticus* (21.4 ± 0.39 g) were randomly cultured for 60 days in either control or magnetized water at power of 21.57 Milli Tesla (triplicate tank per treatment). Magnetically treated water had a significantly higher pH; electrical conductivity (EC) and salinity, while iron was significantly ($p \leq 0.01$) lower; nevertheless, other studied water parameters showed non-significant changes. Fish in magnetically treated water showed an improvement in growth performance measures that were significant ($p \leq 0.01$) in weight (g) and length (cm), with weight gain trending upward at the 30th and 60th days. Furthermore, fish mineral levels were improved in the magnetically treated water group as compared to the control group. Our analysis revealed that using a magnetic field with a strength of 21.57 mT in a one cubic meter fish tank for three hours and then resting for one hour improved both water quality parameters and fish performance, and that the magnetic field exposure kept water quality parameters as close or even better than the control group, despite the fact that the minimum water exchange in magnetized water tanks was applied.

Keywords: Magnetic Field, Performance, Nile Tilapia, Water quality.

Introduction:

Increased production, lower relative prices, and less price volatility have all been made possible by advancements in aquaculture technology. A sustainable improvement in global food and nutrition security can only be achieved via policies that acknowledge and protect the complementary and diverse contributions provided by fisheries and aquaculture. ***(Belton and Thilsted, 2014).***

Oreochromis spp. (tilapia) is one of the most widely cultivated food fish species in the world. ***(Renuhadevi et al. 2019).*** According to some, the Nile Tilapia *(Oreochromis niloticus)* is the cheapest and most popular fish in Egypt. Egypt ranks as the largest Nile tilapia producer throughout the entire African continent and 3rd largest world tilapia producer ***(Gafrd, 2014).*** As a result of its rapid growth, capacity to resist disease and stress, and ease of spawning, it has become a popular choice for cultivation ***(Nandlal and Pickering, 2004)***.

Food fish cultivation is facing shortage in access to freshwater resources, mainly because of ongoing global water crisis. Both horizontal expansion in cultivation as well as improvements in production in aquaculture. Fresh water scarcity is a major global concern, with more than 40% of the global population facing this problem. The scenario in coming days is expected to be worse, some authors expect that (there will be no freshwater available to even for human usage) , and thus : access to fresh water for fish culture will be even harder ***(Ajmal et al. 2019).***

The magnetic field has been thoroughly investigated in agriculture and summarized its physiological and biochemical. Magnetic field treatments emerged as alternative, and its practical application and use in the agricultural field has wide application in varied sectors. It has been already used in seed germination, seedling development and yields of different species, like, fodder and industrial crops ***(Kahrizi et al. 2013),*** herbs and medicinal plants, different vegetables and tree species, grasses, ornamentals, and poultry production. Such contributions led to and contribute in decreasing the shortage of nutrition in area facing shortage, like developing countries ***(Abobatta, 2015).***

Since there is a lack of information on the use of magnetic fields in aquaculture, this study was carried out to evaluate the effect of a specified magnetic field intensity (21.57 mT) in fresh water on various physicochemical parameters of water and the performance of fish.

Materials and Methods:

Experimental fish and design

Started with 300 healthy (apparently) *Oreochromis niloticus* weighting an average of 21.4 ± 0.39 g were collected from nursery ponds located at the Central Aquaculture Research Laboratory, Suez Canal University, Ismailia, Egypt, and the fish were acclimatized to laboratory condition for 15 days. The DO for example is maintained at level ≥ 5 mg L^{-1}, temperature of the water was kept about 24 ± 1°C, and a cyclic photo period of 12 hours light then 12 hours dark**,** photoperiod was adopted according to ***(Veras et al. 2013)*** using fluorescent tubes as a light source. Ammonia (NH_3) levels in the water were kept controlled, and were measured every other day (3 times a week), and its levels did not exceed 0.05 mg $L^{-1.}$ Measurement was done using spectrophotometric phenate methods ***(APHA, 2017).***

Two hundred and forty apparently healthy *Oreochromis niloticus* were randomly assigned to two groups (control and magnetic field systems), each of which was transformed into 1000 L fiberglass tanks with a fish-holding capacity of 40. The experiment was carried out for 60 days. During the trial, continuous aeration was given in the control system to maintain water DO, and one-third of the water volume was replaced every three days. In the second system, on the other hand, the magnetic field device was operated without aeration, and water Self-stirring was performed continuously, one third of the water column was exchanged every 10 days, for removal of the residues and to compensate the evaporation, as the motor draws water from the basins evenly and passes it on to the magnetic field device to treat it and descends into the basins. The electrical panel of the device was set to work 3 hours 180 minutes) and one-hour rest.

Food was provided on daily basis, and fish were fed until apparently satieties, on commercial pellets of 1.5 mL (Skereting 30% protein). The experimental diet was delivered at a rate based on fish body weight, approximately 3% of fish body weight per day, as described by***(Eurell et al. 1978),*** twice daily.

Measurement of some physiochemical parameters of water:

According to ***(APHA2017),*** physicochemical examination of the obtained water samples was performed, including temperature, pH, and dissolved oxygen determination (daily). Furthermore, nitrogenous substances (un-ionized ammonia (NH_3), nitrite (NO_2), and nitrate (NO_3) with organic matter were measured three times each week. Weekly measurements of salinity, electrical conductivity, chloride, total hardness, calcium (Ca^2), and magnesium (Mg^{+2}) were also conducted. At the end of the experiment, iron (Fe) and lead were examined at 60 days in addition. PH was measured, a pH meter was used (Jenway, 370 pH meters, U.K), DO and Temperature were measured using DO meter (Crison OXI 45 P, EU), and EC μS/cm and salinity g/L were measured by means of conductivity meter (Jenway, 4520 conductivity meter, U.K). Ammonia was determined with Phenate method (spectrometry), according to ***(APHA 2017)***, and Nitrite (NO_2^-) was measured and determined according to ***(Epa 1979)*** using UV screening spectrophotometric diazatation method and Nitrate was determined according to ***(APHA 2017)*** by using UV screening spectrophotometric method using 1100 Techocomp UV/visible spectrophotometer. Organic matter (organic carbon) was performed according to modified WB method – Meibus method ***(Mebius 1960).*** Chloride was determined by Argentometric Method according to ***(APHA 2017)***. Total Hardness of the water, levels of calcium, and magnesium were measured using Ethylene diamine tetra acetic acid (EDTA) titrimetric method according to ***(APHA 2017).***

For detection of lead and iron in water samples few drops of nitric acid (0.001% v/v) were added to a portion of the sample to keep the metals in suspension and the samples were kept at less than 5 °C ***(Goan et al.1994)*** using an Atomic Absorption Spectrophotometer (Spectrophotometry) (Thermo Electron Corporation, type S4AA sys.)

Growth performance parameters and mortality rate

Body weight

The initial live body weight of each fish was recorded on day one of an experiment, after which it was measured each month for two months using digital scales.

Body weight gain

The gain in body weight was calculated by subtracting the original body weight from the absolute body weight (g) = final weight – initial weight.

Condition factor (K)

The condition factor (k) of the fish in the experiment was estimated from the following relationship:

K = 100 * W / L (Pauly 1983)

Where,

W = Weight of the fish (in the experiment) in grams

L = The total length of the fish (in the experiment) in centimeters

Mineral content (Iron; Calcium and Magnesium) of Nile Tilapia tissue

Five Fish from each replicate were analyzed as described by the Association of Official Analytical Chemists ***(Mohamed et al. 2010).*** All fish were analyzed for their mineral contents (Calcium, Magnesium, and Iron) of the ashed sample using an Atomic Absorption Spectrophotometer (Spectrophotometry) (Thermo Electron Corporation, type S4AA sys. USA).

Statistical Analyses

Obtained results were statistically analyzed to show Significant Difference by (T- test) at p<0.05 and P<0.01 using SPSS version 22 computer program ***(Inc. 1989-2013)***

Results and Discussion

Dissolved Oxygen (mg/l), Temperature ºC, and pH of water in both systems

The magnetic field treated water showed a trend toward increase in temperature compared to control water system. Slight increase in water temperature in magnetic field exposure tanks could be explained in the light of that magnetic field action changed the water properties, like : specific heat, evaporation amount and decreased boiling point when tap water was exposed to 30 mT field power ***(Wang et al. 2018)*.** This increase could be also due to increase heat absorption from environment in magnetically treated water compared to control. Also, in magnetic treated group water column was changed twice along the experimental period, while in non-treated groups ⅓ water column was changed every day (20 times per 60 days). This result is in agreement with those obtained by ***Ahmed and Manar (2021), Irhayyim and Fotedar (2019), Khater and Ibraheim (2016)***.

In all living organisms , dissolved oxygen (DO) is required in particular for the respiratory process of energy production from lipid, protein, and carbohydrate sources ***(Hochachka and Lutz, 2001)*** and it is a critical characteristic for aerobic metabolism**.** Data illustrated in Table (1) revealed that DO concentration in both systems was almost the same. This is consistent with ***(Al-Ibady 2015)*** who illustrated that found a rise in the DO concentration when magnetic intensity was increased. Aerators aren't needed because the magnetic device can improve water quality. Following the decrease in organic matter that occur in magnetic water, there has been always an increase in the measured dissolved oxygen (DO) ***(Yacout et al. 2015)*.**

In ***(Anzecc2000), (Ayoola and Kuton 2009), (Sithik et al. 2009)*** studies, there was an increase in O_2 after the magnetic exposure. In ***(Abdelkhalek et al. 2021)*** study, DO recorded high significant increase ($P<0.001$) in MW group 6.74 mg/L compared to NW group 5.64 mg/L. ***(Ahmed and Abd El-Hamed 2020)*** reported that DO values measured in magnetized water are higher, compared to control water, there was an aeration in the non-magnetized tanks in all the previous studies.

When it comes to aquatic environments, concentration of hydrogen ion (pH) is the most important regulatory parameter. Despite the fact that the pH value in water treated with a magnetic field system were lower significantly compared to control water ($P\leq 0.001$). This decrease in pH could be attributed to the attraction force of the magnet to some elements, which was found after dis-assembling the system, whereas the inner lumen of the magnet showed some precipitations. In the current investigation, pH in both systems was ranging in the desirable ranges (6.2-8.3) required for aquatic animals' survival and growth ***(Khater and Ibraheim 2016, Korai et al. 2008, Pandey and Tiwari, 2009). (Hassan and Rahman 2016)*** also found that pH levels decreased with exposure to magnetic field. On the other hand, **(Abdelkhalek et al. 2021), (Mabrouk et al. 2016)** found no significant variations in water pH between the magnetized water and the un-magnetized water. However, previous studies have found a decrease in water pH post-magnetization because of an increased level of free carbonate content in water due to a magnetic field's effect on salt dissociation ***(Hasson and Bramson, 1985).*** Because this result differs from those of previous investigations, this difference could be due to a difference in magnetic strength, whereas magnetic field strength they used were able to generate some OH^{-} and water absorbed H+, level used in our study was not enough to do so.

Salinity, hardness, and chloride parameters (mg/l) of water in both systems

Concerning Salinity, hardness and chloride parameters, data shown in Table (1), revealed that magnetic field exhibited a significant ($P \leq 0.0001$) increase in electrical conductivity (EC) (12.77%) and salinity (12.74%), a trend toward decreases in total hardness (6.36%) and magnesium (10.144%).

The present study's enhanced EC is in line with the findings of ***(Hassan and Rahman 2016)*** who studied the effects of magnetic field exposure on water properties by passing water through three magnetic devices of different intensities, and consequently affected the hatchability of A. *salina*. H. Magnetizations of 0.1, 0.15, and 0.2 T were applied once every 5 hours, respectively, and the magnetization increased salinity (psu), conductivity (velocity/cm), and total dissolved solids (mg/L). ***(Browne and Wanigasekera (2000), Soundarapandian and Saravanakumar 2009)*** found that, when the magnetic devices were fixed to generate of 0.10+0.15, 0.15+0.20, and 0.10+0.15+0.20 T, EC led to increased, and the polarization features of molecules and their distribution in magnetized water changed, resulting in changes in the transition character of the electrons. The effect was dependent on the magnetic field's intensity. Water quality can be assessed using the EC, which is a commonly used as an indicator because of its positive correlation with nitrate ions, ammonia, and a range of 26-263 speed/cm values ***(Varga, 1976)***. According to ***(El-Yazied et al. 2011)***, magnetic fields can affect water salinity. Even very low magnetic fields (0.3-0.7 T) can reduce total dissolved solids to a level appropriate for irrigation with magnetized water to remove salinity from irrigated land ***(Alkhazan and Saddiq, 2010)***.

The results obtained by***(Hassan et al. 2018)*** demonstrated that after water was magnetized at a strength of 0.10 T chlorides decreased significantly ($P \leq 0.05$). A drop in Cl content was originally observed, but an increase in Cl content was observed when the magnetic devices were fixed to generate fields at intensities of 0.10+0.15, 0.10+0.20, and 0.15+0.20 T.

There was no statistically significant difference between chloride, total hardness, calcium, and magnesium (mg/l) in control and magnetized water tanks (Table 1). In our study, total hardness and magnesium concentrations revealed a trend toward decrease in control water system than magnetic system. ***(Ahmed et al. 2020)*** state that maximum values of total hardness were plotted in different fish stocks during magnetic water treatment. This high value is because of magnetic exposure, leading to an increase in soluble salts consistent with conductivity ***(Yacout et al. 2015)***, with significant variation in total hardness concentration ($P \leq 0.01$), which is are consistent with the findings of ***(Ebrahim and Azab 2017), (Hassan and Rahman 2016)***.Exposing water to a magnetic field alters its molecular and physicochemical properties, via modifying the nucleus of the water ***(Coey and Cass, 2000, Gehr et al. 1995, Hasson and Bramson, 1985)***. The relaxation of bonds causes the water molecules to align in a single direction and reduces their angle to less than 105 degrees (Song et al. 2013). The degree of water molecule condensation reduces which could lead to larger molecules. Water's TDS can be altered by this process and This study was carried out against the backdrop of serious water quality-related problems in closed-loop aquaculture systems, which adversely affect the growth of aquaculture species. ***(Hassan et al. 2018).***

The current study's findings are in line with those of***(Al-Ibady 2015)*** **s**tudy which was conducted the dipolar magnetized water at different levels of intensities such as: 0.05 , 0.1 and 0.15 T, and its effect on some environmental factors for one species of ostracod animals, *Cypris laevis* , and found that increasing the intensity of the magnetic field increased salinity and total dissolved solids. There were many variables that affect the effectiveness of a magnetic water treatment. These include water composition, magnetic field strength, the rate at which water moves, and how long the water is in the magnetic field. Because of the magnetically altered chemical and physical properties of water, the salts become more soluble when exposed to magnetic fields, ***(Hassan et al. 2018).***

Nitrogenous compounds and organic matter (mg/l)

Regarding the levels of toxic ammonia (NH_3), nitrite (NO_2) and nitrate (NO_3) there were no significant difference between both water treatment systems, while organic matter levels (Figure 1) showed a trend toward decrease in magnetic field system compared to control system, the magnetic field system was conducted with water exchange 1/3 every 10 days during the experiment, but the water column in control system was changed every 3 days.

Our results are partially in accordance with those obtained by ***(Krzemieniewski et al. 2004b)*** who studied the effect of a constant magnetic field on physicochemical parameters of water, and on rearing of larvae of the European sheatfish *Silurus glanis* L. larvae, using intensities ranging from 0.4 to 0.6T. River water was circulated in the aquarium, and both groups were reared for 15 days at an initial release rate (8 fish per liter). They found no change in levels of phosphate, ammonium, organic compounds, or chloride concentrations in the water. In addition, ***(Irhayyim et al. 2020)*** found that magnetized water had no effect on concentrations of ammonia nitrogen, nitrite nitrogen, and nitrate nitrogen. On contrary, In ***(Abdelkhalek et al. 2021)*** study, NH4, NO3 and NO2 levels were significantly decreased in the MW group (0.021, 0.026 and 0.028 mg/L respectively) compared to the NW group (0.034, 0.031 and 0.031 mg/L respectively) (P <0.001). The different results could be explained by the exposure time used in this study and/or the lower magnetic intensity (21.56 mT) compared to that reported by ***(Hassan and Rahman 2016) and (Hassan et al**. **2018)*** Values used (100-200 mT)**.** ***(Tan et al. 2015)*** reported that magnetic field effects are influenced by exposure time, magnetic field strength, and sensitivity for different species. ***(Hasan et al. 2018)*** suggested that increasing the magnetic intensity from 100 mT to 200 mT could reduce the ammonium concentration in aquarium water. ***(Krzemienewski et al. 2004a)*** found that increasing magnetic intensity can reduce ammonia in rearing tanks. Nevertheless, using a constant magnetic field, a reduction in ammonia was also observed in effluent from sewage.

The high reactivity and oxidation potential of these compounds may have reduced the concentration of organic matter in the studied liquids, while the magnetic field boosted the generation of free radicals ***(Krzemieniewski et al. 2003).***

Magnetic fields affect certain parameters of water such as dissolved oxygen, pH value, total hardness and ammonium, leading to improved water quality. Similar results were reported by***(El-Ratel and Fouda 2017), (Ahmed and Abd El-Hamed 2020).*** Also, other studies revealed that magnets can substantially improve quality of the water ***(Hassan et al. 2018, Krzemieniewski et al. 2004 a).***

Lead and iron (mg/l) parameters of water in both systems

Our findings indicated absence of detectable levels of lead in either water system, but iron concentrations decreased significantly ($p \leq 0.01$) in the magnetic field system when compared to the non-exposed group (Table 2), possibly because of the magnetic field's direct impact on water's chemical properties and macromolecules' attraction to it ***(Alkhazan and Saddiq, 2010, Ibraheim and El-Din Darwish, 2013)*** all concur. Because hydrogen bonds between water molecules are broken by magnetic forces, ions split, mix with other elements, and some precipitate, which could explain why the concentration is dropping. The improved motion of some ions under the effect of magnetic field in the high Na concentration solution, damages the hydrogen bonds ***(Alkhazan and Saddiq, 2010)***.

Magnetic fields can improve the technical properties of water. H. The solubility of salt is improved, the rate of crystallization of salt is changed, and colloidal solidification is promoted. Magnetic fields are also known to create asymmetries in hydrated shells as they affect water molecules around charged particles (colloids). Exposure to a magnetic field increases the electrokinetic motion within the colloid. This definitely increases the chances of particles being attracted to each other and obscuring them. Theories about the influence of magnetic fields on the technological processes of water treatment can be divided into his two main categories: crystallization in magnetic water treatment and aggregation of impurities in water systems ***(Fadil et al, 2***Effect of different water systems on Nile Tilapia performance

Data illustrated in Table (3) showed fish performance and mortality rate. It worth mentioning that fish in magnetic field treatment showed an increase in growth performance parameters which were significant ($p \leq 0.01$) in weight (g) and length (cm); while weight gain showed a trend toward increase at 30^{th} 60^{th} days. Additionally, fish condition factor (K) revealed noticeable increase in magnetically-treated water compared to control system after 30 days which was significant ($p \leq 0.01$) after 60 days. These results are in parallel with other results reported by several authors including, ***(Zhang et al. 1987)*** who reported that the fish in magnetically-treated water grew faster than those in ordinary one, ***(Rosen 2010)*** who revealed superior rates of growth and less mortality of juveniles. Also, ***(Tang et al. 2015),*** studied the effect of magnetically treated water in juvenile sea cucumbers and found positive effect on growth. In ***(Mabrouk et al. 2016)*** study, they found a significant difference in growth performance in magnetic water ($P<0.001$). After water being treated for 16 weeks, FW, DWG, CF and SGR were 21.42, 21.89, 30.00, 8.97 and 5.63%

higher in groups of fish reared in magnetic water than in groups of normal water. ***(Abdelkhalek et al. 2021)*** investigated the effects of magnetic fields (0.2 T) on Nile Tilapia (69.86± 0.8) performance for 8 weeks, and they found that weight (FW), weight gain (WG) and daily weight gain (DWG) were affected significantly ($P<0.001$) with feeding rate. (3, 4, 5 %). Additionally, ***(***Ahmed ***and Abd El-Hamed 2020)*** documented a significant difference ($P<0.01$) between treatment mean weight gain values. Also, body length recorded in magnetic water was relatively high, averaging 14.87 cm, and the lowest average in control water reared at 15 fish/m3 he was 14.13 cm. The condition coefficient (K) and specific growth rate (SGR) showed the same trend in their variation, increasing in magnetic water and decreasing in control water. They also reported that the SGR and condition factor (K) values of fish reared in magnetic water were significantly higher than those in control water ($P<0.01$). The highest feed conversion rate (1.43) was found for magnetic water fish in the group fed at 15/m3, significantly superior to control water ($P<0.01$).

Various factors can affect fish growth and feeding. These may include stresses such as diet palatability, digestible energy intake, quality of water and stocking density ***(Carter et al. 2001)***. Magnetized water improves fish growth, nutrient and energy utilization. ***(Hasan et al. 2018)***, ***(Irhayyim and Fotedar 2019)*** concluded that magnetized water improves the growth performance of tilapia and carp.

Furthermore, our results revealed that fish exposed to magnetic water showed superior activity than in control, also there was no mortality detected in magnetic exposed group, on the other hand, the mortality rate was 8.1% in control fish (Table 3). ***(Hassan et al. 2017)*** found no change in the survival rate of tilapia compared to that of the fish in normal water, at magnetic field strength of 0.10, 0.15, and 0.20 T and exposure time of 5, 10, and 15 hours in magnetic water

Mineral content (Iron; Calcium and Magnesium) of Nile Tilapia tissue Iron concentrations revealed non-significant increase in tilapia fish tissues of magnetic treated system compared to control system fishes. While calcium and magnesium concentrations revealed a trend toward decrease in their concentrations in fish tissues of magnetic treated system compared to control system fish (Table 4). High level of iron, which was not significant in fish tissue in magnetic system as compared to control might be due to field effects on iron compound releasing iron ions in the water, while decreased levels of both calcium and magnesium were in consistent with results indicate that level of hardness as well as both calcium and magnesium showed trends towards decrease in

Table (1): *Some physiochemical parameters of water*:

Parameters Treatments		Mean	Std. Error	Increase or decrease % in magnetic treated water
Temperature °C	Control	25.743	0.232	1.239
	Magnetic	26.062	0.237	
DO (mg/l)	Control	4.927	0.36	-17.008
	Magnetic	4.089	0.261	
	Control	8.212^{a}	0.029	-2.679
pH*	Magnetic	7.992^{b}	0.024	
Electrical conductivity (ms)*	Control	646.722^{b}	13.267	12.722
	Magnetic	729^{a}	23.068	
Salinity (g/l)*	Control	0.259^{b}	0.005	12.741
	Magnetic	0.292^{a}	0.009	
Chloride (mg/l)	Control	147.719	4.242	1.504
	Magnetic	149.94	5.284	
Total hardness (mg/l)	Control	163.333	14.485	-6.362
	Magnetic	152.941	10.564	
Calcium (mg/l)	Control	46.76	2.174	-1.176
	Magnetic	‘46.21	1.093	
Magnesium (mg/l)	Control	115.965	13.894	-10.144
	Magnetic	104.201	10.473	

*Means, labelled with different superscript letters, are different statistically (P≤0.0001)

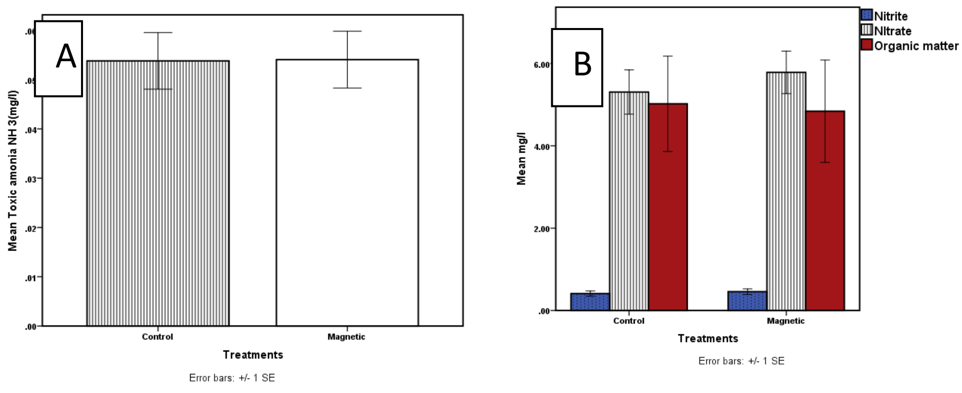

Figure (1): Nitrogenous substances and organic matter (mg/l) in control and magnetized water tanks. (A) Toxic ammonia (NH_3); (B) Nitrite, Nitrate and organic matter

Table (2): *Lead and iron (mg/l) parameters of water in both systems*

TREATMENTS	Iron (mg/l)	Lead (mg/l)
Control	$0.64^{a}\pm0.075$	ND
Magnetic	$0.4^{b}\pm0.0001$	ND

*Means, labelled with different superscript letter within the column, are different statistically (P<0.01) ND = not detected

Table (3) *The effect of different water systems on Nile Tilapia performance*

Days		30 days				60 days				
Treatments	Parameters	Weight (g)	Weight gain (g)	Length (cm)	Condition Factor	Weight (g)	Weight gain (g)	Length (cm)	Condition Factor	Mortalities
Control	Mean	21.75^{b}	8.92	10.52^{b}	1.085	27.94^{b}	8.92	11.15^{b}	0.627^{b}	N=9 (8.1%)
	Std. Error of Mean	0.48	0.71	0.1	0.0325	0.68	0.71	0.09	0.0274	
Magnetic	Mean	25.38^{a}	9.92	11.02^{a}	1.898	32.69^{a}	9.92	11.92^{a}	0.741^{a}	0
	Std. Error of Mean	0.56	0.88	0.11	0.0283	0.85	0.88	0.13	0.0335	

Means, labelled with different superscript letter are different significantly (P≤0.05), magnetized water as compared with non-exposed control group.

Table (4): *Calcium and Magnesium content in Nile Tilapia tissue in both water systems*

Treatments	Iron (mg/kg)	Calcium (g/kg)	Magnesium (g/kg)
Control	34.427±3.44	22.709±1.87	1.088±0.12
Magnetic	35.072±6.38	20.188±1.52	0.993±0.03

Conclusion:

In general, the strength of the magnetic field (21 mT) used proved to be beneficial in improving aquaculture water quality as well as fish performance.

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الملخص العربي

تأثير المجال المغناطيسي أحادي القوة على بعض معاملات المياه الفيزيائية والكيميائية وأداءالبلطي النيلي

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أجريت هذه الدراسة لمعرفة تأثير المجال المغناطيسي (21.57 ملي تسلا) على بعض معاملات المياه الفيزيائية والكيميائية بما في ذلك (درجة الحرارة ، الأس الهيدروجيني ، الأكسجين المذاب ، المواد النيتروجينية مع المادة العضوية ، الملوحة ، التوصيل الكهربائي ، الكلوريد ، الصلابة الكلية ، الكالسيوم (Ca2) ، والمغنيسيوم (Mg + 2) والرصاص والحديد) ؛ فضلا عن الأداء وبعض المحتويات المعدنية من الاسماك. تم زراعة مائتين وأربعين من البلطي النيلي الصحية ظاهريا (21.4 ± 0.39 جم) بشكل عشوائي لمدة 60 يومًا إما في ماء المجموعه الضابطة أوالماء الممغنط (خزان ثلاثي لكل معاملة). كان للمياه المعالجة مغناطيسيا درجة حموضة أعلى بكثير ؛ الموصلية الكهربائية والملوحة ، بينما الحديد كان أقل معنويا ($p \leq 0.01$). ومع ذلك ، أظهرت معاملات المياه الأخرى المدروسة تغيرات غير معنوية. أظهرت الأسماك في المياه المعالجة مغناطيسيًا تحسنًا في مقاييس أداء النمو التي كانت معنوية ($p \leq 0.01$) في الوزن (جم) والطول (سم) ، مع زيادة الوزن تتجه صعودًا في اليومين الثلاثين والستين. علاوة على ذلك ، تحسنت مستويات المعادن في الأسماك في مجموعة المياه المعالجة مغناطيسيًا مقارنة بالمجموعة الضابطة. أظهرت النتائج أن استخدام مجال مغناطيسي بقوة 21.57 ملي تسلا في حوض سمك بمتر مكعب واحد لمدة ثلاث ساعات ثم الراحة لمدة ساعة واحدة أدى إلى تحسين معايير جودة المياه وأداء الأسماك ، وأن التعرض للمجال المغناطيسي يحافظ على معايير جودة المياه أقرب أو أفضل من المجموعة الضابطة ، على الرغم من أن معدل تغيير الماء بخزانات الماء الممغنط كان ⅓ المجموعة الضابطة.

الكلمات المفتاحية: المجال المغناطيسي ، الأداء ، البلطي النيلي ، جودة المياه