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Original research

Effects of Using Magnetized Water on the Quality of Broodstock and Hatching of Tilapia Fish in Egypt

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Abstract:

This study aimed to determine the effects of various techniques of magnetized water on the water quality, broodstock, egg production, fry quality, and growth of red tilapia in Egypt. The red tilapia broodstock was divided into three cement ponds, each of which was divided into two hapas (2m × 3m × 1m), corresponding to two replicates for each treatment with a total of six hapas; each one was stocked with ten fish. Submersible pumps created a closed water circle. Commercial diet containing 44% protein was used to feed the fish. Male and female broodstocks weight 230 ± 20 g and 200 ± 20 g, respectively. Length of male and female broodstocks was 25 ± 5 cm and 20 ± 5 cm, respectively. Two types of magnetic water were compared with normal water for each of the three groups of fish. Group A is the control group (untreated), group B was treated with magnetized water (treated with the Neferttari magnetic device) and group C was treated with a solution of paramagnetic minerals. Among the three groups of fish, magnetized waters (B / C) demonstrated the best results in terms of water quality (D.O mg/I (A) 7.60 ± 0.10, (B) 8.82 ± 0.74, (C) 8.83 ± 0.94), and feed utilization SGR (A) 1.55± 0.26, (B) 1.69± 0.29, (C) 1.73± 0.36. (FCR) in (A) 1.56 ± 0.31, (B) 1.49 ± 0.22, and (C) 1.48 ± 0.20. Condition factor (K) was in (A) 2.07 ± 0.76, (B) 2.28 ± 0.91, (C) 2.31 ± 0.96. Also, a significant difference between the groups in absolute fecundity as for egg production 750±12 in (A), 1250±14 in (B), and 1360±15 in (C) with an increase of 4.83% in (B) and 6.15% in (C) corresponding total lengths of 20–25 cm. Egg diameter (mm) was 0.955 ± 0.09 in (A), 1.020±0.58 in (B), and 1.095 ± 0.49 in (C), hatching rates 534 ± 10 (71.2%) in (A), 1045±15 (83.6%) in (B), and 1100 ± 13 (80.88%)in (C),and Fingerlings Survival Rate 79.5% in (A), 91.0% in (B), and 91.5% in (C)) were checked.
Therefore, the present study recommended that the use of magnetic treated waters in the large-scale aquaculture systems to improve the water quality, reproduction, and growth performance of red tilapia.

Keywords: Magnetic fields, Red Tilapia, Water quality, Growth indices, Egg production, Egg quality, Hatching rate

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1- Introduction

Aquaculture production is a rapidly evolving field that provides a significant portion of the animal protein required by humans. Among all freshwater cultured fish, tilapia species is one of the most important species for global fish production. Tilapia, particularly Nile tilapia (*Oreochromis niloticus*), is considered one of the most cultivated fish species worldwide (**Abdul Qayyum and Ahmed, 1995)** identified 23 different species –starting with tilapia- with potential for aquaculture. Tilapia farming is popular because the species is adaptable to a wide variety of aquaculture systems. Tilapia farming is primarily based on three *Oreochromis* species (*0. aureus*, *0. mossambicus*, and *0. niloticus*) and two Tilapia species (*T. rendalli* and *T. zillii*). Global tilapia culture has exploded in popularity over the last two decades, with more than 130 countries cultivating the fish. Tilapias are the world's second most farmed finfish **(FAO, 2018)**. Egypt has Africa's largest aquaculture industry and the world's third largest after China and Indonesia **(FAO, 2018)** with annual fish production reached two million tons in 2019, achieving 85 % self-sufficiency 1.6 million tons are produced by aquaculture and the remainder originated in the Mediterranean, the Red Sea, the Nile River, and other water bodies **(GAFRD, 2020)**.

Magnetic fields have seen an increase of importance in recent years in a variety of sectors, including agriculture, food processing, wastewater treatment, aquaculture etc. Numerous studies have demonstrated the potential of magnetic treatment in a variety of fields of environmental management **(Ali et al., 2014)**.Magnetized water is gaining significant interest due to its low cost in comparison to physical and chemical treatment **(Ebrahim and Azab, 2017)**; additionally, it is an environmentally friendly method **(Ebrahim and Azab, 2017; Silva and Dobranszki, 2014)**. Magnetic fields have been shown to affect the physio-chemical properties of water, which in turn affect the biological properties of the organisms that consume the water **(El Katcha et al., 2017; Sedigh et al., 2019; Mahmoud et al., 2019)**.

Magnetic field treatment can have an effect on free radicals and biochemical processes by stimulating the proteins and enzymes activity. Additionally, it has a beneficial effect on growth, immune function, protein metabolism, blood parameters, and the levels of digestive enzymes in the majority of organisms **(Moon and Chung, 2000 ; Florez et al, 2007**).

According to (**El-Ashry and Nejib, 1984)** magnetic susceptibility is defined as the ratio of induced magnetization to the strength of the magnetic field that induces it. Magnetic (susceptibility) occurs when the magnetic susceptibility of a mineral with low crystal symmetry or a rock with a planar or linear fabric is not perfectly parallel to the inducing magnetic field due to direction which induced magnetization.

This study aimed to determine the effects of magnetic treated water on the water quality of fish culture by determining the changes in ammonia levels after the water was magnetized by a magnetic field and evaluating the effect of magnetically treated water on broodstock, egg production, larval quality, and growth rate of Red tilapia (*Oreochromis sp*.) in Egypt.

2- Materials and Methods

2.1- Study site

The experiment was carried out at the experimental units, Fish Farming and Technology Institute, Ismailia, Egypt. It lasted for 13 weeks from 21st January to 28th April 2020 (one week without any exposer to the magnetic fields for fish preparation and acclimation followed by 12 weeks of exposer to the magnetic fields for the experiment). The purpose of this study was to determine the effects of various magnetic water treatment techniques on water quality, broodstock, egg production, fry quality, and Red tilapia growth in Egypt.

2.2- Magnetic device

The "NEFERTARI" magnetic device used in this study consisted of a cylindrical trunk of polyvinyl chloride (PVC) with similar sized magnetic pieces which generate a magnetic field with a fixed intensity of 30 µT. The strength of the magnet is related by its magnetic flux density and was measured using a Gauss meter according to (**Ahmed et al., 2020)**.

2.3- Laboratory-combined chemicals that have magnetic properties

The solution (100 mL ≈ 0.016 % of total water body) used in this study was prepared by the research team using natural paramagnetic minerals which were collected from the High Dam Lake in Aswan Governorate (Table1) which have a small positive magnetic susceptibility, with some concerns about Iron toxicity in fish and no previous references or studies regarding Iron toxicity -with the used concentrations- in fish or fish tolerance toward magnetic treatment techniques; the research team prepared a small concentrations-solution with the following components:

Table 1: Chemical analyses of the laboratory combined chemical solution

Components	Concentration (mg/L)
Nitrogen	0.17
Phosphor	0.6
Potassium	6.8
Calcium	37.9
Magnesium	28.7
Iron	650
Copper	3
Manganese	16
Zinc	2

Magnetic (susceptibility) anisotropy, in minerals with low crystal symmetry or in rocks with planar or linear fabric, refers to magnetic susceptibility that is not perfectly parallel with the inducing magnetic field because it depends on direction and induced magnetization. Ferromagnetism is basically a type of magnetic order in which all magnetic atoms in a domain have their moments aligned in the same direction. (**Lindsley et al., 1966)** reported that almost all minerals are diamagnetic or paramagnetic with negative or positive susceptibilities on the order of 10^{-6} cgs. The susceptibility of these minerals is essentially independent of the applied field. Nerveless, for ferromagnetic materials such as iron or nickel, the intensity of magnetization reaches a maximum value within a finite strength of applied field and the susceptibility approaches or exceeds unity.

Paramagnetic Minerals: those do not have a spontaneous magnetic order but having a small positive magnetic susceptibility with magnetic ions that tend to align along an applied magnetic field.

Diamagnetic Materials: have a small negative magnetic susceptibility and do not show Para magnetism or magnetic order. Typical diamagnetic minerals are quartz and feldspar. Coal is a diamagnetic rock. So we can say that rocks have magnetic properties because of the presence of ferromagnetic and paramagnetic minerals scattered among a nonmagnetic (basically diamagnetic) matrix.

2.4- Experimental fish

Red tilapia broodstock was obtained from the hatchery units, Fish Farming and Technology Institute, Suez Canal University, Ismailia, Egypt. Prior the experiment the fish were starved for 24 h and then measured for their body weight and total body length. with a body weight of male 230 ± 20 g and female 200 ± 20 g in average and total body length of male 25 ± 5 cm and female 20 ± 5 cm. The fish were prepared and acclimated for 7 days prior the beginning of the experiment. The fish were fed on the same artificial feed used throughout the experiment.

2.5- Experimental design

The Red tilapia broodstock was divided into 3 cement ponds. Each pond was divided by 2 hapa (3m × 2m × 1m) representing two replicates for each treatment (Figure 1). The total number of hapas was 6; each one was stocked by 10 fish and separated sexually to ensure that there is no previous ovulation cycle or/and the fish is not carrying any eggs.A closed water circle was formed by submersible pumps and a timer (on for 60 min. and off for 30 min). to ensure the maximum water exposure time to the magnetic field. A water exchange rate of 33% / day (the water body is completely changed every 3 days).Two types of magnetized water were compared with normal water for the three groups of fish. Group A is the control group (without any treatment), group B was treated with magnetized water (treated with the Neferttari magnetic device) and group C was treated with laboratory-combined chemicals that have magnetic properties.After one week of acclimation and exposure to the magnetic fields, the groups were placed by sex ratio 1 male to 1 female (1:1) to complete mating and hatching. The eggs were collected and incubated in incubating bottles with the continued use of magnetically treated water on groups (B) and (C) (Figure 1)

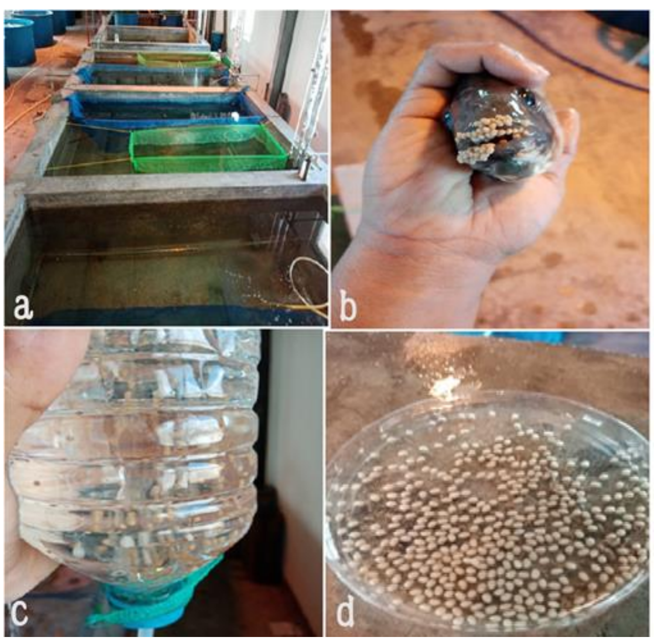


Figure 1: a. The habas used in the experiment, b. Collection of eggs from broodstock, c. artifacial incubation in bottles, d. the producd eggs

Measuring water quality characteristics periodically to evaluate the effect of magnetic treatment on water quality, broodstock's conditions, egg production and fry survivability.A water temperature range (26° ±1.5°) was maintained throughout the entire experiment period with water salinity level of 0ppt.

2.6- Fish Diet

Fish were fed on "Skretting Nutra Tilapia Feed 80" (44% protein) and the chemical composition of the experimental diets as follows:

Table 2: The chemical composition of the experimental diets

Chemical Composition	%
Dry mater	90.1
Crude Protein	44
Fat	6.1
Ash	4.65
Carbohydrate	40.65
Crude fiber	4.6
Organic carbon	37.45
Gross Energy Kcal/ 100g	450.70

For the broodstock: the researcher used "Skretting Nutra Tilapia Feed 80 (44% protein) with a ratio of (4 %) of total biomass in each hapa through the duration of the experiment.

For the larva: the researcher used Skretting Nutra Larva Feed 0 (44% protein) with a ratio of (8 %) of total fry biomass in each hapa.

2.7 Water quality parameters

Freshwater (zero salinity) was used throughout the entire experiment.

2.7.1 Daily water parameters

With the help of an ordinary thermometer graduated in centigrade scale (YSI Model 60/10 FT), the water temperature was recorded on the spot.

The amount of dissolved Oxygen in water (DO) was estimated with the help of a dissolved Oxygen meter (YSI MODEL 58, USA).

The water pH was recorded on spot by pH meter device (YSI Model 60/10 FT).

2.7.2 Biweekly parameters

Water samples were collected from each pond to be analyzed for total alkalinity, total hardness and ammonium were determined according to (**Delfino, 1977 ; APHA, 2000)**.

2.8 Growth performance parameters

The following growth indices were measured

1. Broodstock gained body weight and egg production.
2. Egg development, diameter and hatching rate.
3. Fry survival rate.

Fish were collected from each hapa every two weeks and were put in bucket filled with water and weighted on a scale to get the individual weight (scale capacity: Max: 5000g accuracy: 0.1g).

2.9 Measurements and Equations used in the study

2.9.1 Weight Gain in average (g/fish)

(A W G) = Average Final weight (g) – Average Initial weight (g)

2.9.2 Values for total ammonia (NH_4^+ +NH_3)

$$NH_3 = \frac{NH_4{}^+ + NH_3}{10^{(10.07-033T-pH)}+1}$$

2.9.3 Total body length (BL) was measured by the ruler (cm).
2.9.4 Feed conversion ratio (FCR) = Feed intake (g) / Weight gain (g)
2.9.5 Specific growth rate (SGR % / day) =100 x (LnW_2-InW_1) / T
Where: W_1 = initial weight (g). W_2 = final weight (g).Ln = normal log (Log 10)
T = the number of days in the feeding period.
2.9.6 The total number of ripe eggs in the gonad E= W_g x E_s/ W_e
Where: E = the total number of eggs in a gonad. W_g = weight of the gonad.
E_s = number of eggs in the sample. W_e = weight of eggs in the egg sample.
2.9.7 Relative fecundity was calculated by using the following formula

$$\text{Relative fecundity} = \frac{\text{total number of eggs}}{\text{weight of the fish}}$$

2.9.8 Magnetic susceptibility formula

$\chi_m = \frac{I}{H}$ Where, I is the intensity of magnetization, H is the magnetic intensity

2.9.9 Condition factor (K) reported by (**Schreck and Moyle, 1990)** K= (W / L^3) x l00
Where: W = body weight (g). L = total length (cm).

2.10 Statistical Analysis

Statistical evaluation of results was done by using the analysis of variance (ANOVA) one way to detect the significance of differences of various parameters among the treatments according to SPSS software (version 16). If there was significant different among the treatments Duncan test was performed. **(Duncan, 1955)**

3- RESULTS AND DISCUSSION

Water characteristics:

There were no significant differences in the means of the temperature and total alkalinity between the magnetic water and the control water in different groups. These results agree with the findings of (**Ibrahim and Khater, 2013**; **Irhayyim et al., 2019** and **Ahmed et al., 2020)**. The differences in magnetic intensity could probably be the reason why there was a difference between our results and the findings of the previous studies.

The dissolved oxygen significantly increased from 7.60 mg/L in control water (group A) to 8.82 mg/L in magnetic water (group B) and to 8.83 mg/L (group C) with mean of ($p < 0.01$) (Table 3).pH is the master control parameter in aquatic environment and affects the metabolism and other physiological processes. The data indicated that the pH increased slightly with total means of 8.35 in control water (group A) to 8.84 in magnetic water (group B) and to 8.95 (group C) ($P > 0.01$). The increase of (pH) and water softens could be the reason of the exposure of water to the magnetic field **(Lowe, 1996)**.

The difference in ammonium concentrations between control and magnetic water are shown in (Table 3). There was significant decrease in NH^4 concentration ($P>0.05$) in group A (mean 0.47 mg/L) compared to group B (mean 0.40mg/L) and decreased to (0.39 mg/L) in group C. free radical formation increased by magnetic field, while the high reactivity and oxidation potential of those chemical compounds may have reduced the concentration of organic matter **(Krzemieniewski *et al.*, 2003)**.

The maximum values 158 mg/L were recorded in magnetic water (group C). The high value due to the magnetic exposure which leads to increasing of soluble salts which concurred with the conductivity **(Yacout *et al*., 2015)** The minimum value of total hardness was found in control water (group A) and magnetic water (group B) with mean 147 mg/L and 155 mg/L, respectively.

There was a significant variation in total hardness concentration (P>0.01).Many studies reported that when water is exposed to a magnetic field, its molecules will be arranged in one direction due to the relaxation of bonds and decrease in their angle to less than 105^o (**Lowe, 1996)**, which affects the molecular and chemical properties of water (**Coey and Cass, 2000) ;Cai *et al*.2009)**.

Table 3: Impact of magnetic treated water on selected water parameters

Water parameters	Group A	Group B	Group C	F value
DO mg/L	**7.60 ± 0.10^b**	**8.82± 0.74^a**	**8.83± 0.94^a**	**142.61 ****
Temperature C^O	**27.40± 0.21**	**28.30± 0.92**	**28.40± 0.96**	**0.01**
pH	**8.35± 0.41^a**	**8.84± 0.81^b**	**8.95± 0.91^c**	**13.63 ****
NH_4 mg/L	**0.47± 0.11^b**	**0.40± 0.09 ^{a}**	**0.39± 0.11^a**	**5.18 ***
Total alkalinity mg/L	**177 ± 22.10^a**	**179 ± 26.40^b**	**180 ± 27.60^b**	**0.07**
Total Hardness mg/L	**147 ± 18.70^a**	**155 ± 20.10^b**	**158 ± 22.10^c**	**100.04****

a,b,c: means significant difference at the same row, Means ± standard deviations Remarks: * P ≤ 0.05, ** P ≤ 0.01, *** P ≤ 0.001

The results indicated that the magnetic field has an influence on certain parameters of water as dissolved oxygen, pH, total hardness and ammonium which cause improvement of water quality. Similar results were recorded by (**El Hanoun *et al*. (2017); El-Ratel and Fouda (2017)** ; **Ahmed (2020)**.

Growth performance and feed utilization:

Growth and feed intake in fish could be affected by various factors such as energy intake, feed palatability, digestibility, stressors as stocking density and water quality **(Houlihan *et. al*., 2001)**. The values of the growth parameters and feed utilization are presented in Table (4) and figures (5 and 6).

Table 4: Impact of magnetized water on growth performance and feed utilization

Growth parameters	Group A	Group B	Group C	F value
Initial weight (gr.)	**200±10**	**215±10**	**210±10**	**1.25 ****
Final weight (gr.)	**235±10^b**	**255±10^a**	**260±10^a**	**1.23 ****
Weight gain (gr.)	**35 ± 10^c**	**40± 10^b**	**50± 10^a**	**1.65 ****
Initial body length (cm)	**22 ± 0.5**	**24 ± 0.5**	**23 ± 0.5**	**2.00 ****
Final body length (cm)	**27.20 ± 0.61^b**	**30.30± 0.87^a**	**30.60± 0.94^a**	**9.28 ****
Condition factor (K)	**2.07± 0.76^b**	**2.28± 0.91^a**	**2.31± 0.96^a**	**7.77 ****
SGR %	**1.55± 0.26^b**	**1.69± 0.29^a**	**1.73± 0.36^a**	**1.29 ****
FCR	**1.56 ± 0.31^b**	**1.49 ± 0.22^a**	**1.48 ± 0.20^a**	**1.30 ****

a,b,c: means significant difference at the same row, Means ± standard deviations Remarks: * P ≤ 0.05, ** P ≤ 0.01, *** P ≤ 0.001

The highest means of weight gain (50± 10 gm. and 40± 10 gm.) were recorded in groups C and B respectively. On the other hand, the lowest values (35 ± 10 gm.) were recorded in group A. (Figure 2).There were significant differences (P<0.01) observed among the mean weight gain values of the treatments.

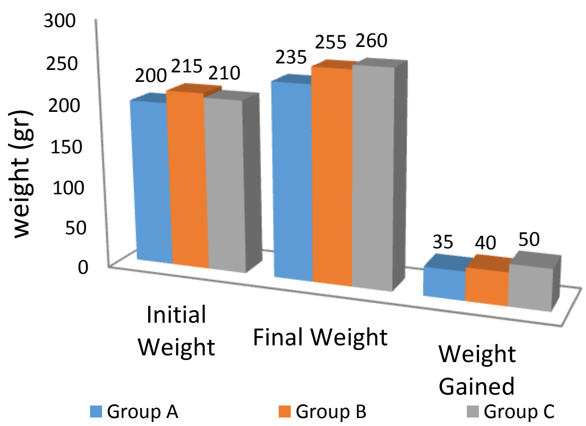


Figure 2: Values of growth parameters and weight gained for Red Tilapia in normal and magnetized water

Similarly, the increase in body length recorded was relatively high in magnetic water with mean value from 24 cm to 30.3 cm in group B and from 23 cm to 30.6 cm in group C and the lowest mean value was from 22 cm to 27.2 cm in control group A. Condition factor (K) and specific growth rate (SGR) exhibited the same trends in its variations where increase in magnetic water and decrease in control water (Figure 3: Condition factor, (K) - and specific growth rate, (SGR) .

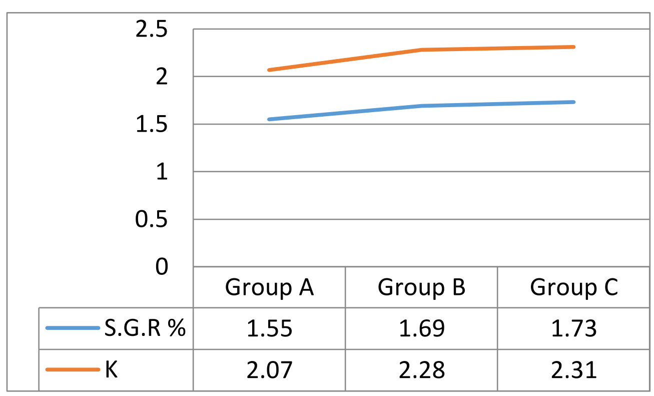


Figure 3: Condition factor, (K) - and specific growth rate, (SGR) % for Red Tilapia in normal and magnetized water

The values of SGR and condition factor (K) of fish reared in magnetic water were higher (P>0.01) than in the control water (Figure 3: Condition factor, (K) - and specific growth rate, (SGR)). The best feed conversion ratio (FCR) was in group (C) 1.48 and group (B) 1.49 than in the control water group (A) 1.56 (P<0.01)

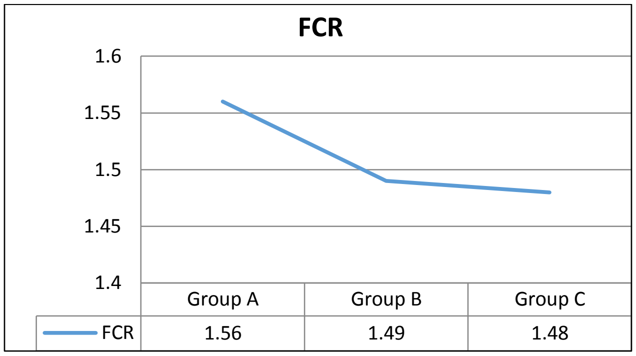


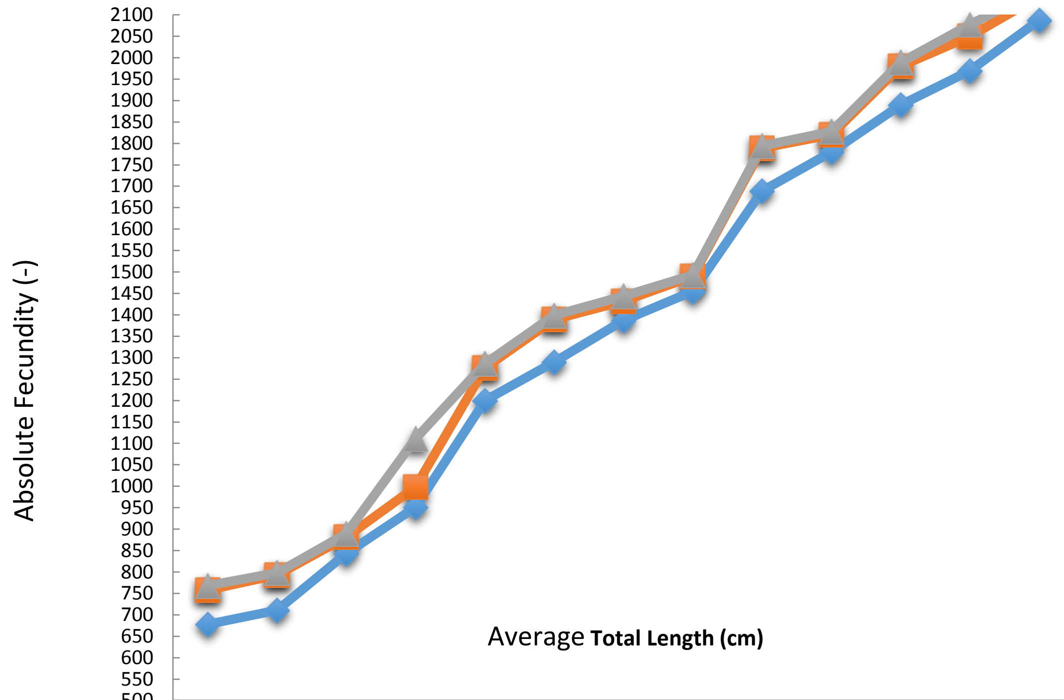
Figure 4: Feed conversion ratio (FCR) of Red Tilapia in normal and magnetized water

The results indicated that growth of fish and feed utilization were improved by the magnetized water. Similarly, (**Mannan *et. al*. 2012; Hassan *et. al*. 2018**; **Irhayyim *et. al*. 2019; Ahmed *et al*.2020)** concluded that magnetized water improved the growth performance of Tilapia and common carp. Despite the most parameters of water were found within the suitable range for fish. These results are coincided with the study of (**Mannan *et. al*.2012)** who reported that if the physico-chemical parameters of water will be in the describe range, stocking density and feeding will be probably maintained then the production will be raised.

Tyari *et. al.(* 2014) stated that magnetic water changes physical, chemical and biological properties of water and it increases the solubility of minerals which eventually improves the transfer of nutrients to all parts of the body. The overall yield has been affected and improved. Also, other studies revealed that the magnetic field can change the water's surface tension, density, viscosity, hardness, conductivity and solubility of solid matter, which changes the properties of water and improve the biological activities of the water, affecting positively the performance of all organisms living in it **(Gabrielli *et al*., 2001; Krzemieniewski *et al*., 2004 and Khudiar ; Ali, 2012)**.

Absolute fecundity:

The absolute fecundity can be identified as the total number of ripe eggs prior to the next spawning period. **(Bagenal, 1978)** stated that absolute fecundity could be determined by counting the number of eggs in the ripe gonads through a gravimetric sub-sampling method. In the final maturation stage of the gonads (stage V), fecundity could be estimated by counting oocytes with the largest diameter **(Duponchellé *et al*. 2000)**. The procedure involved weighing small portion from each lobe of the whole ripe gonads stored in (4% formaldehyde) and taken from the posterior, middle and anterior regions. The total number of ripe eggs in the gonad from a single fish was calculated. The most advanced maturity stage encountered was determined by counting ovaries with GSI larger than 3% in order to determine the absolute fecundity **(De Graaf *et al.* 1999)**. Significance of differences was judged at (**$p < 0.05$**). All statistical analyses were performed using SPSS 13 for Windows **(Landau and Everit, 2004)**. Egg count of red tilapia reared in group (A) was (750 ± 12) increased to (1250 ± 14) in group (B) and (1360 ± 15) in group (C) **(Figure 5)** and **(Table 5)**.



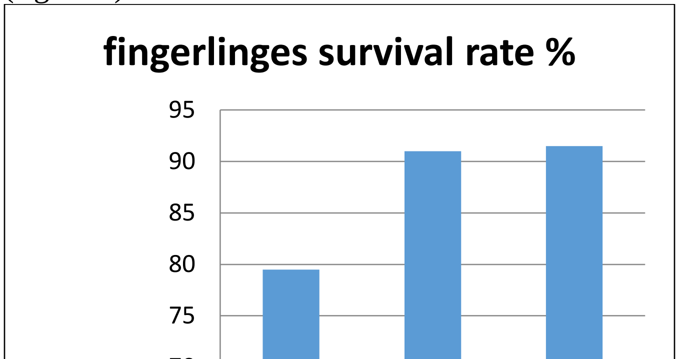
	14.0	14.5	15.0	15.5	16.0	16.5	17.0	17.5	18.0	18.5	19.0	19.5	20.0
Absolute Fecundity (Group A- Normal water)	678	711	843	951	1200	1290	1387	1455	1689	1780	1890	1970	2088
Absolute Fecundity (Group B - Maganetic water)	758	793	881	998	1276	1389	1432	1490	1789	1820	1980	2050	2143
Absolute Fecundity (Group C Maganetic water)	768	798	889	11[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1794	1828	1989	2077	2159

Average egg production

Figure 5: The relation between Absolute fecundity, egg production and means of total Length (cm) for Red Tilapia in normal and magnetized water

Fry survival rate:

The Red Tilapia fry survival rate reared in group (A) 79.5%, increased to 91% in group (B), and to 91.5% in group (C) (figure 6)



	grpup A	grpup B	grpup C
fingerlinges survival rate	79.5	91	91.5

Figure 6: Value of fingerlings survival rate (%) for Red Tilapia in normal and magnetized water

The present study concluded that the fry survival rate in captivity is affected positively by magnetic water treatment. (**Gómez-Márquez *et al*. 2003), Murua *et al*. 2003; Shoko *et al*.2015)** obtained a consistent result.

Egg production:

Egg production could be related to egg count and egg diameters. The egg production of group (A) ranged from 750 to 1250, group (B) increased to 758 to 2143, and group (C) increased to 768 to 1360.With the corresponding total weight of 230 – 250gm., respectively (**Table 5**).These results are consistent with the results obtained by **Gómez-Márquez *et al*. 2003 ; Murua *et al*. 2003 ; Peterson *et al*., 2004 ; Shalloof and Salama,2008)**.

Table 5: The Absolute fecundity, egg diameter and hatched fry for Red Tilapia in normal and magnetized water

Egg production	Group A	Group B	Group C	F value
Fish weight (gr.)	230 ± 7.89	240 ± 8.11	250 ± 9.34	40.22**
Average of egg count	750 ± 12[c]	1250 ± 14[b]	1360 ± 15[a]	90.88**
Total of egg production	17,932[c]	18,799[b]	19,035[a]	90.55*
Average of egg production / fish	3,586.4[c]	3,759.8[b]	3,807[a]	20.55**
% of increase in egg count	---	4.83 %[b]	6.15 %[a]	9.77 **
Fecundity of fish	0.1559 %[b]	0.1567 %[a]	0.1523 %[c]	9.2***
Egg diameter (mm)	0.955 ± 0.09[c]	1.020 ± 0.58[b]	1.095 ± 0.49[a]	11.38**
Hatched fry	534 ± 10[b]	1045 ± 15[a]	1100 ± 13[a]	8.67*
Hatching %	71.20%[c]	83.60%[a]	80.88%[a]	8.88*

[a,b,c:] means significant difference at the same row, Means ± standard deviations Remarks:
* $P \leq 0.05$, ** $P \leq 0.01$, *** $P \leq 0.001$

4- Conclusion and Recommendations

The present study demonstrated that the magnetic field has positive influence on certain water parameters as dissolved oxygen, pH, total hardness and ammonium which cause improvement of water quality. But in the means of the temperature and total alkalinity between the magnetic water and the control water there were no significant differences.

As for the values of the growth parameters and nutrient utilization the highest means of weight gain in groups (B and C) 40 gm. and 50 gm., respectively were recorded in magnetic waters. Feed utilization SGR (A) 1.55± 0.26, (B) 1.69± 0.29, (C) 1.73± 0.36. FCR in (A) 1.56 ± 0.31, (B) 1.49 ± 0.22, (C) 1.48 ± 0.20. Condition factor (K) was in (A) 2.07 ± 0.76, (B) 2.28 ± 0.91, (C) 2.31 ± 0.96.

Between the two systems (normal and magnetic water) there was significant difference in absolute fecundity as for egg production 750±12 in (A), 1250±14 in (B), and 1360±15 in (C) with an increase of 4.83% in (B) and 6.15% in (C) corresponding total lengths of 20–25 cm, respectively.

Egg diameter (mm) was 0.955 ± 0.09 in (A), 1.020±0.58 in (B), and 1.095 ± 0.49 in (C), hatching rates 534 ± 10 (71.2%) in (A), 1045±15 (83.6%) in (B), and 1100 ± 13 (80.88%)in (C),and Fingerlings survival Rate 79.5% in (A), 91.0% in (B), and 91.5% in (C).

Therefore, this study recommends using magnetic treated water in the large scale aquaculture systems to improve water quality, reproduction and growth performance of Red tilapia.

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