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Impact of magnetic water treatment technology on water parameters, growth performance and blood parameters of the Nile Tilapia (*Oreochromis niloticus)*

Norhan H. Ahmed*[1], and Nadia N. B. Abd El-Hamed[2]
[1]Department of Animal production, Faculty of Agriculture, Zagazig University, Egypt
[2]Department of Basic Science, Labor University, Kafr El-Sheikh, Egypt
*Corresponding author: hamednourhan55@gmail.com

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ABSTRACT
The study was conducted to evaluate the effects of magnetic water treatment technique on water parameters and the Nile tilapia (*Oreochromis niloticus*). Magnetic water at 2000 gausses was used compared with normal water for triplicate groups of fish, which reared with different stocking densities 15 fish / m^3, 20 fish / m^3 and 25 fish / m^3 and each group was replicated with 5g / fry an average initial weight. Fish were fed on commercial diet (40% protein). The tanks in the two groups were supplied with air pumping and filtration system. The results revealed that dissolved oxygen, pH and total hardness values in magnetic water increased as compared to control water, but ammonia was inversely related to magnetic field, while total alkalinity and water temperature were not affected by treatment. The data indicated that growth performance, feed utilization, water parameters, some blood parameters and body composition improved and significantly in magnetic water treatment between different stocking densities. The results pointed that, the stocking density of 15 fish/m^3 with magnetized water was the best system where it has high water quality, growth performance and blood parameters of *O. niloticus* compared with other stocking densities.

INTODUCTION

In recent years, there is an increase in the use of the electromagnetic field in different sectors such as agriculture, food processing, wastewater treatment, aquaculture and others. The potentials of magnetic treatment in different fields of environmental management have been highlighted in different studies (Ali *et al*., 2014)**.** The use of magnetic field to improve water quality is significant interest due to low cost compared to chemical and physical treatment (Ebrahim and Azab, 2017), also it is an environmentally friendly way (Silva and Dobranszki, 2014). Studies revealed that exposing water to magnetic field influences the water's physiochemical properties which 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 transfers water from dead to live (Hussein *et al*., 2015). Several researches proved the positive effect of magnetized water on all living cells (Smirnov 2003 & Yacout *el al.*, 2015). Water and water-based solutions that pass through magnetic fields acquire a finer and more homogeneous structure as various minerals are dissolved and removed, this increases fluidity and improves the biological activity of these solutions which positively affect the performance of humans, animals and plants that consume or absorb them (Cho and Lee, 2005 & Al.Hilali, 2018).Magnetic field treatments through stimulating the activity of proteins and enzymes can influence free radicals and overall biochemical processes (Moon and Chung, 2000 & Florez *et al*, 2007). Also, it has a positive effect on growth, immune status, proteins metabolism, blood parameters and digestive enzymes levels in most organisms. Rosen (2010) and Zhao *et al*. (2015) reported that magnetic biological technology offers a number of advantages over traditional chemical treatments and has been shown to improve growth rates and reduced the mortality rate.

Aquaculture production is a highly progressive field and it covers large portion of the requirements of protein for human. Among all cultured freshwater fish, Tilapia species specially Nile Tilapia (*Oreochromis niloticus*) has the greatest importance in global fish production, since it is considered the most widely farmed type of aquaculture in the world. Since protein is the most expensive component of feed items, inclusion of protein in its optimum amount will enable us to develop cost- effective dietary formulations. To optimize the protein level in fish diets, data on the essential amino acids requirements and bioavailability are needed. Determining the essential amino acid requirements of cultured fish is of extreme importance due to the significant effects of these nutrients on muscle deposition, feed costs and nitrogen pollution (Small and Soares 1999). Therefore, the overall goal of our studies is to set up and evaluate new ways to increase the productivity of Tilapia fish. Particularly, the Nile Tilapia (*Oreochromis nilolicu*s) through modulating its nutritional regime or modulating its water ecosystem.

However, the application of the magnetic treatment in aquaculture sector is still a new approach of several studies have been conducted to test the effect of magnetic field on aquaculture as Jamabo *et al*. (2016); Hassan et *al.* (2018) & Hassan et *al.* (2019). Therefore, the purpose of this study was to evaluate the influence of using magnetic treated water and stocking density on water quality, growth performance, feed utilization, body composition and blood parameters of Nile Tilapia (*Oreochromis nilolicus*).

MATERIAL AND METHODS

Magnetic devices

The Neferttari magnetic devices used in the current study each consisted of a cylindrical trunk of polyvinyl chloride (PVC) with similar sized magnetic pieces. The magnetic pieces generate a magnetic field with a fixed intensity of 2000 gausses (where one gauss equals 10^{-4} Tesla). The strength of the magnet is related by its magnetic flux density, and was measured using a Gauss meter.

Experimental design

The present study was carried out to investigate the effect of magnetic water treatment technique on Nile tilapia (mono sex) in aquaria of 25x35x80 cm each were used, stocked by the rate of 15, 20 and 25 fish/m^3 with initial average weight 5 ±0.2 g /fish from the hatchery of Central Laboratory for fish research, belonging to Ministry of

Agriculture, Egypt. Fish were fed on commercial diet (40% protein). Magnetic water at 2000 gausses was used compared with normal water for the three groups of fish. The magnetic devices used in the experiment which lasted for 4 months.

Water quality analysis

Water quality measurements were taken daily: temperature, dissolved oxygen (DO) and pH values using pH meter. Measurements of total alkalinity, total hardness and ammonium were determined according to (APHA, 2000).

Fish growth measurements

Fish were collected from each tank every two weeks and were put in bucket filled with water and weighed on a scale in order to get the individual weight. The weight gain (g/fish) was calculated using the following equation**:**

Body weight gain = Final weight (g)-Initial weight (g).

Total body length (BL) was measured at the end of experimental by the ruler (cm). Condition factor (K) was calculated using the following equation according Schreck and Moyle (1990).

$$K = (W / L^3) \times 100$$

Where, W= body weight (g), and L= total length (cm).

Feed conversion ratio (FCR) and specific growth rate (SGR) were determined by using the following equations:

$$FCR = \text{Feed intake (g)} / \text{Weight gain (g)}.$$

$$SGR = 100 \times (\ln W2 - \ln W1) / T$$

Where W1 are initial weight and W2 final weight (g), T is the number of days in the feeding period.

Eight fish from each tank were weighed and dried at 60 ^{o}C for 3 hours. The proximate composition was done according to standard AOAC (1997) methods.

Blood Parameters

At the end of the trial, fish were not fed for 24 hr., immediately prior to blood sampling. Fish per each tank were an anesthetized with buffered tricaine methane sulfonate (30 mg/1). Three fish were taken from each aquaria and prepared for blood analysis. The blood samples were obtained from the heart of the fish with a hypodermic syringe and were collected in sterilized tubes. The separation of blood serum was completed by centrifugation for 20 minutes at 3000 rpm, blood hemolysis was avoided. Serum total protein, albumin, globulin, triglycerides and cholesterol determined according to Reitman (1957). Serum total protein (g/dl), albumin (g/dl), and cholesterol (mg %) were determined colorimeterically using kits supplied by El-Nasr Pharmaceutical Chemicals Co. (Egypt) (Henery, 1974). Serum globulin (g/dl) levels were obtained by differences between total protein (g/dl) and albumin (g/dl) according to Sundeman, (1964). Serum triglycerides (mg/dl) were determined colormetrically using commercial kits of Bio-diagnostic Co. (Egypt).

Statistical Analysis

Statistical evaluation of results was carried out 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).

RESULTS AND DISCUSION

Effect of magnetic water and stocking density on selected water parameters

There were no significant differences in the means of temperature and total alkalinity between the magnetic water and the control water in different stocking groups (Table 1). These results are in agreement with the findings of Ibrahim and Khater (2013) & Irhayyim *et al.* (2019). The differences between our results and the results of the other studies could be related to the differences in magnetic intensity.

The dissolved oxygen significantly increased ($p<0.01$) with mean from 7.83 mg/l to 8.73 mg/l in control and magnetic water, respectively in fish groups reared at 15 fish/m^3 ,which were more than in fish groups reared at 20 and 25 fish/m^3. Similar results were recorded by Hassan *et al*. (2017), Ebrahim and Azab (2017); Hassan *et al*. (2018) & Mahmoud *et al*. (2019). Al-Ibady (2015) pointed that the increase in magnetic intensity led to an increase in dissolved oxygen concentration compared to normal water (control) this insure that magnetic device improve water quality. The increase of dissolved oxygen may be due to the decrease in organic matter in magnetic water (Yacout *et al*. 2015).

Hydrogen ion concentration (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 8.36 and 8.76 in control and magnetic water, respectively. The lowest mean values (7.90 and 8.30, respectively) were in fish groups reared at 15 fish/m^3 in two treatments. There was a significant difference in pH measurement ($P>0.01$). The exposure of water to magnetic field softens the water and increase the pH (Lowe, 1996). This was supported by Hasson and Bramson (1985) who reported an increase of 12 % in water pH post-magnetization. High pH value probably related to the increase in free carbonate content in water according to the salt dissociate due to magnetic field (Alabdraba *et al*., 2013).

The difference in ammonium concentrations between control and magnetic water are shown in Table (1). There was significant decrease in NH4 concentration ($P>0.05$) in magnetic water (mean 0.28 mg/l) compared to control water (mean 0.32 mg/l) in fish groups reared at 15fish/m^3. The results are in accordance with the studies of Hassan *et al*. (2018). The magnetic field increased the free radical formation while the high reactivity and oxidation potential of those chemical compounds may have reduced the concentration of organic matter contained in the analyzed liquids (Krzemieniewski *et al*., 2003). The lowest value of ammonium may be as the result of oxidizing ammonia into NO2 and NO3 (Abdo, 1998). While the maximum value of ammonium in fish groups reared at 20 and 25 fish/m^3 may be attributed to higher pH and high stock of fish. The results are in agreement with Konsowa (2007) who reported that ammonia concentration was correlated with the amount of stocked fish population.

Total hardness, the minimum value was found in control water and magnetic water with mean 145.93 mg/l and150.07 mg/l, respectively in fish groups reared at 15 fish/m^3. The maximum values were recorded in magnetic water treatment in different fish stocking groups. The high value due to the magnetic exposure which leads to increasing soluble salts which concurred with the conductivity (Ycout *et al.*, 2015).There was a significant variation in total hardness concentration (P>0.01).This is coincided with findings of Hassan and Abdul Rahman (2016) & Ebrahim and Azab(2017).

Table 1: Impact of magnetic treated water and stocking density on selected water parameters (means ± standard deviations).

Parameter	Control water				Magnetic water				F value
	15 fish/m^3	20 fish/m^3	25 fish/m^3	Total mean	15 fish/m^3	20 fish/m^3	25 fish/m^3	Total mean	
Do mg/l	7.83±0.20	7.80±0.10	7.50±0.0	7.71±0.19	8.73±0.20	8.4±0.15	8.5±0.00	8.54±0.18	142.63**
T (C^o)	28.47±0.15	28.33±0.32	28.47±0.15	28.42±0.20	28.69±0.06	28.83±0.28	28.69±0.23	28.7±0.0	0.01
pH	7.90±0.10	8.63±0.32	8.57±0.32	8.36±0.42	8.30±0.17	9.27±0.25	8.70±0.32	8.76±0.46	13. 62**
NH4 mg/l	0.32±0.02	0.37±0.06	0.53±0.08	0.46±0.17	0.28±0.02	0.43±0.1	0.67±0.06	0.41±0.11	5.19*
T.alk mg/l	153.3±18.4	185.7±30.1	190.7±42.6	176.6±32.8	166.7±33.3	178.3±28.7	189.3±47.6	178.1±33.9	0.07
T.H. mg/l	145.93±2.0	150.0±0.0	153.0±3.6	149.64±3.7	150.07±3.9	170.0±0.0	167.0±3.6	162.36±9.7	100.03**

* P ≤ 0.05 ** P ≤ 0.01 *** P ≤ 0.001

Many studies reported that when water is exposed to a magnetic field, its molecules will be arrange 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).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 Hanoum *et al*. (2017) & El-Ratel and Fouda (2017).

Effect of magnetic water and stocking density on selected Serum biochemical parameters of Nile Tilapia (*Oreochromis niloticus*)

Biochemical parameters can be used to evaluate the health of aquatic organisms and ecosystems (Loghmannia *et al*. 2015). The effects of magnetic treated water and stocking density on some selected serum parameters including: total protein, albumin, globulin, triglyceride and cholesterol at the end of the experiment were showed in the Table (2). The data revealed that decrease in triglyceride and cholesterol in magnetic water more than control water. But the statistical analysis of the results showed a significant increase in total protein, albumin and globulin in magnetic water treatment compared with control water (P> 0.05, 0.01). The highest mean values of total protein, albumin and globulin (6.85, 4.57 and 1.86 g/dl, respectively), (6.37, 4.37 and 1.67 g/dl, respectively) were in fish groups reared at 15 fish/m^3 in two treatments. Elevation of blood total proteins by magnetic water treatment may play positive role in increasing the growth and the consumption of protein to build somatic cells (Yacout *et al*.,2015). Also the change in protein metabolism and magnetic field also interacts directly with electrons in DNA to affect protein biosynthesis (Schmidt *et al.*, 2009& Khudiar and Ali, 2012). The obtained results are similar to the study of Nofouzi *et al*., (2015); Ebrahim and Azab (2017) and Al. Hilali (2018). But disagree with Hussein *et al*., (2015)and Hassan *et al.* (2018). The effect of magnetic water on blood parameters may be different according to the species, intensity and duration of magnetic field (Sedigh *et al*., 2019).

Table 2: Impact of magnetic treated water and stocking density on selected Serum biochemical parameters of Nile Tilapia *(Oreochromis niloticus)*.

parameters	Control water				Magnetic water				F value
	15 fish/m^3	20 fish/m^3	25 fish/m^3	Total mean	15 fish/m^3	20 fish/m^3	25 fish/m^3	Total mean	
Total protein (g/dl)	6.37±0.15	6.20±0.17	6.03±0.11	6.20±0.20	6.85±0.18	6.08±0.24	6.33±0.28	6.42±0.40	5.38*
Albumin (g/dl)	4.37±0.06	3.70±0.17	3.53±0.15	3.87±0.4	4.57±0.06	4.18±0.14	3.85±1.13	4.2±0.32	39.82**
Globulin (g/dl)	1.67±0.06	1.63±0.15	1.62±0.13	1.64±0.11	1.86±0.12	1.72±0.10	1.77±0.15	1.78±0.13	5.35**
Triglycerides (mg/dl)	168.23±30.2	170.57±17.9	169.23±14.4	169.34±19.5	169.57±29.9	171.63±20.1	170.8±19.4	170.7±20.5	0.61
Cholesterol (mg/dl)	146.5±7.4	148.47±20.5	148.67±20.6	147.88±15.1	144.5±20.9	150.33±20.3	150.33±30.1	148.39±19.1	0.46

* P ≤ 0.05 ** P ≤ 0.01 *** P ≤ 0.001

Effect of magnetic water and stocking density on proximate composition of Nile Tilapia *(Oreochromis niloticus*)

The obtained results indicated that all body composition parameters insignificantly affected with stocking fish density (Table 3). The data showed decrease in crude protein and ash, on the other hand dry matter, ether extract and gross energy, slightly increase in fish groups reared at 25 fish /m^3 compared to those reared at 15 and 20 fish /m^3. These results are in accordance with the findings of Mahmoud (2007) who found that body composition of Nile tilapia was insignificantly affected by stocking density. There were significant variations in all studied body composition parameters (P>0.01,0.05) affected with water treatments. Where were higher in magnetic water than control water. The results are in accordance with the study of Hassan *et al.*, 2019, who reported that in magnetic the fish were more efficiently converting food into muscle and energy.

Table 3: Impact of magnetic treated water and stocking density on proximate composition (means ± standard deviations) of Nile Tilapia *(Oreochromis niloticus*) .

Parameters	Control water				Magnetic water				F value
	15 fish/m^3	20 fish/m^3	25 fish/m^3	Total mean	15 fish/m^3	20 fish/m^3	25 fish/m^3	Total mean	
Dry matter%	21.55±0.05	21.77±0.25	25.8±0.10	23.04±2.07	22.13±0.32	22.59±0.41	27.0±0.03	23.91±2.3	78.67**
Crude protein%	62.18±1.43	60.83±0.35	38.88±1.33	53.97±11.4	63.43±1.40	61.77±0.15	40.50±0.45	55.23±11.1	14.41**
Ether extract %	15.8 ±0.26	16.88±0.34	17.78±0.41	16.82±0.91	16.82±0.46	17.80±0.26	18.93±1.10	17.85±1.0	48.14*
Ash%	20.8±1.31	18.19±0.45	20.33±1.07	19.77±1.33	21.8±1.31	19.23±0.40	21.55±0.51	20.86±1.3	41.00**
Gross energy	5239.8±2.0	5352.0±1.0	5363.3±3.2	5318.4±59.2	5242.9±1.5	5360.6±1.0	5373.3±3.0	5325.6±62.3	65.05**

* P ≤ 0.05 ** P ≤ 0.01 *** P ≤ 0.001

Effect of magnetic water and stocking density on growth performance and feed utilization **of Nile Tilapia *(Oreochromis niloticus).***

The values of the growth parameters and nutrient utilization are presented in Table (4). The highest means of weight gain (74.85 gm and 71.73gm, respectively) were recorded in magnetic and control water in fish groups reared at 15 fish/m^3 and the lowest values were recorded in magnetic and control water in fish groups reared at 20 and 25 fish/$m^{3,}$ this may be due to density and competition**.** There were significant differences (P<0.01) observed among the mean weight gain values of the treatments. Similarly, the body length recorded was relatively high in magnetic water with mean value of 14.87 cm and the lowest mean value was 14.13 cm in control water in fish groups reared at 15fish/m^3.

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 in different groups of stocking density. The values SGR and condition factor (K) of fish reared in magnetic water were significantly higher (P>0.01) than in the control water (Table 4). The best feed conversion ratio (1.43) was found in fish of magnetic water in groups reared at 15 fish/m^3 and was significantly better than control water (P<0.01). Various factors can influence growth and feed intake in fish and some of these can include feed palatability, digestible energy intake, water quality and stress as stocking density (Houlihan *et. al*., 2001). The results indicated that growth of fish, nutrient and energy utilization are improved by the magnetized water. Similarly, Mannan *et. al*. (2012), Hassan *et. al*. (2018) & Irhayyim *et. al*. (2019) concluded that magnetized water improved the growth performance of Tilapia and common carp.

Table 4: Impact of magnetic treated water and stocking density on growth performance and feed utilization (means ± standard deviations) of Nile Tilapia (*Oreochromis niloticus*).

parameter	Control water				Magnetic water				F value
	15 fish/m^3	20 fish/m^3	25 fish/m^3	Total mean	15 fish/m^3	20 fish/m^3	25 fish/m^3	Total mean	
weight gain	71.37±0.32	57.47±0.21	46.87±0.23	58.57±10.6	74.85±0.56	62.73±1.86	53.33±1.53	63.64±9.	110.9**
body length	14.13±0.5	13.83±0.5	13.73±0.2	13.9±0.42	14.87±0.2	14.20±0.3	14.30±0.1	14.43±0.4	9.30**
k factor	1.23±0.02	2.01±0.11	2.94±0.13	2.06±0.74	1.28±0.01	2.19±0.06	3.05±0.05	2.17±0.8	7.67**
SGR	1.78±0.04	1.61±0.04	1.23±0.06	1.54±0.25	1.87±0.03	1.75±0.05	1.37±0.06	1.66±0.23	38.14**
FCR	1.49±0.04	1.56±0.01	1.59±0.03	1.54±0.1	1.43±0.02	1.48±0.01	1.53±0.03	1.48±0.04	27.08**

* P ≤ 0.05 ** P ≤ 0.01 *** P ≤ 0.001

Moreover, the highest growth parameters were found in fish groups reared in 15 fish/m^3 , it could be due to comparatively lower stocking density and good water quality than other groups(20,25 fish/m^3).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. According to Tyari *et. al*. (2014) magnetic water changes physical, chemical 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 effected and improved organism performance. 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 animals (Gabrielli *et al.*, 2001; Krzemieniewski *et al.*, 2004 & Khudiar and Ali, 2012).

CONCLUSION

The study concluded that the magnetic field affects certain physico-chemical properties of water. However, pH, DO and T.H. water values increased but NH4 was inversely related to magnetic field. The use of magnets to improve quality is of significant interest due to low cost compared to chemical and physical treatments. Magnetic treated water improves some water quality parameters, some blood parameters, feed utilization and growth performance of fish.

Using magnetic force has a vital role in treatment of the polluted water and positive implication for aquaculture. This encourages more researches in this field to overcome negative effects of water pollution.

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