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MANUFACTURED MAGNETIC DEVICE FOR IMPROVING WATER QUALITY AT TILAPIA FINGERLINGS

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The current study focusing to solve the water quality in aquaculture system by manufacturing the magnetic unit with different magnetic flux density 2500 µT and 3500 µT, As well as, study the effect of the magnetic field in agricultural field specially on growth performance and feed intake of Nile tilapia (*O. niloticus*). Three fish tanks selected randomly for the experiment. The experiment was conducted for two production periods. Each period was 24 weeks. The devices were connected to the water inlet of experimental fish tank in which the water passes through the magnetic treatment devices from South Pole to North Pole before filling the tank. The results of laboratory tests show that there are an increase in DO concentration up to 52.6 %, PH value up to 6.2%, and a decrease in NH_3 concentration up to 35.9%with increasing the number of turns through MTD units and with increasing the magnetic flux density to 3500 µT without any considerable change in EC and temperature. In addition, the results of field test show that there are an increase in DO concentration up to 12% in the morning and 12.8% in evening. On the other hand, the decrease of NH_3 concentration up to 48.9% in the morning compared to 64.9% in the evening in tank water when it was exposed to magnetic treatment units without any considerable change in PH, TDS concentration. Tank treated with MTD_2 followed by tank treated with $MTD_1$was superior in water quality parameters as well as growth parameters compared with control tank in the two experimental periods. From the results we concluded that the more we increased the magnetic flux density of the unit with reducing the speed of the water within the unit, the more we increase the effect of magnetic treatment unit on improving water quality parameters. The total power consumption was 0.00384 kW h^{-1} for MTD1 unit compared to 0.01536 kW h^{-1} for MTD2 unit. The cost of Power consumption was 8003.8 EGP/Period for MTD1 unit and 8033.8 EGP/Period for MTD2 unit compared to 7993.9 EGP/Period for control.
Keywords: Magnetism, fish, water quality, aquaculture system.

INTRODUCTION

Most of developing countries are suffering a severe lack of hygienic water, 80% of illnesses in these countries are linked to poor water and sanitation conditions (Annan, 2003). Currently the available water quantity in Egypt is limiting the national economic development (MWRI, 2014). 1000 m^3/capita/year was defined by the United Nations to be the threshold of water scarcity, Egypt has passed that threshold already in nineties and will reach to threshold of absolute scarcity 500 m^3/ capita/year in 2025 (MWRI, 2014). Water quantity and quality are inseparable, as the water quality limits its use. The current rate of deterioration of water quality will increase the acuteness of water scarcity problem and its cost for treatment and management (MWRI, 2014). Tilapia is the third most important cultured fish group in the world, after carps and salmonids (FAO, 2002).Tilapia are currently raised in different types of production systems ranging from pond, tank, cage, flowing water and intensive water reuse culture systems (El-Sayed *et al.,* 2005). In 2014, fish accounted for 17 percent of the global population's intake of animal protein that amount is equivalent to 20 kilograms per capita annually (Bennett *et al.*, 2018). There is a severe need to increase the agricultural productivity in Egypt using the available resources, which requires detailed investigations and appropriate solutions for the challenges facing sustainable aquaculture in Egypt. Fish ponds suffered from problems which decrease the production from these ponds. One of major problem is oxygen depletion during growing warm month. the depletion of oxygen happens when water become warmer it holds less amount of oxygen, respiration rates of both plants and animals increase with warmer water, large amount of feed given to fish result in large quantities of fish waste which create higher demand for oxygen (Jensen *et al.*, 1989). Fish ponds water stratifies into three layers the top layer was warmer and contains more oxygen produced by algae and wind action and most fish are in this layer, the middle layer has less dissolved oxygen and temperature the bottom layer contains cool water with little oxygen and fish rarely enter this area. One of the common ways to overcome the depletion of oxygen and to increase the production efficiency is using aeration system and circulate water ponds by this way it is possible to increase dissolved oxygen in water, reduce the mortality rate, improve water quality . In Egypt the aquaculture farm established in desert land which depends on non-renewable ground water in Western Desert and Sinai suffers from bad water quality and poor dissolved oxygen with total volume of ground water estimated at 40,000 BCM (MWRI, 2014). Water quality is very important to maintain viable aquaculture production. Another important water quality parameter is the concentration of dissolved nitrates, nitrites and ammonia (Schwartz and Boyd, 1994). A high concentration of dissolved nitrates, nitrites and ammonia can induce sub lethal stress to fish and can be toxic to culture organisms and led to decrease resistance to diseases (Boyd, 1998). The magnetic water treatment which is passing water through a magnetic field using a Magnetic Treatment Device (MTD) has been claimed to affect chemical physical water quality and non-conventional method to improve water quality. Currently, there are many of experiments done on magnetic water treatment with a considerable percentage attaining success in the treatment (Hassan, 2015), though the most beneficial magnetic water treatment applications include improvement in scale reduction in pipes and enhanced crop yields with reduced water usage .The magnetic water treatment process has been used for decades; however it still remains in the realms of pseudoscience. If the positive claims of treating water with magnets are true, there will be worldwide beneficial applications (McMahon, 2009). There is need for more investigation to understand the magnetic water treatment, to benefit from its applications especially in the field of agriculture. The major problems facing applications of MTDs are: the lack of fundamental and scientifically acceptable explanation for the magnetic effect on water, and the lack of illustration for the conditions under which the magnetic water treatment is most effective or even works at all (Kenneth and Busch, 1997). This problem still exist until now because there are no new comprehensive studies to understand the magnetic water treatment and how to get benefit from its applications especially in agricultural field (Hassan, 2015). The main objectives of the study are to construct two prototypes of magnetic unit MTD1and MTD2 with different magnetic flux density 2500 µT and 3500 µT respectively, investigate the effect of fabricated magnetic units on water quality employed in aquaculture system in field and laboratory, investigate of the effect of the magnetic units in agricultural field specially on growth performance and feed intake of Nile tilapia (*O. niloticus*).

MATERIALS AND METHODS

The experiments were carried out in a commercial fish farm Elknana fish farm, Wadi natrun, Elbeheira governorate, Egypt located between latitude (30º 10′ 52″ N / longitude 30º 12′ 22″ E). The farm contains forty poly ethylene plastic fish tanks with outer metal frame. Three fish tanks selected randomly for the experiment. The experiment was conducted for two production periods. Each period was 24 weeks. The first experiment started in February 2017 and lasted up to July 2017. The second experiment started in July 2017 and lasted up to December 2017. The magnetic treatment devices are a prototype devices made of 12 layer solenoid coils. Each layer contains 440 turns off wire with wire thickness 0.5mm. The pipes of devices have inner diameter (5.86 cm) and outer diameter (6.032 cm) with wall thickness (0.15 cm). The length of the solenoid coil is 22 cm figure 1a. The cores of devices are made of seamless Carbon Steel Pipe which became the artificial magnet when current is applied to solenoid coil. The magnetic flux density was measured by digital GAUSS /TESLA Meter F.W. bell model 5080, The first device produces 2500 µT /12V/0.32A with power consumption 3.84 watt/h. the second device produce 3500µT/24V/0.64A with power consumption 15.36watt/h. The magnetic flux density was constant for the two fabricated magnetic units through operation time in the two production periods. The devices were connected to the water inlet of experimental fish tanks in which the water passes through the magnetic treatment devices from South Pole to North Pole before filling the tank figure 1b. Every device was connected to Chinese AC/DC adaptor as a power source and produce variable voltage and ampere with output specifications 12v/.32A and 24v/.64A model CYBER made in china figure 1a.

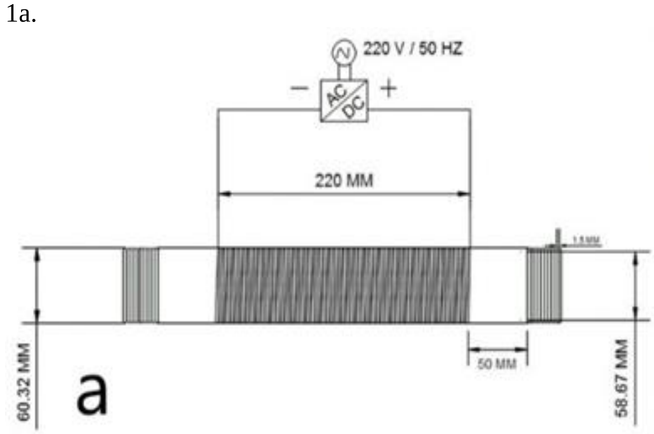

Figure 1. (a) Dimensions of fabricated magnetic device.

Figure 1. (b) the final fabricated magnetic unit.

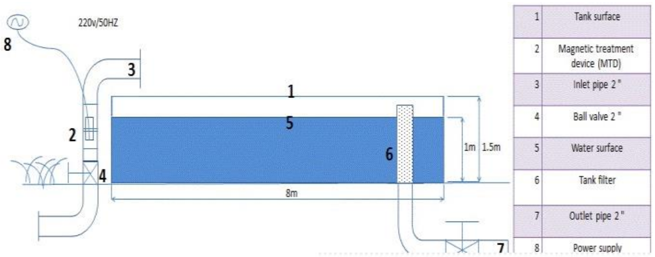

Figure 3. Illustrated the dimensions of the fish tanks used in experiments.

***Procedure and experiments*:** The first device of magnetization (MTD_1) was attached to the inlet water pipe of the first tank. The second device of magnetization (MTD_2) was attached to the inlet water pipe of the second tank. the third tank was taken as a control tank without magnetization unit. The source of water to the farm is artesian well working by electric mixed flow submersible pump model farm through electric mixed flow submersible pump model Caprari, made in Italy with maximum power 93.2 kW and average flow rate100 m^3/h. The average flow rate divided to forty tanks; the flow rate for each tank was 2.5m^3/h. with discharge rate 2.5m^3/h in order to have stable water level in all tanks estimated with 50.24 m^3. A group of 6000 Nile tilapia fingerlings (*O. niloticus*) with an average initial body weight 15.00 g were allotted into 3 polyethylene tanks with diameter 8 m and height 1.5 m with water volume 50.24 m^3, (2000 fish/tank). All tanks fed a control diet containing (30%) crude protein and consisted of fish meal (60%), soybean meal (46%), yellow corn wheat bran, Dai calcium phosphate, mineral mixture and vitamin. mixture, vegetable oils and fish oil. Fish in two periods were fed daily at level of 2% of the fish biomass in the first two weeks of the experiment then fish were fed daily at level of 3 %from the third week until the end of the two experimental period. Three fish tanks were used to test experimental treatment. 54.9% of the water in each aquarium was replaced daily. Photoperiod was adjusted to be 12-hour light and 12-hour darkness using eight florescent light lamps with maximum power 400 W/lamp. The aeration system in the farm consists of 22 air blowers. The first 20 air blower model SKG 250 - 2V.02 was capacity power of 1.1 kW for every air blower and last 2 air blower model GHBH 010361R8 was capacity maximum power of 7.5 kW for each one. Fish feces and feed residues were removed daily. The feed was offered three times daily at 10, 14, and 17 clock. The fish were weighed weekly and the amount of the feed was adjusted according to the actual body weight changes. Samples of water were taken in plastic test bottles each bottle was 50 ml and tested for Dissolved oxygen with digital oxygen meter model BANTE 820 by immersing the tip of the probe over temperature sensor in the test bottles. The NH_3 test was done by using Ammonia medium range meter model martini 405. The measurement procedure follows the method as described by the manual of martini ammonia medium range meter model MI 405. The TDS was measured by digital EC/TDS meter ADWA AD 31, the measurement procedure follows the method as described by the manual of EC/TDS meter ADWA AD 31. The temperature and PH value was measured by digital pH meter ADWA AD 11 and the temperature digital thermometer was attached into PH meter. The measurement procedure was done by dipping the probe of pH meter ADWA AD 11 into test bottles according to the method which described in user manual. Some growth performance parameters such as initial body weight, final body weight was calculated as follow:

Total weight gain (TWG) = final weight - initial weight)

Average daily gain (ADG) = [TWG / Experimental period])

Specific growth rate (SGR) = 100 × ([In wt1- In wt0] / experimental period)

Whereas:

In Natural log,

Wt1 Final weight, and

Wt0 Initial weight

Feed conversion ratio (FCR) = Feed Intake / live Weight gain).

Protein efficiency ratio (PER) = (Live weight gain / protein intake) and

Survival (SR %) = 100 [Total number of fish at the end of the experimental / total number of fish at the start of the experiment]

The Laboratory tests were done to observe closely the change in the water quality parameter in control condition. Twenty-five liters were taken from fish tank in the farm to the laboratory tests and divided into five tests Figure 4: Illustrate the laboratory tests set up. Each test bottle contains 5 liters. four samples were taken A, B1, B2 and B3 in the first test, sample A was taken from the inlet tank without magnetization and aeration, sample B1 was taken from the outlet tank after passing through the device pipe without magnetization with Flow rate 0.5 m^3/h and ten min. aeration. B2 was taken from the outlet tank after passing through the device pipe without magnetization with Flow rate 0.5 m^3/h plus twenty min. aeration, B2= (B1+ten min. aeration). B3 was taken from the outlet tank after passing through the device pipe without magnetization with Flow rate 0.5 m^3/h plus thirty min. aeration, B3= (B2+ten min. aeration) samples B1, B2 and B3 were taken as a control after 10, 20, 30 min. aeration respectively and without magnetization. Three samples were taken C, D and E in the second test, after 1, 2 and 3 turns through the device pipe with magnetic flux density 2500 µT, Sample C = (turn + ten min. aeration), D = (C+ ten min. aeration +turn), E = (D+ ten min. aeration + turn) with flow rate 0.5 m^3/h respectively. Three samples were taken F, G and H in the third test after 1, 2 and 3 turns through the device pipe with magnetic flux density 2500 µT. Sample F = (turn + ten min. aeration), G = (F + ten min. aeration +turn), H= (G + ten min. aeration + turn) with flow rate 0.25 m^3/h respectively.

Three samples were taken I, J and K in the fourth test after 1, 2 and 3 turns through the device pipe with magnetic flux density 3500 µT Sample I = (turn + ten min. aeration), J= (I + ten min. aeration +turn), K= (J + ten min. aeration + turn) with flow rate 0.5 m^3/h respectively. Three samples were taken L, M and N in the fifth test after 1, 2 and 3 turns through the device pipe with magnetic flux density 3500 µT with flow rate 0.25 m^3/h respectively, Sample L = (turn + ten min. aeration), M= (L + ten min. aeration +turn), N= (M + ten min. aeration + turn). Small aquarium air pump xilong model AP-004 made in china with maximum power 2 W was used for aeration in laboratory tests with specifications. All samples were taken in plastic test bottles each bottle was 50 ml and tested for Dissolved oxygen, NH_3, Electrical Conductivity (EC µS/cm), Temperature and PH value as previous described measurement procedure with the same instruments. Power and Economic evaluation for the experimental tanks has been calculated by evaluation the Energy requirements which contains the power consumption of fish tanks per day, month and period in kW. As well as, the cost analysis of this project, magnetic units fabricated cost (L.E/unit) was estimated whereas: fabricated cost = (cost of solenoid coil +cost of carbon steel pipe +cost of AC/DC Adapter + cost of magnetic unit frame). The Power consumption of the two constructed magnetic units was calculated according to (Fink *et al.,* 1978) P = I * V where P is Electric power in Watt, and I is intensity of the current in Ampere, V (Voltage difference, V). The power consumption for experimental tanks (kW/period) and the cost of power consumption (L.E/Period) was assumed as 1kW = 0.9 LE, total power cost, the total production (kg tilapia/Tank) was calculated and used to evaluate the two fabricated units.

The power consumption to produce1kg (kW/kg) = (Power consumption, kW / Production, kg) also, the total profit (LE/tank/Period) assuming that 1kg tilapia = 23 LE and the net profit calculated whereas, net profit (LE/tank/Period) = (Total profit – Cost of power consumption). Period refer to total days of each experimental period.

RESULTS

***Energy requirements*:** The detailed results of Energy requirements of experimental fish tanks in the two periods represented in Table 1. The power consumption for MTD1 and MTD2 unit were 8893.16, 8926.34 kW /period respectively. As well as, the total power consumption was 0.00384 kW h^{-1} for MTD1 unit compared with 0.01536 kW h^{-1} for MTD2 unit.

***Cost analysis*:** the cost analysis of experimental fish tanks in the two periods represented in Table 2. As well as, the cost of power consumption was 8003.8 EGP /Period for MTD1 unit and 8033.8 EGP/Period for MTD2 unit compared to 7993.9 EGP/Period for control.

***Magnetic water quality*:** Average water temperature of different treatment was ranged between 27.6 and 29.8C° in the first period and between 26.9 and 29.4 in the second period. Average of pH values was still constant in the two experimental periods 7.7 and this result may be because the aquarium system with open cycle and eighty percent of tanks water were replaced daily. The concentration of dissolved

Table 1. Energy requirements of experimental fish tanks in the two periods.

Load	No. of loads	Loads Consumption (kW)	Total power consumption (kW / h)	The loads working hour (h)	The loads consumption per day (kW)	The loads consumption per month (kW)	The power consumption of 40 fish tanks per month (kW)	The power consumption of control tank per month (kW)	The power consumption of MTD1 tank per month (kW)	The power consumption of MTD2 tank per month (kW)
Aeration	20	1.1	22	12	264	7920	59214	1480.35	1482.1932	1487.7228
	2	7.5	15	12	180	5400	The power consumption of 40 fish tanks per Period (kW)	The power consumption of control tank per period (kW)	The power consumption of MTD1 tank per period (kW)	The power consumption of MTD2 tank per period (kW)
Farm lighting	8	0.4	3.2	12	38.4	1152				
inlet water motor to the fish farm	1	93.2125	93.2125	16	1491.4	44742				
first magnetic unit (MTD1)	1	0.00384	0.00384	16	0.06	1.84	355284	8882.1	8893.16	8926.34
second magnetic unit (MTD2)	1	0.01536	0.01536	16	0.25	7.37				

Table 2. Cost analysis of experimental fish tanks in the two periods.

period	magnetic treatment	cost of magnetic unit (EGP)	power consumption (kW/Period)	Cost of Power Consumption (EGP/Period)	Total cost (EGP)	Production (kg tilapia)	Power consumption (kW/kg)	total profit (EGP/tank/Period)	Net profit (LE) (EGP/tank/Period)	NET Profit %
1st period	control	0	8882.1	7993.9	7993.89	560	15.861	12880	4886.1	00.0
	MTD 1 Tank	430	8893.2	8003.8	8433.84	618	14.390	14214	5780.2	18.3
	MTD 2 Tank	430	8926.3	8033.7	8463.70	644	13.861	14812	6348.3	29.9
2nd period	control	0	8882.1	7993.9	7993.89	580	15.314	13340	5346.1	00.0
	MTD 1 Tank	430	8893.2	8003.8	8433.84	634	14.027	14582	6148.2	15.0
	MTD 2 Tank	430	8926.3	8033.7	8463.70	671	13.303	15433	6969.3	30.4

oxygen (mg/l) in the first period was ranged between 3.74 and4.19 mg/l in the morning and between 2.50 and 2.82 mg/l in the evening, in the second period dissolved oxygen concentration was ranged between 3.76 and 4.15 mg/l in the morning and between 2.57 and 2.86mg/l in the evening. The concentration of dissolved salts (ppm) was ranged between 672 and 673 ppm in the first period and between 671 and 672 ppm in the second period. Average of NH_3 values (mg/l) in the first period were ranged from 0.23 to 0.45 in the morning and from 0.13 to 0.37 in the evening. In the second period, readings were ranged from 0.34 to 0.48 mg/l in the morning and between 0.28 to 0.40 mg/l.

***Dissolved oxygen concentration*:** In the first period, the average of DO reading for control tank was ranged from 3.47mg/l in the morning to 2.50 mg/l in the evening and ranged from 3.76 mg/l in the morning to 2.57 mg/l in the evening in the second period.

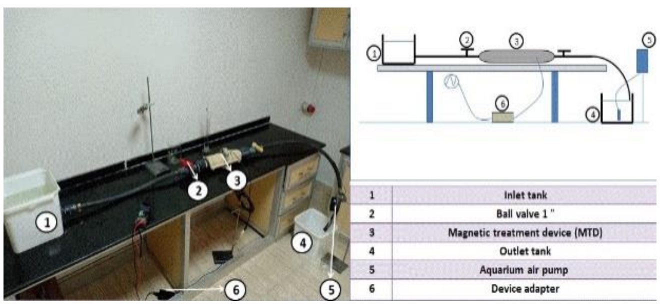

Figure 4. Illustrate the laboratory tests set up.

MTD_1 tank the average of DO reading was 4.06 mg/l in the morning and 2.74 mg/l in the evening in the first period and ranged from 4.02 mg/l in the morning to 2.78 mg/l in the evening in the second period. MTD_2 tank the average of DO reading was 4.19 mg/l in the morning and 2.82 mg/l in the evening in the first period and ranged from 4.15 mg/l in the morning to 2.86 mg/l in the evening in the second period. The following graph illustrates the average of dissolved oxygen concentration in the two periods.

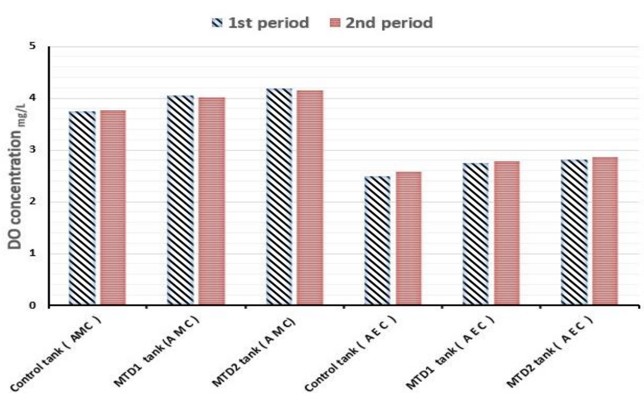

Figure 5. Average concentration of DO during Morning and Evening for two periods under the influence of magnetic treatment units.

The results show that there is a clearly change in DO concentration when it was exposed to magnetic treatment units. In the first period DO concentration increment value compared to the control tank DO values was 8.6 % in MTD_1 tank in the morning and by 9.6 % in the evening. In tank treated with MTD_2 the concentration of DO increased by 12% in the morning and by 12.8% in the evening compared to the control tank DO values. In the second period DO concentration increment value compared to the control tank DO values was 6.9% in the morning in MTD_1 and by 8.2 % in the evening. In tank treated with MTD_2, the concentration of DO increased by 10.4% in the morning and by 11.3% in the evening compared to the control tank DOES values.

***Ammonia concentration*:** The average of NH_3 reading for control tank was ranged from 0.45mg/l in the morning to 0.37 mg/l in the evening in the first period and ranged from 0.48mg/l in the morning to 0.4 mg/l in the evening in the second period. For tank treated with MTD_1, the average of NH_3 reading was 0.28 mg/l in the morning and 0.18 mg/l in the evening in the first period and ranged from 0.37mg/l in the morning to 0.31 mg/l in the evening in the second period. For tank treated with MTD_2, the average of NH_3 reading was 0.23 mg/l in the morning and 0.13 mg/l in the evening in the first period and ranged from 0.34mg/l in the morning to 0.28 mg/l in the evening in the second period. The following graph illustrates the average of dissolved ammonia concentration in the two periods. The results show that there is a change in NH_3 concentration when water exposed to magnetic treatment unit. In the first period NH_3 concentration in tank treated with MTD_1 decreased by 37.8 % in the morning and by 51.4 % in the evening. In tank treated with MTD_2, the concentration of NH_3 decreased by 48.9% in the morning and by 64.9% in the evening. In the second period tank treated with MTD_1, the concentration of NH_3 decreased by 22.9% in the morning and by 22.5 % in the evening. In tank treated with MTD_2 the concentration of NH_3 decreased by 29.2% in the morning and by 30% in the evening.

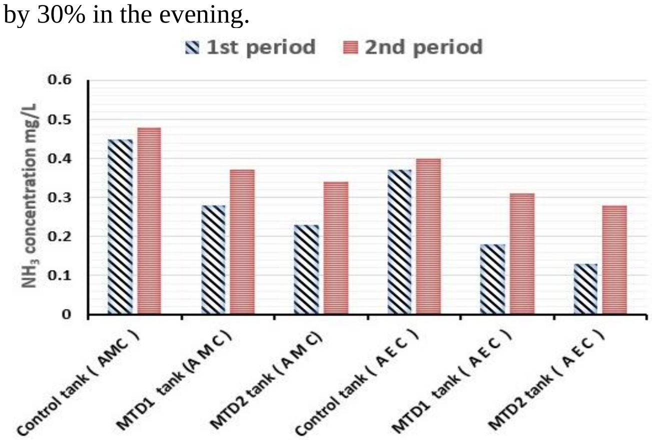

Figure 6. Average concentration of NH_3 during Morning and Evening for two periods under the influence of magnetic treatment units.

pH value**:** In the first period and the second period the average of pH reading for control tank, tank treated with MTD_1 and tank treated with MTD_2, were still constant at average value of 7.7.

TDS Concentration**:** In the first period, the average of TDS reading for control tank was ranged from 673 ppm in the morning to 672 ppm in the evening and still constant at 672 ppm in the second period. For MTD_1 tank, the average of TDS reading was 673 ppm in the morning and 672 ppm in the evening in the first period and in the second period ranged from 671ppm in the morning to 672 ppm in the evening in. For MTD_2 tank, the average of TDS reading was 673 ppm in the morning and 672 ppm in the evening in the first period and ranged 671ppm in the morning to 672 ppm in the evening in the second period.

The results show that there is no considerable change in TDS concentration in tank water when it was exposed to magnetic treatment units in the first and second period.

Effect of magnetic units on Feed intake and growth performance of Nile tilapia (O.niloticus)**:** The data pointed out that the FCR were affected with MTD units in the first and second period. The best FCR was for tank which treated with MTD_2 then tank treated with MTD_1 as compared with control tank. The FCR for tank treated with MTD_1 was improved by 9.49 % and 8.62 % as compared with control tank fish in first and second experimental periods respectively. The FCR for tank treated with MTD_2 was improved by 13.40 % and 13.21 % as compared with control tank in first and second experimental periods respectively. Figure 7 illustrates the FCR for experimental tanks in the two periods. The PER was higher for tank treated with MTD_2 then tank treated with MTD_1 as compared with control tank. The PER for tank treated with MTD_1 was improved by 10.16 % and 9.42 % as compared with control tank fish in first and second experimental periods respectively. The PER for tank treated with MTD_2 was improved by 14.97 % and 15.70 % compared with control tank in first and second experimental periods respectively. Figure 8 illustrate the PER in the two experimental periods.

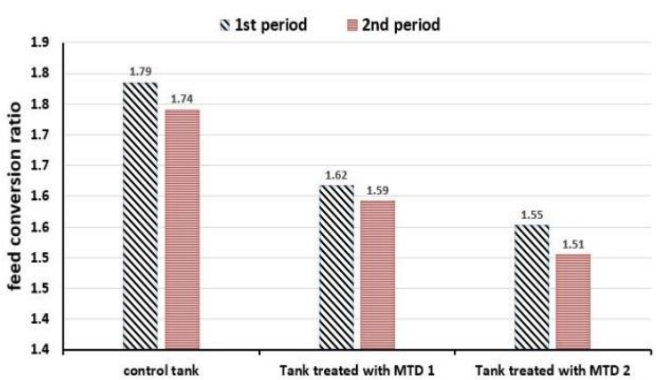

Figure 7. Average of feed conversion ratio of experimental tilapia tanks in the two periods.

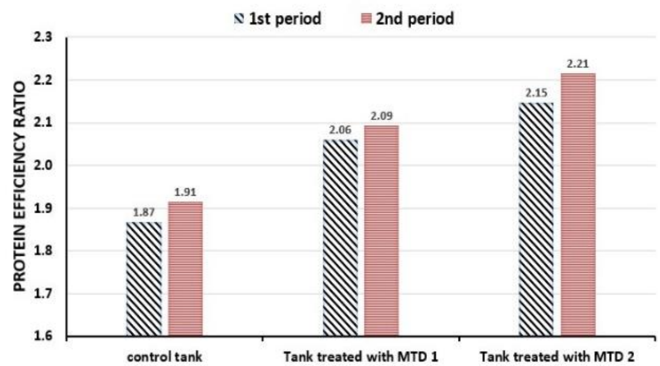

Figure 8. Protein efficiency ratio of experimental tilapia tanks in the two periods.

Results showed that tank fish treated with MTD_2 had higher growth performance as compared with control tank fish in the two experimental periods.

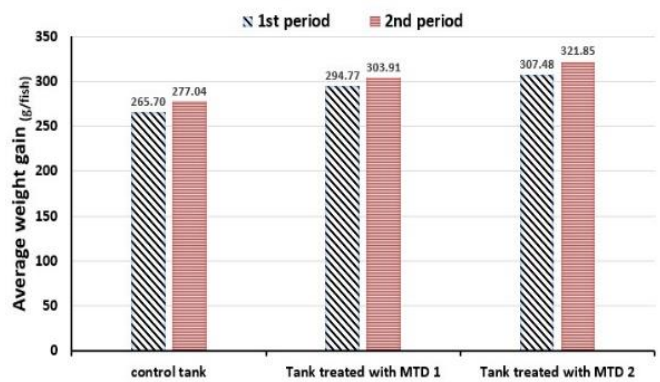

Figure 9. Average weight gain (g/fish) of experimental tilapia tanks in the two periods.

Results also showed that tank fish treated with MTD_2 had highest average of weight gain then tank fish treated with MTD_1 as compared with control tank fish in the two experimental periods**.** The AWG for tank fish treated with MTD_1 was improved by 10.94 % and 9.69 % as compared with control tank fish in first and second experimental periods respectively. The AWG for tank fish treated with MTD_2 was improved by 15.72 % and 16.17 % as compared with control tank fish in first and second experimental periods respectively.

As well as, the tank fish treated with MTD_2 and tank fish treated with MTD_1 gave the highest average of daily gain compared to control tank fish in the two experimental periods**.** The ADG for tank fish treated with MTD 1 was improved by 11.25 % and 9.94 % as compared with control tank fish in first and second experimental periods respectively. The ADG for tank fish treated with MTD 2 was improved by 15.62 % and 16.37 % as compared with control tank fish in first and second experimental periods respectively.

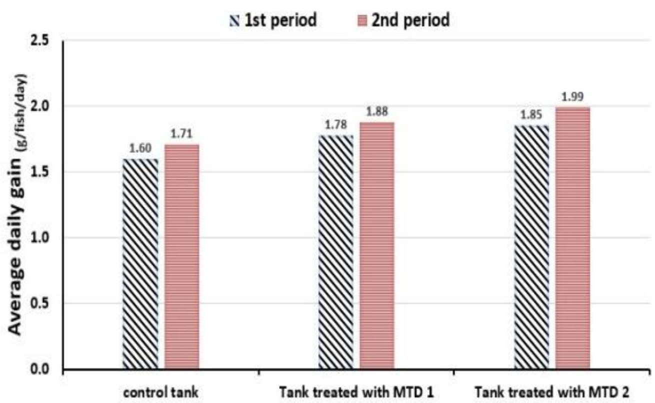

Figure 10. Average daily gain (g/fish/day) of experimental tilapia tanks in the two periods.

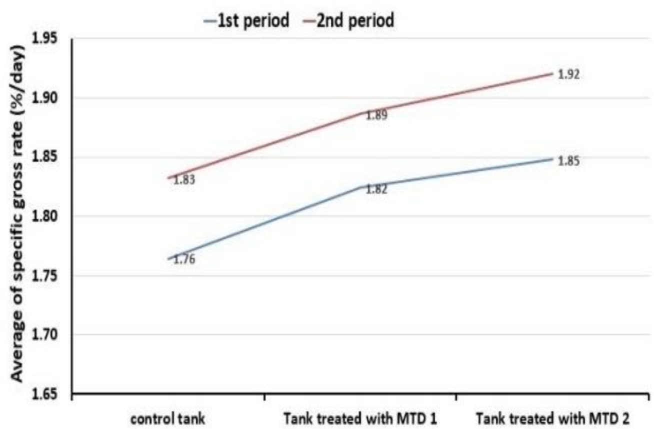

Figure 11. Average of specific gross rate of experimental tilapia tanks in the two periods.

Results showed that tank fish treated with MTD_2 had highest average of specific gross rate then tank fish treated with MTD_1 as compared with control tank fish in the two experimental periods**.** The SGR for tank fish treated with MTD $_1$ was improved by 3.41 % and 3.28 % as compared with control tank fish in first and second experimental periods respectively. The SGR for tank fish treated with MTD $_2$ was improved by 5.11 % and 4.92 % as compared with control tank fish in first and second experimental periods respectively.

Laboratory tests for treated water with magnetic unit: Sixteen samples divided into five tests were taken and analyzed for Water quality parameters which significantly affected by magnetic treatment devices Table 3.

pH value: In the first test, four samples were taken and analyzed for pH values. These samples are A, B1, B2 and B3. Samples B1, B2 and B3 were taken as a control samples after 10, 20, and 30 min. aeration respectively without magnetization. The pH value for A, B1, B2, B3 was 8.1. In the second test, the PH value for C, D and E was 8, 8.2, and 8.3 respectively after 1, 2 and 3 turns through the device pipe with magnetization flux density 2500 µT and flow rate 0 .5 m^3/h. In the third test, the pH value for F, G and H was 8.1,8.3 and 8.4 respectively after 1, 2 and 3 turns through the device pipe with magnetization 2500 µT and flow rate 0 .25 m^3/h. In the fourth test, the PH value for I, J and K was 8.1, 8.4, and 8.6 respectively after 1, 2 and 3 turns through the device pipe with magnetization flux density 3500 µT and flow rate 0 .5 m^3/h. In the fifth test, the pH value for L, M and N was 8.1, 8.4, and 8.4 respectively after 1, 2and 3 turns through the device pipe with magnetization 3500 µT and flow rate 0 .25 m^3/h. The percentage of change in pH for samples C, D, and E was-1.2, 1.2, and 2.5 respectively and for F, G, H was 0.0, 2.5, and 3.7 respectively and for samples I, J, and K was 0.0, 3.7, and 6.2 respectively and for samples L, M, and N was 0.0, 3.7, and 3.7 respectively. The results show that there is an increase in PH value with increasing the number of turns through MTD unit and with increasing the magnetic flux density to 3500 µT. The high percentage in pH increase was

Table 3. Laboratory tests for water quality parameters.

Test	Sample	MTD unit	magnetic flux density µT	Time of aeration after passing through MTD min	Flow rate m^3/h	Number of turns through MTD unit	Parameters				
							Do mg/l	NH3 mg/l	EC µS/cm	PH	Temp °C
1	A	Before	0	0	0	0	1.4	1.36	1086	8.1	31.7
	B1	Before	0	10	0.50	1	1.5	1.34	1086	8.1	32.3
	B2	Before	0	20	0.50	2	1.7	1.30	1086	8.1	32.2
	B3	Before	0	30	0.50	3	1.9	1.28	1087	8.1	32.3
2	C	MTD1	2500	10	0.50	1	1.8	1.30	1127	8.0	32.2
	D	MTD1	2500	20	0.50	2	2.1	1.11	1073	8.2	32.3
	E	MTD1	2500	30	0.50	3	2.4	0.86	1073	8.3	32.3
3	F	MTD1	2500	10	0.25	1	1.7	1.33	1112	8.1	32.3
	G	MTD1	2500	20	0.25	2	2.3	1.00	1110	8.3	32.2
	H	MTD1	2500	30	0.25	3	2.6	0.83	1102	8.4	32.0
4	I	MTD2	3500	10	0.50	1	1.8	1.40	1110	8.1	31.7
	J	MTD2	3500	20	0.50	2	2.3	1.00	1110	8.4	31.4
	K	MTD2	3500	30	0.50	3	2.7	0.95	1106	8.6	31.2
5	L	MTD2	3500	10	0.25	1	1.8	1.38	1106	8.1	31.4
	M	MTD2	3500	20	0.25	2	2.4	1.10	1095	8.4	31.1
	N	MTD2	3500	30	0.25	3	2.9	0.82	1095	8.4	30.8

6.2 % for sample K; however, the increase in PH value in the rest samples did not exceed 3.7 %.

***Electrical Conductivity ($EC_{\mu S/cm}$)*:** In the first test, four samples were taken and analyzed for EC. Samples A, B1, B2 and B3. Samples B1, B2 and B3 were taken as a control samples after 10, 20, 30 min. aeration without magnetization respectively. The EC for A, B1, B2, and B3 were 1086, 1086, 1086 and 1087 µS/cm respectively. In the second test, the EC for C, D and E was 1127, 1073, and 1073 µS/cm after 1, 2 and 3 turns through the device pipe with magnetization flux density 2500 µT and flow rate 0 .5 m3/h respectively. In the third test, the PH value for F, G and H was 1112, 1110, and 1102 µS/cm after 1, 2 and 3 turns through the device pipe with magnetization 2500 µT and flow rate 0 .25 m3/h respectively. In the fourth test, the PH value for I, J and K was 1110, 1110, and 1106 µS/cm after 1, 2 and 3 turns through the device pipe with magnetization flux density 3500 µT and flow rate 0 .5 m^3/h respectively. In the fifth test, the pH value for L, M and N was 1106, 1095, and 1095 µS/cm respectively after 1,2 and 3 turns through the device pipe with magnetization 3500 µT and flow rate 0 .25 m3/h. The percentage of change in EC for samples C, D, and E was 3.8, -1.2, and -1.3 % respectively. Also, the percentage of change in EC for samples F, G, and H was 2.4, 2.2, and 1.4% respectively. As well as, for samples I, J, and K the percentage of change in EC was 2.2, 2.2, and 1.7% respectively and for samples L, M, and N was 1.8, 0.8, and 0.7% respectively. The results show that there is no considerable change in EC values between treated water with MTD unit and control samples with increasing the number of turns through MTD unit and magnetic flux density.

***Dissolved oxygen concentration*:** In the first test, four samples were taken and analyzed for Dissolved Oxygen concentrations (mg/l). Samples B1, B2 and B3 were taken as a control samples after 10, 20, 30 min. aeration without magnetization respectively.

The DO concentration for B1, B2, and B3 was 1.5, 1.7, and 1.9 mg/l respectively. In the second test, the DO concentration for C, D and E was 1.8, 2.1, and 2.4 mg/l respectively after 1,2and 3turns through the device pipe with magnetization flux density 2500 µT and flow rate 0 .5 m3/h. In the third test, the DO concentration for F, G and H was 1.7, 2.3, and 2.6 mg/l respectively after 1,2and 3 turns through the device pipe with magnetization 2500 µT and flow rate 0 .25 m3/h. In the fourth test, the DO concentration for I, J and K was 1.8, 2.3, and 2.7 mg/l respectively after 1, 2 and three turn through the device pipe with magnetization flux density 3500 µT and flow rate 0 .5 m^3/h. In the fifth test, the DO concentration for L, M and N was 1.8, 2.4, and 2.9mg/l respectively after 1, 2 and 3 turns through the device pipe with magnetization 3500 µT and flow rate 0 .25 m3/h. The percentage of change in DO concentration for samples C, D, and E was 20.0, 23.5, and 26.3% respectively and for F, G, and H was 13.3, 35.3, and 36.8 % respectively and for samples I, J, and K was 20.0, 35.3, and 42.1 % respectively and for samples L,M,N was 20.0,41.2, and 52.6 % respectively. The following graph illustrates the DO concentration for laboratory test samples.

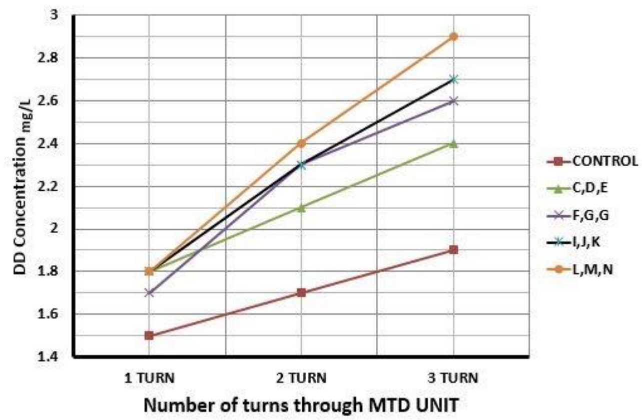

Figure 12. The DO concentration for laboratory test samples.

The results show that there is an increase in DO concentration with increasing the number of turns through MTD unit and with increasing the magnetic flux density to 3500 µT. The high percentage in DO concentration increase was 52.6 % for sample N after three turns through MTD unit with increasing magnetic flux density to 3500 µT and reducing flow rate to 0.25 m^3/h.

***Temperature*:** In the first test, four samples were measured for temperature. Samples A, B1, B2 and B3. Samples B1, B2 and B3 were taken as a control samples after 10, 20, 30 min. aeration respectively without magnetization. The temperature for A, B1, B2, B3 was 31.7, 32.3, 32.2 and 32.3˚C respectively. In the second test, the temperature for C, D and E was 32.2, 32.3, and 32.3 ˚C respectively after 1,2and 3 turns through the device pipe with magnetization flux density 2500 µT and flow rate 0 .5 m3/h. In the third test the temperature for F, G and H was 32.3, 32.2, and 32 ˚C respectively after 1, 2 and 3 turns through the device pipe with magnetization 2500 µT and flow rate 0 .25 m3/h. In the fourth test, temperature for I, J and K was 31.7,31.4,31.2 ˚C respectively after 1, 2 and 3 turns through the device pipe with magnetization flux density 3500 µT and flow rate 0 .5 m^3/h. In the fifth test, the temperature for L, M and N was 31.4, 31.1, and 30.8˚C respectively after 1,2and 3 turns through the device pipe with magnetization 3500 µT and flow rate 0.25 m^3/h. The percentage of change in temperature for samples C, D, and E was -0.3,0.3,0.0 % respectively and for F, G, and H was 0.0, 0.0, and -0.9%respectively and for samples I, J, and K was -1.9, -2.5, and -3.4 % respectively and for samples L, M, and N was -2.8,-3.4, and -4.6% respectively. The results show that there is no considerable change in temperature between treated water with MTD unit and control samples with increasing the number of turns through MTD unit or magnetic flux density.

Ammonia concentration: In the first test, four samples were taken A, B1, B2 and B3 analyzed for ammonia (NH_3) concentrations (mg/l) and it's taken as control samples after 10, 20, and 30 min. aeration without magnetization respectively. The NH_3 concentration for B1, B2, and B3 was 1.34, 1.3, and 1.28 mg/l respectively. In the second test the NH_3 concentration for C, D and E was 1.3, 1.11, and 0.86 mg/l respectively after 1,2 and 3 turns through the device pipe with magnetization flux density 2500 µT and flow rate 0 .5 m^3/h. In the third test, the NH_3 concentration for F, G and H was 1.33, 1.0, and 0.83mg/l respectively after 1,2 and 3 turns through the device pipe with magnetization 2500 µT and flow rate 0 .25 m^3/h. In the fourth test, the NH_3 concentration for I, J and K was 1.4, 1.0, and 0.95mg/l respectively after 1, 2 and 3 turns through the device pipe with magnetization flux density 3500 µT and flow rate 0 .5 m^3/h. In the fifth test, the NH_3 concentration for L, M and N was 1.38, 1.1, and 0.82mg/l respectively after 1,2and 3 turns through the device pipe with magnetization 3500 µT and flow rate 0.25m^3/h. The percentage of change in NH_3 concentration for samples C,D,E was -3.0, -14.6, and -32.8% respectively and for F,G,H was -0.7, -23.1, and -35.2% respectively and for samples I,J,K was 4.5, -23.1, and -25.8 % respectively and for samples L,M,N was 3.0, -15.4, and -35.9%respectively. The following graph illustrates the NH_3 concentration for laboratory test samples.

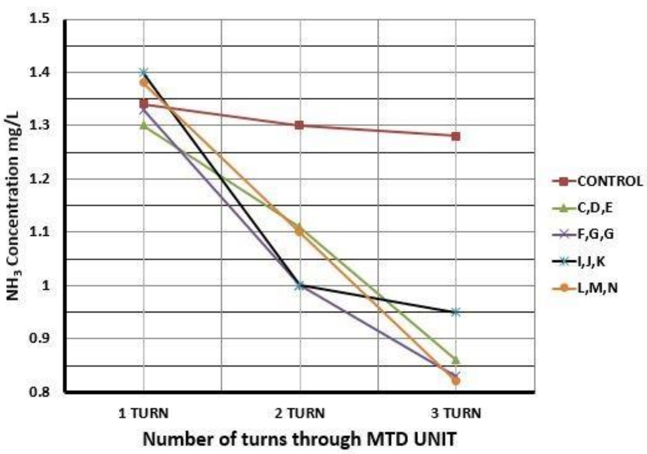

Figure 13. The NH_3 concentration for laboratory test samples.

The results show that there is a decrease in NH_3 concentration with increasing the number of turns through MTD unit and with increasing the magnetic flux density to 3500 µT. The high decreasing percentage in NH_3 concentration was 35.9 % for sample N after three turns through MTD unit with increasing magnetic flux density to 3500 µT and reducing the flow rate to 0.25 m^3/h. The second-high decreasing percentage in NH_3 concentration was 35.2 % for sample H after three turns through MTD unit with magnetic flux density to 2500 µT and flow rate to 0 .25 m^3/h. It's obvious that the concentration of NH_3 decrease with increasing the number of turns through MTD unit and reducing the flow rate of MTD unit to increase the contact time between water and magnetic field.

The above results may be due to the magnetized water helps in dissolving minerals and acids by a higher rate than unmagnetized water, in addition to dissolving oxygen and increasing the speed of chemical reactions (Moon and Chung, 2000). As well as, the application of a magnetic field creates changes in the physical and chemical properties of water at microscopic and macroscopic scales (Pang and Deng, 2008). In addition, these changes by the formation of a large number of hydrogen bonds (Cai *et al.*, 2009). Today, magnetic processing is of interest to several sectors of activity such as health, environment, industry, etc. In particular, we are targeting its applications in agriculture field.

Conclusion: Obtained laboratory tests results showed that there were increases in Dissolved oxygen concentration; slightly increase in PH value and a decrease in NH3 concentration with increasing the number of turns through MTD units and with increasing the magnetic flux density to 3500 µT without any considerable change in EC and temperature.

The field tests results showed that there was an increase in Dissolved oxygen concentration and a decrease in NH3 concentration in tanks when it was exposed to magnetic treatment units without any considerable change in PH, TDS concentration. Tank treated with MTD2 was superior in measurements of water quality as well as growing measurements and production followed by tank treated with MTD1 as compared to control tank in two experimental periods. From the results we concluded that the more we increased the magnetic flux density of the unit with reducing the speed of the water within the unit, the more we increase the effect of magnetic treatment unit on improving water quality parameters. Magnetic treatment units improve water properties, break down large water cluster to small one and reduce water surface tension which reflects on improving aeration system, reducing the water used in the system and increasing production, by other meaning, magnetic treatment units are help tools to increase the efficiency of aeration and purification systems by enhancement water properties. In future studies, it is recommended to fabricate a new magnetic unit with higher magnetic flux density and study the effect of these units on other fish varieties.

REFERENCES

Annan, K. 2003. World Environment Day. Available online with Updates at http://www.un.org/press/en/2003 /sgsm8707.doc.htm.

Boyd, C.E. 1998. Pond water aeration system. J. Aqua. Eng. 18:9-40.

Bennett, A. P., K. Patil, D. Kleisner, Rader, J. Virdin and X. Basurto. 2018. Contribution of Fisheries to Food and Nutrition Security: Current Knowledge, Policy, and Research. NI Report 18-02. Durham, NC: Duke University, Available online with Updates at http: // Nicholas institute. Duke.edu/publication.

Cai, R., H., Yang, J. He and W. Zhu. 2009. The effects of magnetic fields on water molecular hydrogen bonds. J. Mol. Struct. 938:15-19.

El-Sayed, A. F. M., A. A. Ezzat and C. R. Mansour. 2005. Effects of dietary lipid source on spawning performance of Nile tilapia (*Oreochromis niloticus*) brood stock reared at different water salinities. J. Aquac. 248:187-196.

FAO. 2002. Evaluation of certain mycotoxins in food: fifty – sixth report of the joint FAO / WHO expert committee on food additives, World Health Organization, Geneva.

Hassan, K. K. 2015. Magnetic treatment of brackish water for sustainable Agriculture, Cairo, Ph.D. diss., The American University, Cairo, Egypt.

Jensen, G.L., J.D. Bankston and J.W. Jensen. 1989. Pond aeration. Agriculture extension service, Southern Regional Aquaculture Center, SARC. Publication No.370.

Kenneth W. and M. A. B. Busch. 1997. Laboratory studies on magnetic water treatment and their relationship to a possible mechanism for scale reduction. J. Desalination: 109:14-19.

McMahon, C. A. 2009. Investigation of the quality of water treated by magnetic field, Ph.D. diss. Faculty of Engineering and Surveying. University of Southern Queensland. Toowoomba, Australia.

Moon, J. D. and H.S. Chung. 2000. Acceleration of germination of tomato seed by applying an electric and magnetic field. J. Electro-Stat. 48:103-114.

MWRI, 2014. Water Scarcity in Egypt, Cairo: Ministry of Water Resources and Irrigation, Available online with update at http://extwprlegs1.fao.org/docs/pdf/ egy147082.pdf, accessed [10-11-2018].

Pang, X.F. and B. Deng. 2008. The change of macroscopic features and microscopic structures of water under influence of magnetic field. J. Phys. B. 403:3571- 3577.

Schwartz, M. F. and C. E. Boyd. 1994. Effluent quality during harvest of channel catfish from watershed ponds. J. Prog. Fish-Cult. 56:25-32.

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