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Effect of using Aquaponic system in fish culture to improve the aquatic environment and fish health

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Abstract: The present study was carried out in AHRI (Aquaculture Disease unit) from January 2020 to April 2020, to evaluate the impact of aquaponic system on water quality and health of *Oreochromis niloticus*. Fifty apparently healthy fingerlings fish were collected and divided equally into two groups representing aquaponic system and the aquaria (control). Water quality was measured on basis of both daily Temperature (thermometer), pH (PH meter), Dissolved Oxygen and weekly for 8 weeks, total Ammonia, NO2, NO3, and Growth rate (measuring by ruler). Results of water analysis showed improvement of water quality parameters in aquaponic system. Total bacterial count (TBC) of water and fish skin and gills revealed that the (TBC) in both aquaponic and aquaria were nearly similar and ranged from 6.6×10^5 to 12.4×10^5 (CFU/ml) at the beginning of the experiment. At the end, The (TBC) increased in aquaria with water had the highest number of bacteria 11.1×10^5 (CFU/ml). The most prevalent isolates from aquaria and aquaponic were *Aeromonas hydrophila* with (30% and 20%) isolation rate respectively. *Pseudomonas spp.* were isolated with a percentage of (20%) from aquaria and (15%) from aquaculture. *E.coli* was also identified in (15%) of the examined samples of each system. While one isolate of *staphylococcus aureus* was isolated only from aquaria. The highest isolation rates were from skin of fish and water. PCR was applied on five isolates from each bacterial species for the detection of 16S rRNA as an accurate method for isolate identification.
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Key words: Fish, Aquaponic system, Aeromonas, Pseudomonas, PH, Ammonia, Dissolved Oxygen, Temperature

1. Introduction

Aquaponics, a method of food production that combines aquaculture with soilless plant production, is growing in popularity and gaining sustainable method of growing food. Aquaponics combines the cultivation of both fish and plants into a recirculating ecosystem that utilizes natural nitrifying bacteria to convert fish wastes into plant nutrients. Water chemistry requirements, and optimal water quality is essential to a healthy, balanced, functioning system, **Rossana (2016)**.

Nile tilapia *Oreochromis niloticus* is considered as one of the most important freshwater species for commercial Aquaria in Egypt, due to its high nutritional values, rapid growth rate and resistance to diseases leading to high production level **(Barcellos *et al.*, 1999)**. Dense stocking density results in high organic wastes that increase water pollution and disease susceptibility. As a result, the need for an alternative method for fish culturing emerged. Indoor aquaponic system is the integration of fish culture and hydroponic plant and it was operated for minimizing water consumption and to improve the water quality and the fish health. Aquaponic is a system allows the reuse of nutrient-rich waste water from fish as organic fertilizers for plants grown in the system **(Rakocy *et al.*, 2006),** thus reducing the use of plant fertilizers, and the needed resources as land, water, and energy **(Timmons *et al.*, 2002).** As well, it aimed to decrease the environmental impact of both fish and plant production **(Buzby and Lin, 2014 and Delaide *et al.*, 2017).** Aquaponics rely on water filtration technologies and bacterial community to transform fish excreta high in ammonium concentration, into plant fertilizer which should be a combination of low ammonium and high nitrate **(Somerville *et al.* 2014)** providing locally grown vegetables without using pesticides, chemical fertilizers, or antibiotics **(Love *et al.*, 2015).** Aquaponic systems were applied in tilapia **(Graber and Junge, 2009)**, hybrid catfish **(Sikawa and Yakupitiyage, 2010**) and African catfish **(Endut *et al.*, 2010)** cultivations. Bacteria are very necessary in aquaponic system for decomposing and transforming the toxic constituents of the fish wastes into useful nutrients for vegetables; while, some undesirable pathogenic bacteria could cause fish diseases. The main bacterial fish pathogens are *Aeromonas, Pseudomona, stapHylococcus, E.coli and Vibrio*. Therefore, the objective of the present study was to

evaluate the effect of using Aquaponic system on the water quality, growth rate, mortality and bacterial load and compare it with the aquaria (control).

2. Material and methods

The present study was carried out in AHRI-Zagazig (Aquaculture Disease Research unit) from January 2020 to April 2020, to evaluate the impact of aquaponic system on water quality and health of *Oreochromis niloticus*. Fifty apparently healthy fingerlings fish were collected from Abbasa and divided equally into two groups representing aquaponic system and the aquaria (control).

Fig (1): Aquaponic System

Fig (2): Aquaria (Control)

Water quality monitoring and Growth Rating:

In order to make sure the system is operating correctly; the water quality and growth rate must be monitored. The typical monitoring was scheduled as follow:

Daily:

Temperature (pcc. Digital thermometer **TPM-10**), pH (PH meter PH-**220** pen), and Dissolved Oxygen (code **1761** DO tracer pocket-tester kit **La Motte**).

Weekly for 8 weeks:

Ammonia (**LH-N12** Ammonia nitrogen meter) Nitrite (NO2) and Nitrate NO3 (**DR890** for chemical tests for nitrite and nitrate), Growth rate (measured by **ruler**). These parameters were measured in Animal Health research institute – Zagazig branch, Aquaculture Disease Research unit.

Data for physicochemical parameters of water samples were presented as minimum, maximum, mean values and analyzed using **Student *t*-test**, for exploring whether there was any significant relationship among water quality parameters or not according to **Tamhane and Dunlop (2000).**

Aquaria (control) and Aquaponic system components:

1- Aquaria (control):

This system consists of fish glass tank + water flow source + water without Cl and 25 of fingerlings Tilapia Fish (*Oreochromis niloticus*), **(Fig.1).**

2- Aquaponic system:

This system consists of 2 barrels, a water lifting system with a submersible lever motor, water pipes, 10 pots of basil (plant) and 25 of fingerlings Tilapia Fish (*Oreochromis niloticus*)**, (Fig.2)**.

Table (1): Normal parameters range of water for *Oreochromis niloticus*:

Parameter	Normal Range
Temperature ^{O}C	26-28
PH	6-8
Dissolved Oxygen (DO, mg/L)	4-8
Nitrite (No2, mg/L)	< 1.0
Nitrate (NO3, ppm)	<50
Total Ammonia Nitrogen (TAN, mg/L)	<2.0

Bacteriological examination:

Sampling:

Water Sampling:

Water samples were randomly taken from both systems every two weeks. The 10-fold diluted samples were spread uniformly over the surface of Tryptic Soy Agar (TSA) and incubated at 28 °C for 24–36 hours. Colonies were counted and the bacteria were further purified and identified.

Fish sampling:

Fifty fish samples from both systems as 25 samples each, were taken by rubbing the sterilized cotton swab over the skin and gills then inoculated into 9ml of Nutrient broth tubes.10-fold serial dilution of the bacterial suspension already inoculated

in peptone water was prepared and total bacterial counts were enumerated using 0.1ml and 1ml inoculums in standard plate count agar as described by **(Slaby *et al.*, 1981)**.

Phenotypic Identification:

Phenotypic identification of the organisms was done using the following media: Tryptic soya agar; Rimmel's and Shoot agar, MacConkey's agar, mannitol salt agar, Thiosulphate –Citrate –Bile – Sucrose (T.C.B.S) agar and Eosin methylene blue agar (EMB). All plates were incubated for 24hours at 37ºC.The developed colonies were picked up and subculture for purification. The purified colonies were morphologically identified by Gram stain and biochemical tests (**Jayavignesh *et al.*, 2011, Markey *et al.*, 2013 and Austin and Austin 2016).**

Molecular identification:

DNA extraction and PCR amplification

Genomic DNA of the strains was obtained using the genomic DNA Extraction Kit (GeneJET Genomic DNA purification Kit Thermo-scientific) following the manufacturer's instructions. DNA concentration was determined using nanodrop. The PCR primers used in this study were synthesized by metabion international AG, (Germany). The PCR reaction was performed in an Gradient Thermal cycler (1000 S Thermal cycler Bio-RAD USA).The reaction mixture (total volume of 50 µl) was 25 µl PCR master Mix (Thermo Scientific™ PCR Master Mix (2X) Catalog number: K0171, USA.), 3 µl target DNA, 1 µl of each primers (10 p mole/ µl) and the mixture was completed by PCR grade water to 50 µl. The PCR primers used in this study were summarized in **Table (2).**

PCR amplification conditions:

PCR products for any gene was separated by 1.5% agarose gel electrophoresis (Agarose, Sigma, USA) using Tris-boric EDTA buffer. Stained with ethidium bromide using GeneRuler 100bp DNA Ladder: Fermentas Company, Cat.No.SM0243, US. PCR amplification conditions were summarized in **Table (3).**

Table (2): Primers sequences and amplicon sizes of target genes:

Target agent	Target gene	Nucleotide sequence 5`-3	Amplicon Size bp	References
A.hydrophila	16S rRNA gene	GAAAGGTTGATGC CTAATACGTA	**625**	**Gordon *et al.*, (2007)**
E.coli	16s rRNA gene	GCT TGA CAC TGA ACA TTG GCA CTT ATC TCT TCC GCA TT AG	**662**	**Riffon *et al.*, (2001)**
Pseudomonas	16S rRNA gene	GACGGGTGAGTAATGCCTA CACTGGTGTTCCTTCCTATA	**618**	**Spilker *et al.*, (2004)**
Staph aureus	16S rRNA gene	GTA GGT GGC AAG CGT TAT CC CGC ACA TCA GC GTC AG	**228**	**Monday and Bohach (1999)**

Table (3): PCR protocol for amplification conditions of PCR:

	Primary Denaturation	Amplification (35 cycles)			Final extension
		Sec.den.	Ann.	Ext.	
A. hydrophila	94˚C	94˚C	50˚C	72˚C	72˚C
	5 min	30 sec	40 sec.	45 sec	10 min
E. coli	94˚C	94˚C	57˚C	72˚C	72˚C
	2 min.	45 sec.	1 min.	2 min.	10 min.
Pseudomonas	95˚C	94˚C	55˚C	72˚C	72˚C
	5 min.	30 sec.	40 sec.	45 sec.	10 min.
Staph aureus	94˚C	94˚C	55˚C	72˚C	72˚C
	4 min.	45 sec.	1 min..	45 sec.	10 min.

3. Results

Water quality monitoring and Growth Rating for *Oreochromis niloticus*:

Water quality:

The water physicochemical characteristics of both aquaria (control) and aquaponic systems were investigated and the results were illustrated in **Table (4) and (5).**

Table (4): Physicochemical components of the examined water samples for aquaria (control) and aquaponic system:

Parameter	Daily System					
	Aquaria (Control)			Aquaponic system		
	Min.	Max.	Mean	Min.	Max.	Mean
Temperature(°C)	15.2	24.3	19.75	21.74	23.76	22.75
PH	7.54	8.1	7.82± 0.01	7.42	8.31	7.865±0.01
Dissolved Oxygen (DO, mg/L)	5.723	6.87	6.29± 0.02	5.21	7.1	6.155±0.02

*± Standard error

In the **table (4)** minimum temperature was 15.2 °C while the maximum was 24.3 °C and the mean temperature in aquaria (control) was 19.75 °C. In aquaponic system temperature increases as minimum was 21.74 °C while the maximum was 23.76 °C and the mean temperature 22.75 °C. The minimum PH in aquaria (control) was 7.54, the maximum 8.1 and the mean 7.82. While in aquaponic system the minimum PH was 7.42, the maximum 8.31 and the mean 7.865. The minimum dissolved oxygen in aquaria (control) was 5.723 mg/L, the maximum 6.87mg/L and the mean 6.29mg/L. While in aquaponic system the minimum was 5.21mg/L, maximum 7.1mg/L and mean 6.155mg/L.

Table (5): Nitrogenous components of examined water samples every week for 8 weeks in Aquaria (control) and Aquaponic system (mean ± SE) (n=8)

Parameter / Group	Aquaria (Control)	Aquaponic system
Total Ammonia Nitrogen (TAN mg/L)	2.85 ± 0.44	0.39 ± 0.08 ***
Nitrite (No2, mg/L)	1.41 ± 0.12	0.03 ± 0.01 ***
Nitrate (No3, mg/L)	53.75 ± 8.23	21.94 ± 1.99 **

: highly significant at P ≤ 0.01 *:very highly significant at P ≤ 0.001

In **table (5)** we found that there was very highly significance decrease in total ammonia nitrogen and nitrite in aquaponic system (0.39mg/L and 0.03mg/L) when compare with aquaria (control) (2.85mg/L and 1.41mg/L). While in nitrate there was highly significance decrease 21.94mg/L when compare with aquaria (control) 53.75mg/L, due to high conversion rate in aquaponic system.

When water quality troubleshooting:

Each water quality parameter in both aquaria (control) and aquaponic systems will affect the fish stock and it may cause mortality. The following table gives an overview of the water quality problems and importance, with possible root causes, **Table (6):**

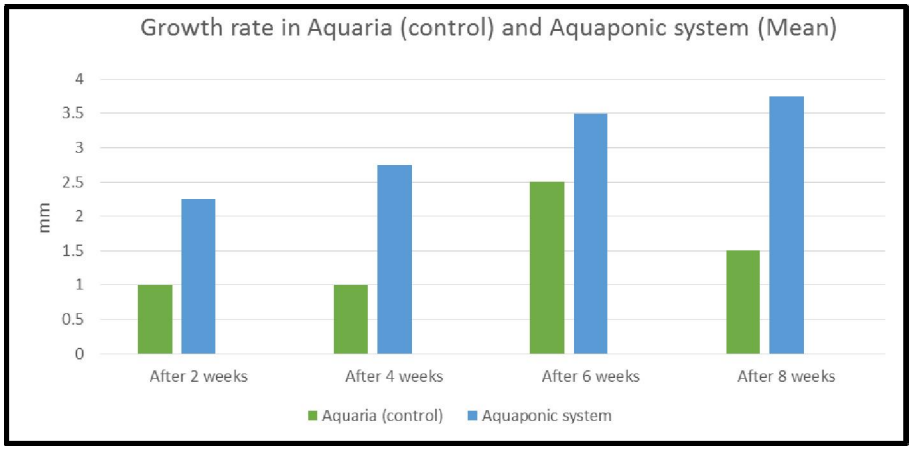
Growth rate in Aquaria (control) and Aquaponic system:

At the beginning of the experiment, we brought 50 fingerlings of Tilapia Fish (*Oreochromis niloticus*) all about (5.8cm – 6.4cm) length.

Fish were measured every 2 weeks from the beginning of the experiment to the end. A comparison was made between the growth rate in both aquaria (control) and the aquaponic system and the results showed that the growth in aquaria (control) was mild when compared with the aquaponic system. Fish growth rate was going in an identical way in aquaponic system while, in the aquaria (control) the rate was extremely low as illustrated in **Table (7)** and **graph (1).**

Table (6): water quality problems and importance, with possible root causes:

Parameter Temperature	Clinical signs	Possible causes .	Solution
(Hypothermia& Hyperthermia)	**Hypothermia**: fish become inactive **Hyperthermia:** fish stop eating.	Water heater failure	Monitoring cooling or heating systems. Cover water surfaces with permeable sheets.
Low Dissolved Oxygen (DO)	(Fish swimming close to the surface)	Aeration is insufficient. Fish overcrowd or overfeed.	Add more air flow, stop feeding and transport some fish to other tanks.
PH Disturbance	PH doesn't itself affect the fish directly, but it effects on water quality parameters.	Complete loss of system pH buffering capacity. (PH rises) or (PH lowers)	Maintain alkalinity to at least 100 mg/L (of CaCO3). To adjust pH to normal levels.
Nitrite poisoning	Pale gills. Dyspnea (fish can't breathe)	Biofilter failure. Solids accumulation in the system.	Stop feeding and make water exchange. Adding 2-4 gm of salt per liter of water.
Nitrate poisoning	Growth disturbance, poor feed and erratic swimming behaviors.	Nitrate accumulation occurs naturally in systems.	Water exchange rates increase in the system or add more plants.
Ammonia poisoning	Fish become jumping. Fish stop feeding.	Biofilter failure, too much feeding.	Stop feeding for fish and water exchanges.



Graph (1): Growth rate in Aquaria (control) and Aquaponic system:

Table (7): Growth rate in Aquaria (control) and Aquaponic system:

Weeks	Aquaria (control)			Aquaponic system		
	Min	Max	Mean	Min	Max	Mean
After 2 weeks	+0 mm	+2mm	+1mm	+2mm	+2.5mm	+2.25mm
After 4 weeks	+1mm	+1mm	+1mm	+2mm	+3.5mm	+2.75mm
After 6 weeks	+2mm	+3mm	+2.5mm	+3mm	+4mm	+3.5mm
After 8 weeks	+1mm	+2mm	+1.5mm	+3.5mm	+4mm	+3.75mm

Mortality rates in both Aquaria (control) and Aquaponic system

We found that after 2 weeks there are 2 fish in the aquaria (control) died on the other hand there was no mortality in aquaponic system. After 4 weeks, there were 3 fish died in the aquaria and 2 fish in the aquaponic system. After 6 weeks, there were 3 fish died in aquaria on the other hand there was no mortality in aquaponic system. After 8 weeks, there were 6 fish died in the aquaria and one fish in the aquaponic system (**Table 8).** Clinical signs of fish in the aquaria (control) system showed hemorrhages all

over the body surface with laceration and rot in tail fin while postmortem examination in those fish revealed congested organs as showed in **figures (7,8 and 9)**

Table (8): Mortality rates in both Aquaria (control) and Aquaponic system:

Weeks	Aquaria (control)	Rate%	Aquaponic system	Rate %
After 2 Weeks	2 fish	8%	-	0%
After 4 Weeks	3 fish	12%	2 fish	8%
After 6 Weeks	3fish	12%	-	0%
After 8 Weeks	6 fish	24%	1fish	4%

Bacteriological examination:

Total bacterial count in water and fish samples:

After the first month of the experiment, the (TBC) in both aquaponic and aquaria groups were nearly similar and ranged from 6.6×10^5 to 12.4×10^5 (CFU/ml). At the 6th week, the (TBC) began to decrease in aquaponic system untill reach its lowest level at the end of the experiment (2.4×10^5, $2.7\times10^5$and 0.8×10^5 CFU/ml) in water, skin and gills respectively. Whereas, The (TBC) increased in aquaculture with water had the highest number of bacteria 11.1×10^5 (CFU/ml) at the end of the experiment **Table (9).**

Table (9): Total bacterial count in water and fish samples:

Isolation period	TBC *(CFU/ml)*					
	Aquaria (control)			Aquaponic		
	Water	skin	gills	water	skin	gills
After 2 weeks	9.5×10^5	11.3×10^5	8.2×10^5	8.4×10^5	12.4×10^5	7.6×10^5
After 4 weeks	8.3×10^5	9.2×10^5	6.6×10^5	7.3×10^5	10.4×10^5	7.5 ×105
After 6 weeks	8.9×10^5	10.1×10^5	7×10^5	4.9×10^5	3.1×10^5	1.4×10^5
After 8 weeks	11.1×10^5	10.8×10^5	7.8×10^5	2.4×10^5	2.7×10^5	0.8×10^5

Bacteriological isolation and identification:

The screening of bacterial isolates was carried out based on their colony morphology, biochemical and molecular characterization of different samples collected from water and fish. The most prevalent isolates from aquaria and aquaponic were *A.hydrophila* with (30% and 20%) isolation rate respectively.

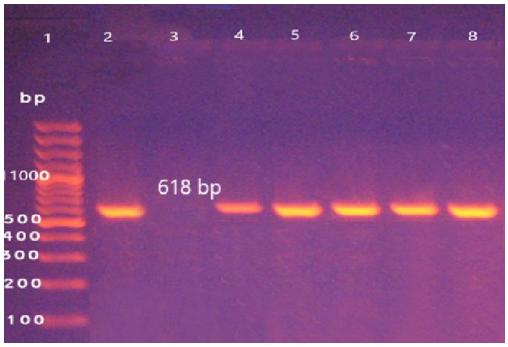
Pseudomonas spp. were isolated with a percentage of (20%) from aquaria and (15%) from aquaculture. *E.coli* was also identified in (15%) of the examined samples of each system. While one isolate of staphylococcus aureus was isolated only from aquaria. The highest isolation rates were from skin of fish and water **(Table 10).** PCR was applied on five isolates from each bacterial species for the detection of 16S rRNA gene and results showed that this gene was detected in all examined isolates and gave characteristic bands at as shown in **Figs (3, 4, 5 6).**

Table (10): Prevalence of bacterial isolates:

Isolates	No. of isolates							
	Aquaria (control) (n=20)				Aquaponic (n=20)			
	Water	Skin	Gills	Total	Water	Skin	Gills	Total
A.hydrophila	2 (10%)	3 (15%)	1(5%)	6(30%)	1 (5%)	2(10%)	1(5%)	4(20%)
Pseudomonas	1(5%)	2(10%)	1(5%)	4(20%)	2(5%)	1(5%)	--	3(15%)
E.coli	1(5%)	2(15%)	--	3(15%)	1(5%)	1(5%)	1(5%)	3(15%)
S. aureus	1(5%)	--	--	1(5%)	--	--	--	--

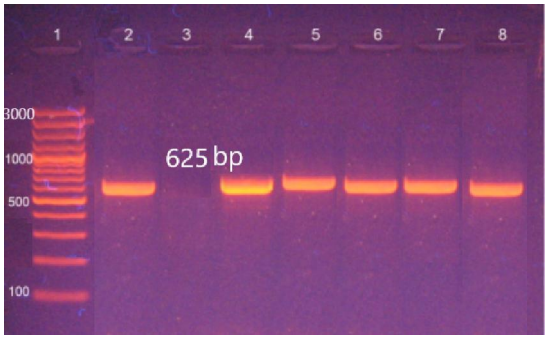
S. aureus :*Staphylococcus aureus*; ***A.hydrophila:*** *Aeromonas hydrophila*

Fig (3): PCR identification of 16S gene of *stapH.aureus* strain



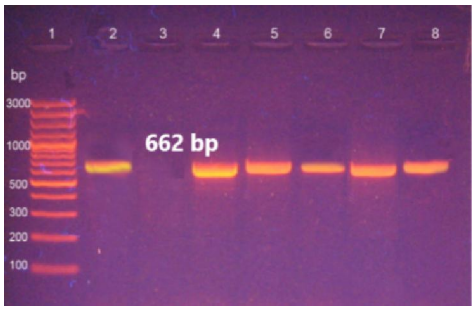
Lane 1: Ladder, Lane 2: Control Positive, Lane3: Control Negative, Lane 4-8: positive amplification of ***16S*** rRNA gene in all examined *Pseudomonas* isolates at 618bp

Figure (4): PCR amplification of 16SrRNA gene of *Aeromonas* strains



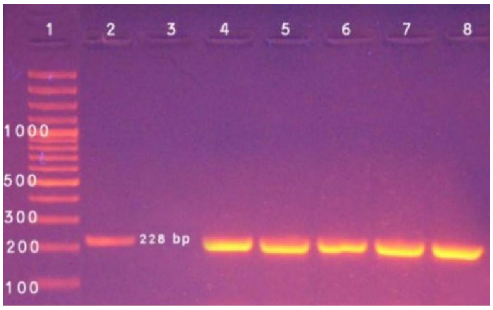
Control Negative, Lane 4-8: positive amplification of ***16S*** rRNA gene in all examined *Aeromonas* isolates at 625bp

Fig (5): PCR amplification of 16SrRNA gene of *E.coli* isolates



Lane 1: Ladder Thermo-scientific Gene-Ruler 100bp plus, Lane 2: Control Positive, Lane3: Control Negative, Lane 4-8: positive amplification of ***16S*** rRNA gene in all examined *E.coli* isolates at 662bp.

Fig (6): PCR amplification of 16SrRNA gene of *S.aureus* isolates



Lane 1: Ladder Thermo-scientific Gene-Ruler 100bp plus, Lane 2: Control Positive, Lane3: Control Negative, Lane 4-8: positive amplification of ***16S*** rRNA gene in all examined *S.aureus* isolates at 228bp.

Fig (7): shows laceration in tail fin surface.

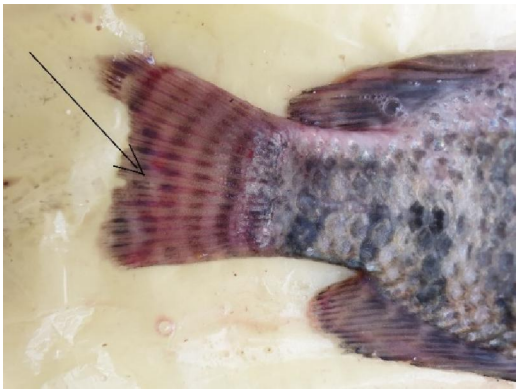


Fig (8): shows Hemorrhages all over the body.

Fig (9): shows Congested internal organs

4. Discussion

The present study was carried out to evaluate the impact of aquaponic system on water quality, growth rate and health status of *Oreochromis niloticus*. Fifty apparently healthy fish were collected and divided equally into two groups representing aquaponic system and the aquaria (control). Water quality in aquaponics doesn't affect fish only, but also the plants grown in the system and plays an important role in finding the best balance between them (**Timmons & Ebeling, 2010).**

Several studies (**Petrea,*et al* 2013; Petrea, *et al* 2014, Lennard and Leonard, 2004, 2006)** have demonstrated that the substrate aquaponic technique has the most significant water treatment when compared with ordinary aquaculture.

Graber and Ranka (2009) mentioned that plants can be grown in aquaponic system, on different types of media, thus combining the ammonia nitrogen oxidation process with the absorption of the final products and nitrates. Therefore, the use of aquaponic technique is recommended.

One of the negative aspects of recirculating integrated aquaponic system is the major deficiencies in various nutrients concentration in terms of nitrogen concentration, the system is in equilibrium (Ministry of Foreign nutrient balance in RAIS is very different in terms of the concentration of added compounds (**Racoky et al., 2006**). It should be pointed out that, compared to hydroponic systems. In the present investigation, measuring of water quality parameters revealed that, the mean values of temperature in aquaria and aquaponic were 19.75℃ and 22.75℃ respectively. It was mentioned that the acceptable range of temperature for all three components of the aquaponic system (fish, plants and nitrifying bacteria) was ranged from 21.1 to 29.4°c. (**Sallenave, 2016)**

PH can affect health of fish when increase or decrease than specific limit, but in this study pH of both aquaria (control) and aquaponic was within certain limits 7.82 ± 0.01 and 7.865 ±0.01 respectively, which was in accordance with **Abdel-Satar *et al.* (2010)** who reported that the optimum pH for *Oreochromis niloticus* is usually between pH 7.5 and 8.5. Alkalinity is the reliable indicator for pH, alkalinity of both aquaria and aquaponic system was found to be within permissible limits according to **Lawson (1995)**.

In the present study, the mean DO in aquaria was 6.29 ±0.02mg/L and aquaponic system 6.155 ± 0.02mg/L. Dissolved Oxygen is an important parameter for identification of different water masses (**Ibrahim and Ramzy, 2013**). In addition, nitrifying bacteria are aerobic and need oxygen to produce nitrate (NO3) (**Henriksen *et al.* 1981**). Where in, DO level reported significant improvement ($p \leq 0.01$) in aquaponic system with mean value of 6.23± 0.05 mg/L as compared to control (6.14± 0.03 mg/L), that was in the permissible limits as mentioned previously by **Lioyd (1992**). The improvement in DO level in aquaponic may be attributed to the interaction of DO with temperature and other factors in which the solubility of oxygen in the water decreases as the temperature increases. That was in accordance with (**Eissa *et al.*, 2015).**

Aquaponic approach provided one of the best water quality control in the industry" (**Savidov, 2004**). Toxic Nitrite is the intermediate product of nitrogen cycle that produced under the effect of the gram-negative, aerobic bacteria lives naturally in the system (**Lawson, 1995**). In aquaponic the nitrite level was founded to be low within the permissible limits (0.5 mg/L due to its quick conversion rate to nitrate which is non-toxic to fish (**Swann., 1997**and **Salam *et al.* 2013**). Meanwhile, the nitrate concentrations showed slight increase in aquaria group (53.75 ±8.23

mg/L) when compared with aquaponic (21.94 ±1.99 mg/L), the results were partially in consistence with the results of **Stone and Thomforde (2004)**.

Concerning toxic ammonia, the maximum concentration in the aquaria (control) (2.85 ± 0.44 mg/L) and in the aquaponic system (0.39 ± 0.08 mg/L), which in agreement with **EPA (1999)** who reported that, the mean limit of ammonia concentration is 0.3 mg. While, disagreement with the ammonia content in 0 day is 0.350 mg/L. In the aquaponic system, the concentration of ammonia on 10th day was 5.11 mg/L, compared with ammonia levels on day 0 with 10th day there was an increase because on 10th day, the aquaponics system was already operating even though it wasn't optimal, **Deswati et al. (2020).** In regard to fish growth rates, fish were measured every 2 weeks from the beginning of the experiment to the end and the results showed that, the growth in aquaria (control) was mild when compared with the aquaponic system and increased with +1.5mm mean value at the end of the experiment. Whereas, fish growth rate was going in an identical way in aquaponic system with +3.75mm increase. That was in accordance to **(Effendi *et al.* 2015**), who mentioned that tilapia well-grown in aquaponic system using vegetables.

Regarding the mortality rates in aquaria and aquaponic systems in a time period of 8 weeks, it was observed that there were 2, 3, 6 fish died in the aquaria (control) after 2, 4, 6 and 8 weeks from the beginning of the experiment. On the other hand, there were 2 fish died in the aquaponic system after 2 weeks with no mortalities after 4 and 6 weeks and only one fish died at the end of the experiment. These mortalities in aquaria (control) could be attributed to higher toxic ammonia and nitrite which increase the stress on fish and the chance to acquire infection. Our results were nearly similar to the mortality percentages observed by **Roberts, (2012),** who reported mortality rates of 30%, 20%, 30% at the 2nd, 3rd, 4th weeks, respectively, and completing 100% at the 5th week of his experiment.

Aquaculture is always plagued by diseases caused by pathogens due to high stocking density and monotonous ecological structure **(Kim *et al.*, 2018).** More than half of the infectious disease outbreaks in aquaculture (54.9%) are caused by bacteria **(McLoughlin and Graham, 2007).**

Aquaponics as a closed aquaculture system reduced the risk of proposing pathogens and contaminants for aquatic environment and maintained water quality by solid removal and biological filtration **(Rurangwa and Verdegem 2015)**. Clinical signs in the infected fish showed exophthalmia, detached scales and hemorrhages all over the body surface. These results are partially in agreement with those obtained by **Fard *et al.* (2014)**.

At the beginning of the experiment, our investigation revealed that, the total bacterial count in examined samples of the aquaculture were 9.5×10^5, 11.3×10^5 and 8.2×10^5 cfu/ml from water, skin and gills, respectively. This count tended to increase to be 11.1×10^5, 10.8×10^5 and 7.8×10^5 cfu/ml at the end. Out of the 20 fish samples analyzed for TPC, the skin had the highest number of bacteria 11.3×10^5 cfu/ml. while, gills had the lowest TBC with 6.6×10^5 cfu/ml. our results were in consistence with a study conducted by **(Sichewo *et al.*, 2013).** In the aquaponic, the highest TBC was obtained from skin of examined fish as 12.4×10^5 cfu/ml at the beginning of the experiment and the count reduced to reach 2.7×10^5 cfu/ml. On the other hand, the lowest TBC was found in gills at the end of the experiment with 0.8×10^5 cfu/ml. in comparing the TBC in both systems, it was found that the TBC in water of aquaponic system was the lowest (0.8×10^5cfu/ml) which may be attributed to the capacity of aquaponic to maintain the water quality for both aquatic species and plants **(Bai, *et al.*, 2005 and Rurangwa and Verdegem, 2015).**

In the present study, bacteriological and the molecular identification of the isolates revealed that, the most prevalent bacterial isolates in both aquaculture and aquaponic was *A. hydrophila* with a percentage of 30% and 15% respectively. These findings were nearly similar to what recorded by other researchers as **(El-Barbary and Hal, 2016)** who isolated *A. hydrophila* with incidence rate 21.8 %. Higher rates were stared by **Emeish *et al.* 2018** who isolated *A. hydrophila* with a percentage of 50%. Whereas, very high isolation rate was reported by **(Kusdarwati *et al.* 2017)** who found who identified A. hydrophila in 95% of the examined fish. This wide spread distribution of *Aeromonas spp.* may be attributed to its high affinity to adapt the environmental stress factors and its ubiquitous nature in the aquatic environment (**Dong *et al.*, 2017; Eissa *et al.*, 2015**).

In our investigation, *pseudomonas, E.coli and S.aueus* where isolated from aquaculture with percentage of 20%, 15% and 5% respectively. In consistent with our results, **Akoll and Mwanja, 2012** reported the isolation of same bacterial species from inspected fish samples in Uganda and Kenya. *E. coli* was isolated with 14.3 % from the examined Nile Tilapia in Gharbiya governorate in Egypt as previously cited by **(Lobna and Salem, 2010).** On the other hand, **Metwally *et al.*, (2020)** reported higher recovery rate of *S.aureus* (25%) from Nile Tilapia from Kafr Elzayat city EL-Gharbia governorate, Egypt, during the period from

November 2015 to January 2017. Concerning the aquponic system bacteriological screening, *A. hydrophila, pseudomonas, E.coli* were isolated. Likewise, **Chitmanat *et al.*, (2015**) found out that bacterial populations in Water of examined aquaponic systems with different fish densities were dominated by *Aeromonas hydrophila, Pseudomonas fluorescens, Plesiomonas shigelloides, Escherichia coli, Acinetobacter baumannii, Salmonella sp., Staphylococcus sp., Micrococcus sp*.

It was spotted that bacteria assume to increase in number in recirculating systems include *Aeromonas spp., Vibrio spp., Mycobacterium spp., Streptococcus spp. and Flavobacterium columnare* **(Yanong, 2013),** owing to the fact that recirculating systems are mechanically sophisticated and biologically complex which sometimes fails due to poor water quality leading to fish stress, diseases and off-flavor in poorly managed systems **(Masser *et al*., 1999 and Emperor Aquatics, 2013).** The molecular identification is considered the ideal aid for identification of fish pathogens than phenotypic and biochemical methods **(Buller, 2004 and Hossain, 2008).** Herein, PCR was applied on five randomly selected isolates from each bacterial species for the detection of 16S rRNA gene and results showed that this gene was detected in all examined isolates and gave a characteristic band at 625bp, 618bp, 662bp and 228bp of *A. hydrophila, pseudomonas, E.coli and s.aureus* respectively.

From the present study, it was concluded that Aquaponic system overcome poor water quality by improving parameters which reflected on fish health, growth and releasing stress on challenged fish with bacteria which showed in form of low mortality rates.

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