COMPARATIVE STUDY OF NITROGEN BIOREMOVAL FROM AQUACULTURE WASTEWATER USING BIOFLOCS TECHNIQUE (BFT) VERSUS BIOFILTRATION SYSTEM

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ABSTRACT

*Laboratory experiment aimed to comparison between treatment of fish wastewater using biofloc technology **(BFT)** and biofilter system to re-use water and reduce its change periods. Ammonium concentration increased from 0.51 mg/l at beginning of experiment to 0.54 mg/l and decreased to 0.25 mg/l and is fixed at 0.49 mg/l for biofilter samples. While, these concentrations ware 0.62- 0.87-0.12-0.27 mg/l for biofloc treatment samples. Ammonium reduction ratio of biofilter was 32% versus 17.33% for biofloc technique at beginning of experiment then it still increasing and reached to 42 % for biofilter against 7.45% of biofloc technique. Unexpected decrease in the ammonium reduction ratio for biofilter system by 21.87 and 15.52% versus 62.50 and 53.45% correspondingly for biofloc. These results were referred to biofiltration process adaptation and lack of uniformity of bioflocs throughout whole water tank. Results of measured ammonium concentrations show superiority of the use of biofloc technique over biofilter system. The decline in nitrite reduction ratio for biofilter of 63.16% at the second week of the start of experiment happened and then there was a slight increase in nitrite reduction ratio 63.49% to be settled on the 65% reduction ratio value. This was referred to biofilter clogging and biomass accumulation. Biofloc technique demonstrated an excessive superiority (93.02%) in nitrite reduction ratio at beginning of the experiment over biofilter system (70.54%). Two systems had similar behavior of nitrite reduction ratio throughout the rest of experiment. Finally, use of **BFT** systems to freshwater tilapia aquaculture benefits both the reduction in ammonium and nitrite concentrations and can be effective in improvement fish production.*

Keywords: *Nitrogen, bioremoval, aquaculture, wastewater, biological, bioflocs technique, BFT biofiltration system.*

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INTRODUCTION

Egypt occupies 6^{th} place among the Top-10 producers (finfish-inland aquaculture) by 1,091,688 T; live weight (2.6%), 7^{th} place in (crustaceans-inland aquaculture) by 5, 856 T; live weight (0.2%), 7^{th} place in farmed food fish by 1,097,544 T; live weight (1.6%) and 9^{th} place in (food fish and aquatic plants) by 1, 097, 544 T; live weight (1.1%) (**FAO,2015**).

Water quality and quantity limitations, cost of land, water discharges limitations, environmental impacts and diseases, are driving aquaculture industry toward more intensive practices and will force producers to adopt environmentally friendlier technologies (**Gutierrez-wing and Malone, 2006**). To produce large quantities of fish or shrimp in a high rate, intensive aquaculture systems is an efficient way (**Avnimelech, 2007**). **Avnimelech *et al.*, 1992** concluded that it is possible to grow a dense fish biomass in a closed system if a method to control the inorganic nitrogen accumulation is practiced. Long-term growth of the aquaculture industry requires both ecologically sound practices and sustainable resource management (**Naylor et al., 2000**).

Biofloc technology (**BFT**) is one method with filtration directly from water. It is a technique of enhancing water quality in aquaculture through balancing carbon and nitrogen in the system (**Crab et al., 2012)**. **BFT** has recently achieved attention as a sustainable method to control water quality, with the added value of producing proteinaceous feed in situ. **BFT** has beneficial effects in aquaculture management, including water quality, feeding and disease control (**Choo and Christopher 2015).**

Unlike the conventional techniques such as biofilters, biofloc technology supports nitrogen removal even when organic matter and biological oxygen demand of the system water is high (**Avnimelech, 1999**). Moreover, **Hargreaves, 2006** reported that this promoted nitrogen uptake by bacterial growth decreases the ammonium concentration more rapidly than nitrification. Ammonia accumulation in the water is considered as one of the problems associated with the intensification of pond aquaculture (**Avnimelech, 2009**). This accumulation places the fish at risk from elevated levels of the toxic ammonia (NH_3) and nitrite (NO_2^-) species.

In the study by **Körner et al., (2001)**, both NH_3 and NH_4^+ proved to be toxic to fish. Un-ionized ammonia proved to be more detrimental because it is lipid soluble and is uncharged which makes it easy to move across the biological membranes than the charged NH_4^+. Ammonia is toxic in above 1.5 mg N/l to most cultured fish (**Neori et al., 2004**). To the species ***Gilthead seabream*** **(*Sparus aurata*)** the value should not exceed higher than 1.2 mg/l TAN (0.064 mg/l NH_3-N). Theoretically the fish will not suffer any deleterious effects from the presence of ammonia up to this level (**Wajsbrot et al., 1991**).

Addition of carbonaceous materials leads to the conversion of inorganic deleterious nitrogen to microbial proteins. Roughly, 20-25 g of carbonaceous material was needed to convert 1 g of ammonia nitrogen into microbial protein (**Avnimelech, 1999**). This process is relatively fast and it is possible to reduce an elevated level of ammonia to any desired level within a period of 1-3 days. One feature of this mechanism is the possibility of using the microbial protein as a source of protein for fish.

Biofloc technique can be implemented in aquaculture systems by two methods: (a) Integration of bioflocs within the culture unit by using feed with a relatively low N content and/or the addition of a carbon source and (b) Use of a separate bioflocs reactor (**Crab et al., 2012)**. Although most water treatment methods used in intensive or recirculating aquaculture systems result in a relocation of nutrients and organic matter and not in an overall reduction in discharges, this relocation makes it possible to reduce potential environmental impacts by facilitating effluent treatment (**Piedrahita, 2003**).

BFT applied in aquaculture to avoid environmental impact of high nutrient discharges and reduce artificial feed usage. In **BFT**, excess of nutrients in aquaculture systems are converted into microbial biomass, which can be consumed by the fish as a food source. Review of previous studies demonstrated that **BFT** benefits were also evident in the freshwater tilapia culture to include improved production through lower feed conversion rate, better nutrition, optimum water quality and health **(Choo and Christopher, 2015).**

The excretion of nitrogenous metabolic wastes and their assimilation by heterotrophic bacteria maintain a balance by manipulating the C/N ratio by addition of carbon sources in the water. The production of heterotrophic bacterial biomass further results in macroaggregates formation known as biofloc (**Hargreaves, 2013**). In **BFT**, locally available cheap carbon sources are added into the system to manipulate the C/N ratio in order to stimulate heterotrophic bacteria growth and control inorganic nitrogen concentration through assimilating of ammonia into bacteria as single-cell microbial protein. Biofloc will then be eaten by the fish, thereby recycling protein that are excreted from the fish as only 20-25% of fed protein is retained in the fishes raised in intensive system, with the remainder being excreted into the system as ammonia and organic nitrogen in feces and feed residues (**Avnimelech, 1999**).

Nile tilapia is used in many studies with **BFT** with positive results. A big constraint that is of importance is the fact that tilapia is cold sensitive (**Charo-Karisa et al., 2005**). Nile tilapia reduces feeding and activity at 20°C and at 16°C growth stops. If it becomes 10°C the fish won't survive for many days (**Dan and Little, 2000**). **Avnimelech (1999)** evaluated feed uptake and response to additional carbohydrates with tilapia hybrids (***O. niloticus x O. aureus***), fish growth in **BFT** ponds enriched with carbohydrate fed with 20% protein, feed yielded superior fish growth compared to conventional non-**BFT** ponds fed with 30% protein. Daily gain and final weight of tilapia were higher in the **BFT** ponds compared to the conventional ponds and mortality rate was lower in the **BFT** ponds.

Azim et al., (2008) found that the concentrations of BOD level and TSS in **BFT** tanks were higher than the control tanks because the readings for BOD level corresponded to the TSS level, where TSS levels of control tanks (16 mg/l) were 36 times lower than **BFT** tanks (597 mg/l). **Azim and Little., (2008)** observed that individual fish weight at harvest was higher in **BFT** treatment compared to the control using a recirculating system. **BFT** treatments also contributed 44-46% greater individual weight gain and net fish production than those in controls. Food conversion ratio was also significantly higher in the control compared to the **BFT** treatment tanks.

Rotating biological contactors, trickling filters, bead filters and fluidized sand biofilters were conventionally used in intensive aquaculture systems to remove nitrogen from culture water. Nitrifying microorganisms in fixed bed biofilm reactors fed with different nitrite and ammonia concentrations were reported by (**ter Haseborg et al., 2010**). Trickling filter design procedures were presented and one of them, a model describing the nitrification performance of trickling filters by plug-flow characteristics. **Breisha, (2010)** reported that factors affecting the nitrogen removal efficiency included temperature, dissolved oxygen, nitrate concentration, salinity, pH or the free ammonia concentration.

Research work scope is to perform a comparative study for nitrogen bioremoval from aquaculture wastewater using bioflocs technique versus biofiltration system and study the effect of use of these two methods on each of the conversion rates of ammonia and nitrite transformation and fish performance rates.

MATERIAL AND METHODS

Present research work was performed at Bio-Engineering Lab, Agric. Eng. Dept., Fac. of Agric., Cairo Univ., through March to April, 2015. The purpose of the laboratory experiment was to treat wastewater from fish farms using biofloc technology to re-use water and reduce its change periods. Where another treatment process was performed through biofilteration technique that was working on water purification and filtration of organic and inorganic materials present in the water, whether stuck or dissolved using dynamic filtering technology. In addition to use of the biofloc system, biofloc is a bacterial communities to use non-self-feeding, which is active when there is a high percentage of organic carbon, then were collected and hold together with other microorganisms, such as rotifers and nematodes and become gatherings consuming nitrogen compounds in the farming environment, a high source of protein. Comparison between a biofilter and biofloc technique can be performed and realized. Fig.(1) illustrates a schematic diagram of whole experimental aquarium with both biofilter and bio-flock units.

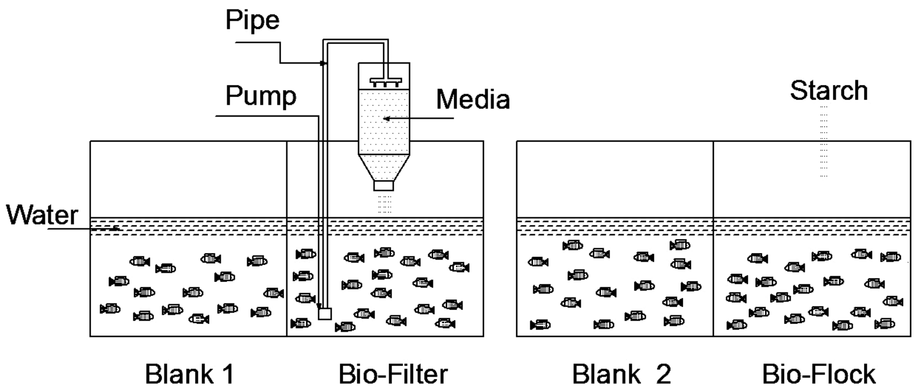

Fig.(1). Schematic diagram of whole experimental aquarium with both biofilter and biofloc units.

Experimental Design

Four aquarium fish tanks with high pressure resistance Spanish glass thickness of 8 mm were designed and examined. Aquariums had dimensions of (50 x 50 x 50 cm as length, width and height respectively, with water height of 30 cm and total water volume of 0.075 m^3 (75 liters)). Most aquaculture biofilters are designed for the purpose of converting and removing ammonia and nitrites from the system. The type of biofilter under investigation is a filter that employs a non-moving surface area to provide a substrate for various bacteria to attach and grow. The substrate remains in place while the water flows through the system. The heart of these biofilters is the packing or media used to provide the surface area.

A trickling filter consisted of a fixed bed of mixture of [gravel, 5-10 mm diameter, and Basalt Black, sand] was used as a biofilter medium. Gravel have relatively high specific surface areas "packing density" (820 m^2/m^3), high void fraction and resistance to plugging, are typically very inert and durable with excellent mechanical strength and are usually wetable immediately. Basalt Black, sand is a natural stone containing olivine, 0.5-1 mm, fire-dried, (silicates and quartz), grains form, black color, odorless, pH value of 7 (20°C) and insoluble in water. Table (1) illustrates technical data for biofilter mixture medium. Aquarium wastewater flows downward and causes a layer of microbial slime (biofilm).

Table (1). Technical data for Basalt Black, sand 0.5 - 1 mm, fire-dried biofilter medium (Basalt Black, sand belongs to the group of magnetic pigments).

Item	Description
Chemical description	Natural stone containing olivine, silicates and quartz
Suitability	Acrylics, Lime / Fresco, Cement / Tadelakt
Color	Black
Form	grains
Light fastness medium	8 (1 is poor, 8 is best)
Light fastness thinned	8 (1 is poor, 8 is best)
Light fastness concentrated	8 (1 is poor, 8 is best)
Solubility in water	insoluble

The filter with a black basalt medium (basalt No. 11) with calculated detention time of 50 s and total volume of 6 l (70% medium) is placed (20 cm above aquarium. Figure (2), also illustrates gravel, mixed basalt and gravel and mixed sand and gravel medium testing, porosity ratio testing and whole biofilter system. Porosity ratio and bulk density were calculated and it was found as approximately equal to (50%) for gravels with diameters ranging between (0.5-1.0 mm) with average diameter of (0.75 mm).

Submersible air pump, (AP-1350L), (220-240V,50/60Hz,18W,200 l Aquarium size and Q. Max of 1000 l/h, total dynamic left of 120 cm, and temperature range of 0-35 °C was used to recycle tank water to biofilter. Two plastic air pump, (SILVER LAKE, SP-780), (220/240V,50Hz, 220V~240V/50Hz, 5W and double air vents with air flow rate of 3.5 l/min (air outlet)) and cord length of 63 cm were used to supply aquariums with fresh air through air publishers.

(a) (b) (c) **(d)**

Fig.(2). Alternatives tests for available biofiltration media used in the final operation of the basins, (a) gravel testing, (b) basalt medium (basalt No. 11) testing, (c) mixed sand and gravel medium testing, (d) Imhoff suppression method.

10 ml of water sample was taken and placed in a beaker for NH_3 analysis. Add 0.5 ml of chlorine solution and was shaken, addition of 0.6 ml of phenol solution and was shaken, wait for 15 minutes to get a stronger color blue. Chlorine solution consisted of (20 ml chlorine with 80 ml of distilled water and dilute Hydrochloric acid (HCL acid) (3:1) was added gradually to decrease pH from 11 to (6.5-7) (this solution was valid for five days). Phenol solution consisted by addition of 100 ml of distilled water to the graduated cylinder, then addition 2.5 g of sodium hydroxide to distilled water after weighing, and then melted 10 g of phenol in the same tester. Phenol solution was valid for 5 days usage and was kept in a dark bottle away from direct light so as not to oxidize. 50 mm sample water was pulled and filtered for NO_2 analysis, then was placed in a 100 milliliter beaker. Add 1 ml of Salicylic-acid solution with well mixing for (2-3 minutes, no more than 4 minutes) after that 1 ml of Naphthyl solution was added and mixed well. Imhoff cones, Fig. (2), were used to measure biofloc as the concentration of solids that settle after 10 to 20 minutes. The desired range for operation of biofloc systems is a settleable

solids concentration of 25 to 50 ml/l for tilapia (Adapted from **Hargreaves, 2013**).

Nile Tilapia (***Oreochromis niloticus***) fingerlings with a ranged weight of (5 to 10 g) average (7.5 g) were used (30 fingerlings/aquarium). Anti-chlorine (2- 5 g) has been added to the water before placing the fish with a period of time not less than 60 minutes.Tilapia fish fingerlings were fed a certain diet depends on nutrition rate of 3 % of the fish weight (about 9 g/aquarium) and manufactured fishmeal containing 25% protein, 2.4 g starch as carbon source (0.5 g C per g) in addition to the 3 g protein, were added to formulate C/N ratio of 10:1 in Biofloc treatment (Adapted to **Crab et al., 2012)**.

Water temperature, ambient air temperature and relative humidity have been recording, on a daily basis throughout the duration of the test. Water samples were taken every week to measure the proportion of ammonia NH_3, NO_2 nitrite and then to compare the three treatments (Biofilter-Biofloc - Blank). Chemical analysis of water sample, for Ammonia-N, NH_3^- and Nitrite-N, NO_2^- N, of water samples was performed at Animal Prod. Dept., Fac. of Agric., Cairo Univ., Detention time and porosity ratio can be calculated for biofilter medium using the following equations, (Eq 1, 2) :

$$DT = \frac{V_f}{Q} \qquad (1)$$

$$Porosity,\% = \left({(Total\ Volume - Volume\ of\ Voids)} \big/ {Total\ Volume} \right) \times 100 \qquad (2)$$

The control of organic nitrogen accumulation is based upon carbon metabolism and nitrogen-immobilizing microbial processes, and can be expressed by the following equation (Eq 3):

$$Organic\ nitrogen \xrightarrow{Heterotrophic} NH_4^+ \xrightarrow{Nitrosomonace} NO_2^- \xrightarrow{Nitrobacter} NO_3^- \qquad (3)$$

Microorganisms use carbohydrates (sugars, starch and cellulose) as a food, to generate energy and to grow (produce proteins and new cells); as illustrated in the following equation (Eq 4); (According to **Avnimelech, 1999**):

$$Organic\,Carbon \rightarrow CO_2 + Energy + C\ assimilated\ in\ microbial\ cells \quad (4)$$

The percentage of the assimilated carbon with respect to the metabolized feed carbon is defined as the microbial conversion efficiency (***E_m***). Nitrogen is also required since the major component of the new cell material is protein. Thus, microbial utilization of carbohydrate or any other low nitrogen feed is accompanied by the immobilization of inorganic nitrogen. This process is a basic microbial process and practically every microbial assemblage performs it. The addition of carbohydrates is a potential means to reduce the concentration of inorganic nitrogen in intensive aquaculture systems. The amount of carbohydrate addition dC_s needed to reduce the ammonium can easily be evaluated using Eq (5):

$$dC_m = dC_s \times C_S \times E_m \quad (5)$$

The amount of nitrogen needed for the production of new cell material depends on the C/N ratio in the microbial biomass, it can be expressed by the following equation (Eq 6):

$$dN = {dC_m}/{[C/N]_m} = dC_S \times C_s \times E_m / [C/N]_m \quad (6)$$

Fish assimilate only about 25% of the nitrogen added in the feed (**Crab et al., 2012**), the rest is excreted as NH_4 or as organic N in feces or feed residue. Ammonium flux into the water, dNH_4 , directly by excretion or indirectly by microbial degradation (of the organic N residues, is roughly 50% of the feed nitrogen flux (**Avnimelech, 1999)**, that can be calculated by the following equation (Eq 7):

$$dN = F_d \times N_f \times N_e \quad (7)$$

RESULTS AND DISCUSSION

One of the biggest operational challenges in increasing global aquaculture production is the strict limitations on discharge of effluent from aquaculture farms. Effluents from aquaculture farms discharged into local water bodies can result in low levels of oxygen and increased sediment and nutrient loading, potentially harming local fauna and flora. Management of ammonia concentration below toxic levels is considered as one major aim of water quality management in aquaculture.

Nile tilapia reduces feeding and activity at 20°C and at 16°C growth stops. If it becomes 10°C the fish won't survive for many days as illustrated in advance. Water temperature was ranged between (19-21°C) throughout experiment period, ambient air temperature did not exceed more than 21°C and air relative humidity was 45%. Trickling filters typically consist of a packing or media contained in a vessel. The wastewater to be treated is sprayed over the top of the media and collected in a sump underneath the media. The surface of the media or packing provides the substrate for the growth of a biofilm. One of the big advantages of a trickling filter is that the water can leave with more oxygen than it entered. The first step in the design of a trickling filter is to pick the right packing or media. Table (2) illustrates calculated porosity ratio and detention time for different biofiltration media.

Table (2). Porosity ratio and detention time for different biofiltration media.

Biofilter media	Porosity Ratio (%)	Detention Time (s)
Gravel medium	75	10
Mixed sand and gravel medium	60	30
Mixed basalt and gravel medium (black basalt No. 11)	50	50

Porosity ratio is 75%, 60 % and 50% for gravel, mixed sand and gravel and mixed basalt and gravel media respectively, whereas, calculated detention time was increased gradually from gravel to mixed sand and gravel reaching to mixed basalt and gravel medium correspondingly. From porosity ratio and detention time calculated results, mixed basalt and gravel medium (black basalt No. 11) was chosen as biofiltration medium to its standard porosity ratio of (50%) and also it achieved an appropriate detention time of (50 s). Biofilter medium should be non- corrodible, UV resistant, resistant to rot or decay and generally impervious to chemical attack.

Ammonia concentration can also be controlled by a biofiltration system, which is through the use of the nitrification process. This process is a two-step oxidation of toxic ammonia to nitrate, a form of inorganic nitrogen that is only toxic at high concentration. Nitrification process can be found in intensive aquaculture system and is responsible for the long term ammonia control because ultimately, 25-50% of the nitrogen from feed added to the intensive system are controlled through this pathway. Table (3) demonstrates the results of chemical analysis of water samples for available nitrogen in ammonium form for both of blank water sample, biofiltration and biofloc treatment samples.

Table (3). Chemical analysis results of water samples, available nitrogen, Ammonium-N, NH_4^-, mg/l.

Sample No.	Ammonium-N, NH_4^-, mg/l			Ammonium reduction ratio (%)	
	Blank	Biofilter	Biofloc	Biofilter	Biofloc
1	0.75	0.51	0.62	32.00	17.33
2	0.94	0.54	0.87	42.55	7.45
3	0.32	0.25	0.12	21.87	62.50
4	0.58	0.49	0.27	15.52	53.45

Biofloc technology also, was applied by adding available cheap carbon sources (starch) into the system to manipulate the C/N ratio in order to stimulate heterotrophic bacteria growth as well as control inorganic nitrogen concentration in the system through assimilating of ammonia into bacteria as single-cell microbial protein. Ammonium concentration increased from 0.51 mg/l at the beginning of the laboratory experiment to 0.54 mg/l and decreased to 0.25 mg/l and is fixed at 0.49 mg/l for biofilter samples. While, these concentrations ware 0.62 - 0.87 - 0.12 - 0.27 mg/l for biofloc treatment samples respectively. To compare between the two systems, ammonium reduction ratio (%) was calculated. Ammonium reduction ratio of biofilter was 32% versus 17.33% for biofloc technique at the beginning of the experiment then it still increasing and reaching to 42 % for biofilter against 7.45 % of biofloc technique. This situation may be referring to biofiltration process adaptation and lack of uniformity of bioflocs throughout whole water tank.

In **BFT** system, C/N ratio is increased through supplementation of an organic carbon source or reduced protein levels in feed. By this manipulation, the heterotrophic bacteria create a demand for nitrogen in the form of ammonia in the water. This could explain the reason behind the increase of ammonium reduction ratio for biofloc technique at third and fourth week of the experiment by 62.50 and 53.45 % respectively. In opposition to unexpected decrease in the ammonium reduction ratio for biofilter system by 21.87 and 15.52 % correspondingly. Figure (3) shows the available nitrogen, Ammonium-N, NH_4^-, mg/l, of water samples for blank, biofilter and biofloc technique. As organic carbon and inorganic nitrogen are generally taken up in a fixed ratio by the bacteria, therefore, ammonia concentration can be controlled through the addition of a carbon source. Ammonium is assimilated into microbial protein in the water when adding some source of organic carbon which is increasing the ratio between carbon and nitrogen (C/N).

Results of measured ammonium concentrations inside water basins show superiority of the usage of biofloc technique over treatment of water by biofilter system. That, also emphasizes the efficient usage of biofilter system in the treatment process, although, the high rate of ammonium concentrations mean more fixed ammonia in the water.

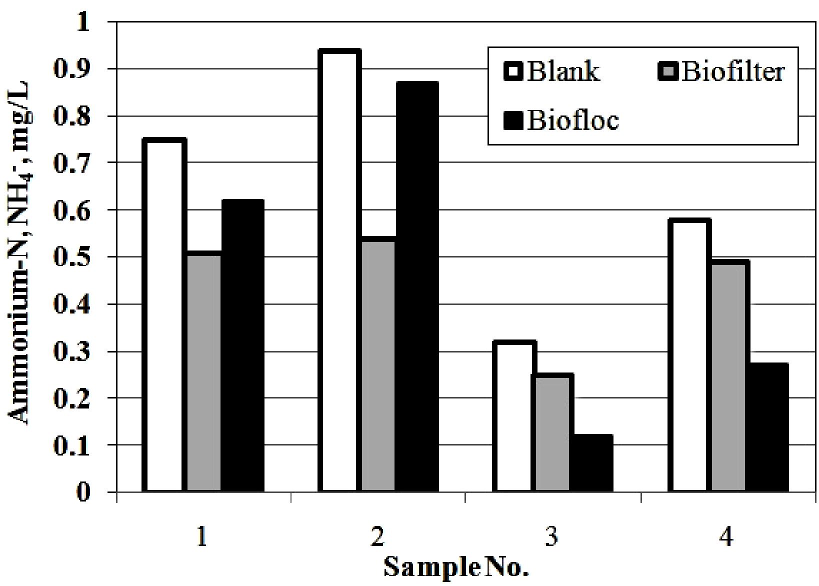

Fig. (3). The available nitrogen, Ammonium-N, NH_4^-, mg/l, of water samples.

Low efficiency of biofilter may be due to blockage of the biofilter medium that can occur by increasing the growth rate of aerobic bacteria inside the medium. As well as, increasing in the efficiency of biofloc technique was due to the significant increase in air temperature and the growth rate and activity of bacteria more vital communities. Table (4) illustrates chemical analysis of water samples of nitrite concentrations for both experimental treatments (blank, biofilter and biofloc).

In order to assess the state properly, a comparison between nitrite reduction ratio of biofilter system and biofloc technique should be performed and discussed. Nitrite reduction ratio calculated for biofilter system as 70.54 %, 63.16 %, 63.49% and 65% for treatments respectively. Whereas, the decline in nitrite reduction ratio (63.16%) at the second week of the start of the experiment happened and then there was a slight increase in nitrite reduction ratio (63.49%) to be settled on the (65%) reduction ratio value. This may be the consequence of plugging problems of biofilter that were resulted from biomass accumulation in biofilter medium and caused the clogging of biofilter.

Table (4) presents also, the concentrations of resulted nitrite analysis for water samples of biofloc technique. These were 93.02 %, 60.52 %, 61.90% and 65 % for treatments respectively. Where biofloc technique demonstrated an excessive superiority (93.02%) in nitrite reduction ratio at the beginning of the experiment over biofilter system (70.54 %). Two systems had similar behavior of nitrite reduction ratio throughout the rest three weeks of experiment.

Table (4). Chemical analysis results of water samples, available nitrogen, Nitrite-N, NO_2^- N, mg/l.

Sample No.	Nitrite-N, NH_4^-, mg/l			Nitrite reduction ratio (%)	
	Blank	Biofilter	Biofloc	Biofilter	Biofloc
1	1.29	0.38	0.09	70.54	93.02
2	1.14	0.42	0.45	63.16	60.52
3	1.26	0.46	0.48	63.49	61.90
4	1.20	0.42	0.42	65.00	65.00

Figure (4) illustrates the available nitrogen, (in nitrite form) for both water samples of two techniques. Nitrite concentrations for water samples of biofilter system were 0.38, 0.42, 0.46 and 0.42 mg/l for four weeks of experiment. Resulted of nitrite concentrations showed that consecutive increase which points to an increased rate of nitrification process. Indeed, partial nitrification, that procedure which will be taken into consideration, and resulted from nitrite analysis data. The same behavior can be noticed when analysis of nitrite concentration data for biofloc technique, which were 0.09, 0.45, 0.48 and 0.42 mg/l respectively. Increasing of the nitrite concentration for biofloc technique was due to a well mixing of water that was happened gradually by the stability of the experiment.

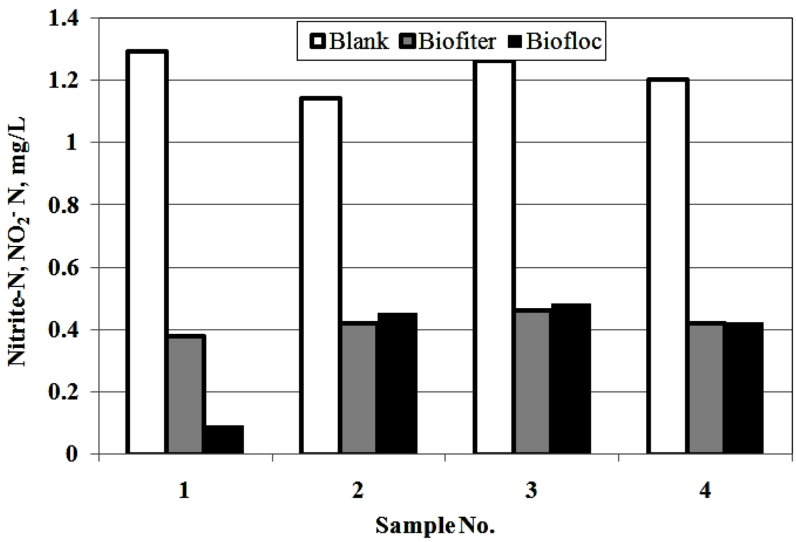

Fig.(4) . The available nitrogen, Nitrite-N, NO_2^- N, mg/l, of water samples.

CONCLUSION

Biofloc technology (**BFT)** is an applicable alternative for removing effluent discharge, and increasing feed efficiency by lowering protein feed requirements for aquaculture. However, **BFT** needs to be well managed due to probable sedimentation creating toxic sludge and increases in dissolved oxygen requirements due to respiration of heterotrophic bacteria associated with biofloc. Smaller usage of water helps reduce the cost of water exchange in aquaculture that could become a limiting factor in intensive aquaculture operations. Beneficial effects of **BFT** usage for freshwater tilapia aquaculture include improvement fish production, reduce feeding costs, low feed conversion, better nutrition and health (help to control bacterial infections in the pond).

LIST OF SYMBOLS

BFT	Is biofloc technology.
BOD	- biochemical oxygen demand.
TSS	- total suspended solids.
DT	- detention time, s.
V_f	- biofilter media volume (m^3).
Q	- air flow rate (m^3/s).
dC_m	- amount of carbon assimilated by microorganisms, g.
dC_s	- amount of carbohydrate addition to reduce ammonium, g.
C_S	- carbon content of the added carbohydrate, %.
E_m	- microbial conversion efficiency, % - (40-60 % (**Avnimelech, 1999**).
dN	- amount of nitrogen needed for the production of new cell, g.
$[C/N]_m$	- C/N ratio in the microbial biomass, dimensionless.
F_d	- amount of daily feed, g (2-3 % of fish weight, (Crab et al., 2012) - 1.5 %, (Azim & Little 2008).
N_f	- nitrogen content of feed, %.
N_e	- nitrogen excretion, %.

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الملخص العربي

دراسة مقارنة لإزالة النيتروجين حيويا من مياه صرف المزارع السمكية باستخدام تقنية الندف البيولوجية مقابل نظام الترشيح الحيوى

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هدفت هذه التجربة المعملية إلى إجراء دراسة لمقارنة معاملة مياه المزارع السمكية بنظامين للمعاملة الحيوية وهما نظام الترشيح الحيوى وتقنية الندف البيولوجية (**BFT**) وذلك حتى يمكن إعادة استخدام تلك المياه مرة أخرى أو تقليص فترات تغيير المياه. حيث زاد تركيز الأمونيوم فى عينات المياه المعالجة بنظام الترشيح الحيوى من ٠,٥١ مجم/لتر فى بداية التجربة الى ٠,٥٤ مجم/لتر ثم انخفض الى ٠,٢٥ مجم/لتر واستقر فى نهاية التجربة عند ٠,٤٩ مجم/لتر بينما كانت هذه التركيزات ٠,٦٢ - ٠,٨٧- ٠,١٢- ٠,٢٧مجم/لتر بالنسبة لعينات المياه المعاملة بتقنية الندف البيولوجية. تم حساب نسبة التخفيض فى تركيز الأمونيوم بمقارنة كل معاملة مع عينة المياه الغير معاملة وكانت النتيجة انه فى بداية التجربة كانت نسبة تخفيض الأمونيوم اكبر لعينة المياه المعاملة بنظام الترشيح الحيوى (٣٢%) بالمقارنة بالعينة المعاملة بتقنية الندف البيولوجية (١٧%) ثم زادت تلك النسبة بمقدار ٤٢ % للترشيح الحيوى مقارنة بـ ٧,٤٥ % للمعاملة بتقنية الندف البيولوجية. وعند نهاية التجربة حدث انخفاض غير متوقع في نسبة التخفيض للأمونيوم لنظام الترشيح الحيوى من ٢١,٨٧ و ١٥,٥٢٪ فى مقابل ٦٢,٥٠٪ و ٥٣,٤٥% للمعاملة بتقنية الندف البيولوجية. هذه النتائج تشير إلى نسب الانخفاضات هذه قد تكون راجعة إلى مرحلة التكيف فى عملية الترشيح الحيوى والى عدم انتظام توزيع الندف البيولوجية على طوال حوض المياه. وتشير كذلك نتائج تركيزات الأمونيوم إلى تفوق تقنية الندف البيولوجية على نظام الترشيح الحيوى فى نسبة تخفيض الأمونيوم.

الكلمات الدالة: *نيتروجين – إزالة حيوية – تربية الأحياء المائية - مياه الصرف الصحي - بيولوجي- تقنية الندف البيولوجية* ***BFT*** *- نظام الترشيح الحيوى.*

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حدث تراجع في نسبة انخفاض النتريت للمرشح الحيوى من ٦٣,١٦٪ في الأسبوع الثاني من بداية التجربة وحدث بعد ذلك زيادة طفيفة في نسبة تخفيض النتريت ٦٣,٤٩٪ إلى أن استقرت على ٦٥٪ قيمة نسبة التخفيض. و يعزى هذا السلوك إلى مشاكل انسداد المرشح الحيوى الناجم عن تراكم الكتلة الحيوية.

أظهرت المعاملة بتقنية الندف البيولوجية تفوق واضح في تخفيض نسبة النتريت (٩٣,٠٢٪) في بداية التجربة على نظام الترشيح الحيوى (٧٠,٥٤٪) كما كان للنظامين سلوك مماثل للحد من ارتفاع نسبة النتريت خلال الفترة المتبقية من التجربة. أخيرا كان لاستخدام تقنية الندف البيولوجية فى المياه العذبة فوائد عديدة فى تربية السمك البلطي من انخفاض في تركيزات الأمونيوم والنيتريت ويمكن أيضا أن تكون هذه التقنية فعالة في تحسين إنتاج الأسماك.