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RESEARCH PAPER

Effect of the Integration between Plankton Natural Productivity and Environmental Assessment of Irrigation Water, El-Mahmoudia Canal, on Aquaculture Potential of *Oreochromis niloticus*

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Abstract

Aquaculture ecosystem assessment is a major key for successful aquaculture Planning. There are many aquaculture farms constructed in Egypt, but because of the non-sufficient studies about the environmental conditions of aquaculture ecosystem assessment, many projects achieved negative results and had low economical returns. The present study was conducted to evaluate the aquaculture ecosystem assessment of irrigation water of El-Mahmoudia Canal, Alexandria, Egypt. The result indicated that temperature (24.65±0.4°C), DO (5.38±0.20mg/l), COD (14.40±4.5mg/l) and BOD (2.86±0.20 mg/l) were in the optimum range for *O. niloticus*. Chlorophyll *a*, *b* and carotenoids were 10.449±0.953, 4.685±0.704 and 2.374±0.054 µg/g, respectively. The biochemical composition of plankton showed that protein, lipid and carbohydrate were 37.7±3.39 %, 16.33±0.85%, and 11.23±2.63%, respectively. Moreover, SFA, MUFA and PUFA were 70.29±4.07%, 11.172±0.132 %, and 18.55±0.525 % of total fatty acids, respectively. Zooplankton community showed that rotifers and copepods configured the main bulk of zooplankton community (95.9% to the total zooplankton community). These conditions are considered the ideal recommended conditions for cultivation of *Oreochromis niloticus* that started with 100,000 fingerlings (distributed as 4.76 fish/m^3 of earth pond) for six months with 82% survival rate with final yield of 21.3 ton/1.6 hectare.

Keywords: Aquaculture ecosystem, Tilapia, phytoplankton, zooplankton, fatty acids.

Introduction

Aquaculture is a global important industry that supplies essential food to a growing world population, with an essential role in providing a cheap animal protein. In recent years, aquaculture sector has been greatly developing and is considered one of the most promising industries in Egypt. Subsequently, aquaculture acts as the most important tool for decreasing the current gap between consumption and fish production in Egypt**.** Despite the pressure on water, Egypt has the largest aquaculture industry in Africa with a market value of over $2.18 billion, and globally, Egypt ranks the 8th in fish farming production and the 1st among African countries. Widely geographic distribution of *Oreochromis niloticus* is nominated to be a major freshwater aquaculture species in several developing countries (Ble, Etchian, Alla, Adingra, Niamke, & Diopoh, 2012). Tilapia, especially *Oreochromis niloticus*, comprises more than 75% of Egyptian aquaculture production, the production in 2012 estimated about 768,752 ton. Furthermore, after China, Egypt ranks the 2nd in the production of *Oreochromis niloticus*, which represent the main farmed fish in Egypt (Soliman & Yacout, 2016). There are many aquaculture farms constructed in Egypt, but because of the non-sufficient studies about the environmental conditions of aquaculture ecosystem, many projects achieved negative results and had low economical returns.

The aquaculture production is directly affected by aquaculture ecosystems. Nutrient availability, water quality, soil grain size analysis, and plankton (community, productivity and nutritional composition) are the main ecosystem components affecting the cultured fish in earthen ponds (Ssanyu, Rasowo, Auma, & Ndunguru, 2011). The enhancement of nutrient availability in the aquaculture ecosystems is controlled by added fertilizers (El-Otify, 2015). Fertilization in fish earthen ponds accumulates nutrients at the bottom of ponds. The main source of the important nutrients (nitrogen and phosphorus) in earthen fish ponds are the added fertilizers, fish excretion and unconsumed feed. Moreover, decomposition of organic matter produces ammonia, which diffuses from sediment to the water column. Consequentially, nutrient availability is easily incorporated into the plankton (mainly phytoplankton and sequentially zooplankton) community (Case *et al*., 2008), productivity (Chib, Masud, & Proch, 2015), biochemical composition (Mitra, Mukhopadhyay, & Ayyappan, 2007) and ultimately into the fish biomass (Tavares, Millan, & Santeiro, 2010). Zooplankton takes a central position between the autotrophs and other heterotrophs maintaining an essential link in the food chain sustainability. In aquaculture conditions, cultured species derive an essential part of their dietary nutrient needs from available plankton as a live food exist in water column, which they are a valuable source of protein, carbohydrate, lipid, fatty acids, and vitamins (Mitra *et al*., 2007).

Egypt is a country which has limited water resources and that reflects the quality and quantity of available water for aquaculture. (Soliman & Yacout, 2016). Alexandria, the main coastal city of Egypt, is limited in aquaculture activity because of many considerations, although this coastal city contains all different water resources of marine, freshwater, brackish water, Lake Maryout and underground water. El-Mahmoudia Canal is considered the main freshwater source of Alexandria City, Egypt. However, this study may be considered the first study that investigates the aquaculture potential and aquaculture ecosystem of El-Mahmoudia Canal.

The present study was conducted to evaluate the feasibility, natural plankton productivity and environmental assessment of utilizing the irrigation water of El-Mahmoudia Canal, Alexandria, Egypt, as a supplemented water source for culture of Nile Tilapia *Oreochromis niloticus.*

Materials and Methods

Before the beginning of culture, water quality, nutrient availability, soil grain size analysis, phytoplankton pigments, zooplankton community, total plankton productivity and nutritional composition (protein, carbohydrate, lipid and fatty acid profile) were measured in irrigation water of El-Mahmoudia Canal, Alexandria, which is used as culture water for *O. niloticus* in earthen pond.

Water Quality

Water quality parameters, *like* temperature (C^o), pH (pocket digital pH meter), turbidity (***NTU***, Turbidity Meter bench HACH), electrical conductivity (EC, E.C-Meter portable HACH), total dissolved solids (TDS, Salinometer Oyster, inspected 82738, Extech instruments, Germany) and dissolved oxygen (DO, DO- meter HQ30d flexi meter HACH) were measured. Biological oxygen demand (BOD) and chemical oxygen demand (COD) were measured according to Pawlowski (1994). Moreover, spectrophotometric determination of nitrate (NO_3), nitrite (NO_2) free ammonia (NH_3) and phosphate (PO_4) were measured according to Grasshoff (1976).

Grain Size Analyses

Grain size analyses of soil were conducted according to ASTM D421-85 (1998).

Plankton Investigations

Phytoplankton

Chlorophyll was measured as an indicator for Phytoplankton biomass. Chlorophyll-*a*, chlorophyll-*b* and total carotenoids were determined according to Dere, Gunes, and Sivaci (1998).

Plankton Productivity

One ton of irrigation water of El-Mahmoudia Canal, Alexandria, was filtered (three replicates) by plankton net (55 µm). The obtained biomass was washed twice with distilled water, dried at 70 ^oC for 24 h, cooled in desiccator and weighted to determine the plankton productivity in dry weight form (Olguin, Galicia, Angulo-Guerrero, & Hernndez, 2001).

Plankton Nutritional Composition

Dried plankton samples were kept under -20^{o}C until the analysis of biochemical composition, as total proteins, total carbohydrates, total lipids and fatty acids (three replicates for each analysis). Total proteins were extracted according to Rauch (1981) and determined according to Hartree (1972). Total carbohydrates were extracted according to Myklestad and Haug (1972) and determined according to Dubois, Giles, Hamilton, Rebers, and Smith (1956). Total lipid was calculated according to Bligh and Dyer (1959). Preparation of fatty acids methyl ester from total lipids was performed according to the procedure of Radwan (1978). Identification of fatty acids fractions were performed on gas chromatography instrument, model HP (Hewlett Packard) 7890 GC equipped with a flame ionization detector; column (HP-5, 30 m, 0.32 mm ID, 0.25 µm film thickness), detector (FID) with detector temperature (250 ºC), injected temperature (220 ºC, injection volume 2 µl, splitless mode), and nitrogen carrier gas with gas flow 1 ml/min.

Zooplankton Community

Collections of samples were carried out by standard plankton net (No. 25) of 55 µm mesh size which lowered vertically till near bottom then pushed up to the water surface. Zooplankton organisms were transferred from the plankton net into small glass bottles, preserved in 5% neutralized formalin solution and then the sample volume was adjusted to 100 ml. The samples were examined under a binocular research microscope. The identification was undertaken to species levels. For estimation of standing crop, subsamples of 5 ml were transferred to a counting chamber (Bogorov chamber) using a plunger pipette (three times). Identification of zooplankton community was carried out according to Sars (1911, 1918 and 1926), Gurney (1927 and 1931), Edmondson (1959), Berzins (1960), Hardig and Smith (1974), Hutchinson (1967), Dussart (1969) and Bick (1972). All zooplankton organisms were counted to species level and the standing crop was calculated and estimated as organisms per cubic meter, according to the following formula:

$$N = n\,(v/V) * 1000$$

Where, *N:* Total number of zooplankton per cubic meter. *n:* Average number of zooplankton in 1 ml of the sample. *v:* Volume of zooplankton concentrate (ml). *V:* Volume of total water filtered (L).

Oreochromis Niloticus Culture

100,000 fingerlings of *Oreochromis niloticus*, with mean body weight 3.77 g obtained from tilapia hatchery in Kafer El-sheekh, Egypt, were transported and acclimatized into the earthen fish pond in Mr. Ehab Abdel-Fatah fish Farm exist Alexandria City (31° 12' 30.07" N and 29° 58' 41.66" E), Egypt, (Figure 1). The experiment was set in three connected earthen ponds with total area about 4 acre (about 1.6 hectare). The depth of ponds ranges from 1.2 to 1.4 m with a total volume of water of 21,010 m^3.

O. niloticus were randomly distributed with stocking density 4.76 fish/m^3. The culture of *O. niloticus* in ponds was conducted for 210 days. Ponds preparations included the basal fertilization of cow dung at 10 ton/1.6 ha, followed by chicken manure (3 ton/1.6 ha/month) in burlap bags 50 kg/bag. *O. niloticus* were fed 20 tons supplementary diet containing 25% crude protein (diet composition are shown in Table 1). The feeding rate was 3% of fish body weight, for twice a day, six days a week, depending on fish biomass. Growth performance parameters in term of weight gain (TWG), average daily gain (ADG), specific growth rate (SGR, %/d), feed conversion ratio (FCR) and Protein efficiency ratio (PER) were calculated according to Bahnasawy, Abdel-Baky, and Abd-Allah (2003) as the following**:**

WG (kg) = Final Weight (kg) – Initial Weight (kg);

ADG (g/d) = Weight Gain (g) / Time (days);

SGR (%/d) = 100 X (Ln Final Weight (g) – Ln Initial Weight (g))/Time (days);

FCR = Food Consumed (kg) / Weight Gain (kg);

PER = Live Weight Gain (g) / Protein Consumed (g).

Results

Water Quality

Table 2 shows the mean values of different water quality parameters recorded of irrigation water of El-Mahmoudia Canal, as a water source for cultured *O. niloticus*. The results indicated that the

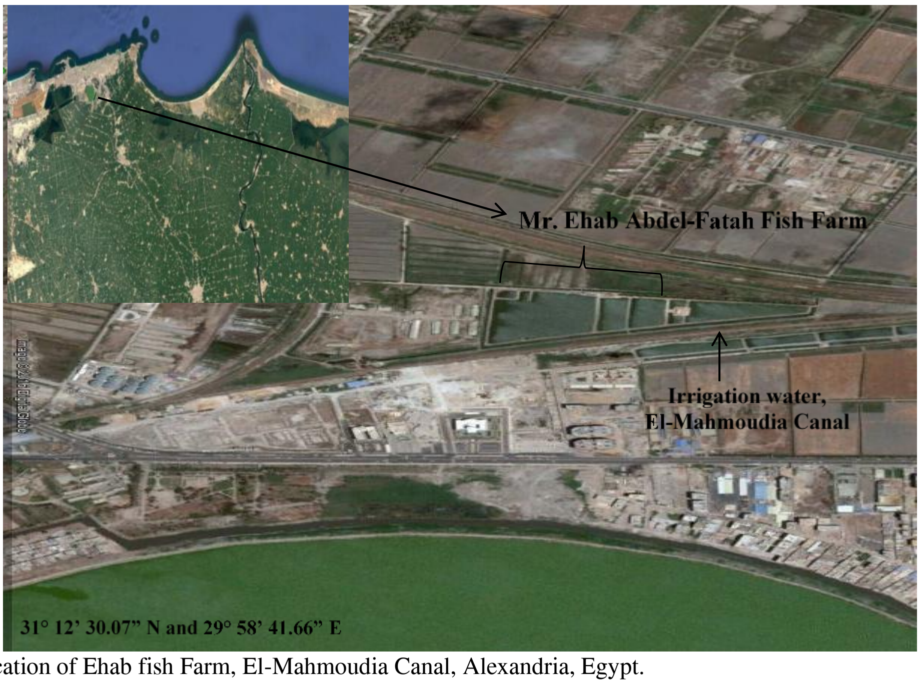

Figure 1. Location of Ehab fish Farm, El-Mahmoudia Canal, Alexandria, Egypt.

Table 1. Composition of supplemental pelleted diets (25% crude protein)

Ingredients	%
Fish Meal	20
Soy Bean	15
Yellow Corn	30
Wheat bran	30
Oil	3
Vitamin & Mineral	1
Baker Yeast	1

Table 2. Water quality parameters of irrigation water of El-Mahmoudia Canal

Parameter	*Means±SD*
Temperature (°C)	24.65±0.4
Dissolved Oxygen (DO, mg/l)	5.38±0.20
pH (pH)	7.51±0.10
Turbidity (NTU)	9.75±1.10
Chemical Oxygen Demand (COD, mg/l)	14.40±4.5
Biological Oxygen Demand (BOD, mg/l)	2.86±0.20
Alkalinity (mg $CaCO_3$/l)	162.8±12.7
Total Dissolved Solids (TDS, mg/l)	340.0±27.4
Electrical Conductivity (EC, µS/cm)	566±32.1
Nitrate (NO_3, mg/l)	1.96±0.60
Nitrite (NO_2, mg/l)	0.50±0.10
Ammonia, free (NH_3, mg/l)	0.84±0.20
Phosphate (PO4 , mg/l)	0.59±0.20

recorded water quality parameters, including temperature (24.65±0.4 °C), DO (5.38±0.20 mg/l), pH (7.51±0.1), turbidity (9.75±1.10 NTU), COD (14.40±4.5 mg/l), BOD (2.86±0.20 mg/l), alkalinity (162.8±12.7 mg/l), TDS (340.0±27.4 mg/l), and EC (566±32.1 µS/cm). As well as, the values of NO_3 (1.96±0.60 mg/l), NO_2 (0.50±0.10 mg/l) and NH_3 (0.84±0.20 mg/l), and PO_4 (0.59±0.20 mg/l) were recorded in irrigation water of El-Mahmoudia Canal.

Soil Grain Size Analysis

The grain size analysis of sediment sample that collected from the farm location area indicated that the sediment type was mostly fine silt. It composed of the 50.4% fine silt, 31.3% medium silt, while 13.7% was very fine silt and 4.5 % clay (Table 3 and Figure 2). The relation between particles diameter and class weight proportions showed that more than 70% of the sediment particles diameter was between 5 and 8 µm (Figure 3). The sediment cumulative mass retained proportions were negatively correlated with the particles size, they decreased gradually with the increasing of particles size and reached their maximum values at the sediments with particle diameter more than 10 µm (Figure 4).

Plankton Investigations

Plankton Productivity and Nutritional Composition

The results in Table 4 showed that chlorophyll *a*, *b* and total carotenoids were 10.449±0.953, 4.685±0.704 and 2.374±0.054 µg/g fresh wet of total plankton, respectively. As well as, the present study found that the plankton productivity (in dry weight form) was 4.281±0.216 g dw/ton of El-Mahmoudia Canal irrigation water, as shown in Table 4. Furthermore, the nutritional composition of total plankton (total protein, total lipid and total carbohydrate) were 47.7±3.39%, 16.33±0.85%, and 11.23±2.63%, respectively, as shown in Table 4. Moreover, fatty acids profiles were shown in Table 5. The contents of total saturated fatty acids (SFA), monounsaturated fatty acids (MUFA) and polyunsaturated fatty acids (PUFA) were 70.29±4.07%, 11.172±0.132 %, and 18.55±0.525 % of total fatty acids, respectively. The predominant fatty acid in SFA was 16:0 (28.38%), while the predominant in MUFA were 18:1n-9 (3.47%) and 16:1n-7 (3.31%). The predominant fatty acids in PUFA were DHA C22:6n-3 (10.40 %) followed by C18:2n-6 (7.896 %) and LNA 18:3 n-3 (0.25%), as shown in Table 5.

Zooplankton Community

In the present study, zooplankton community showed in Table 6 and Table 7 found that there were 57 forms of different organisms, including the mature and immature forms. The most diversified groups were Rotifera, Copepoda, Protozoa and Cladocera. Rotifers were represented by 27 species in order to several forms of rotifers metamorphoses which represent 49.8% of the total recorded species. There were 7 Copepod species and their immature forms (Copepodite stages and Nauplius larvae). Cladocerans

Table 3. Grain size analysis of studied sample

SAMPLE STATISTICS

SAMPLE IDENTITY: 5 ANALYST & DATE: Abou-Mahmoud, 26-7-2016
SAMPLE TYPE: Unimodal, Moderately Well Sorted TEXTURAL GROUP: Mud
SEDIMENT NAME: Fine Silt

	μm	ϕ
MODE 1:	8.250	6.922
MODE 2:		
MODE 3:		
D_{10}:	2.848	6.771
MEDIAN or D_{50}:	6.753	7.210
D_{90}:	9.157	8.456
(D_{90} / D_{10}):	3.215	1.249
$(D_{90} - D_{10})$:	6.309	1.685
(D_{75} / D_{25}):	1.737	1.115
$(D_{75} - D_{25})$:	3.461	0.797

GRAIN SIZE DISTRIBUTION			
GRAVEL:	0.0%	COARSE SAND:	0.0%
SAND:	0.0%	MEDIUM SAND:	0.0%
MUD:	100.0%	FINE SAND:	0.0%
		V FINE SAND:	0.0%
V COARSE GRAVEL:	0.0%	V COARSE SILT:	0.0%
COARSE GRAVEL:	0.0%	COARSE SILT:	0.0%
MEDIUM GRAVEL:	0.0%	MEDIUM SILT:	31.3%
FINE GRAVEL:	0.0%	FINE SILT:	50.4%
V FINE GRAVEL:	0.0%	V FINE SILT:	13.7%
V COARSE SAND:	0.0%	CLAY:	4.5%

	METHOD OF MOMENTS			FOLK & WARD METHOD		
	Arithmetic	Geometric	Logarithmic	Geometric	Logarithmic	Description
	μm	μm	ϕ	μm	ϕ	
MEAN ($\bar{x}$):	6.374	5.773	7.426	5.974	7.387	Fine Silt
SORTING (σ):	2.350	1.640	0.713	1.577	0.657	Moderately Well Sorted
SKEWNESS (Sk):	-0.413	-1.510	1.551	-0.473	0.473	Very Fine Skewed
KURTOSIS (K):	2.389	5.422	5.507	1.165	1.165	Leptokurtic

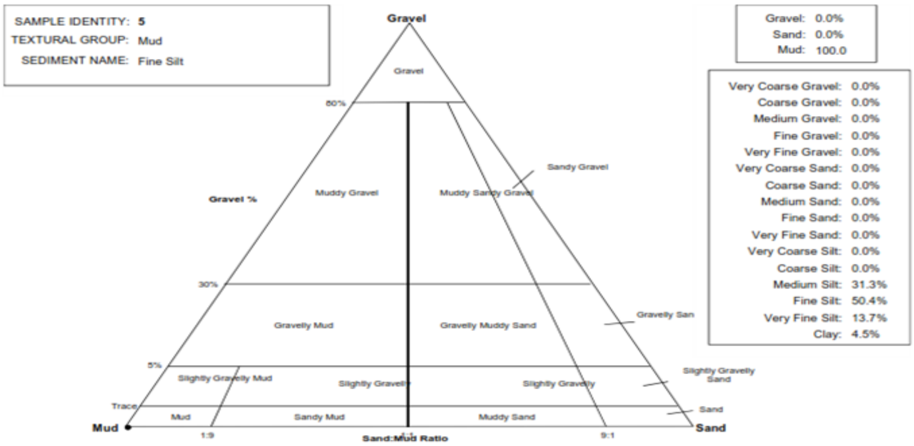

Figure 2. Grain size analysis of studied sample.

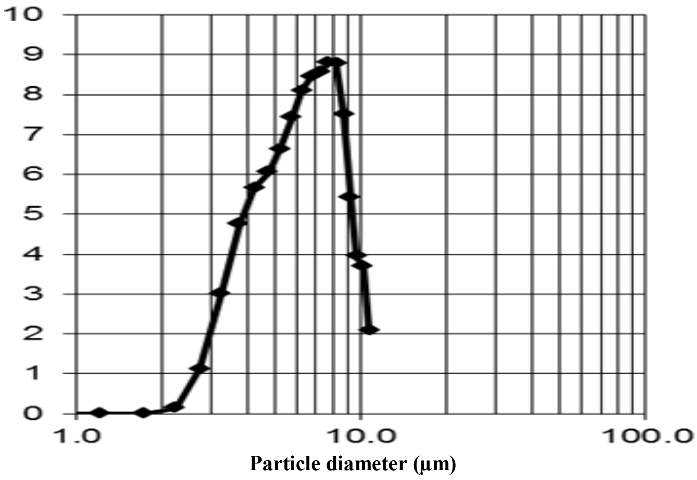

Figure 3. The relation between particles diameter and class weight proportions.

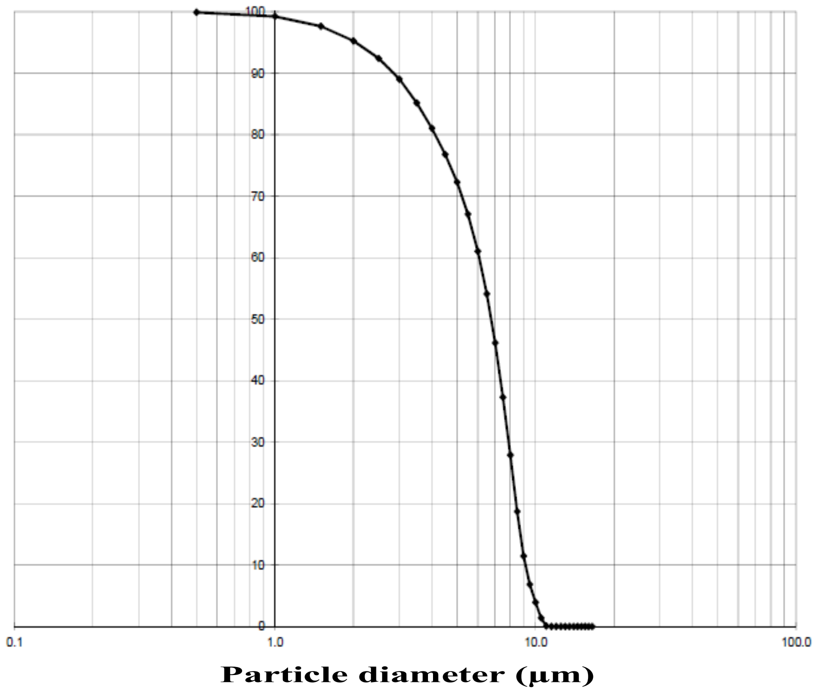

Figure 4. Cumulative frequency curve.

Table 4. Pigments (µg/g), biochemical composition (% of dw) and productivity (g dw/ton) of total plankton presented in irrigation water of El-Mahmoudia Canal

Pigments of Phytoplankton			Biochemical composition			Plankton productivity
Chlorophyll a	*Chlorophyll b*	*Carotene*	*Protein*	*Lipid*	*Carbohydrate*	(Dry weight)
10.449±0.953	4.685±0.704	2.374±0.054	47.7±3.39	16.33±0.85	11.23±2.63	4.281±0.216

Table 5. Fatty acid profile (g/100g lipid) of mixed zooplankton presented in irrigation water of El-Mahmoudia Canal

Fatty Acids	Fatty acid %
C8:0	0.08±0.006
C10:0	0.23±0.002
C12:0	0.34±0.004
C13:0	0.73±0.002
C14:0	3.74±0.226
C15:0	2.57±0.125
C16:0	28.38±2.98
C17:0	3.08±0.002
C18:0	13.43±0.663
C20:0	14.57±0.261
C21:0	3.14±0.179
*Σ SFA	*70.29±4.07*
C14:1n-5	0.30±0.018
C15:1	1.32±0.027
C16:1n-7	3.31±0.048
C17-1	2.75±0.009
C18:1n-9	3.47±0.103
*Σ MUFA	*11.17±0.132*
C18:2n-6	7.896±0.513
C18:3n-3	0.25±0.014
C22:6n-3	10.40±1.053
*Σ PUFA	*18.55±0.525*

SFA: saturated fatty acids
MUFA: Monounsaturated fatty acids
PUFA: Polyunsaturated fatty acids

and Protozoa were expressed by 5 and 6 species, respectively. On the other hand, there were two Molluscan forms (Lamellibranch and Gastropod larvae). Moreover, two types of insect larvae (Chironomus and non Chironomus) were observed. Also, in addition to fish eggs, one of Diplostraca and Ostracod species were observed, as presented in Table 6 and 7.

Regarding to the density, the total zooplankton number was 33565 organism/m^3. Rotifers and copepods configured the main bulk of zooplankton and they figured together 95.9% to the total zooplankton numbers (32189 org./m^3). Rotifers were the highest population recorded during the present study, and estimated by 16716 org./m^3 and represent 49.8% of total zooplankton community. Genus *Brachionus* expressed by 8 species formed about 11148 org./m^3 (33.2% of total zooplankton and 67% of total rotifer community). Copepods were the second highest population recorded after rotifers, estimated by 15473 org./m^3 and constituted 46.1% of the total zooplankton counts. There were two species of the genus *Acanthocyclops* formed 40% of the total copepods community and 18% of total zooplankton community. In conclusion, 10 species (8 rotifers and 2 copepods) formed more than 50% of the total

Table 6. Different zooplankton groups recorded in irrigation water, El-Mahmoudia Canal

Groups	Composition		
	No.	*Org./m^3*	*%*
Rotifera	28	16716	49.80
Copepoda	9	15473	46.10
Protozoa	6	297	0.88
Cladocera	5	367	1.09
Mollusca	3	146	0.43
Insecta	2	92	0.27
Diplostraca	1	65	0.19
Nematoda	1	32	0.10
Ostracoda	1	372	1.11
Fish eggs	1	5	0.01
Total	57	33565	100

Table 7. List of the recorded zooplankton organisms (community) at the study area, irrigation water, El-Mahmoudia Canal

ROTIFERA	COPEPODA	MOLLUSCA
Ascomorpha saltan saltans Bartsch, 1870	*Acanthocyclops americanus* Marsh, 1893	*Pleurocera acuta* Rafinesque, 1831
Asplanchna priodonta Gosse, 1850	*A. vernalis* Fischer, 1853	Gastropoda veligars
Brachionus angularis, Gosse, 1851	*Diacyclops bicuspidatus odessanus* Shmankevich, 1875	Lamellbranchveligar
B. budapestinensis Daday, 1885	*Halicyclops magniceps* Lilljeborg, 1853	
B. calyciflorus Pallas, 1766	*Mesocyclops leuckarti* Claus, 1857	DIPLOSTRACA
B. caudatus Barrois and Daday, 1894	*Schizopera clandestina* Klie, 1924	*Oxyurella tenuicaudis* G.O.Sars, 1862
B. leydigii Cohn, 1862	*Thermocyclops crassus* Fisher, 1853	
B. plicatilis Müller, 1786	Copepoid stages	INSECTA
B. quadridentatus Hermann, 1783	Nauplius larvae	*Chironomus* larvae Meigen, 1803
B. urceolaris Müller, 1773		Insects larvae
Diplois daviesia Gosse, 1886	PROTOZOA	
Filinia longiseta Ehrenberg, 1834	*Centropyxis aculata* Ehrenberg, 1832	NEMATODA
Keratella cochlearis Gosse, 1851	*C. ecornis* Ehrenberg, 1841	Nematode larvae
K. quadrata Müller, 1786	*Difflugiaglobulosa* Dujardin, 1837	
K. tropica Apstein, 1907	*Difflogia sp.* Lamarck, 1816	OSTRACODA
Lecane luna Müller, 1776	*Eugelina acus* (O.F. Müller, 1786) *Ehrenberg, 1830*	Ostracod species
Lepadella ovalis O.F.Müller, 1896	*Euplotes sp.* O.F.Müller, 1786	
Monostyla bulla Gosse		EGGS
Philodina sp. Ehrenberg, 1830	CLADOCERA	
polyarthra vulgaris Carlin, 1943	*Diaphanosoma excisum* G.O.Sars, 1885	
Pomopholyx sulcata Hudson, 1885	*Bosmina longirostris* O.F.Müller, 1878	
Rotaria rotatoriaria Pallas, 1766	*Conochilus unicornis* Rousselet, 1892	
Synchaeta oblonga Ehrenberg, 1832	*Lynceus bukobensis* O.F.Müller, 1776	
S. okai Sudzuki, 1964	*Moina micrura* Kurz, 1874	
Testudinella patina Hermann, 1783		
Trichocerca cylindrica Imhof, 1891		
T. Semilis Wierzejski, 1893		
Metamorphoses of rotifers		

zooplankton community. Ostracoda, Cladocera and Protozoa were estimated by 372, 367 and 297 org./m^3 and represented about 1.11%, 1.09% and 0.88% of total zooplankton community, respectively. Diplostraca was represented by one species expressed by 65 org./m^3 (0.19% total zooplankton community). Molluscan was estimated by 146 org./m^3 (0.43% of total zooplankton community), while insects, represented by several larvae and the chironomus larvae, were 92 org./m^3 (0.27% of total zooplankton community). On the other hand, Nematoda, which were considered a pollution bio-indicator, was estimated by 32 org./m^3 (0.1% of the total zooplankton community). Finally, eggs estimated by 5 egg/m^3 (0.01 org./m^3 of the total zooplankton community), as shown in Figure 5.

Oreochromis niloticus Culture

The mean values of growth performance, survival rate and feed utilization efficiency of *O. niloticus* cultured in earthen pond using irrigation water of El-Mahmoudia Canal, Alexandria, were summarized in Table 8. In the present study, we used 100,000 fry of *O. niloticus* with average of initial individual body weight 3.77 g with stocking density 4.76 fish/m^3 and the optioned survival rate was 82%. Therefore, the initial total weight and final number of fish was 370 kg and 82000 fish, respectively. Growth performance data presented in Table 8 showed that WG, ADG and SGR were 20930 kg, 99.67 g/d, and 1.93 % d^{-1}, respectively. As well as, feed utilization data showed that FCR and PER was 0.96 and 4.19, respectively, as shown in Table 8. The economic return of *O. niloticus* cultured in irrigation water, El-Mahmoudia Canal, Alexandria, Egypt was presented in Table 9. The final production yield of *O. niloticus* was about 21.3 ton/1.6 ha (about 4 acre) with three different marketing size; (1) grade A: 6.3 ton (weight mean 350 g/fish), grade B: 11 tons (weight mean 250g/fish) and (3) grade C: 4 ton (weight mean 200 g/fish), however, the economic analysis of the current experiment are presented in Table 9.

Discussion

Water Quality

In aquaculture, fish productivity mainly depends on aquaculture ecosystems, especially water quality.

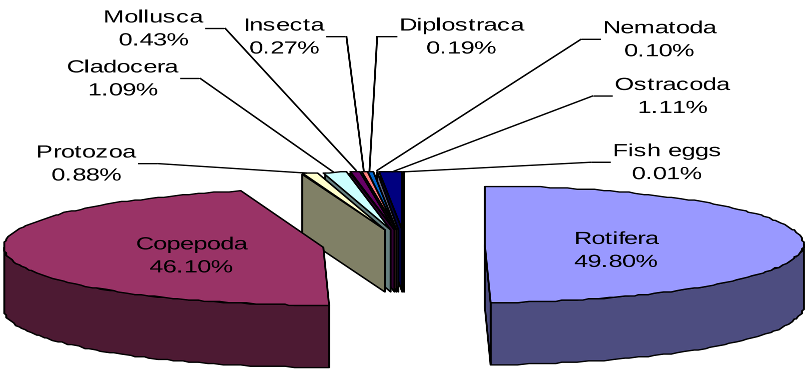

Figure 5. Percentage of different groups of total zooplankton community in irrigation water, El-Mahmoudia Canal.

Table 8. Growth performance and feed utilization of *O. niloticus* cultured in earthen pond using irrigation water of El-Mahmoudia Canal

Parameters	Value
Initial number of fish (fish)	100000
Initial mean individual weight (g)	3.77
Initial total weight (kg)	370
Survival ratio (%)	82
Final number of fish (fish)	82000
Final total weight (kg)	21300
WG (weight gain, kg)	20930
ADG (average daily gain, g/d)	99.67
SGR (Specific growth rate, % d^{-1})	1.93
Total feed given (kg)	20000
Protein consumed (kg)	5000
FCR (Feed conversion ratio)	0.96
PER (Protein efficiency ratio)	4.19

Table 9. Economic return of *O. niloticus* in irrigation water, El-Mahmoudia Canal

Item	Price($)
Costs:	
O. niloticus fry	357
Diets used	6571
Fertilizers	557
Working cost	3486
Total	*10971*
Gross Return:	
Fish of grade A: 6.3 ton (mean weight 350 g/fish)	10800
Fish of grade B: 11 ton (mean weight 250 g/fish)	15714
Fish of grade C: 4 ton (mean weight 200 g/fish)	5143
Total	*26514*
Net return	*15543*

Poor water quality causes decrease of fish productivity, increase of production costs and risk of diseases. In addition, it has negative effects on the environment, human health, laborers and consumers**.** *O. niloticus* is one of the most important cultured freshwater fish over the world. *O. niloticus* can tolerate a wider range of environmental conditions such as DO, pH, NO_3, NO_2 and ammonia levels. Therefore**,** *O. niloticus* can easily culture and adaptable to a wide range of environmental conditions (El-Sayed, 2006). The results of the present study indicated that the recorded water quality parameters, including temperature, DO, pH, COD, BOD, turbidity and alkalinity were in the optimum range for *O***.** *niloticus* (Ross, 2000). Despite the high relative value of TDS (340.0±27.4 mg/l)**,** PO_4 (0.59±0.20 mg/l) and EC **(**566±32.1 µS/cm)**,** these recorded values have no negative effects on the cultured *O. niloticus* (Meade, 1989; El-Sayed, 2006).

The total ammonia nitrogen (TAN) exists in water in two forms: ammonia (NH_3, or unionized ammonia) and ammonium (NH_4^+, or ionized ammonia). NH_3 is more toxic than 300 - 400 time of NH_4^+. Only the NH_3 form goes freely through fish gills and it is therefore considered the TAN's most toxic form. However, it was demonstrated that the toxicity of ammonia relatively depends on pH and temperature (Silva, Lima, Vale, & Marcelo, 2013). In aquaculture, high doses of ammonia either from excretion or from external pollution can cause reduction in fish growth or even death. The resistance of fish for toxicity of ammonia differs between species, however, rainbow trout *O. mykiss* was found to be the most sensitive to ammonia (LC50 values ranging between 0.068- 0.62 ppm), whereas Common carp *C. carpio* (LC50 values ranging between 0.43-2.1 ppt) and channel catfish *I. punctatus* (LC50 values ranging between 1-3.8 ppm) were the most resistant (Arthur, Corlis, Allen, & Hedtke, 1987). On the other hand, many authors cited that the *O. niloticus* can withstand up to 7.1 ppm of ammonia, while the optimum concentration for growth is <0.05 ppm (El-Shafey, 1998). Many authors reported that tilapia can be counted as more tolerant species to ammonia and can withstand a very polluted environment, feeding on animal manure and even sewage sludge (Wong, 1989; EPA, 1998; Semra, 2014; Silva *et al*., 2013).

In the present study, the recorded values of NO_3 (1.96±0.60 mg/l), NO_2 (0.50±0.10 mg/l) and NH_3 (0.84±0.20 mg/l) were high in irrigation water of El-Mahmoudia Canal, however, Bahnasawy *et al*. (2003) studied the aquaculture ecosystem to evaluate the using of irrigation water of El-Salam canal (near Damietta City, Egypt) to culture *O. niloticus* in earthen ponds, and he found that the values of NO_3, NO_2 and NH_3 were 0.12-0.78, 0.06-0.60, and 0.142-0.570, respectively in irrigation water of El-Salam canal. However, during ponds preparations, we enhanced the oxygen content in pond culture water by aeration with two paddles for each pond for eight hours per day for two weeks. As a result of this process, the value of DO was increased to be 8.63±0.20 mg/l, and the values of NO_3 (1.38±0.24 mg/l), NO_2 (0.34±0.07 mg/l) and NH_3 (0.15±0.04 mg/l) in pond culture water at the beginning of *O. niloticus* culture were in the recommended limit for *O. niloticus* culture **(**Lawson, 1995 and Bahnasawy *et al*., 2003).

Plankton

Tilapia ecosystems and productivities are indirectly affected by the changes of water quality conditions, which can regulate the plankton productivity, biochemical composition and community in such tilapia earthen pond. These conditions fundamentally change due to the availability of nutrient concentrations. These conditions mainly depend on the initial and the following of fertilization (El-Otify, 2015). Plankton are relevant to the changes in the environmental conditions. Several studies carried out in freshwater ecosystems have established that the growth, composition and density of phytoplankton may be controlled by the limitation of nutrients, light and the abundance and composition of zooplankton community (Basualto *et al*., 2006).

Tilapia production may be increased by supplying of organic fertilizers in fish earthen ponds, as a result of increasing the primary live feeds productivity. Primary live feeds exist in earthen ponds can increase the quality and survival of tilapia larvae, fingerlings and fry. Therefore, using the manures, as a low cost fertilization technique, in ponds preparation is the most effective way to increase live feed production in earthen ponds and thereby increase the final fish production (Chib *et. al*., 2015).

In the present study, in order to obtain an optimal natural productivity level, the fertilization program composed of cow dung (during the preparation of ponds before start *O. niloticus* culture) and chicken manure (during *O. niloticus* culture) were used. To determine the possible success or failure of *O. niloticus* propagation system in earthen ponds, the management of plankton is very important (Mischke & Zimba, 2004). Ssanyu *et. al*., (2011) concluded that the relative status of plankton gives an indicator of water quality parameter and the possible success or failure of the aquaculture system of *O. niloticus*.

Quantification of phytoplankton as a primary production in terms of chlorophyll-*a* is alternative, easy and quick to measure phytoplankton biomass in aquaculture (Kundu & Jana, 1994). In the present study, we evaluate the phytoplankton pigments (chlorophyll-*a*, chlorophyll-*b* and total carotenoids) as an indicator for phytoplankton productivity and biomass. The results showed that the irrigation water of El-Mahmoudia Canal, Alexandria, Egypt, is considered a rich source of nutrient, pigments, phytoplankton productivity and biomass, which means that zooplankton, and consequentially cultured *O. niloticus*, will derive significant part of their immense from available phytoplankton, especially with the concentration of total carotenoids (2.374±0.054 μg/g). On the other hand, the high recorded phytoplankton biomass may be due to high recorded concentration of NO_3 (1.96±0.60 mg/l) in irrigation water of El-Mahmoudia Canal. Nitrate is the major form of nitrogen that is easily used by phytoplankton (El-Otify, 2015).

Protein is the most expensive component in the diets for aquatic species. One of the most important problems in aquaculture industry over the world, and especially in Egypt and developing countries, is the availability, cost, adulteration and bad treatments of protein during diet manufacture (GAFRD, 2012). Despite the efforts in the formulation development of starter diets, live food still remains a stable option in terms of survival and growth compared to formulated diet alone (Verreth, Storch, & Segner, 1987). One of the most effective factors which can evaluate the quality of natural live food for *O. niloticus* in earthen pond is the nutritional value of available plankton (Ssanyu *et al*., 2011; and Mitra *et al*., 2007). In the present study, in consideration of aquaculture ecosystem assessment, the evaluation the biochemical composition (protein, carbohydrate, lipid and fatty acid profile) of total plankton exist in irrigation water of El-Mahmoudia Canal, as a water source for *O. niloticus* culture were investigated. Mitra *et al*. (2007) studied the biochemical composition of zooplankton community grown in freshwater earthen ponds, in the term of nutritional implication in nursery rearing of fish larvae and early juveniles and he found that protein, lipid and carbohydrate were ranging from 73–79%, 10.8–14.5% and 3.0–4.8%, respectively. Moreover, he reported that the content of SFA, MUFA and PUFA ranged from 64–81%, 7–15% and 6–20% of total fatty acids, respectively. On the other hand, the present study found that the plankton productivity (in dry weight form) was 4.281±0.216 g dw/ton of El-Mahmoudia Canal irrigation water. There are no previous plankton studies performed on El-Mahmoudia Canal in Alexandria, in consideration to aquaculture ecosystem, however, the average of plankton dry weight reported by Mitra *et al*. (2007) ranged from 1.2 to 4.2 mg/l. The variation in biochemical composition (protein, carbohydrate, lipid and fatty acids) and productivity of freshwater plankton between our study and that observed by Mitra *et al*. (2007) may be due to many reasons, such as (1) water quality parameters, (2) nutrient limitation, (3) phytoplankton (availability, species and biochemical composition) and (4) zooplankton community and species structure (Vijverberg & Frank, 1976; Proulex & Nove, 1985; Kibria, Nugegoda, Fairclough, Lam, & Bradbv, 1999; Basualto *et al*., 2006). In aquaculture, species derive a substantial part of their dietary needs from available plankton as a valuable source of protein, amino acids, lipid, fatty acids and vitamins (Evjemo, Reitan, & Olsen, 2003). Therefore, plankton seems to provide a good source of immune and exogenous enzymes for larvae, however, the nutritional quality of plankton varies and plays a major role in producing high quality of fish larvae, juveniles and fry (Meeren, Olsen, Hamre, & Fyhn, 2008).

Another interesting investigated point in the current plankton study is zooplankton community. Investigations of zooplankton community in fish farm systems are important tools to evaluate the success of aquaculture ecosystem (Tavares *et al*., 2010; Ssanyu *et al*., 2011). On the other hand, fish density and nutrient supply are the two major factors affecting plankton communities in aquaculture ponds (Mitra *et al*., 2007). In the present study, rotifers and copepods configured the main bulk of zooplankton community and they figured together 95.9% to the total zooplankton numbers. Many authors found that rotifers and copepods configured the main bulk of zooplankton communities in marine (Case *et al*., 2008) or freshwater ecosystem (Ssanyu *et al*., 2011), regardless to the type of cultured water, cultured fish, water quality and geographical location. However, the structure and functioning of the zooplankton community, regarding to species compositions and densities of each species, are affected by several factors, such as (1) water quality aspects, (2) nutrient limitation, (3) phytoplankton (availability, species and community structure) and (4) predator types and densities (Tavares *et al*., 2010; Ssanyu *et al*., 2011).

Oreochromis niloticus Culture

Many authors cited that growth performance and feed utilization efficiency of *O. niloticus* were affected by different environmental factors in regarding to aquaculture ecosystem, such as water quality and live food quality and quantity (Gjedrem, 1997; and Workagegn, Ababbo, Yimer, & Amare, 2014). The average of ADG, SGR investigated in our results was higher than that observed by Bahnasawy *et al*. (2003), who studied the growth performance of *O. niloticus* cultured in earthen pond (with supplemental feed 25% protein at 50% satiation), in regard to enhance the natural feed (phytoplankton and zooplankton), it was 0.90 g/d and 1.55 %/day, respectively. Moreover, Goda, EWafa, El-Haroun, and Chowdhury (2007) found that SGR of *O. niloticus* ranging from 1.74 to 1.97 %/day, while Hassaan, Wafa, Soltan, Goda, and Mogheth (2014) found that SGR ranging from 2.98 to 3.10 %/day. The higher or lower IDG and/or SGR of *O. niloticus* recorded by different authors may be due to different initial weight, stoking density, offered live food and water quality (Bahnasawy *et al*., 2003; Workagegn *et al*., 2014). Feed conversion ratio FCR recorded in our results (0.96) was higher than that observed (0.82) by Bahnasawy *et al*. (2003), while protein efficiency ratio PER observed in our study (4.2) was lower (4.87) than Bahnasawy *et al*. (2003). On the other hand, El-Sayed, El-Ghobashy, and Al-Amoudi (1996) found that the FCR ranged from 2.2 to 3.15 in *O. niloticus* fed on artificial diets twice daily, while Goda *et al*. (2007) found that FCR of *O. niloticus* ranged from 1.70 to 2.00. The differentiation in feed utilization efficiency between the present study and that obtained by other authors may be due to the different growth performance, offered live food, protein offered in supplemental diets and water quality (Bahnasawy *et al*., 2003).

Conclusions

Aquaculture productivity mainly depends on aquaculture ecosystems. Aquaculture ecosystems contain various living communities which constitute the biotic load of aquaculture pond. Natural productivity has the ability to increase this biotic load. Environmental assessment of water quality and natural productivity is required in order to determine how much aquaculture ecosystem can generate or produce using natural resources.

Although aquaculture is one of the most promising industries in Egypt, this sector, because of the Egyptian law, is not allowed to use the irrigation water. In general, Egyptian freshwater aquaculture sector depends on agricultural drainage channels and/or groundwater. Our study strongly recommends that the irrigation water of El-Mahmoudia Canal is very successful and stable for aquaculture ecosystem of *O. niloticus.*

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