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Effect of different water sources on phytoplankton biodiversity in fish farms

Soha M.A. El-Said, Naglaa I.I. Shalaby and Enas M.G. Mansour

Central Lab. For Aquaculture Research, Abbassa, Abou-Hammad, Sharkia, Egypt, limnology department.

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Abstract

The objective of this study was to investigate the composition of phytoplankton communities in fish farms irrigated with different water sources. Phytoplankton samples were collected from three different fish farms. Each farm was stocked with Nile tilapia fingerlings in a monoculture system. Concerning phytoplankton community composition; *Cyanophyceae* dominated other groups at F1, while *Chlorophyceae* species were the dominant group at F2 and *Bacillariophyceae* dominated other groups at F3. With concern to species composition; *Closterium* sp. counts were constant at both F2 and F3, when *cladophora* sp. was constant in F1 among Chlorophyceae. While Microcystis, *Anabaena*, *Merismopedia* and Lyngbya sp were constant in F3 among Cyanophyceae. Where Navicula and *Melosira* were constant sp at F2 and F3, and *Cyclotella* sp was constant at F1, F2 and F3 among Bacillariophyceae, the presence of some sp such as (*Closterium*, Lyngbya, *Merismopedia*, *Nitzschia*) in constant form at F3 indicated that water are highly organic polluted waters. The Palmer's algal index showed that the F3 has high organic pollution, while F1 and F2 have moderate pollution. The **biodiversity index** of overall phytoplankton genera was high at F2. It's concluded that the water sources in the fish ponds had an influence on the plankton community, leading to the appearance and disappearance of some species relating to organic pollution of water, so it is suggested to take awareness with the water source especially sewage waste water before the water is used for aquaculture.

Key words: fish ponds, plankton, aquaculture, diversity.

INTRODUCTION

The phytoplankton community is one of the main sources of energy flow in water environment. Its composition and density are relevant to detect changes in the environment. Fluctuations in plankton communities in fish farms indicate the organisms' dependence on the physical and chemical conditions and on the management employed, which lead to great oscillations caused by the very dynamics of the fish ponds. (Lúcia et al., 2010). Ponds are relatively shallow bodies of standing water and are generally rich in biodiversity (Williams and Biggs. 2004).

Phytoplankton community structural changes are a good indicator of eutrophication. It is recognized that, phytoplankton composition is a natural bio- indicator for pollution because of its complex and rapid responses to fluctuations of environmental conditions (Livingston, 2001).

Phytoplankton is the major primary producers in many aquatic systems and is important food source for other organisms (Gupta and Dey, 2012). It also play an important role in maintaining the biological balance and quality of water (Benarjee and Narasimha, 2013). Several studies carried out in fish farm have established that the growth of phytoplankton may be controlled to a large degree by the limitation of nutrients, availability of light and the composition and abundance of zooplankton (Basualto *et al*., 2006).

So, estimation of the plankton community structure (density and composition) in fish farm systems irrigated with different sources of farms is an important tool to evaluate water quality conditions, as changes in nutrient concentrations led to corresponding changes in species composition. The current study investigated the influence of different water sources for irrigating fish farms on phytoplankton density and community composition.

MATERIALS and METHODS

phytoplankton samples were collected from three different fish farms irrigated with different water sources, the first farm (F1) which located at the World Fish Center, irrigated with fresh water through Ismailia Canal, the second farm (F2) was at the Central Laboratory for Aquaculture Research (CLAR) in Abbassa, Abou-Hammad, Sharkia governorate, and was irrigated with agricultural drainage water through El-Wady drain, while the third farm (F3) was a private fish farm located at El-Hessania region, Sharkia governorate, which was supplied with sewage drainage water from Bahr El-Bakar drain. Water samples were collected monthly from May to November. Each farm was stocked with Nile tilapia fingerling (*Oreochromis niloticus*) in a monoculture system.

Phytoplanktons sedimentation and counting:

One liter of water was collected monthly from the different farms in polyethylene bottles. Phytoplankton was concentrated by settling 500 ml sample in a volumetric cylinder for about 24 hours after being kept in lugol̓s solution (APHA, 1985). The surface water was siphoned and the settlement was examined. One ml of sample was transferred into Sedgwick-Rafter cell and counted microscopically. Different algal species were identified according to Boyd and Tucker (1992). Occurrence frequency was also estimated for total phytoplankton organisms, divided into three categories: constant (50% or above), common (between 10 and 50%), or rare (between 1 and 10%) (Sampaio *et al*., 2002).

The Algal Generic Pollution Index (Palmer, 1969) was employed to determine the degree of pollution at each farm.

Simpson's Diversity Index is a measure of diversity which takes into account the number of species present, as well as the relative abundance of each species. As species richness and evenness increase, the diversity increases.

$D= \sum n (n-1)/N (N-1)$ where

n = the total number of organisms of a particular species

N = the total number of organisms of all species

The value of D ranges between 0 and 1. With this index, 1 represents infinite diversity and 0, no diversity.

RESULTS and DISCUSSION

Phytoplankton community was represented by three groups; *Chlorophyceae*, *Cyanophyceae* and *Bacillariophyceae*. The total standing crop of phytoplankton decreased during May, June and July, and this may be due to the efficient grazing by zooplankton and fish. This coincided with results obtained by Ali (2007) who reported that phytoplankton considered the main food of tilapia species especially at early stages. And regained its maximum abundance during September and October in different fish farms (Table 1). The highest density of the phytoplankton was related to the highly available nutrients in fish ponds which led to subsequent increase in phytoplankton production (Hargreaves, 1998).

The composition and structure of phytoplankton communities reveal changes in water quality, especially with regard to organic matter inputs. Fish farms normally receive great quantities of allochthonous matter, consisting of feed, fertilizers and food remains during period of higher fish production (extensive feed supply), has a positive effect on fish farms (SipaúbaTavares *et al*., 2007)**.**

The phytoplankton communities showed marked variations among the investigated farms. Their percentages at F1, were 40%, 46% and 14%, respectively, while at F2 these percentages were 42%, 32% and 26 % respectively, Moreover at F3 these percentages were 29%, 23% and 48% respectively, which revealed that *Cyanophyceae* dominated other groups (46%) in F1, and *Chlorophyceae* was the dominant group (42%) in F2, while in F3, *Bacillariophyceae* dominated the other groups (48%). Phytoplankton growths are mostly restricted by available solar energy input, differences in levels of nitrogen and phosphorus (Chellappa *et al*., 2009). The abundance of *Bacillariophyceae* at F3, may be related with high level of nutrients (particularly total phosphorus), as this site received organic residue and inorganic nutrients are regarded as the main source of diatom nutrition; many studies have focused on the availability and uptake of organic substrates by diatoms as means of diversifying from conventional trophic sources (Loureiro *et al*., 2009).

Three phytoplankton groups (*Chlorophyceae*, *Cyanophyceae* and *Bacillariophyceae*) were recorded in different water farms. 19 species of phytoplankton (*Scenedesmus*, *Crucigenia*, *Pediastrum*, *Protococcus, Spirogyra, ankistrodesmus, Tetraspora, Mougeotia, Microcystis, Anabaena, Nostoc, Polycystis*, *Tetrapedia*, *stephenodiscus*, *Navicula*, *Melosira*, *Synedra*, *Stauroneis* and *Cyclotella*) were found at F1 and 30 species (*Scenedesmus, Crucigenia*, *Closterium*, *Pediastrum*, *cladophora, Protococcus, Spirogyra, Dictyosphaerium, ankistrodesmus, Tetraspora, Mougeotia, Zygnema, Phormidium, Microcystis*, *Anabaena, Nostoc, Spirulina, Polycystis, Tetrapedia, Rivularia*, *Merismopedia*, Lyngbya, *stephenodiscus*, *Navicula*, *Melosira*, *Synedra*, *Stauroneis, Cyclotella, Eunotia* and *Cocconeis*) were found at F2 while 27 species (*Scenedesmus*, *Crucigenia*, *Closterium, Pediastrum, cladophora, Protococcus, Spirogyra, Dictyosphaerium, ankistrodesmus, Zygnema, Phormidium, Microcystis, Anabaena, Spirulina, Polycystis, Merismopedia*, Lyngbya, *stephenodiscus*, *Navicula*, *Melosira*, *Synedra*, *Stauroneis* , *Cyclotella*, *Eunotia*, *Amphora*, *Cocconeis* and *Nitzschia*) were found at F3. (Table 2).

Total 32 phytoplankton species were encountered in all the investigated farms. Concerning occurrence frequency 13 species were found to be common at the three farms. Two species were recorded from F2 (*Rivularia* and *Cocconeis*) and three species were recorded from F3. (Lyngbya, *Amphora* and Nitzschia sp). It's indicated that *Closterium* sp. was constant in F2 and F3, where *cladophora* sp. was constant at F1 among Chlorophyceae. While *Microcystis*, *Anabaena*, *Merismopedia* and Lyngbya sp were constant at F3, Nostoc, *Tetrapedia* and *Rivularia* at F2 among Cyanophyceae. where Navicula, *Melosira* were constant sp at F2 and F3 water farm and *Cyclotella* sp was constant at F1, F2, and F3 among *Bacillariophyceae* (Table 3), the presence of some sp such as (*Closterium*, Lyngbya, *Merismopedia* and *Nitzschia*) in constant form at F3 indicated that water are highly organic polluted waters (Kumar et al., 2012).

Algae, being a main inhabitant of water, play a significant role in the ecology of these water bodies. The algal communities dominated by Microcystis, Ankistrodesmus, Dictyosphaerium, Scenedesmus, Melosira and Nitzschia at F3 farm indicated the organic pollution of water (Hosmani and Bharati, 1980). The genus, Scenedesmus is present in the three investigated farms but at F2, and F3 farm its occurrence in aconstant is an indication for water pollution (Tripathi *et al.*, 1987). Microcystis was considered as the best single indicator of pollution (Singh, 1973). The presence of Microcystis at F3 in aconstant form indicating the deteriorated quality of water.

According to Palmer’s Algal Pollution Index, values between 0-10 indicate lack of organic pollution, 10-15 moderate pollution, 15-20 probable high organic pollution and above 20 as confirmed highly organic pollution. Table 4 revealing that F1 and F2 water considered moderately polluted, while F3 could be considered probable high organically polluted.

The Simpson's Index of Diversity of overall phytoplankton genera were 0.70, 0.64, and 0.61 at F2, F3 and F1 respectively this indicates that there is a high biodiversity of algae at F2 compared to F3 and F1. Phytoplankton diversity is more in nutrient rich waters than those in nutrient deficient waters (Margalef, 1964).

Table 1: Total density, maximum and minimum of phytoplankton classes in different fish farms

Farms	Type	maximum	minimum	Total density(org./l*10^3)
F1	*Cholorophyceae*	August	November	17.11
	Cyanophyceae	September	May	19.67
	Bacillariophyceae	September	July	5.98
F2	*Cholorophyceae*	June	November	22.10
	Cyanophyceae	September	July	16.77
	Bacillariophyceae	August	May	13.62
F3	*Cholorophyceae*	August	June	18.74
	Cyanophyceae	October	November	14.86
	Bacillariophyceae	August	May	31.03

Table 2: Phytoplankton diversity and distribution of different fish farm

Class	Species	Distrubtion
Cholorophyceae	*Scenedesmus*	F1,F2 and F3
	Crucigenia	F1,F2 and F3
	Closterium	F2 and F3
	Pediastrum	F1,F2 and F3
	cladophora	F2 and F3
	Protococcus	F1,F2 and F3
	Spirogyra	F1,F2 and F3
	Dictyosphaerium	F2 and F3
	ankistrodesmus	F1,F2 and F3
	Tetraspora	F1 and F2
	Mougeotia	F1 and F2
	Zygnema	F2 and F3
Cyanophyceae	*Phormidium*	F2 and F3
	Microcystis	F1 and F2
	Anabaena	F1, F2 and F3
	Nostoc	F1 and F2
	Spirulina	F2 and F3
	Polycystis	F1,F2 and F3
	Tetrapedia	F1 and F2
	Rivularia	F2 only
	Aphanocapsa	F2 and F3
	Lyngbya	F3 only
Bacillariophyceae	*stephenodiscus*	F1,F2 and F3
	Navicula	F1,F2 and F3
	Melosira	F1,F2 and F3
	Synedra	F1,F2 and F3
	Stauroneis	F2 and F3
	Cyclotella	F1,F2 and F3
	Eunotia	F2 and F3
	Amphora	F3 only
	Cocconeis	F2 only
	Nitzschia	F3 only

Table 3: Specific composition and frequency of occurrence (F) of phytoplankton taxa in fresh water farm, where: + = presence; - = absence; C = constant; c = common and r = rare.

Taxa	F1		F2		F3	
	C	F	C	F	C	F
Cholorophyceae						
Scenedesmus	+	r	+	C	+	C
Crucigenia	+	c	+	c	+	C
Closterium	-		+	C	+	C
Pediastrum	+	c	+	c	+	r
cladophora	+	C	+	r	+	r
Protococcus	+	C	+	c	+	r
Spirogyra	+	r	+	C	+	c
Dictyosphaerium	-		+	r	+	c
ankistrodesmus	+	r	+	r	+	C
Tetraspora	+	r	+	r	-	
Mougeotia	+	c	+	c	-	
Zygnema	-		+	C	+	
Cyanophyceae						
Phormidium	-		+	c	+	C
Microcystis	-		+	c	+	C
Anabaena	+	c	+	c	+	C
Nostoc	+	C	+	C	-	
Spirulina	-		+	r	+	r
Polycystis	+	r	+	c	+	c
Tetrapedia	+	c	+	C	-	
Rivularia	-		+	C	-	
Merismopedia	-		+	r	+	C
Lyngbya	-		+	c	+	C
Bacillariophyceae						
stephenodiscus	+	r	+	r	+	C
Navicula	+	c	+	C	+	C
Melosira	+	c	+	C	+	C
Synedra	+	r	+	C	+	c
Stauroneis	-		+	c	+	C
Cyclotella	+	C	+	C	+	C
Eunotia	-		+	r	+	c
Amphora	-		-		+	C
Cocconeis	-		+	c	+	C
Nitzschia	-		-		+	C

Table 4: Palmer's algal pollution index values in three farms

genus	Pollution index	F1	F2	F3
Microcystis	1	0	1	1
Oscillatoria	4	0	0	0
Phormidium	1	0	1	1
Chlamydomonas	4	0	0	0
Pandorina	1	0	0	0
Scenedesmus	4	4	4	4
Micratinium	1	0	0	0
Ankistrodesmus	2	2	2	2
Chlorella	3	0	0	0
Closterium	1	0	1	1
Stigeoclonium	2	0	0	0
Cyclotella	1	1	1	1
Melosira	1	1	1	1
Gomphonema	1	0	0	0
Navicula	3	3	3	3
Nitzschia	3	0	0	3
Synedra	2	2	2	2
Euglena	5	0	0	0
Phacus	2	0	0	0
Lepocinclis	1	0	0	0
Total		**13**	**16**	**19**

Figure 1: Percentages of different phytoplankton groups at F1

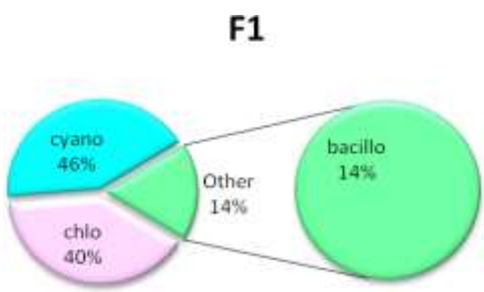


Figure 2: Percentages of different phytoplankton groups at F2

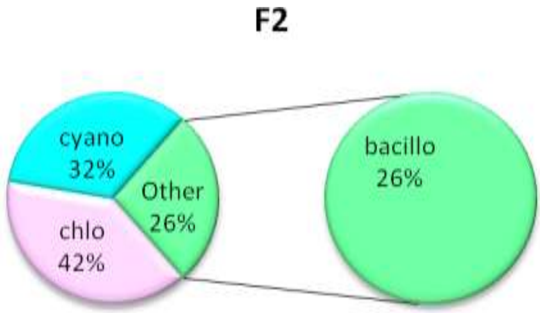


Figure 3: Percentages of different phytoplankton groups at F3

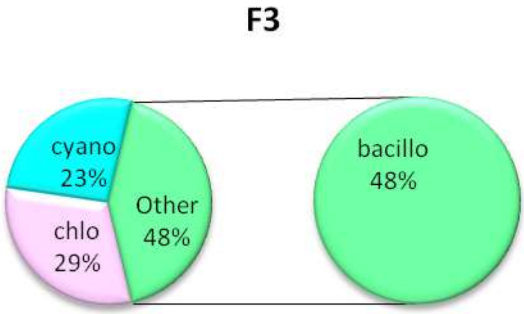
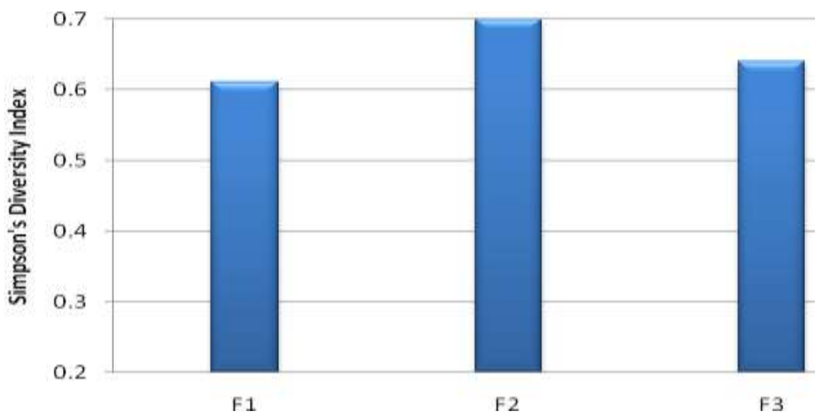


Figure 4: The Simpson's Index of Diversity of overall phytoplankton genera at the three different farms.



CONCLUSION

It's concluded that the different water sources at the fish ponds had an influence on the phytoplankton community, leading to an appearance and disappearance of some species in related to organic polluted water. According to Palmer’s Algal Pollution Index, the farm irrigated with sewage water is highly organic polluted and must be take all the precautions before the water used for aquaculture by this source of water.

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تأثير مصادر مياه مختلفة علي التنوع البيولوجي للهائمات النباتية في المزارع السمكية

سها محمود أحمد السيد, , نجلاء اسماعيل اسماعيل شلبي, إيناس محمد جلال منصور
قسم الليمنولوجي-المعمل المركزي لبحوث الثروة السمكية- العباسة- ابو حماد- الشرقية

الملخص العربي

أجريت هذه الدراسة لبيان تأثير مصادر مختلفة من المياه علي كثافة وأنواع الهائمات النباتية في ثلاث مزارع سمكية مروية بمصادر مياه مختلفة ؛ وتم زراعة كل مزرعة بأسماك البلطي النيلي في نظام الاستزراع أحادي الجنس. وفيما يخص التركيب المجتمعي للهائمات النباتية فقد بينت النتائج سيادة الطحالب الخضراء المزرقة في مزرعة المياه العذبة والتي تستمد مياها من ترعة الاسماعيلية وسيادة الطحالب الخضراء في مزرعة الصرف الزراعي التي تستمد مياهها من مصرف الوادي بالعباسة وسيادة الديتومات في مزرعة الصرف الصحي التي تستمد مياهها من مصرف بحر البقر بالحسينية. وكذلك أوضحت النتائج أن المزرعة المروية بالصرف الزراعي كانت أكثر تنوعا في الانواع النباتية مقارنة بمزرعتي المياه العذبة والصرف الصحي. ومن خلال مؤشر بلمير للتلوث تبين أن مزرعة الصرف الصجي تحتوي علي تركيز عالي من التلوث بينما مزرعتي المياة العذبة والصرف الزراعي تحتوي علي تركيز متوسط من التلوث من النتائج السابقة يمكن القول أن المصادر المختلفة للمياه في المزارع السمكية كان لها تأثير على التركيب المجتمعي للهائمات النباتية، مما أدى إلى ظهور بعض الأنواع المتعلقة بالمياه الملوثة عضويا في مزرعة الصرف الصحي لذا يجب اخذ كل الاحتياطات الواجبة قبل استخدام مياه الصرف الصحي في الاستزراع السمكي وأيضا لابد من معالجتها.