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EVALUATION OF PHYSICO-CHEMICAL PARAMETERS, HEAVY METALS AND ZOOPLANKTON IN SOME FISH FARMS AT KAFR EL-SHIEKH, EGYPT

Mona H. Ahmed; Eman A. Abd El-Hameed and Ahmed Battran

Limnology Dept., Central Laboratory for Aquaculture Research Center, Egypt.

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Abstract

This study was carried out through different seasons of all over a year in five sites located at Kafr El-Sheikh governorate, Egypt. Irrigation canal (Site 1), drain number 6 (Site 2) in El-Hamol (A mixture of agriculture drainage, sugar factory drainage of sugar factory and Ketchainar drain effluents), a private fish in El-Hamol (Site 3) which irrigated from drain number 6 directly, private fish farm (Site 4) which irrigated from expulsion pumps number 7 (A mixture of agricultural drainage and industrial effluents + wastewater) and fish farm (Site 5) which closer to Lake Borollus about 3 km and irrigated from the same source of site 4. All fish farms had the same management systems; all ponds have 1.25m in column water depth.

The obtained results showed that water temperature readings in spring, summer and autumn in all sites were within the permissible range for fish culture. The pH values were fluctuated in the alkaline side within the allowable limits for fish health in all sites. In winter, dissolved oxygen showed higher values in all sites followed by those in autumn. The lowest levels were detected in spring and summer. In addition, site 2 water recorded the minimum values of DO among all sites and during all seasons. Salinity levels at site 2 and 3 were higher than that in the site 4 and 5. Total alkalinity and total hardness were fluctuated among all seasons. The highest levels of alkalinity and hardness were recorded in site 2 and 3. Ammonia concentrations were in the critical fluctuations in all sites. Nitrate and nitrite levels were fluctuated in all sites recorded the highest levels during summer and autumn and all the recorded levels were favorable for fish culture. The studied metals were copper, lead, iron, cadmium and zinc. These metals except copper were more than the permissible limits in water in some sites where they were recorded the highest concentrations as following 0.054, 0.036, 19.52, 23.41 and 44.37 mg/l respectively. Rotifer is dominant order of zooplankton followed by cladocera, copepod and ostracoda. The highest abundance of zooplankton orders rotifer, cladocera and copepod were noticed in site 5 whereas the highest number of order ostracoda was recoded in site 2.

INTRODUCTION

Water quality is the most important factor affecting fish health and performance in aquaculture production systems. Different fish species have different and specific range of water quality aspects. The most critical water quality parameters in aquaculture production systems are dissolved oxygen, un-ionized ammonia, carbon dioxide, nitrate and nitrite concentration, pH, salinity, turbidity and alkalinity levels (Mmochi *et al*., 2002; Tiwari and Chauhan, 2006) within which fish can survive, grow and reproduce. Water quality plays a significant role in the biology and physiology of fish and may impact on the health and productivity of the culture system (Landau, 1992; Boyd, 1997; Boyd and Tucker, 1998). It is therefore very important for fish producers to ensure that the physical and chemical conditions of the water remain, as much as possible, within the optimum range of the fish under culture all the time. Outside these optimum ranges, fish will exhibit poor growth, erratic behavior and disease symptoms or parasites infestations. Under extreme cases, or where the poor conditions remain for prolonged periods of time, fish mortality may occur (Barker *et al.*, 2009). The composition of pond water changes continuously, depending on climatic and seasonal changes, and on how a pond is used. It is the aim of good management to control the composition to yield the best conditions for the fish. For producers to be able to maintain ideal pond water quality conditions, they must understand the physical and chemical components contributing to good or bad water quality (Pereira *et al.*, 2004).

Metal concentrations in water depend in part on water quality and watershed influxes and have a significant impact on aquatic organisms, disturbing the ecological poison such as Cd and Pb as previously recorded by Mason (2002). Fish are often at the top of the food chain and have the tendency to concentrate heavy metals from water. Therefore, bioaccumulation of metals in fish can be considered as an index of metal pollution in the aquatic bodies.

ECDG (2002) reported that, the agricultural drainage water, effluents of industrial activities and sewage effluents supply the water bodies and sediment with huge quantities of inorganic anions and heavy metals. Further, the concentrations of heavy metals in natural water bodies are often elevated due to anthropogenic interferences. The most anthropogenic sources of metals are industrial, petroleum contamination and sewage disposal. Investigations on heavy metals in natural waters have received considerable attention as they provide a coded history of lake's environment (Singh *et al.*, 2008). Osman and Kloas (2010) illustrated that, a number of metal ions are essential for biological systems as Ca, Mn, Fe, Cu and Zn. These metals become toxic when their concentration levels exceed those required for correct nutrition. Some other metals are non-essential and influenced by many factors such as pH, hardness, alkalinity and temperature of water.

There are many factors, physico-chemical and biological factors, affecting the accumulation and toxicity of metals in aquatic organisms. Physico-chemical factors including temperature, dissolved oxygen, hardness, alkalinity, pH, salinity and suspended particulate matter (Karakoç, 1999).

Zooplankton is indispensable in maintaining the balance of river ecosystems, and occupy an important intermediate link of food chain between phytoplankton and plantivorous fish and adjusting the water self-purification capacity (Xiaoyu *et al*., 2014). The interaction between zooplankton and environment forms a special community distribution pattern. Because of environmental selectivity, plankton species composition varies from one habitat to another. Temperature and salinity are important factors in explaining the inter annual variability of the copepod *Eurytemora affinis* (Valérie *et al*., 2005). Also, Zooplankton is a vital link in the food webs of large rivers, and their communities are shaped by both local environmental features and advection (Dickerson *et al*., 2009). Among the Branchiopoda, Cladocera encompasses the morphologically most diverse group (Fritsch *et al*., 2013). Cladocera are commonly known as 'water fleas' due to their jerky swimming movements facilitated by their paired second antennae (Bro¨nmark and Hansson, 1998).

MATERIALS AND METHODS

Sites and experimental design:

The study was carried out in five sites in Kafr El-Sheikh governorate, Egypt during four seasons.

The five sites were:-

1- Irrigation canal (**Site 1**).
2- Drain number 6 (**Site 2**) in El-Hamol (A mixture of agriculture drainage, sugar factory drainage of sugar factory and Ketchainar drain effluents).
3- A private fish in El-Hamol (**Site 3**) which irrigated from drain number 6 directly.
4- Private fish farm (Site 4) which irrigated from expulsion pumps number 7 (A mixture of agricultural drainage and industrial effluents + sewage drain).
5- Fish farm (Site 5) which closer to Lake Borollus about 3 km and irrigated from the same source of site 4.
   All fish farms had the same management systems, all ponds have 1.25m in column water depth.

Sampling and laboratory analyses:

Water Quality Analyses:

At different locations of each site, water temperature and dissolved oxygen (DO) were measured by using a digital oxygen meter (Model YSI 55). pH was measured with a pH meter (Model 25, Fisher Scientific). Salinity as mg/l was determined using salinity, conductivity meter (model, YSI EC 300).

After that, water samples were taken monthly at different locations at each site by a vertical PVC water sampler at depth of a half meter from the water surface. Samples at each site were mixed in a plastic bucket and a sample of 1 liter was placed in a polyethylene bottle and transferred to the laboratory for analysis. The total hardness, total alkalinity (carbonate and bicarbonate as $CaCO_3$), total ammonia (NH_4^+-N^+NH-N), nitrate (NO_3-N), nitrite (NO_2-N), orthophosphate (PO-P) were measured by the methods described in Boyd and Tucker (1992).

Heavy Metals Analyses:

Concentrations of copper, lead, iron, cadmium and zinc were determined according to APHA (1998), using atomic absorption spectrophotometer (Thermo 6600 Thermo Electron Corporation, Cambridge, UK).

Zooplanktons analyses:

Samples were taken in vertical hauls from the water column with totally filtered 10 L. samples were obtained using 40 µm mesh net, and preserved in formalin (4%) for quantitative and qualitative analysis. Data were expressed in abundance percentage spacemen/L, organisms were counted in Sedgwick-Rafter cell and examined under 25 x magnifications. Water samples count by sedimentation and density were calculated according to APHA (1989).

Water temperature in different fish farms sites were not significantly ($P<0.05$) in different sites and months.

Statistical analysis:

One-way ANOVA and Duncan multiple range test were used to evaluate the difference between the concentrations of different studied variables with respect to sites. The software CoStat version 6.311(CoStat, CoHort software, USA) was used for data analysis. A probability at level of 0.05 or less was considered significant (Bailey, 1981).

RESULTS AND DISCUSSION

Data in Table 1-a showed that, the variation in the water temperature is directly related to the atmospheric temperature among different seasons and ranged from 15.8±0.4 ºC (in winter) to 29.1±1.3 ºC (in summer). The lowest temperature values were recorded in the site 1 (Irrigation canal) in most cases this related to the sampling time. Water temperature readings in spring, summer and autumn in all sites were within the permissible range for fish culture according to Boyd (1998). Water temperature in all sites in all sites has no significant difference.

pH values were fluctuated between all sites and seasons recorded minimum levels equal 7.7±0.3 and maximum level equal 9.5±0.6. In general all values were within the allowable limits for fish health according to Boyd (1998) and Barker *et al.* (2009).

Further, distribution of dissolved oxygen was influenced by external and internal events and showed a considerable wide range of variations in the studied sites. In winter dissolved oxygen (DO) showed higher values in all sites in winter followed by those in autumn. This may be as a result of stirring up of water by wind in these seasons as well as low temperature. The lowest levels were detected in spring and summer in site 2. Results noticed that significant difference increase in fertilized sites. This may be attributed to the presence of higher organic matter concentration in this area due to the discharge of industrial effluents of the sugar factory and municipal wastewater (untreated and detergent-carrying wastewater) from the Ketchainar drain effluents and other wastes from agricultural drainage as previously mentioned by Singh *et al*. (2005) ; Osman and Kloas (2010) and Yadav *et al.* (2014). Also, Okbah and El-Gohary (2002) stated that, the decrease in DO may be due to several factors as the rise in temperature and the increased rate of decomposition of organic matter, increased biological activity, respiration of organisms and excess amount of biological oxygen demand - BOD which use up DO.

In general, warm water species such as tilapia need a dissolved oxygen concentration of 5-15 mg/l of DO or greater to maintain good health and feed conversion (Boyd, 1998).

Data in Table 1-a showed higher salinity levels in site 2 (3.62±0.12 g/l) and site 3 (3.96±0.31 g/l) water followed by site 4 and site 5 in comparison with that in the site 1 (Irrigation canal) which found with the lowest salinity levels (0.24±0.01 to 0.34±0.01 g/l) this was related dissolved salts in drain was waste water salinity was highly significant difference increase in sites and site 4 while low significant in site 4 and 5 followed by site 1. As the salinity tolerances vary amongst species therefore it is important to choose an aquaculture species that is best suited to the salinity of that water sources.

Table 1-a. Seasonal fluctuation of water quality in different locations during the study periods.

Water Quality parameters	Sites	Spring	Summer	Autumn	Winter
Temperature (^oC)	1	23.4^b±0.6	28.1^a±0.8	25.3^a±0.7	15.8^c±0.4
	2	26.2^a± 1.2	29.1^a±1.3	23.8^b±0.9	19.3^a±0.5
	3	27.2^a±1.1	28.6^a±0.8	24.2^a±0.9	17.9^b±0.3
	4	25.2^a±0.7	28.5^a±0.7	24.8^a± 0.6	16.7^b±0.4
	5	27.5^a±1.2	27.2^b±0.6	25.2^a±0.9	17.4^b±0.5
pH	1	8.3^a±0.3	8.1^{ab}±0.2	8.4^b±0.3	7.8^b±0.4
	2	7.7^b±0.3	7.8^a±0.5	7.9^c±0.2	7.7^b±0.3
	3	8.4^a±0.5	8.8^a±0.3	9.3^a±0.6	9.5^a±0.6
	4	8.5^a±0.4	8.6^a±0.5	8.9^a±0.5	9.3^a±0.5
	5	8.6^a±0.3	9.5^a±0.6	9.2^a±0.5	8.9^a±0.3
DO (mg/l)	1	4.8^c±0.2	4.5^b±0.2	7.2^a±0.3	6.6^b±0.4
	2	4.1^c±0.4	4.1^b±0.3	4.8^d±0.3	5.5^d±0.3
	3	5.5^b±0.2	5.7^a±0.3	5.0^c±0.3	6.6^b±0.4
	4	4.6^c±0.2	5.8^a±0.3	6.3^b±0.3	7.4^a±0.5
	5	6.3^a±0.4	5.9^a±0.4	6.0^b±0.3	6.3^c±0.3
Salinity (g/l)	1	0.33^c±0.02	0.24^c±0.01	0.32^c±0.02	0.34^c±0.01
	2	3.23^a±0.20	3.62^a±0.30	3.56^a±0.21	3.62^a±0.12
	3	3.29^a±0.30	3.65^a±0.23	3.68^a±0.32	3.96^a±0.31
	4	2.92^{ab}±0.30	2.74^b±0.22	2.65^b±0.22	2.53^b±0.19
	5	2.59^b±0.20	2.65^b±0.22	2.78^b±0.25	2.68^b±0.15
T. Alkalinity (mg/l)	1	187.0^e±11.0	188.0^e±15.0	179.0^e±17.0	167.0^e±13.0
	2	578.0^b±11.0	589.0^b±14.0	612.0^b±23.0	593.0^b±76.0
	3	754.0^a±23.0	785.0^a±11.0	821.0^a±18.0	769.0^a±63.0
	4	417.0^c±23.0	480.0^c±54.0	456.0^c±55.0	480.0^c±64.0
	5	355.0^d±43.0	335.0^d±44.0	345.0^d±47.0	375.0^d±34.0
T. Hardness (mg/l)	1	264.0^c±23.0	260.0^d±21.0	298.0^c±25.0	265.0^c±19.0
	2	434.0^a±32.0	454.0^a±44.0	423.0^a±24.0	397.0^a±33.0
	3	474.0^a±43.0	510.0^a±67.0	454.0^a±33.0	440.0^a±44.0
	4	363.0^b±19.0	404.0^b±25.0	397.0^b±25.0	367.0^{ab}±33.0
	5	344.0^b±21.0	321.0^c±19.0	320.0^c±31.0	352.0^b±21.0

$^{a-d}$Means with the same letter in the same column and the same season within each parameter are not significantly different.

Alkalinity refers to amount of carbonates and bicarbonates in the water and water hardness refers to the concentration of calcium and magnesium. As calcium and magnesium bond with carbonates and bicarbonates, water alkalinity and hardness are closely interrelated and produce similar measured levels. This is very clear in the data recoded in this study (Table 1-a). Total alkalinity and total hardness were fluctuated among all seasons and this is may be attributed to the changes in the climatic factors such as temperature as well as fish culture practices such as fertilization (Boyd, 1998).

The highest levels of alkalinity (821±18 mg/l) was recorded in site 3 in autumn whereas the lowest value (167±13 mg/l) was recorded in site 1 in winter, this is may be due to the discharge of large amount of carbonate ions from sugar factory and the nature of the soil (Shivappa *et al.,* 2007). The highest value of hardness (510.00± 67.00) was recorded in site 3, while the lowest one (260.00±21.00 mg/l) was recorded in site 1 through summer season.

Ammonia is the by-product from protein metabolism excreted by fish and bacterial decomposition of organic matter such as wasted food, feces, dead planktons, sewage, agricultural fertilizers and some industrial effluents. The unionized form of ammonia (NH_3) is extremely toxic while the ionized form (NH4+) is not and both the forms are grouped together as “total ammonia” (Felipo and Butterworth 2002). Data in Table 1-b showed significant difference in total ammonia among the different sites. The lowest levels were recorded in the site 1 (0.31±0.02mg/l) in winter, but the highest levels (2.66±0.04mg/l & 2.55±0.06) were recorded in site 2 and site 3 in autumn and spring respectively, on the other hand the site 4 and 5 showed fluctuations. All readings were in the critical range according to Bhatnagar and Singh (2010) who recommended that the level of ammonia (<0.2 mg/l) is suitable for pond fishery. The toxic levels for un-ionized ammonia for short-term exposure usually lie between 0.6 and 2.0 mg/1 for pond fish, and sublethal effects may occur at 0.1 to 0.3 mg/l. Experiments have shown that the lethal concentration for a variety of fish species ranges from 0.2 to 2.0 mg/l. Ammonia levels in zero-salinity surface water increase with increasing pH and temperature. At low pH and temperature, ammonia combines with water to produce an ammonium ion (NH_4+) and hydroxide ion (OH^-). The ammonium ion is non-toxic and not of concern to organisms. Above a pH of 9, un-ionized ammonia is the predominant species. The un-ionized ammonia (NH_3) can cross cell membranes more readily at higher pH values.

Table 1-b. Seasonal fluctuations of water quality in different locations during the study period.

Water Quality parameters	Sites	Spring	Summer	Autumn	Winter
T. Ammonia (mg/l)	1	0.37^{d}±0.02	0.35^{d}±0.03	0.38^{c}±0.04	0.31^{c}±0.02
	2	2.57^{a}±0.05	2.45^{a}±0.07	2.66^{a}±0.04	2.18^{a}±0.04
	3	2.55^{a}±0.06	1.89^{b}±0.08	2.23^{a}±0.05	2.32^{a}± 0.07
	4	0.52^{c}±0.04	0.65^{c}±0.03	0.81^{b}±0.04	0.47^{c}±0.08
	5	1.45^{b}±0.04	1.62^{b}±0.19	0.79^{b}±0.06	0.96_{b}±0.09
Nitrate (mg/l)	1	0.163^{d}±0.009	0.213^{d}±0.018	0.243^{d}±0.013	0.189^{d}±0.008
	2	0.176^{d}±0.013	0.367^{c}±0.019	0.567^{c}±0.021	0.387^{c}±0.045
	3	0.254^{c}±0.023	0.476^{b}±0.015	0.634^{b}±0.021	0.307^{c}±0.039
	4	0.392^{b}±0.019	0.489^{b}±0.029	0.652^{b}±0.034	0.468^{b}±0.025
	5	0.609^{a}±0.023	0.892^{a}±0.032	0.975^{a}±0.043	0.632^{a}±0.031
Nitrite (mg/l)	1	0.054^{b}±0.003	0.059^{b}±0.004	0.063^{b}±0.003	0.063^{b}±0.004
	2	0.045^{c}±0.002	0.064^{b}±0.003	0.072^{b}±0.003	0.038^{c}±0.002
	3	0.035^{d}±0.002	0.083^{a}±0.004	0.088^{a}±0.005	0.073^{a}±0.006
	4	0.043^{c}±0.002	0.047^{c}±0.004	0.054^{c}±0.004	0.066^{b}±0.004
	5	0.073^{a}±0.002	0.078^{a}±0.002	0.081^{a}±0.003	0.084^{a}±0.003
O-phosphorus (mg/l)	1	0.18^{b}±0.01	0.17^{c}±0.03	0.18^{b}±0.03	0.17^{c}±0.02
	2	0.20^{b}±0.01	0.29^{b}±0.03	0.32^{a}±0.03	0.47^{a}±0.04
	3	0.34^{a}±0.03	0.25^{b}±0.02	0.37^{a}±0.03	0.33^{b}±0.02
	4	0.33^{a}±0.02	0.35^{a}±0.01	0.31^{a}±0.01	0.33^{b}±0.02
	5	0.34^{a}±0.01	0.33^{a}±0.02	0.38^{a}±0.01	0.43^{a}±0.02

[a-d]Means with the same letter in the same column within each parameter are not significantly difference)

On the other hand, Nitrate and nitrite levels were fluctuated in all sites recorded the highest levels during summer and autumn. Although nitrate is less toxic than ammonia, it causes stress at all levels making a fish's organs work harder to adjust to its new environment. The nitrate was ranged from 0.163±0.009 mg/l in site 1 in winter to 0.975±0.43mg/l at site 1 in autumn. This variation may be due to the management of fertilization in the ponds. Nature provides an almost nitrate free environment with levels around 5 mg/l or less. Meck (1996) recommended that its concentrations from 0 to 200 mg/l are acceptable in a fish pond and is generally low toxic for some species whereas especially the marine species are sensitive to its presence. According to Stone and Thomforde (2004) nitrate is relatively nontoxic to fish and not cause any health hazard except at exceedingly high levels (above 90 mg/l). Santhosh and Singh (2007) described the favorable range of 0.1 mg/l to 4.0 mg/l in fish culture water. Accordingly, the recorded levels of nitrate in all sites of this study area are within the safe levels for fish.

Nitrite is an intermediate product of the aerobic nitrification bacterial process, produced by the autotrophic *Nitrosomonas* bacteria combining oxygen and ammonia. Nitrite can be termed as an invisible killer of fish because it oxidizes hemoglobin to methemoglobin in the blood, turning the blood and gills brown and hindering respiration also damage for nervous system, liver, spleen and kidneys of the fish. The ideal and normal measurement of nitrite is zero in any aquatic system. Stone and Thomforde (2004) suggested that the desirable range is 0.0 to1.0 mg/l. According to Bhatnagar *et al*. (2004), 0.02 to1.0 mg/l is lethal to many fish species, >1.0 mg/l is lethal for many warm water fishes and <0.02 mg/l is acceptable. Santhosh and Singh (2007) recommended nitrite concentration in water should not exceed 0.5 mg/l. OATA (2008) recommended that it should not exceed 0.2 mg/l in freshwater and 0.125 mg/l in seawater. Nitrite ranged from 0.038±0.002 mg/l at site 2 in winter to 0.088±0.005 mg/l at site 3 in autumn. These levels of nitrite in all sites are within the safe levels for fish.

Phosphorus (PO_4) is often in limited supply and stimulates plant (algae) growth and its role for increasing the aquatic productivity (including fish) is well recognized. In Table 1, the phosphorus level was low (0.17 to 0.18 mg/l) in site 1 (irrigation canal) in all seasons but it was higher in the other sites (0.47 mg/l in site 2 and 0.43mg/l in site 5) in winter and fluctuated with non-significant differences in the most cases. However, all the recorded levels were favorable for fish culture according to Bhatnagar and Devi (2013) who stated that many studies found that the desirable limits of phosphate for fish culture ranged from 0.01 to 3.0 mg/l. On the other hand, Stone and Thomforde (2004) previously mentioned that, the phosphate level of 0.06 mg/l is desirable for fish culture and Bhatnagar *et al*. (2004) suggested 0.05-0.07 mg/l is optimum and productive.

Data in Table 2 showed the concentrations of copper, lead, iron, cadmium and zinc in water. The highest values of copper were found in site 2 in all seasons (0.054, 0.047, 0.052 and 0.049 mg/l in spring, summer, autumn and winter, respectively). According to WHO (2011), the recorded data were less than the permissible limits (2 mg/l). The highest levels of lead (0.027, 0.036, 0.03 and 0.035mg/l) were found in spring, summer, autumn and winter, respectively exceeded the permissible limits (0.01 mg/l, WHO 2011).

In addition, the highest concentrations of iron (18.87, 18.91, 17.75 & 19.52 mg/l) were recorded in site 2 in spring, summer, autumn and winter, respectively exceeded the permissible limits (0.3 mg/l, WHO 2011).

Also, according to WHO (2011) cadmium (23.07, 29.61, 22.63 & 23.41 mg/l) and zinc (43.6, 44.37, 32.46 & 35.12 mg/l) showed the highest concentrations in the site 5 in spring, summer, autumn and winter, respectively exceeded the permissible limits (0.01 & 5 mg/l, respectively).

Table 2. Seasonal fluctuations of some heavy metal concentrations (mg/l) in water of different locations during the study period.

Metal	Sites	Spring	Summer	Autumn	Winter
Copper	1	0.027^{c}±0.002	0.039^{b}±0.004	0.024^{d}±0.002	0.021^{c}±0.003
	2	0.054^{a}±0.005	0.047^{a}±0.007	0.052^{a}±0.001	0.049^{a}±0.005
	3	0.036^{b}±0.004	0.033^{c}±0.004	0.034^{c}±0.003	0.032^{b}±0.003
	4	0.037^{b}±0.007	0.051^{a}±0.007	0.041^{b}±0.002	0.044^{a}±00.005
	5	0.035^{b}±0.005	0.039^{b}±0.004	0.036^{c}±0.003	0.037^{b}±0.002
Lead	1	0.004^{d}±0.001	0.006^{c}±0.001	0.003^{d}±0.001	0.003^{d}±0.001
	2	0.027^{a}±0.003	0.036^{a}±0.004	0.030^{a}±0.002	0.035^{a}±0.004
	3	0.019^{b}±0.00b	0.012^{b}±0.002	0.013^{b}±0.002	0.014^{b}±0.002
	4	0.018^{b}±0.002	0.009^{b}±0.001	0.011^{b}±0.001	0.009^{c}±0.002
	5	0.009^{c}±0.001	0.009^{b}±0.001	0.008^{c}±0.002	0.007^{c}±0.001
Iron	1	6.83^{c}±0.32	8.87^{d}±0.76	6.12^{c}±0.51	5.87^{c}±0.31
	2	18.87^{a}±0.65	18.91^{a}±1.97	17.75^{a}±1.92	19.52^{a}±1.78
	3	16.75^{a}±0.76	17.1^{a}±0.56	16.32^{a}±2.23	17.13^{a}±0.91
	4	9.84^{b}±.0.62	11.64^{c}±0.71	9.04^{b}±0.87	10.63^{b}±0.75
	5	11.54^{b}±0.42	14.85^{b}±0.62	10.08^{b}±1.83	11.71^{b}±0.81
Cadmium	1	0.005^{c}±0.001	0.006^{d}±0.001	0.004^{c}±0.001	0.004^{d}±0.0005
	2	0.013^{b}±0.002	0.014^{b}±0.004	0.012^{b}±0.003	0.013^{b}±0.002
	3	0.010^{b}±0.001	0.010^{c}±0.001	0.008^{b}±0.002	0.009^{c}±0.002
	4	0.006^{c}±0.001c	0.008^{c}±0.002	0.005^{c}±0.001	0.007^{c}±0.001
	5	23.071^{a}±0.97	29.61^{a}±0.89	22.63^{a}±3.12	23.413^{a}±0.94
Zinc	1	0.037^{d}±0.005	0.058^{d}±0.007	0.040^{c}±0.002	0.041^{d}±0.006
	2	0.100^{b}±0.009	0.116^{b}±0.011	0.101^{b}±0.00	0.112^{b}±0.011
	3	0.092^{b}±0.006	0.084^{c}±0.007	0.073^{b}±0.002	0.083^{c}±0.008
	4	0.067^{c}±0.005	0.089^{c}±0.009	0.069^{b}±0.002	0.082^{c}±0.007
	5	34.602^{a}±2.44	44.37^{a}±3.52	32.46^{a}±2.21	35.116^{a}±3.61

$^{a\text{-}d}$Means with the same letter in the same column and the same season within each parameter are not significantly different

Accumulation of heavy metals in the food web can occur either by accumulation from the surrounding medium, such as water or sediment, or by bioaccumulation from the food source (Tulonen *et al.*, 2006). Aquatic organisms have been widely used in biological monitoring and assessment of safe environmental levels of heavy metals. Due to the toxicity of heavy metals, accurate information about their concentration in aquatic ecosystems is needed

(Janssen *et al*., 2000). Further, the concentrations of lead were showed exceed the permissible limit (0.01 mg/l) in site 2 (Bank No. 6) during all seasons and fluctuated in site 3 and 4 (El-Hamoul and Massoud fish farms) (Table, 2). In site 2, the concentrations of Cu, Pb and Fe were showed with higher levels than those in the other sites as well as in case of cadmium except in site 5. This may be due to the sugar mill effluent which rich in these metals according to Javed and Usmani (2013). Also, the present findings may be due to the possible pollution of these sites with agricultural and industrial wastewaters which contain large quantities of Fe, Cu, Zn, Pb and Cd as previously reported by Saeed and Shaker (2008) in Lake Manzala, Egypt. Omolara *et al.* (2014) found that aquatic organisms including fish accumulate metals in concentrations many times higher than present in water. So, the accumulation of these metals in the fish will increase and may affect the fish production as well as the human health causing many diseases.

Ikem and Egiebor (2005) and Schuurmann and Markert (1998) stated that the major sources of pollution of surface waters include effluent discharges by industries, atmospheric depositions of pollutants and occasional accidental spills of toxic chemicals and trace metals are regarded as serious pollutants of the aquatic environment because of their toxicity, their persistence, their difficult biodegradability and their tendency to concentrate in aquatic organisms.

Zooplankton plays an important role in matter and energy flow in most river ecosystems. It is also indispensable in maintaining the balance of river ecosystems. The fresh water zooplankton fauna of water bodies comprised of four major groups Rotifera, cladocera, copepod and ostracoda.

Rotifers constitute a high proportion of the freshwater zooplankton population and contribute significantly to maintaining the structure and function of aquatic ecosystems and secondary productivity (Hu *et al.,* 2004). The highest abundance of rotifer were 54.33±5.37 org x10^3./l in site 4 in summer followed by 49±4.36 org x10^3./l in summer at site 5 this was related to high temperature, light and nutrient (fertilizers) which act as the favorable condition for developing phytoplankton thus causing increasing in rotifer abundance these sites which were fertilized so, more nutrient while the lowest number of it was 4.67±o.88 and 7±1.53 org x10^3./l in site 1 in winter and spring respectively this results coordinate with Krylov (2005), Yermolaeva (2015) and Kukharsakaya (2011) who showed that the largest species diversity was marked by rotifer which characterized the fresh water of zooplankton . But Zohra *et al*., (2015) stated that copepods were the most abundant groups of zooplankton

Table 3. Seasonal fluctuations of zooplanktons abundance (org x10^3/l) in water of different locations during the study period.

Organisms	Sites	Spring	Summer	Autumn	Winter	Total
Rotifera	1	7.00^{d}±1.53	9.33^{d}±0.88	5.33^{d}±0.88	4.67^{d}±0.88	26.33
	2	15.00b±2.31	21.67^{c}±1.77	14.67^{c}±1.45	10.00^{c}±0.58	61.34
	3	17.33^{b}±3.48	27.33^{b}±1.45	19.00^{b}±1.53	13.00^{b}±0.58	76.66
	4	38.00^{a}±8.39	54.33^{a}±5.37	27.33^{a}±2.91	18.33^{a}±0.33	137.99
	5	33.00^{a}±7.58	49.00^{a}±4.36	32.00^{a}±3.79	18.33^{a}±2.41	132.33
Cladocera	1	1.67^{b}±0.33	2.33^{c}±0.33	1.67^{c}±0.33	1.00^{c}±0.03	6.67
	2	1.33^{b}±0.33	1.33^{d}±0.33	1.33^{c}±0.00	1.00^{c}±0.03	4.99
	3	11.00^{a}±0.00	10.33^{b}±0.33	9.00^{a}±0.00	5.00^{a}±0.00	35.33
	4	1.30^{b}±0.06	1.67^{d}±0.33	1.30^{c}±0.06	1.30^{b}±0.05	7.57
	5	11.33^{a}±0.33	20.00^{a}±0.00	6.00^{b}±0.00	5.00^{a}±0.00	42.33
Copepoda	1	1.67^{d}±0.33	2.00^{c}±0.58	1.00^{d}±0.00	1.33^{c}±0.33	6.00
	2	3.33^{b}±1.45	5.33^{b}±0.88	3.33^{b}±0.33	1.33^{c}±0.33	13.32
	3	7.00^{a}±1.16	6.33^{a}±0.88	2.67^{c}±0.33	2.33^{b}±0.33	18.33
	4	2.33^{c}±0.33	1.67^{c}±0.33	2.67^{c}±0.33	3.33^{a}±0.33	10.00
	5	8.00^{a}±1.00	7.67^{a}±0.88	4.67^{a}±0.67	2.33^{b}±0.33	22.67
Ostracoda	1	1.33^{b}±0.33	2.67^{bc}±0.88	1.33^{b}±0.67	0.67^{c}±0.07	7.66
	2	2.67^{a}±0.33	4.33^{a}±0.33	2.33^{a}±0.33	1.67^{a}±0.33	11.00
	3	1.67^{b}±0.33	3.00^{b}±0.58	1.33^{b}±0.33	1.00^{b}±0.02	7.00
	4	0.67^{c}±0.33	2.33^{c}±0.33	1.33^{b}±0.33	0.33^{d}±0.00	4.66
	5	2.33^{a}±0.33	1.33^{d}±0.33	0.33^{c}±0.03	1.00^{b}±0.00	4.99

[a-d]Means with the same letter in the same column within each parameter are not significantly different

Cladocera, making a major proportion of zooplankton, and they are more common in fresh water lakes, ponds and sluggish stream (Ashok *et al*., 2016 and Gu, 2000). In this study cladocera represented the third abundance. It showed the peak population in summer and spring in site 5 (20 & 11.33 org x10^3./l, respectively), this may be due to the closed relationship with the temperature of water, when temperature was maximum (27.2 & 27.5 org x10^3./l), while the minimum number was 1.0 org x10^3./l obtained in winter in site 1 and 2 experiencing very low temperature 15.8 and low pH 7.8, low alkalinity 167 mg/l in these sites, this agreed with Ashok *et al.* (2016) who maintained that pollution limits the distribution and density of group cladocera and basin experiencing hyper a trophic condition, but Siraj *et al.* (2007) stated that cladocera community was affected by the fluctuations in water levels and macrophatic density, also the lowest abundance of cladocera levels showed in site 2 which more polluted. This agreed with Punjabi and Yousuf (2005) who found that a shift dominance pattern of cladocera in a highly polluted lake.

In this result copepods comprised the second dominant group after rotifers, the highest density were 22±0.58 org x10^3./l in site 5 in summer, while the lowest one were 2.33±0.33 org x10^3./l in site 1 in winter. Copepods and cladocera represented low abundance in related to rotifers, this may be due to rotifer have sufficient advantages (small individual fast growth and short life cycle) Also, it is more sensitive to changes in the aquatic environments than cladocera and copepods. These results agreed with Xiaoyu *et al.* (2014) and Zohra *et al.* (2015) who stated that the pollution generated by industrial activities has an effect on distribution of copepods community and a reduction of their diversity.

Ostracoda were the lowest abundant group of this study with highly variable number in summer in site 2 (4.33±0.33 org x10^3./l) which characterized by low oxygen, low pH and the lowest number in site 5 (0.33±0.03 org x10^3./l) in autumn. So, Ostracoda can be used as indicator for pollution. These results agreed with Valentina *et al.* (2012) who showed that wastewater discharge associated with farming activities and industry may dramatically reduce the ecological health of water ecosystem

CONCLUSION

Based on this study, it is necessary to exercise cautions towards water resources in these areas where they are vulnerable to further adverse changes threatening deterioration of their quality and lack of suitability for aquaculture, or at least the production of good fish, which negatively affects the health of human being and general economy.

Generally fish farms seem to be affect the biological communities, in the samples collected from fish farms site 3 (A private fish in El-Hamol which irrigated from drain number 6 directly and site 4 (Private fish farm which irrigated from expulsion pumps number 7; a mixture of agricultural drainage and industrial effluents + sewage drain). The total zooplankton density and richness were highly than samples collected from the canal, this may be due to nutrient enrichment in fish farms.

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تقييم التغيرات الطبيعية والكيميائية والمعادن الثقيلة والهائمات الحيوانية في بعض المزارع السمكية بمحافظة كفر الشيخ – جمهورية مصر العربية

منى حامد احمد – إيمان عطية عبد السميع عبد الحميد

– أحمد بطران

قسم الليمنولوجي– المعمل المركزي لبحوث الثروة السمكية بالعباسة – أبوحماد – شرقية – جمهورية مصر العربية.

الملخــص العربــى

حيث أن إنتاج الأسماك الأمثل يعتمد كليا على الصفات الفيزيائية والكيميائية وكذلك البيولوجية للمياه ، فإنه من المهم فهم نوعية المياه وفقا لمتغيرات مثل درجة الحرارة ودرجة الحموضة والقلوية، والعسر الكلي، والأمونيا والنتريت والنترات والفوسفور وتركيز المعادن الثقيلة والهائمات النباتية والحيوانية ...الخ. وقد أجريت هذه الدراسة في خمسة مواقع مختلفة بمحافظة كفر الشيخ في جمهورية مصر العربية خلال عام كامل لتقييم مدى صلاحية هذه المياه للإستزراع السمكي.

وقد أظهرت الدراسة أن درجة حرارة المياه في فصل الربيع والصيف والخريف في جميع المواقع كانت داخل النطاق المسموح به لتربية الأسماك ، كما تذبذبت قيم الأس الأيدروجيني في الجانب القلوي وكانت ضمن الحدود المسموح بها لتربية الأسماك في كافة المواقع. أما الأكسجين الذائب فقد سجل أعلى قيما له في جميع المواقع خلال فصل الشتاء ثم الخريف وكانت أدنى مستوياته في مياه مصرف ٦ (موقع ٢) خلال كل الفصول غير أن جميعها كان داخل الحدود المناسبة لتربية الأسماك. كذلك أظهرت الدراسة أن مستويات الملوحة كانت في مزرعة الحامول ومياه مصرف ٦ أعلى من التي في موقع ٤، ٥.

كذلك تذبذبت مستويات القلوية الكلية والعسر الكلي خلال جميع الفصول حيث سجلت أعلى مستويات لهما في مياه مصرف ٦ و مزرعة الحامول(موقع ٣). أما الأمونيا فقد كانت فوق الحدود المسموح بها في جميع المواقع وخلال العام كله والتي تعد غير مناسبة للاستزراع السمكي.أما النترات والنيتريت فقد سجلتا أعلى مستوياتهما خلال الصيف والخريف في كل المواقع غير أن جميعها يعد مناسبا لتربية الأسماك.

ومن ناحية أخرى فقد وجد أن تركيزات الحديد تجاوزت الحدود المسموح بها لتربية الأسماك في جميع المواقع وخلال جميع فصول السنة ، في حين كانت تركيزات النحاس أقل من الحدود المسموح بها لتربية الأسماك في جميع المواقع وخلال جميع فصول السنة. وكذلك تركيزات الكادميوم والزنك كانت أقل من الحدود الموصى بها في جميع المواقع باستثناء الموقع ٥ خلال جميع الفصول ، أما تركيزات الرصاص فقد تجاوزت الحدود المسموح بها في الموقع ٢ (مصرف ٦) خلال جميع الفصول وتذبذبت في الموقع ٣ و ٤. وقد كانت تركيزات النحاس والرصاص والحديد في الموقع ٢ أعلى من تلك الموجودة في المواقع الأخرى، وكذلك الحال بالنسبة للكادميوم إلا في الموقع ٥.

أما عن الهائمات الحيوانية فقد سجلت الروتيفرا أعلى القيم خلال المواسم الأربعة وكانت الأستراكودا أقل المجاميع تواجدا كما لوحظ أن المواقع الخمسة فقيرة جدا في محتواها من الهائمات الحيوانية

وبناء على هذه الدراسة فإنه من الضروري توخي الحيطة والحذر تجاه مصادر المياه في هذه المناطق وعمل متابعة دورية لها لأنها عرضة لزيادة التغيرات السلبية مما يهدد بتدهور جودتها وعدم صلاحيتها للاستزراع السمكي أو على الأقل انتاج أسماك غير جيدة مما يؤثر سلبا على الاقتصاد العام وصحة الإنسان.