Assessment of water quality of unfertilized fish farm using zooplankton diversity index and some abiotic factors

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ABSTRACT

The goal of this study was to investigate the effects of Nile tilapia and striped mullet fry stocking on the water quality of unfertilized fish farm using water quality index (WQI) method and zooplankton diversity index. Samplings were undertaken from pond 12 from one sample point over a 20- day period. The results indicate that, fry stocking showed detectable changes in the zooplankton assemblages. However, small differences in some limnological variables were noticed. Soon after the fry stocking, rotifers which constituted more than 90% of total zooplankton community were replaced by Copepoda and Cladocera. To qualify the fish farm water, two indices were applied. Water quality (WQI) and zooplankton diversity indices were the same in appreciation. Diversity Index classified the pond water as being among moderately and heavily polluted, whereas the WQI demonstrated it as among medium and bad. It is suggested that Observation of the fish farm is necessary for proper Administration. Application of the WQI is also suggested as a very useful tool that enables the public and decision-makers to estimate water quality of fish farms.

Keywords: Zooplankton, fish fry, water quality, El Max fish farm

INTRODUCTION

Aquaculture plays an important role in growing food divisions of the world. However, poor water quality and disease out breaks are the main constraints to aquaculture production thereby affecting both economic development and socio-economic status of local people in many countries. There is a corresponding growth in Egyptian aquaculture that presents huge development possibilities. The Nile tilapia (*Orcochromis niloticus*) is considered the most important fish species in Egypt. It occupied more than 70% of the Egyptian fish landing (Ishak *et al*., 1985). Also, striped mullet (*Mugil cephalus*) is one of the best-known members of Mugilidae and was significant economic value in most worlds (Oren, 1981). Planktivorous fish have a major influence on the structure of the whole plankton where they modify the density and size structure of communities (Carpenter *et al*., 1985). Phytoplankton and zooplankton are considered the main natural food for fish culture especially during the early stages.

Fish perform all their bodily functions in water. They are totally dependent upon water to respiration, feed and grow, excrete wastes, preserve a salt balance, and reproduce; understanding the physical-chemical parameters is critical to quality aquaculture. The initial source of nutrition for most larval aquatic is phytoplankton. This is may be associated for the size of the larvae at hatching. After a specified period of time the larvae of generality species can be fed exclusively on zooplankton or a combination of plant and animal matter i.e. plankton.

There is need for more intensive study to estimate the water quality of the fish farms by many physico-chemical and biological factors (Sargaonkar and Deshpande, 2003).There is also need for more intensive study on the diversity of zooplankton in fishponds and their contributions in fish diet since plankton are the first food of young fishes. The nutritional necessity of zooplankton for young fishes is considered universal. Zooplankton provide the youngs of fish with nutrients since fish require proteins, fats, carbohydrates, minerals salts and water in the right proportion (Davies and Otene, 2009). The direct restraint of zooplankton communities to visual fish predation (i.e size-selective predation on zooplankton) has been focus of much limnological research. Rotifers and cladocerans are important links in the well documented pelagic and littoral food webs of fish ponds and lakes. They are preyed upon by most fish, especially the young, and account for the majority of nutrition items identified in their guts (Hammer, 1985; Telesh, 1993).

Numerous studies have been carried out on the physico-chemical parameters of El Max fish farm (Tadros *et al*., 2005). El Banna (1993) and Zaghloul *et al*. (2005) studied the physico-chemical characteristics and their impact on phytoplankton community composition. The study concluded that although El Moghzay water is rich in nutrient salts, low in pH values, dissolved oxygen and water salinity, yet it attained lower average of phytoplankton counts than the fish ponds. Fish ponds are very fertile area. This would account for its importance as a nursery ground for fish fry. Abo Elela *et al*. (2005) studied the microbial population in the ponds. Soliman and AboulEzz (2005) studied the spatial and temporal variations in the species composition and diversity of zooplankton community in El Max fish farm.

The goal of this study was to investigate the effect of Nile tilapia (*Orcochromis niloticus*) and striped mullet (*Mugil cephalus*) fry stocking on the quality of pond 12 in El Max fish farm by studying zooplankton community structure, species diversity, and physicochemical status.

MATERIALS AND METHODS

Sampling Site

El-Max Fish Farm was established in 1931, at about 15 km. westward of North Coast of Alexandria City, in the vicinity of Lake Mariut and at about one kilometer south of the Mediterranean Sea Coast. To the north of this farm lies El-Max Pumping Station. It serves to pump out the water from El-Ummoum Drain which connects the lake to the Mediterranean Sea through a channel of about 800 meters long, so that the level of water in the lake is kept at about 2.8 - 3.0 meters below the sea level. Taking advantage of the difference in level between water in this channel and the low water in ponds farm, a line of pipes was constructed to permit the water to flow into the feeding canal which supplies the fish ponds. The total area of this fish farm is about 37 Feddans. This aquatic fish farm is divided into 14 ponds (Fig.1). The largest one is the pond 14 with an area about 14 Feddans and the rest of the ponds area are ranged from 0.14 to 1.25 Feddans. Recently, in 2006, pond 14 is divided into 4 ponds (11, 12, 13 &14). The water depth of all ponds is varied from 0.5 to 1.8 m. These aquatic fish farm ponds receive the feeding waters coming from El- Nubaria freshwater mixed with the water drained through different waste products such as that of the irrigation water, industrial products and others which discharged into Ummoum Drain. Pond 12 was selected for the present study; it measured about 3 Feddans with a depth of about 0.8 m.and stocked with mixed culture of juveniles and fries of Nile Tilapia (*Oreochromis niloticus)* and *Mugil cephalus.*

Sampling and analyses

Zooplankton samplings were carried out at one sampling station in pond 12 of El Max Fish farm every two or three days during the summer (from June 15th to July 5th, 2012) over 20 days (n=11). Samples were obtained under the water's surface, always in the morning, using 55 µm mesh size plankton net to filter 50 liters of water per sample, and preserved in 4% formaldehyde buffered with calcium carbonate.

Fig. 1: Map of El-Max Fish Farm and the location of studied pond (pond 12).

Abundances were expressed as the number of individuals per cubic meter (ind. m^{-3}). Concomitant with zooplankton samplings, some physical and chemical water variables were measured: water temperature was measured with a thermometer sensitive to 0.1°C; Secchi disk of 25 cm diameter is adopted for measuring water turbidity. The pH and the electrical conductivity were measured in situ using portable glass electrode pH-conducti-meter (Type: HANAA instrument), and the water salinity using a Beckman salinometer (Model NO.R.S.10); dissolved oxygen, dissolved ammonia and total dissolved solids were performed according to standard methods described in APHA (1995).

The Water Quality Index (WQI) is a mathematical tool used to transform some quantities of water characterization data into a single number that represents the water quality level (Sanchez *et al*., 2007). The five parameters selected were pH, dissolved oxygen, ammonia, electrical conductivity and total dissolved solids. Then, a quality value (Q value) from 0 to 100, based on the normal data range, was assigned to each parameter. Each Q value was multiplied by a weighting factor based on the importance of the parameter, and summation of the weighted Q values yielded the WQI, which defines the water as very bad, bad, medium, good or excellent.

Statistical analysis

Three indices were used to estimate the community structure: diversity (H′) (Shannon & Wiener 1963), richness (Margalef, 1958) and evenness or equitability (J) (Pielou 1975). The Spearman rank correlation(r) was used to evaluate the relations between environmental variables and zooplankton abundances at each sampling date (N=11) with the SPSS8.0 Statistical Package Program.

RESULTS AND DISCUSSION

Hydrographic conditions

Action water management in aquaculture is one of the important parameters contributing to the success of aquaculture, reducing the occurrence of fish disease and enhancing fish growth and survival.

The parameters of water studied and their values of Mean ± S.D and ranges during the study period before and after stocking are shown in Table 1.

Table 1: Range and mean of water quality parameters in a fish pond before and after fry stocking

parameters	before fry stocking		after fry stocking	
	range	Mean ± SD	range	Mean ± SD
T°C	25.3-29.2	27.6±1.53	27.1-28.6	27.5±0.7
pH	8.01-9.3	8.58±0.42	8.13-9.02	8.68±0.35
Transparency (cm)	25-43	32.6±7.0	25-43	35.2±6.94
TDS(gl-1)	4.95-12.52	6.45±2.99	4.47-4.65	4.59±0.07
EC (ms)	7.65-19.11	10.14±4.44	6.99-7.49	7.3±0.19
Salinity (ppt)	4.1-11.2	5.52±2.8	3.7-3.9±	3.8±0.07
DO (mg-1)	5.1-7.8	6.43±1.21	4.7-8.5	6.86±1.66
Ammonia (mgl-1)	0.045-0.14	0.08±0.03	0.026-0.084	0.05±0.02
WQI	48.0-59.6	52.9±5.0	46.0-62.2	55.0±6.5

Temperature and pH values did not show any variation before and after fry stocking (25.3-29.2°C) and (8.58-8.68), respectively. The range of transparency was 25 cm to 43 cm of the two study periods. The formation of transparency water may be due to the density of zooplankton, clay particles or detritus. The turbid water can provide some advantages not only to stabilize the water quality and fish habitat, but also provide some nutritional effect since the clay particle can absorb nutrients, organic particles and microorganisms to form “clay floccules” which can serve as fish natural feed. The optimum range for secchi disc reading is between 30 and 60 cm to the fry and juvenile stages and between 25 and 40 cm to the sub-adult and final stage (Shailender *et al*., 2012). pH values in the present study within the favorable range for the fry and fingerling growth, ranging between 8.0 and 9.3. Most fish species do well within the pH range of 6.5 to 9.5 (Swingle, 1961 and Boyd and Lichtkoppler1985). If the pH of the water is relatively high (pH = 8 or above), fertilizers containing nitrogen should be avoided as they may be converted to the unionized, toxic form of ammonia (NH_3) (Boyd, 1982). No salinity gradients were observed, except in 15 June when salinity was 11 ppt due to incomplete filing of water pond.

Dissolved oxygen (DO) is by far the most important chemical parameter in fish culture. Low-dissolved oxygen levels are responsible for more fish kills, either directly or indirectly, than all other problems combined. Like humans, fish require oxygen for respiration. The amount of oxygen consumed by the fish is a function of its size, feeding rate, activity level, and temperature. Small fish consume more oxygen than do large fish because of their higher metabolic rate. To obtain good growth, fish must be cultured at optimum levels of dissolved oxygen. Some warm water species such as tilapia is better adapted to withstand occasional low DO levels. Dissolved oxygen concentrations before and after stocking showed the same trend. Results of Table (1) revealed that differences among the physicochemical parameters were insignificant and fluctuated in a narrow range. Although these values fluctuated from time to time and they still within the acceptable and favorable levels required for growth and survival of the fish fry.

Freshwater fish generally thrive over a wide range of electrical conductivity. Electrical conductivity (EC) also can be used to give a rough estimate of the total amount of dissolved solids (TDS) in water. Matsumura-Tundisi & Tundisi (2003, 2005) suggested that conductivity was responsible for the collapse of some and the growth of some Copepoda and Calanoida species in the eutrophic fish farm. Low values of conductivity were noticed in Pond 12 due to the lack of organic manure application which is responsible of the increase of conductivity in the water (Ray and David, 1969).

In the fish farm, ammonia is present in two forms – un-ionized ammonia (NH_3) and the ionized form (NH_4+) $^-$ and the relative proportion of each type depends on pH and temperature. As pH increases, there is an increasing proportion of un-ionized ammonia, which is very toxic to fish. The mean level of ammonia in ponds of tilapia fed by zooplankton ranged from 0.8 to 1.2mg/l while in artificial feed ranged from 1.6 to 2.2mg/l (Abd El Fattah *et al*., 2008). But other studies considered ammonia above 0.1 mg/l is harmful to fish (Sunitha and Padmavathi, 2013); and in the present study it was below these levels (<0.1 mgL^{-1}).

Zooplankton community structure and composition

In the present study, among zooplankters, rotifers were dominant before fry stocking (>90%) while copepods were dominant after stocking (49%), (Figs. 2&3).

Numerically, a few rotifer and crustacean taxa formed the major component of the zooplankton. Rotifers are known to be more species-rich than cladocerans and copepods in subtropical water bodies (Rocha *et al*., 1995). The dominance of rotifers in terms of both species richness and abundance, like in our study, seems to be a common pattern in subtropical water bodies (Fernando *et al*., 1990).

In total, 25 zooplankton species were identified, including the larval stages of different groups. Most of them were rotifers (16 species). Copepods formed 3 species, protozoans (2 species: one of each of tintinnids and foraminiferans), while Cladocera, Ostracoda, Amphipoda and Nematoda were only represented by one species each. The results of the study indicate that, fish fries generate detectable changes in the zooplankton assemblages and their ecological attributes.

Rotifera densities were the highest before fry stocking (15 – 24 June) reaching > 90% of the total zooplankton. They nutrition on bacteria and phytoplankton, and then reproduce to form huge populations (30600 x 10^3 $ind.m^{-3}$) in 24 June. The fries were stocked when rotifer populations are rapidly rising and there will be plenty of nutrition. Fries grow rapidly and are large enough to eat copepod nauplii and larger zooplankton when those organisms appeared. The fry will also have a much better chance of being large enough to avoid being eaten by cyclopoid copepods.

The rotifer community was depressed after stocking to reach 46.67% of the total community, which probably was a combined effect of fish fry prying. Spine-bearing genus *Brachionus* was generally well represented in the two periods; it was represented by 7 species; in which *Brachionus plicatilis* Müller, 1786 and *Brachionus calyciflorus calyciflorus* Pallas, 1776 were the most dominant species.

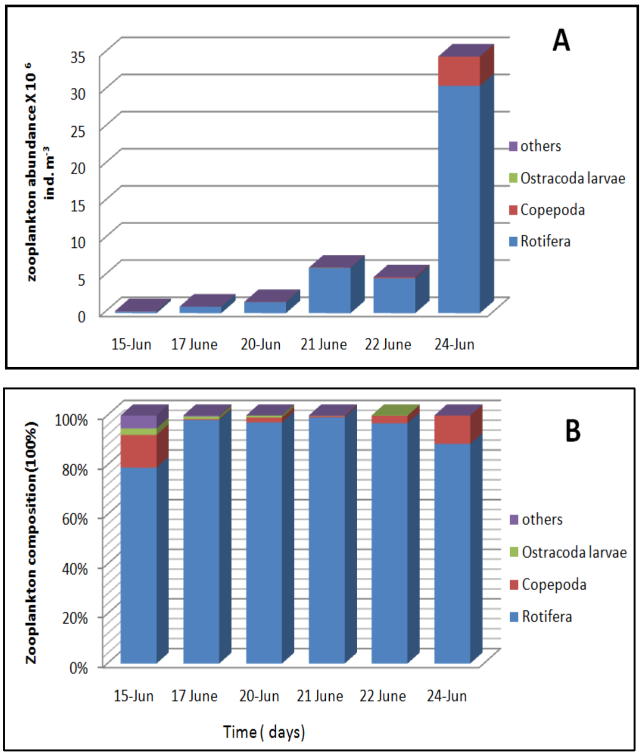

Fig. 2: Daily fluctuation of zooplankton and main groups (A) density ind.x10^6 m^{-3} and percentage frequency (B) before fry stocking.

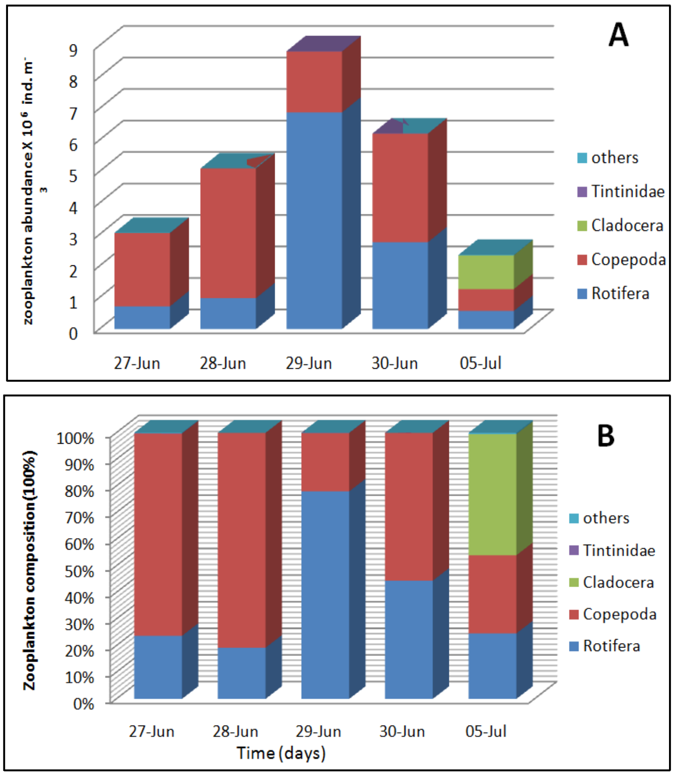

Fig. 3: Daily fluctuation of zooplankton and main groups (A) density ind.x10^6 m^{-3} and percentage frequency (B) after fry stocking.

The genus formed, respectively, 56.74 and 51.70% of the total Rotifera and total zooplankton density before stocking and 54.82 and 25.59% of the total Rotifera and total zooplankton density after stocking. In general, the smallest in size of the main zooplankton groups are rotifers. Body lengths of rotifer species vary from 0.04 to2.5 mm. They are often the earliest visible zooplankton to appear in ponds, hatching almost immediately after pond is filled. Rotifers reach maturity 2 to 8 days after hatching and some species can increase in number very rapidly. However, modest populations of larger rotifers (*Brachionus plicatilis* and *Keratella cochlearis cochlearis* (Gosse, 1851) may appear after stocking, particularly when fish fry and Cyclopoid copepods prey on small rotifers.

Copepods were frequently represented before stocking (8.74%) in which copepod nauplii were the largest copepods (72.65 and 6.35% of the total copepods and zooplankton, respectively). Highest numerical abundance of copepods (3962 x 10^3 indiv. m^{-3}) occurred in 24 June. They showed a high increasing after stocking (49.0% of the total zooplankton) with highest abundance of 4121000 ind.m^{-3} in 28 June (after stocking). Among copepods including adults, *Mesocyclops hyalinus* (Rehberg, 1880) and *Thermocyclops neglectus* (Sars G.O., 1909) were most represented after stocking, in which Copepod nauplii decreased in abundance after stocking due to intensive pry by fish fries. Cyclopoid copepods prey on small rotifers and together, copepods and cladocerans prevent a re-bloom of the smallest rotifers (Ludwig, 1999).

Cladoceran density was low compared to copepods and rotifers. Highest cladoceran abundance (1072000 indiv. m^{-3}) was recorded in 5 July. One cladoceran species: *Daphnia magna* was appeared only in 15 June and 5 July. Cladocerans, are the third major group of zooplankton found in freshwater ponds. Larger fry and even adults of some fish species often selectively prey on these crustaceans. Geiger (1983) stated that the predation exerts perhaps the largest single influence on pond zooplankton communities.

Before fry stocking, the large cladocerans and copepods are greatly reduced in numbers and the small rotifers and copepod nauplii become prevalent. However, after fry stocking the number of smaller sized plankton is greatly reduced and the large cladocerans and copepods prevail.

Tilapia and Mugil are omnivore that feed on both zooplankton and aquatic plants, the fries mainly consume rotifers. Selective fish predation plays a vital role in regulating the diversity and abundance of zooplankton.

Most fish fry eat three main groups of zooplankton-rotifers, copepods and cladocerans. For the tiniest fish fry, such as the newly hatched fry, small rotifers may be the only zooplankton small enough to eat. For larger fry, the smallest rotifers may not provide enough nutrients to make chasing and ingesting them worth the effort. Copepod nauplii, which are just-hatched copepods, are too the important first foods for larval fish. Protozoans may also be eaten, but little is known about their contribution to fry diets.

In general, fry must have zooplankton to survive, or at least to be healthy and grow rapidly. Most fry are not particular about the types of zooplankton they eat, but the organisms must be small enough to fit into their mouths. To maximize survival, stock any fry just as populations of zooplankton small enough for the fry to eat are rapidly increasing and before invading predators become numerous. Ahlen *et al*. (2011) maintained that planktivorous fish are known to affect the zooplankton community both in terms of species composition and species specific morphological traits. This difference in zooplankton diversity and species richness may be linked to differences in predation by the different fish species.

The lowest and highest species diversities (H′) were 0.958 (21 June) and 2.881 (15 June) (Table 2). The correlations of zooplankton abundance with species diversity indices were insignificant (r=0.114, p=0.739). Species evenness (J) varied between 0.310 (21 June) and 0.944 (20 June), indicating a reduction in the degree of dominance at this period.

Table 2: Range and mean of zooplankton density (x10^3), diversity, evenness and richness in a fish pond before and after fry stocking

parameters	before fry stocking		after fry stocking	
	range	Mean ± SD	range	Mean ± SD
zooplankton density	279-34568	8038±13203	2356-8824	5111±2588
Rotefera density	220-30600	7323±11633	580-6880	2386±2661
Copepoda density	3-3962	702±1598	692-4121	2505±1337
Cladocera density	0-7	1±3	0-1072	214±479
number of species	20-22	20.8±0.98	19-22	20.6±1.34
diversity index	0.958-2.881	2.168±0.873	1.830-2.549	2.139±0.349
evenness	0.310-0.944	0.715±0.289	0.592-0.851	0.702±0.121
richness	1.152-1.675	1.355±0.179	1.165-1.431	1.278±0.123

Relations between abiotic parameter and zooplankton community

Spearman Rank correlation analyses were performed on environmental parameters and zooplankton groups in order to examine significant relationships. Most Pearson correlations between zooplankton abundance and limnological variables were insignificant except that of pH which showed positive correlation with total zooplankton density ($r=0.633$, $p < 0.05$), total *Brachionus* ($r=0.616$, $p<0.05$) and nauplius larva of Copepoda ($r=0.719$, $p<0.05$). The single environmental variable that best correlated with the Copepoda was transparency ($r=0.653$ $p < 0.05$) and Foraminifera with ammonia ($r= 0.783$, $p<0.05$). None of the other correlations between Rotifera, Copepoda and environmental variables were statistically significant ($p>0.05$). Among the dominant zooplankton species, *Brachionus plicatilis* showed significant positive correlations with ammonia ($r=0.650$, $p<0.05$) and *Brachionus quadridentatus* Hermann, 1783 with transparency ($r=0.637$, $p<0.05$).

Furthermore, WQI displayed a positive correlation with dissolved oxygen ($r=0.833$, $p<0.05$). In contrast, ammonia exercised negative effects with WQI ($r=-0.712$ $p<0.05$).

CONCLUSION

Present study was such an attempt to estimate the water quality of the fish farm by physicochemical and biological methods. In spite of major changes in the zooplankton community structure were found in pond 12 due to cultivation of planktivorous fish fry, water quality and zooplankton diversity indices were the same in appreciation. Diversity Index classified the pond water as being among moderately and heavily polluted, whereas the WQI demonstrated it as among medium and bad. It is evident that dissolved oxygen and ammonia were the factors governing the health of water in pond 12. And so, it is suggested that monitoring of the fish farm is necessary for proper management. Application of the WQI is also suggested as a very helpful tool that enables the public and decision makers to estimate water quality of fish farms.

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ARABIC SUMMARY

تقييم نوعية المياة بالمزارع السمكية الغير مخصبة باستخدام تنوع الهائمات الحيوانية وبعض العوامل الغير حيه

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تناول هذا البحث دراسة التغييرات التاتجه عن تاثيرات اصباعيات البلطى والبورى على نوعية المياه للمزارع السمكية باستخدام الدليل النوعى للمياه إلى جانب دراسة تنوع وكثافة الهائمات الحيوانية. حيث تم رصد نوعية المياة وبعض العوامل الغير حيه فى مزرعة المكس فى حوض رقم ١٢ لمدة تزيد عن ٢٠ يوماً . حيث انها تقع غرب الساحل الشمالى لمدينة الاسكندرية فنهاية بحيرة مريوط من جهة الشمال وعلى بعد واحد كيلومتر جنوب ساحل البحر المتوسط وشمال محطة رفع المكس على مصرف العموم. ومساحة مزرعة المكس تقدر بحوالى ٣٧ فدان وحوض ١٢ يقدر مساحته بحوالى فدانين ونصف. فى هذه الدراسة تم رصد بعض العوامل الغير حيه مثل درجة الحرارة، ودرجة الشفافية والعكارة ، ودرجة الاس الهيدروجينى، وكذلك الملوحة ، وتركيز الاكسجين الذائب فى المياه، وتركيز الامونيا ، ودرجة التوصيل الكهربائى واخيرا تركيز الاملاح الكلية الذائبة . كما تم معاملة النتائج بالدليل النوعى للمياه وكذلك التحليل الاحصائى باستخدام برنامج spss 8 بحساب كل من Shannon index , Richness index , Evenness index , correlation index .

وأظهرت النتائج أن :-

١- درجة الحرارة ودرجة الاس الهيدروجينى للمياه تسير فى نفس الاتجاة قبل او بعد وضع المخزون السمكى من اصباعيات الاسماك. حيث انها سجلت بين ٢٥,٣ و ٢٩,٢ درجة مئوية. و ٨,٥٨ و ٨,٦٨ بالترتيب.

٢- كما بينت النتائج ان درجة الشفافية كانت تتراوح بين ٢٥ سم و ٤٣ سم قبل وبعد وضع المخزون السمكى من اصبعيات الاسماك. وان التغير الحادث لها نتيجة لكثافة الهائمات الحيوانية.

٣- أظهرت النتائج ان تركيز درجة الاكسجين الذائب فى المياه كانت تتراوح بين ٥,١ و ٧,٨مليجرام /لتر قبل وضع المخزون السمكى، بينما كانت تتراوح بين ٤,٧ و ٨,٥ مليجرام /لتر بعد وضع المخزون من الاصبعيات السمكية.

٤- اوضحت النتائج ان درجة التوصيل الكهربائى كانت تتراوح بين ٧,٥٦ و ١٩,١١ملى سمينز قبل وضع المخزون السمكى، بينما كانت تتراوح بين ٦,٩٩ و ٧,٤٩ ملى سمينز بعد وضع المخزون من الاصبعيات السمكية.

٥- لوحظ ان تركيز الاملاح الكلية الذائبة كانت تتراوح بين ٤,٩٥ و ١٢,٥٢مليجرام/ لتر قبل وضع المخزون السمكى، بينما كانت تتراوح بين ٤,٤٧ و ٤,٦٥ملنجرام/ لتر بعد وضع المخزون من الاصبعيات السمكية.

٦- وجد أن متوسط درجة الملوحة كان ٥,٥٢ جزء فى الالف قبل وضع المخزون من الاصبعيات، بينما كان ٣,٨ جزء فى الالف بعد وضع المخزون من الاصباعيات.

٧- تراوح تركيز الامونيا فى المياه بين ٠,٠٤٥ و ٠,١٤ مليجرام/ لتر قبل وضع الاصبعيات ، بينما تراوحت بين ٠,٠٢٦ و ٠,٠٨٤ مليجرام/ لتر بعد وضع المخزون من الاصبعيات.

٨- وجد ان التغيرات فى تركيب المجتمعات الهائمات الحيوانيه فى حوض رقم ١٢ نتيجه لتغذية اصباعيات الاسماك هلى الهائمات الحيوانيه حيث بلغ متوسطها ٨٠٣٨ × $١٠^{٣}$ كائن/ م^{٣}و ٢٣٥٦× $١٠^{٣}$ كائن/ م^{٣} قبل وبعد وضع الاصبعيات من الاسماك بالترتيب.

٩- كما اظهرت النتائج أن العجليات كانت هى السائدة فى هذه الدراسة. حيث سجلت اعلى كثافة موجودة، كانت تتراوح بين ٢٢٠ × $١٠^{٣}$ و ٣٠٦٠٠ × $١٠^{٣}$ كائن/ م^{٣} قبل وضع المخزون السمكى، بينما كان متوسطها ٢٣٨٦ × $١٠^{٣}$ كائن/ م^{٣} بعد وضع المخزون من الاصبعيات السمكية.

١٠- كما سجلت النتائج أن مجدافية الارجل الترتيب الثانى بعد العجليات. حيث كانت تتراوح بين ٣ × $١٠^{٣}$ و ٣٩٦٢ × $١٠^{٣}$ كائن/ م^{٣} قبل وضع المخزون السمكى، بينما كانت تتراوح بين ٦٩٢ × $١٠^{٣}$ و ٤١٢١ × $١٠^{٣}$ كائن/ م^{٣} بعد وضع المخزون من الاصبعيات السمكية.

١١- اوضحت النتائج ان متفرعة القرون سجلت كثافة بين صفر و ٧ × $١٠^{٣}$ كائن/ م^{٣}قبل وضع المخزون من الاصبعيات السمكية، بينما سجلت كثافة بين صفر و ١٠٧٢ × $١٠^{٣}$ كائن/ م^{٣} بعد وضع المخزون من الاصبعيات السمكية.

١٢- بالنظرالى نتائج التحليل الاحصائى نجد ان

اولاً:- Shannon index كان متوسطه ٢,١٦٨ قبل وضع الاصبعيات السمكية، بينما كان متوسطه ٢,١٣٩ بعد وضع الاصبعيات السمكية.

ثانيا :-Richness index كان متوسطه ١,٣٥٥ قبل وضع الاصبعيات السمكية، بينما كان متوسطه ١,٢٧٨ بعد وضع الاصبعيات السمكية.

ثالثا :- Evenness index كان متوسطه ٠,٧١٥ قبل وضع الاصبعيات السمكية، بينما كان متوسطه ٠,٧٠٢ بعد وضع الاصبعيات السمكية.