Impact of Fish Farming in floating cages on zooplankton Community in Euphrates River, Iraq

Hussein Aliwy Hassan AL-Keriawy

College Environmental sciences, Al- Qasim Green University, Al-Qasim, Iraq.

Abstract

The Impact of floating cages Fish culture on zooplankton in Euphrates river of middle of Iraq was examined from cage and non-cage site at monthly intervals from January 2018 to December 2019, the physical and chemical properties of river water were measured including Water Temperature, Turbidity, Total Solid suspended (TSS), pH, Electrical Conductivity(EC),Total Dissolved Solids(TDS),Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD5),phosphate (PO4) and Nitrate (NO3),The results indicated that: the , Turbidity, Total Solid suspended (TSS), pH, Electrical Conductivity, Total Dissolved Solids(TDS), Biochemical Oxygen Demand (BOD5), (PO4) phosphate and (NO3) Nitrate values in cage site were significantly higher than non-cage site (p<0.05) This gives evidence of the effect of fish cages on this properties . In the current study about 48 Taxonomic units of zooplankton were identified, the rotifer was dominate group including 23 taxa to rotifera, 12 taxa belonging to cladocera and 13 taxa to copepod . The Zooplankton showed high density in river 9470 ind/m$^3$ during April in non-cage site while lower1100 ind/m$^3$ in December in cage site also the rotifer recorder density from (425 ind/m$^3$ in cage site to 4925 ind/m$^3$ non-cage site) , cladocera density from225 ind/m$^3$ in cage site to 1850 ind/m$^3$ in non-cage site and copepod density from 450 ind/m$^3$ in cage site to 2695 ind/m$^3$ non-cage the high values were in spring and autumn while lowest values were recorded in summer and winter .The results of relative abundance index showed that the species rotifera: Keratella cochlearis, K.valga, Euchlanis delatata while the cladocera Alona rectangular, Bosmina longirostris, Chydorus sphaericus, Simecephalus vetulus and the copepods: nauplii were more abundant in the Euphrates river at cage site. The Shanon-Weiner index of total Zooplankton varied from 1.81 to 4.13 bit/Ind while the Shanon index of Rotifer from 1.85 to 3.78 bit/Ind, Cladocera varied from 0.001 to 3.04 bit/Ind and Copeoda varied from 0.35 to 2.71 bit/Ind with greatest values were recorded at April and September in non-cage site while lower values at and June and November in cage site that give evident to effect of cage on zooplankton.

Introduction

Human attention to fish because they are source of high-value animal proteins (Arab Organization for Agricultural Development, 2013).The Environmental pollution and overfishing led to a decline in fish stocks in natural waters, prompting scientists to find alternative methods to avoid the decrease in water productivity of fish (Nabard,2015).fish cages culture is one proven methods of aquaculture to an increase their numbers and provide it for consumption which is the process depend of raising fish in a limited water environment and under human control in different ways to obtain the greatest amount of fish production at the lowest cost. (Mwebaza-Ndawula et al.,2013) fish culture in floating cages which is a technique for Fish production from fingerlings to marketing volumes where fish are held in a cage or basket which...
permitting water to pass freely between fish and water body that allow water exchange and waste removal move. Also this technique has the potential to grow large amounts of fish in a small area of water (Devi et al., 2007). It provides higher production rates than traditional pond culture systems (Saleh, 2010) so this technique has grown significantly in lakes and rivers to become an important industry that due to it has the ability to use the existing water bodies and reducing demand for water and land, flexibility of management, ease of transport from one place to another, which enables us to breed any kind of fish in large quantities and Protect the fish from natural enemies such as birds, predatory fish and frogs (Mondal et al., 2010). However, this activity, especially when practiced in the wrong ways has negative effects on the surrounding water environment, which is reflected economically, socially and health on the societies of countries, both in the near and long term. The Negative environmental impacts in cage culture come from non-scientific and erroneous ways to apply this technique. The most of these impacts are the breeding of omnivorous or carnivorous fish in large numbers in the freshwater cages leading to direct impact on aquatic plants and animals or indirect by the release of solid and soluble waste from the production of fish farming directly into river water, which may lead to an increased nutrient concentrations, especially phosphorus and nitrogen which stimulates the an increase biomass of algae and leading to Eutrophication, evidenced by drifting algal mats, deep-water hypoxia and turbidity which causing pollution and imbalance in natural environments by reduced concentration of dissolved oxygen and threatening the survival of both farmed fish and local native fauna (Guo et al., 2009).

The zooplankton are defined as small aquatic organisms that spend all or part of their life cycle floating or drifting in the water column and have little ability to move horizontally against currents except for some species that have the ability to migrate vertically (Neves et al., 2003) The zooplankton presence in all aquatic environments, including marine and other species living in freshwater or saline and in static and ongoing aquatic environments. This presence is closely related to a large number of environmental factors such as water and light temperatures and chemical agents, especially dissolved oxygen, pH, toxic pollutants and food available, (Aquino, 2008). Almost all species of fish depend during its larval and adult stages on zooplankton in their diets. Therefore, the proportion of zooplankton production can be used to estimate the stocks of fish that can be exploited. In many countries, the decline in stocks is due to the low numbers of zooplankton (Stottrup, 2000).

The aim of this study was to evaluate the possible impacts of fish culture in floating cages on the zooplankton assemblages in the Euphrates river. Furthermore, we investigated their correlation with some physical and chemical variables.

**Materials and Methods**

**Study Area**

The Euphrates River is located in the southwestern part of the Asian continent. This originates from the mountains known as the Taurus Mountains in the Turkish Republic. The length of the Euphrates River is estimated at about 2,940 kilometers, distributed between Turkey, Syria and Iraq. The length of the Euphrates River in Iraq is about 1,160 kilometers. The width of the river ranges from 200 meters to 2,000 meters.
The water and zooplankton samples were collected monthly for the period from January 2018 to December 2019 from the tow sites (site 1). The non-cage was located at the upper part of the fish farm that was not exposed to the effects of fish farming enterprise, was approximately 1 km upstream of the fish cages (sites 2) was located (Figure-1).

Water samples were taken from the surface layer at a depth of about 20 cm below the surface of river water and using 5-liter polythene containers. Well washed with river water and three replicates per sample. For the purpose of conducting limnological variables (water temperature, and turbidity, Total Solid suspended (TSS), pH, electric conductivity, Total Dissolved Solids (TDS), Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD5), Nitrate(NO3), and phosphate(PO4)).

The samples of the quantitative and qualitative study of zooplankton were collected monthly from the banks of the river to each site with 40 liters of water and passed in the plankton net the fiery diameter of 55 microns (type) (Hydro-Bios) and then the samples were concentrated to 10 ml and samples were kept in situ in the special cannons after the addition of formalin at a concentration of 4%. A special slide (Sedwerk Rafter Champer) Prepare 1 ml of the concentrated sample to 10 ml for the purpose of diagnosing the calculation of the zooplankton Groups (rotifer, cladocera).
Based on the taxonomic keys (Edmondson, 1959; Pennak, 1978; Pontin, 1978) and the results were expressed in terms ((Ind/m3))

**Relative Abundance Index**
calculated Based on the formula described in (Omori and Ikeda, 1984).

\[ Ra = \frac{N}{N_s} \times 100 \]

As:
- \( N \) = Number of individuals returning to each taxonomic unit in the sample
- \( N_s \) = Total number of individuals in the sample

The results were expressed using the percentage as follows:
- %70 Dominant species
- %70 - %40 Abundant species
- %40 - %10 Less abundant species
- < %10 Rare species

**Shannon-Weiner Diversity Index (H)**
The values of this index were calculated monthly for the zooplankton groups based on the formula described in Floder and Sommer (1999)

\[ H = -\sum_{i} n_{i} / N \ln \frac{n_{i}}{N} \]

As:
- \( n_{i} \) = Number of individuals per species per site
- \( N \) = total number of individuals in the same site

indicate high The results are expressed in bits/ind. Values below 1 bit/ind indicate low diversity, while values of more than 3 bits/ind indicate high diversity (Porto-Neto, 2003).

**Results**

Table (1) shows the changes in the Some properties of the Euphrates River The first line represents the range and the second line (standard deviation ± average)

| Properties                        | (Control) Site1 | Cage)2 (Site) | Significance |
|-----------------------------------|-----------------|--------------|--------------|
| Water temperature.                | 30 - 7          | 31 - 10      | NS           |
|                                  | 19.5± 7.54      | 21.166± 7.27 |              |
| Turbidity                         | 45.78 - 1.69    | 55.76 - 1.84 | *            |
|                                  | 14.217 ± 12.38  | 17.968 ± 14.64 |              |
| Total Solid suspended (TSS)       | 32.01 - 4.41    | 44.76 - 3.66 | *            |
|                                  | 13.237± 8.52    | 20.728 ± 14.26 |              |
| pH                                | 8.1 - 7.1       | 8.7 - 7.6    | NS           |
|                                  | 7.575± 0.30     | 8.075±0.39   |              |
| Electrical Conductivity           | 820 - 1220      | 930 - 1810   | *            |
|                                  | 1007.5±106.35   | 1306.66±256.45 |              |
| Total Dissolved Solids (TDS) | Dissolved Oxygen (DO) | Biochemical Oxygen Demand (BOD5) | NO\textsubscript{3} (Nitrate) | PO\textsubscript{4} (phosphate) |
|-----------------------------|-----------------------|---------------------------------|-----------------------------|-----------------------------|
| 658 - 440                  | 12.2 - 6.1           | 3.7 - 0.9                       | 4.01 - 4.03                 | 0.15 - 1.26                 |
| 532.5 ± 55.42             | 9.334 ± 1.96         | 1.925 ± 0.82                    | 11.78 ± 7.81               | 0.471 ± 0.388               |
| 977 - 490                  | 10.9 - 5.7           | 6.4 - 1.7                       | 4.01 - 36.43               | 0.17 - 2.89                 |
| 692.91 ± 144.77           | 8.35 ± 1.76          | 3.016 ± 1.24                    | 15.22 ± 11.36              | 0.988 ± 1.020               |

.* Similar significant differences (P < 0.05)

Table (2) Taxonomic units recorded for zooplankton in the Euphrates River and their relative abundance according to Relative Abundance Index

| Taxa                        | Station | Site1 Non-cage | Site2 Cage |
|-----------------------------|---------|----------------|------------|
| ROTIFERA                    |         | Site1 Non-cage | Site2 Cage |
| Asplanchna priodonta       | R       | R              | R          |
| Brachionus angularis       | R       | R              | R          |
| B. calyciflorus            | R       | R              | R          |
| B. urceolaris              | R       | R              | R          |
| Cephalodella auriculata    | R       | R              | R          |
| C. gibba                   | -       | R              | R          |
| Colurella adriatica        | R       | R              | R          |
| Euchlanis delatata         | L        | L              | R          |
| Flinia longiseta           | R       | R              | R          |
| Keratella cochlearis       | R       | L              | R          |
| K. valga                   | L        | L              | L          |
| Lecane depress             | R       | -              | R          |
| Lepadella depresa          | R       | R              | R          |
| L. Ovalis                  | -       | R              | R          |
| Monostyla bulla            | R       | R              | R          |
| M. closterocerca           | R       | R              | R          |
| Notholca acuminata         | R       | R              | R          |
| Platyias patulus           | -       | R              | R          |
| Polyarthra dolicoptera     | R       | R              | R          |
| P. vulgaris                | R       | R              | R          |
| Rotaria nepulina           | R       | R              | R          |
| Trichocerca bicristata     | -       | R              | R          |
Temperature varied from 7°C (January at site 1) to 34°C (August at site 3). No significant differences were found between the sites (P > 0.05). Turbidity range from 1.69 NTU (at site 1) in April to 55.76 NTU (at site 2) in June. Total Solid suspended from 3.45 mg/L (at site 1) in February to 52.05 mg/L in June (at site 2). pH value did not vary much among the sites. The minimum, and maximum pH values were 7.10 (February at second site 1), 8.73 (April at site 2) respectively. The conductivity value varied from 820 μs (February at site 1) to 1810 μs (August at site 2). Total Dissolved Solids values range from 440 mg/L (February at site 1) to 55.76 mg/L (July at site 2). Dissolved oxygen varied from 5.5 mg/L (at site 2) in August to a peak of 12.2 mg/L (at site 1) in March. Biochemical Oxygen Demand reached the maximum values of 9.4 mg/L (in August at site 2) and minimum 0.9 mg/L (in February at site 1). Nitrate nitrogen varied from 3.55 μg/l (May at site 1) to 36.43 μg/l (March at site 2), and...
phosphate varied from 0.15 μg/l (May at site1) to 2.89 μg/l (March at site2). The negative effect of cages on water quality is shown by increasing the values of some of the factors studied in Site 2 compared to this site 1 which is certainly reflected in the presence, density and diversity of zooplankton.

In the current study, the zooplankton fauna of the Euphrates river consists mainly of rotifers, cladocera and copepods. A total of 48 taxa composed of 23 rotifers, 12 cladocera and 13 copepods were identified (Table 1) and accounted for percentages 47%, 26% and 27% respectively Figure (2).

Figure (2) percentages of zooplankton groups in the study sites

The first site (non-cage) recorded 40 taxa as: distributed follows: This taxonomic distributed to the zooplankton groups as follows: 19 taxa to rotifera, 11 taxa to cladocera and 10 taxa to copepoda, while the second site (cage) recorded 34 taxa distributed as follows: 22 taxa to rotifera, 6 taxa to Ccladocera and 6 taxa to copepod. This result show clearly the dominance of the rotifer in both sites that may be attributed to their small size, high reproduction rate, short life cycle small size, and high tolerance to various environmental factors, (Badsi et al., 2010). (Allan, 1976)

The total density of zooplankton in the current study ranged between the highest value and reached 9470( individuals / m³) in Site 1 during April 2017 and the lowest value of 1100( individuals / m³) in Site2 during the month of August 2017 Figure (3).
Figure (3) Monthly changes in the total density of zooplankton individual / m3

There was also a significant positive correlation between the total density of zooplankton with dissolved oxygen (P <0.05 r = 0.636) and Negative correlation with Turbidity (P <0.05  , r = -0.691)

The results of the present study indicate that most of the increases in the total density of zooplankton were during the spring and autumn months, which may have been associated with the availability of their food source from phytoplankton in these two seasons (Thadeus and Lekinson, 2010) as well as increased transparency and the availability of high dissolved oxygen as confirmed by the positive correlation between total density for phytoplankton and dissolved oxygen that correspond to what he said (Saron and Meitei 2013) that zooplankton has two peaks of growth in the first spring and may extend to the late summer and the second at autumn.

The lowest density was recorded in site 2 (cage) may due to the an indirect effect of fish cages on zooplankton by increasing turbidity due to the increase in the amount of organic and inorganic substances resulting from fish feeding, drug residues, non-digested food minutes and fertilizer because an increased turbidity makes adults and eggs in many zooplankton enter hibernation also this conditions may cause high organic pollution in this site, accompanied by the low level of dissolved oxygen, and high BOD5(Davies and Otene, 2009) This is confirmed by the results of statistical analysis, which recorded a negative relationship between the total density of zooplankton and turbidity also The lowest concentration at site 2 (cage) can be attributed to predators, whether they are fish or large invertebrates, which feed on each other, which can be the main cause of low zooplankton density. In some cases predation pressure is more effective in the population density of zooplankton than water quality, especially when present predatory fish species to copepoda and cladocera (Jack and Thorpe, 2002) . or their have ability to vertical migration that reduces competition with other organisms (Moss, 1998) while Telesh (2001) was considered rotifera a strategic or opportunistic organisms with a rapid reproduction and has the ability to maintain its density by substituting new places in the course of the river unlike large zooplankton, such as crustaceans lacking this ability in addition small size, short life cycle and high tolerance to various environmental factors, (Badsi et al., 2010). In general, the density of the
cladocera was lowest between zooplankton and this may be due to the fact that they are very sensitive to pollution, filter-feeding and susceptible to predation by fish and other invertebrates' animals. In addition, the speed of water flow in the rivers allows only to an increase the density of rapidly growing organisms, which have a high rate of reproduction. Therefore, the appearance of the cladocera in water can be linked to running, mixing and increase the concentration of the suspended minutes in that water because it is unable to tolerant the instability of the water column and the presence of suspended matter which cause that damage the digestive system (Ortaga-Mayagoitia et al., 2000). As Ntengwe (2006) points out that when oxygen levels exceed critical limits in any area of the water body, the organisms either die or migrate to areas with sufficient oxygen and since is able to swim more than cladocera so it moves from the areas of environmental disturbance while Jafari et al. (2011), the lack of crustaceans suspended to the hydrological system of the river represented by the size of water and the short time of detention and the relative aging of the river and the absence of pathogenic reproduction in the copepoda may be a reason for the decline copepoda density compared with the rotifer. In addition, the speed of water flow in the rivers allows only to an increase the density of rapidly growing organisms, which have a high rate of reproduction therefore the appearance of the subsurface in water can be linked to running and mixing and increase the concentration of the suspended minutes in that water because it is unable to withstand the instability of the water column.

The population density of the rotifera in the river Euphrates differed according to the differences in the months and locations of the study. The Site 2 recorded the highest density in October and amounted to 4925 individuals/m³ while the lowest density was 425 individuals/m³ recorded during July in site 2 Figure (4).

![Figure (4) Monthly changes in the total density of rotifera individual / m³](image)

The high density may be associated with favorable conditions such as temperature, high oxygen level, and food available in the form of bacteria, phytoplankton or dieters (Dhanpathi, 2000). Hynes (1972) reported that because of the nutritional relationship, the abundance of diatoms in rivers leads to increased density of rotifera because the
environmental conditions of the rivers are suitable for both, and the number of rotifera increases with the rise of temperature and cyanobacteria while the low values of density at site 2 during the summer may it can be attributed to the deficiency of dissolved oxygen by increasing the chemical decomposition of the waste that is removed from the cage. It is also known that the Rotifera in general are living in high dissolved oxygen (Sladecek, 1983). It is also consistent with the results of the study, which recorded the lowest value of oxygen in summer months at site 2. The results of the study agree with the study of (Mangalo and (1979) and Sabri et al., (1993), which returned the temperature and dissolved oxygen, were the main factors that led to the increase of density of rotifer. The high density values of density in site a compared with other groups may be due to the excretion of fish cages from wastes that increase turbidity because the rotifer a can derive some benefits from the higher turbidity conditions of the river than the predators, and other organisms that compete with their food sources, such as crustaceans, which are more sensitive to the turbidity that causes their young to die and inhibit their growth which stimulates and promotes the sovereignty of the rotifer in the turbid rivers (Thorp and Mantovani, 2005) also The other reasons for the dominance of rotifera may be due to small size, short life cycle and high tolerance to various environmental factors, as well as an opportunistic revival capable of swallowing small minutes such as bacteria and organic minutes (Badsi et al., 2010). also the efficiency of Corona and mastax in select the substances that will swallow from the mouth and avoid inorganic molecules may be an important reason for the dominance of rotifera when increasing the concentration of suspended substances (Saron and Meitei, 2013). in other hand the fish prey to large-scale zooplankton may be the main reason for the dominance of rotifera (Srivastava, 2013)

Relative to the relative abundance of rotifera, Table (4) shows the ratios of species in the duration of study and each of the study site. In the site 1, Euchlanis delatata recorded the highest percentage of the total density of the other species in this site and reached 12% followed by Keratella valga 10% followed by K. cochlearis 5%. while In site 2, K. cochlearis recorded the highest percentage compared to the total density of the other species found in this site. It was 15% followed by K. valga and 14% followed by Brachionus calyciflorus 5%.

The species recorded in the current study have been recorded as abundant in many previous local studies on Iraqi inland water, including the study of Abdul-Hussein et al. (1989), which indicated that the species Brachionus calyciflorus calyciflorus prefer to be present in contaminated water and is found in high density in Shatt al-Arab River and some of its contaminated channels And the study of al-Kubaisi (1996), in which he pointed out that the species of Keratella valga exists at high density for most of the study period and it is widespread in the water contaminated organically and this indicates the susceptibility of this species to withstand the conditions of pollution As for the type Brachionus angularis, Saadallah (1998) pointed out that water hardness was suitable for the presence of this species in a distinctive and high densities in the Diyala
River and the study of Nashaat (2001), which indicated that the species Brachionus calyciflorus calyciflorus living in freshwater to the stage of adaptation to live in high salinity water in order to survive and maintain its type. Both Ghazi and Ali (2012) achieved the dominance of the two species Brachionus calyciflorus and Keratella valga in the Shatt al-Arab river and the species K.valga has two peaks of growth, one in summer and one in winter, while B. calyciflorus has one peak of growth usually in summer. Ibanez (2004) explained that the species Keratella cochlearis is characterized by its high ability to withstand a wide range of pH and high concentrations of suspended materials in what is considered Feike et al. (2007) noted that the species Brachionus calyciflorus, B. plicatilis, and Keratella cochlearis are mainly responsible for the collective development of rotifera in the basal environments. Segers (2008) indicated that the Brachionidae family contains genomes, mostly live in oligotrophic to mesotrophic environments and low turbidity and Few acidic water.

Figure(5) The relative abundance of the species dominants rotifer in the study sites

The non-recording of high values for the relative abundance of rotifera species that could not reach to the abundance or prevalence according to the relative abundance index provides evidence that the river is not exposed to any kind of environmental stress during the study period that may provide an appropriate environment for the rotifera
species Resistance to these pressures (Ahmad et al., 2011 also Neves et al. (2003) states that the dominance of one species or a few species in Lake Atalaia in Brazil dates back to the presence of organic waste in high quantities as Proto-Neto (2003) pointed out that the existence of many species of those species that do not tolerate pollution in large numbers is a proof of cleanliness of the environment.

The density of the Cladocera was varied during the months of study in the Euphrates River and ranged between the lowest density and reached 225 individuals / m$^3$ during July at site 2 and the maximum density was 1850 individuals / m$^3$ during April in site 1, Figure (6)

![Figure 6](image)

Figure (6) Monthly changes in the total density of cladocera individual / m$^3$

The maximum density of the Cladocera in the spring season of the current study may be attributed mainly to the availability of an optimal temperature for the growth and diversity of microorganisms and phytoplankton, which provide a suitable food source for these filter-feeding organisms (Amar et al., 2012) This is in line with what Abbas (2010) pointed out that the increase in the densities of Cladocera in the spring and autumn is due to the increase in the abundance of phytoplankton and aquatic plants, which provide an environment suitable for Cladocera because the rate of growth and composition of phytoplankton species affect growth And the spatial distribution of zooplankton, especially in coastal areas, where the diversity of plant species leads to the formation of small, heterogeneous environmental habitats that colonize various populations of zooplankton, especially the Cladocera (Kuczynska-Kippn and Nagengast, 2006).

The lowest density at site 2, possibly due to high organic pollution and high turbidity, was observed on site and its negative impact on the Cladocera due to filter feeding Sluss et al. (2008). As non-selective feeding water, allows the minutes of clay to
accumulate in the digestive system, causing the death and sinking at the bottom. In addition, Cladocera organisms are sensitive to the concentrations of metal ions such as sodium, potassium, calcium and magnesium, and their increased concentration in water causes disability and death (Clare, 2002). Or may be due to its large size compared to other animal populations, making them susceptible to predation by fish culture.

It was noted in the current study low density of Cladocera in some months of the study, despite the presence of food and this may be due to an increase in the density of the copepod in these months, as the group of the Cladocera of the suitable food for the group of copepod. (Herman and Aolito, 1985)

In the current study low density of Cladocera was observed in some months of study, although the presence of this food may be due to an increase in the density of the copepod in these months and predation, for the Cladocera (Hermann and Olito, 1985)

As for the relative Abundance index, Table 4 shows the appearance of the cultocera species in the both sites as follows. In the first site the species of chyodus sphaericus recorded 18%, which is the highest compared to the total density of the other species in this site, followed by Alona rectangular 14%, followed by Bosmina longirostris 5% while at site 2 recorder species Simocephalus vetulus 20% was the highest in comparison with the total density of other species in this site, followed by Bosmina longirostris, 14% followed by Ceriodaphnia rigaudi 4%.

Figure(7) The relative abundance of the species dominants rotifer in the study sites

Cydorus species are among the most preferred species to live near aquatic plants (Hann, 1995). Chyodus sphaericus is commonly used as a biomarker for increasing plant nutrient concentrations and eutrophication status in the aquatic environment (Shumate et al., 2002). And it can adapt to high or variable levels of soluble salts (Medyantseva,
1997). Schmoldt and Anderson (2001) noted that small-sized species of Bosmina longirostrir are generally present in water with high concentrations of Plant nutrients and on the other hand, the control of small species of suspended crustaceans such as Bosmina longirostrir can be a sign of the severity of predation by some predators of zooplankton, which leads to the removal of crustaceans of large sizes and replace them with small crustaceans, especially Bosmina longirostrir Kulkarni and Surwase, 2013) Simocephalus exspinus is one of the most cladocera species resistant and can live in contaminated environments. Mohammed (1979)

In the current study, the density of the copepod in the present study ranged between the maximum value and 2695 individuals / m3 during the month of October at site 1 and the minimum value of 450 individuals / m3 at site 2 during the January

Figure (8)

The high densities of copepoda in the current study during autumn seasons may be due to the fact that their density is affected by water temperature and food availability (Kulkarni and Surwase, 2013). The positive correlation between copepoda with temperature indicates that it grows and develops better in warmer periods (Winkler, 2002) while The lower densities of the copepod in the winter may be due to the fall of rain and increased discharge of the river and increase the turbidity that caused the lack of phytoplankton abundance also Watezel (2001) points out that the relative abundance of foot massages is affected with predation by fish and inorganic turbidity. The lowest values were recorded in Table 2 and may be due to the high level of pollution as well as the high level, the redness at this station corresponds to what is reached, Jafari et al. (2011) that the lack of copepod in the Haraz River in Iran is due to increased turbidity that caused the death of young individual and inhibited their growth by
identifying the food available to them, which encourages the increase of the growth of the rotifera and their dominance in the river also the site 2 is the least valuable for the copepoda, and this may be due to the effect of predation of fish in cages on the relative abundance of copepoda (Hashemzadeh and Venkataramana, 2012) also. Mangalo and Akber (1988) indicated an increase in the density of copepoda associated with an increase in appropriate nutrients and absence of predators that may be selective to certain sizes

The larvae of the copepod formed the high proportion of their densities, Neves et al. (2003) that in the society of the footwheel is the sovereignty of small forms, especially Nuaplii, which is due to the continuous proliferation of foot paddles and lack of predation by the invertebrates and predatory vertebrates (Edmonson, 1959) and the frenzy of the subterranean tentacles and foot paddle provides algae food larvae larvae feet Sabri et al., 1989)

The larvae of the copepod formed the high proportion of their density, which is consistent with what Neves et al. (2003) that the dominance in the copepod community for small forms, especially Nuaplii, which is due to the continuous reproduction of copepod and lack of predation by the invertebrates and vertebrates (Edmonson, 1959) in addition The prey of the cladocera and adult copepoda provides algae food to the larvae of copepoda (Sabri et al., 1989)

The Relative Abundance index of copepoda Table 4 shows the rates of princess of their species in the both sites: Site 1 The larvae of Nuaplii showed the highest percentage compared to the total density of the other species, reaching 69% flowing by Diaptomus alaskaensis 6%, and then Cyclops sp 4%. while In the site 2, the larvae of Nuaplii were highest, 64%, flowing by Paracyclops fimbriatus, 5%, and Halicyclops sp, 4%

Figure (9) the relative abundance of species of copepoda prevailing in the study sites
The emergence of the Nuaplii larvae at the highest values within the relative abundance index at all stations may be due to several reasons, including that this group represents the stages of evolution of the copepoda which passes through its life five or six stages of the Nauplius Stages and six phases of the Copepodid Stages and the latter is similar to the amount and many of the These larval and Copepodid stages are difficult to diagnose and therefore are counted within the unit Nuaplii classification (Edmondson, 1959) also The predominance of these larval stages on other taxonomic units may be due to the appropriate environmental conditions, the continuous reproduction and the presence of predators that feed on adult species as well as their tolerance to a wide range of environmental conditions (Lami, and Abbas 2001).

Thadeus and Lekinson, 2010 indicated that the control of small species of rotifer and of the cladocera species such as Bosmina longirostris and Nauplii larvae in the tropical force river in Nigeria is due to the influence of suspended materials within the wind-induced water column or the pressure of predatory fish.

The species Halicyclop belonging to the cyclopoid group was high in site 2 may be due to individuals of the genus Halicyclop prefer to live in saline water (mutlobe 2005) and the high density of type Diaptomus alaskaensis compared to other species may be due to the fact that this species falls under the group Calanida, most of their species plankton which is in comparison to other undercounts that favor coastal waters (Howis and Wilhm, 1984). This group is also prevalent among copepoda and accounts for about 80% of the total their numbers (Medina et al., 2003).

Shannon –Weiner diversity index (H)

the Shannon Weiner index value for the total diversity of zooplankton range from 1.81 bit / d (July at site2) to 4.13 bit / person (April at site), Fig. 5.

the Shannon Weiner index value for the rotifer varied from 1.85 b / d (July at site2) to 3.78 bit / person (April at site1), Fig. 5;

the Shannon Weiner index value for the cladocera range from 0.001 b / d (July at site2) to 3.04 bit / person (April at site1), Fig. 5.

.. the Shannon Weiner index value for the copepoda range from 0.34 b / d (November in site 2) to 2.74 bit / person (September at site1), Fig. 5.

The recording of high values from Shannon Weiner's biodiversity index in the spring and autumn coincides with its high density in these two seasons, which may be due to increased water content of dissolved oxygen, increased transparency and increased vegetation density that provides a food source and provides shelter for them to avoid predation by many predators (Kuczyńska-Kippen and Nagengast, 2006). As for site changes, site 1 recorded high values of Shannon Weiner's biodiversity index over the study period, which is evidence of favorable environmental conditions such as high dissolved oxygen concentrations and abundance of food for zooplankton in this site, while the low values in the site 2 due to several reasons including the increased concentration of suspended solids, high turbidity, and lack of dissolved oxygen that
effects on the richness and abundance of species (Shah and Pandit, 2013). The recording of the site is a very low value for Shannon Weiner's diversity index for July and January, which was 0.001 bits/person, indicating almost no biodiversity in that site during these two months, an indication of the intensity of organic pollution and its impact on the presence of these organisms in this region, which works on low biodiversity (Jizani, 2005), according to Neves et al. (2003). Organic-rich environments are characterized by low diversity and low species. This provides evidence of the impact of fish cages on the biodiversity of zooplankton.

Figure (10) Monthly changes of Shannon - Weiner (H) bit/total individual values of zooplankton

Figure (11) Monthly changes of Shannon – Weiner index (H) bit/individual values of rotifer
Figure (12) Monthly changes of Shannon – Weiner index (H) bit / individual values of cladocera

Figure (13) Monthly changes of Shannon – Weiner index (H) bit / individual values of copepoda

References

♦ Abbas, M.F. (2010). Abundance of Cladocera and some other zooplankton and Diversity in the Northern part of ShattAl-Arab river. M.Sc. Thesis, College of Education, Uni. of Basrah. 114 pp.
Abdul-Hussein, M. M.; Al-Saboonchi, A. A. and Ghani, A. A. (1989). Brachionid rotifers from Shatt-Al-Arab River, Iraq. Marin Mesoptomaic, 4(1):1-17.

Allan, J.D. (1976). Life history patterns in zooplankton. Amer Nature., 110: 165-180.

Amar, Y.; Djahed, B.; Lebid, Sara.; Anani, M.; Mouedden, K and Mathieu, C. (2012). Impact of Industrial Pollution on the Zooplankton Population Diversity of the Hammam Boughrara Dam. J. of Environ. Sci. and Engin. A 1 : 527-532.

APHA, American Public Health Association (2005). Standard Methods for the Examination of Water and Wastewater, 21st Edition Washington, DC. 22621pp.

Aquino, R. Y.; Carmela, D. C.; Ann, S. C.; Angelica, G. S., and Papa, D. S. (2008). Zooplankton Composition and Diversity in Paoay Lake, Luzon Is, Philippines. Philippine J. of Sci., 137 (2): 169177

Arab Organization for Agricultural Development. (2013). Arabic Agriculture Day, Fish culture and Arab Food Security

Badsi, H.; Ali, H. O.; Loudiki, M.; El Hafa, M.; Chakli, R. and Aamiri, A. (2010). Ecological factors affecting the distribution of zooplankton community in the Massa Lagoon (Southern Morocco) Afr. J. Environ. Sci. Technol. 4(11): 751-762.

Clare, J. (2002). A good intro to Daphnia culturing (kai Schumann’s Daphnia FAQ). Version 3.2 FAQ: 20pp

Davies, O.A. and Otene, B.B. (2009). Zooplanton community of Minichinda Stream, Port Harrcourt, Rivers State, Nigeria. European J. of Scientific Resarch, 26 (4): 490-498

Devi, P.A Padmavathy, P. Anusuya, P., Aanand, S, and Aruljothi.K (2017) Review on water quality parameters in freshwater cage fish culture. International Journal of Applied Research 3(5): 114-120

Dhanpathi, M.V. (2000) Taxonomic notes on the rotifers from India from 1989-2000. Indian Association of Aquatic Biologists (IAAB), Hyderabad.

Duncan, B.D. (1955). Multiple range and multiple F-Test. Biometricis, 11: 1-42.

Edmondson, W.T. (1959) Freshwater biology. 2nd Ed. John Wiley and Sons, New York.Freshwater Ecol. 18: 383-393.

Feike, M.: Heerkloss, R.: Rieling, T. and Schubert, H. (2007). Studies on the zooplankton community of a shallow lagoon of the southern Baltic sea: long-term trends, seasonal changes, and relations with physical and chemical parameters. Hydrobiol., 577: 95-106

Ferraz, H.A.; Landa, G.G. and Paprocki, H. (2009). Zooplankton of an urban stretch, Itapecerica river, Divinópolis, Minas Gerais, Brazil. J.Check List, Campinas, 5(4): 890–894.

Ghazi, A. H. and Ali, M. H. (2012) Rotifers community structure and abundance along Shatt Al-Arab River from Garmmat Ali to Al-Fao, Southern Iraq Marsh Bulletin, 7(2):150-161.

Guo L, Li Z, Xie P, Ni L (2009) Assessment effects of cage culture on nitrogen and phosphorus dynamics in relation to fallowing in a shallow lake in China. Aquacult Int 17: 229–24

Hann, B. J. (1995). Invertebrate associations with submersed aquatic plants in a prairie wetland. UFS (Delta Marsh) Annual Report, 30:78-82.

Hashemzadeh, F and Venkataramana, G. (2012) Impact of PhysicoChemical Parameters of Water on Zooplankton Diversity in Nanjangud Industrial Area, India, Int. Res. J.Environ. Sci. 1(4):37-42.
1st INTERNATIONAL VIRTUAL CONFERENCE OF ENVIRONMENTAL SCIENCES
IOP Conf. Series: Earth and Environmental Science 722 (2021) 012042
doi:10.1088/1755-1315/722/1/012042

Herman, S.S. and Aolito, L.M. (1985). Zooplankton of the Hereford inlet estuary, southern new Jersey. Hydrobiol., 124:229-236.

Howick, G.L. and Wilhm, J. (1984). Zooplankton and benthic macroinvertebrate in lake Carl Black well. Proc. Okla. Acad. Sci 64: 63-65.

Hynes, H.B.N. (1972). The ecology of running waters. Liverpool Univ. Press.

Ibañez, C.; Paggi J.C.; Molina, C.; Pinto, J. and Koste, W. (2004). Zooplankton de las lagunas. Pages 272-299 in Diversidad biológica en la llanura de inundación del Río Mamoré. Importancia ecológica de la dinámica fluvial. Pouilly, M., Beck S.G., Moraes R.M. & Ibañez C. (eds). Fundación Simón I.Patiño, Santa Cruz.

Jack, J.D. and Thorp, J. D. (2002). Impacts of fish predation on an Ohio River zooplankton Community. J. of plankton Res., 24(2):119-127.

Jafari, N.; Nabavi, S. M. and Akhavan, M. (2011). Ecological investigation of Zooplankton abundance in the River Hazar northeast Iran : Impact of environmental variables. Arch. Biol. Sci., Belgrade, 63 (3), 785-798.

Kuczyńska-Kippen, N.M. and Nagengast, B. (2006). The influence of the spatial structure of hydromacrophytes and differentiating habitat on the structure of rotifer and cladoceran communities. Hydrobiol., 559: 203-212.

Kulkarni, D.A and Surwase, S.S. (2013). Studies on Occurrence, Richness and Composition of Zooplankton in Seena river water at, Mohal, Dist- Solapur, MS, India Int. Res. J. Biological Sci 2(2), 25-28.

Madin, L. P.; Horgan, E. F. and Steinberg, D. K. (2001). Zooplankton at the Bermuda Atlantic Time Series Study (BATS) station: diel, seasonal and interannual variation in biomass, 1994-1998. Deep-Sea Res. 48(8-9): 2063-2082.

Mangalo, H.H. and Akbar, M.M (1986). Seasonal Variation in population Density of Zooplankton in the lower Reaches of Diyala River, Baghdad, Iraq. J. Biol. Sci. Res., 7(3):99-113.

Medsantseva, E.N. (1997). Influence of mieralization on fresh water zooplankton under experimental conditions. Symposium for European Fresh water Sciences.Toulouse. 8-12 July, 2001.

Mohammad, M. B. M. (1979). "Annual cycles of some cladocrans in a olluted stream.; Environ. Poll., 18:71-81.

Medina, M. Baratn, C. and Donald, J.B. (2003). Effects of cypermethrin on Marine plankton community a simulated field study using mesocosm. Ecotoxi. and Environ. Safety , In Press.

Mondal MN, Shahim J, Wahab MA, Asaduzzaman M, and Yang Y.( 2010 )Comparison between cage and pond production of Thai Climbing Perch (Anabas testudineus) and Tilapia (Oreochromisniloticus) under three management systems. J. Bangladesh Agril.Univ. ; 8(2):313-322.

Moss, B. (1998). Spatial variation of zooplankton groups in a tropical reservoir (Broa Reservoir, Sao Paulo State-Brazil). Hydrobiol., 357: 89-98.

Mwebaza-Ndawula L, Kiggundu V, Magezi G, Naluwayiro J, Gandi-Pabire W, Ochaya H.( 2013 ) . Effects of cage fish culture on water quality and selected biological communities in northern Lake Victoria, Uganda. UJAS.; 14:2
Nashaat, M. A. (2010). Impact of Al-Durah powerplant effluents on physical, chemical and invertebrates biodiversity in Tigris river, southern Baghdad. Thesis of Doctorate. Coll. of sci. Uni. of Baghdad. 183pp.

Neves, I.F.; Rocha, O.; Roche, K.F.; and Pinto, A.A (2003). Zooplankton community structure of two marginal lakes of the river Cuibá (Mato Grosso, Brazil) with analysis of Rotifer and Cladocera diversity. Braz. J. Biol. 63: 329-343.

Ntengwe, F.W. (2006). Pollutants loads and water quality in streams of heavily populated and industrialized towns. Physics and Chemistry of the Earth. 31:832-839.

Omori, M. and Ikeda, T. (1984). Methods in marine zooplankton ecology. Wiley and Sons, New York on plankton populaon.Report MN7B, National Grants Competition.

Ortega-Mayagoitia, E.; X. Armengol and C. Rojo (2000). Structural and dynamics of zooplankton in a semi-Arid wetland, the national park Las Tablas De Daimil (Spain). WETLANDS, 20 (4):629-638.

Pennak, R. W. (1978). Fresh water invertebrates of the United States. 2nd Ed. John Wiley and sons. Inc. New York, 803pp.

Pontin, R.M. (1978). A key to the freshwater planktonic and semi-planktonic rotifera of the British Isles. Freshwater Biological Association Sci. Puble. No. 38.

Porto-Neto, V.F. (2003). Zooplankton as bioindicator of environmental quality in the Tamandane Reff System (Pernambuco- Brazil): An thropogenic influences and interaction with mangroves. Ph. D. Thesis, Univ. Bremen, Brazil.

Saadallah, Hassan Ali Akbar. (1998). An environmental study on the effect of Hamrin reservoir on the benthic and invertebrate invertebrates of the Diyala River. PhD Thesis - Faculty of Education Aben Al Haytham - University of Baghdad

Sabri, A.W.; Mahmoud, A.S. and Maulood, B.K. (1989a). A study on the cladocered of the river Tigris. Arab Gulf. J. Sci. Res., 7(3): 171- 183. Mangalo, H.H. and Akbar, M.M(1986). Seasonal Variation in population Density of Zooplankton in the lower Reaches of Diyala River, Baghdad, Iraq. J. Biol. Sci. Res., 7(3):99-113.

Saleh, M.A. 2010. Fish Diseases. General Authority for Fisheries Development, Egypt, Bulletin

Saler, S. (2011). Zooplankton of Munzur river (Tunceli, Turkey). J. of Animal and veterinary Advances. 10(2): 192-194.

Saron, T and Meitei, B. (2013). Seasonal Variation of Zooplankton Population withReference to Water Quality of Iril River in Imphal, Himalaya. J. Current World Environ. 8(1):133-141.

Sarwar, M.I.; Majumderb, A.K and Islam, M.N. (2010). Water Quality Parameters: A Case Study of Karnafully River, Chittagong, Bangladesh. Bangl. J. Sci. Ind. Res. 45(2):177-181.

Schmoldst, A.L. and Anderson, R.C. (2001). South east Wisconsins: Pewaukee, lake biological evaluation. Technical. Bulletin 2, Wisconsin, Luthern College.

Schmoldst, A.L. and Anderson, R.C. (2001). South east Wisconsins: Pewaukee, lake biological evaluation. Technical. Bulletin 2, Wisconsin, Luthern College

Segers, H (2008). Global diversity of rotifers (Rotifer) in freshwater. Hydrobiol., 595: 49-59.

Shumate, B.C.; Schelske, C.L.; Crisman, T.L.; Kenney, W.F. (2002). Response of the cladocera coming to trophic state change in lake Apopka change in lake Apoka Florida. J. Paleolimnol., 27:71-77.
Shumate, B.C.; Schelske, C.L.; Crisman, T.L.; Kenney, W.F. (2002). Response of the cladocera coming to trophic state change in lake Apopka change in lake Apoka Florida. J. Paleolimnol., 27:71-77.

Sinha, S. N. and Islami, M. R. (2002). Seasonal variation in zooplankton population of two lentic bodies and Assam state zoo cum botanical garden. Guwahati. Assam. Eco. Environ. Budapest, 43(1): 67–77.

Sivakumar, K. and Karuppusamy, R. (2008). Factors Affecting Productivity of Phytoplankton in a Reservoir of Tamilnadu, India. American-Eurasian J. of Botany, 1 (3): 99-103.

Sladecek, V.(1983). Rotifers as indicators of water quality. Hydrobio.,100:169 - 2011.

Sluss, T.D.; Cobbs, G.A. and Thorp, J.H. (2008.) Impact of turbulence on riverine zooplankton: a mesocosm experiment. Freshw. Biol., 53: 1999-2010.

Srivastava, S. K. (2013) Monthly variation in the Ocurance of Zooplankton in a fresh water body, Ramgarhlake, Gorakhpur, U.P. Int. J. of Appl.Biosci.,1(2) : 23-27

Stottrup, J.G. (2000). The elusive copepods. The production and suitability in marine aquaculture. Aquacul. Res., 31: 703-711.

Suontama, J. (2004). Lack of Suitable raw materials for fish feed – Could we use Plankton? Marine Research News No. 5.

Telesh, I.V. (2001). Zooplankton studies in the Neva Estuary (Baltic sea). Proc. Estonian Acad. Sci. Biol. Ecol., 50(3):200-210.

Thadeus, I.T.O and Lekinson, A. M. (2010) . Zooplankton-based assessment of the trophic state of a tropical forest river Int. J. Fish. Aquac, 2(2): 64-70.

Thorp ,J.H., Mantovani, S .( 2005.) Zooplankton in turbid and hydrologically dynamic, prairie rivers. Freshw. Biol. 50: 1474-1491.

Wetzel, R. G. (2001). Limnology, Lake and river ecosystems. 3rd ed. Academic Press. California, USA.