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# Community Structure of Zooplankton and Water Quality Assessment of Tigris River within Baghdad/Iraq

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**Abstract** For understanding the water quality state of Tigris river, the community structure of zooplanktons was studied in different seasons, and Shannon-wiener diversity index (H), Species Richness Index (D) and Species Uniformity Index (E) were applied. The Results show that the highest number of total zooplanktons in the period of the study was 25036.9 individuals / $m^3$ in the S3, while the lowest number of zooplankton in the period of the study was 16125 individuals / $m^3$ recorded in S1, The current study was recorded The dominance of Rotifers group in All study sites. The species richness index (D) recorded very good abundance and the values ranged between 3.083 to 9.15. The Shannon-Weiner index (H) for diversity ranged from 1.13 bit per Individual in the third station to 2.716 bit per individual in second station, through this Indicator, The Tigris River of the area of the study is a moderate in organic pollution. While the values of species Uniformity index (E) for the appearance of species ranged between the highest value 0.948 during the month of December in the S3 to the less value 0.435 during the month of January in the same station.

***Keywords:*** *zooplankton, community structure, diversity Indexes, water quality assessment*

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## 1. Introduction

Zooplanktons are tiny organisms that are suspended in water. They are usually weak swimmers and typically just drift along with the currents. The zooplankton community is composed of both primary consumers (feed on phytoplankton) and secondary consumers (which feed on the other zooplankton) [1]. They are direct link between primary producers and higher levels of food chain such as fish. The freshwater forms of zooplankton are generally smaller in size and are represented by fewer animal phyla than their marine counterparts [2,3]. Many environmental factors that effect and regulate the spatial and seasonal growth and succession of zooplankton, the environmental variables of DO and nutrients are important for the presence and distribution of zooplankton, the low values of DO would limit the development of zooplankton. Nutrients including $NH4^+$ and $PO4^{3-}$ are important for the growth of zooplankton also, pH and TSS are essential for the distribution of zooplankton [4]. Fresh water zooplankton is an important biological component that used as biological indicator of tropic status of the water systems and its health, since they are larger and easier to identify than phytoplankton and their occurrence, vitality and responses, change under adverse environmental conditions so they can be used as "bio indicators" for water pollution studies [5,6] , In addition, Biodiversity Indices are used to describe and study the components of any community living in the aquatic environment, which are characterized by their ease and the reveal of effective environmental factors. The most common evidence for measuring biodiversity is the Shannon-Weiner Index, the number of species in the sample and the distribution of individuals among these species .Another widely used indicator of biodiversity is the Species Richness Index, which refers to the absolute number of units in a biosphere within water surface. The Species Uniformity Index shows how to representation each species in the sample, and does it contain many common species with rare species or all species are represented equally, and the value of equivalence is linked to the extent of diversity and obtains its highest value if there is no sovereignty [7,8].

## 2. Materials and Methods

### 2.1. Description of the Study Site and Sampling Program

Tigris River is the main source of water in Baghdad. The River divides the city into a right (Karkh) and left (Risafa) sections with a flow direction from north to south. The area is characterized by arid to semi-arid climate with dry, hot summers and cold winters .four sites were chosen for sample collection in the study area from October 2016 to July 2017 along the Tigris River from as it is described in Table 1.

**Table 1. Description of water quality sampling sites**

| Station No. | Description | Longitude | Latitude |
|---|---|---|---|
| S1 | Near al Kharakh hospital | 44º 22' 24.48" | 33º 21' 13.39" |
| S2 | Near the medical city | 44º 22' 40.81 | 33º 20' 19.98" |
| S3 | After the Sarafia bridge | 44º 22' 21.00 | 33º 21' 10.64 |
| S4 | In the north east of Baghdad city | 44º 20' 14.17" | 33º 24' 14.25" |

## 2.2. Zooplankton Analysis

For zooplankton quantitative analysis 60 liters were taken from surface water at each sampling site by filtering through a zooplankton net of 55 µm mesh diameter. Collected samples were kept in plastic bottles with the site water to which 4% formalin was added as a preservative. Samples were studied under the compound microscope and specimens identified at the species level. Zooplankton numbers were expressed as number of organisms per $m^3$.

## 2.3. Biodiversity Indices

To estimate changes in biodiversity of studied zooplankton, we used:

### 2.3.1. Shannon-Wiener Index (H)

$$H = -\sum \frac{ni}{N} \, Ln \frac{ni}{N}$$

Where: (ni) are the number and biomass of one species, and (N) are the total number of individuals of all species [9].

### 2.3.2. Species Richness Index (D)

$$D = (S-1) / \text{Log } N$$

Where: (S) represent the number of species, and( N) are the total number of individuals of all species [10].

### 2.3.3. The Species Uniformity Index (E)

$$E = H / LnS$$

Where: H represents the Shannon-Wiener index values, and S the number of species[11].

# 3. Results and Discussion

## 3.1. Quantitative Study

The densities of zooplankton in the study stations showed that S3 recorded the highest density between stations and it was in January and estimated at 10417 Ind / $m^3$ for the year 2017, while recorded less density in S1 and estimated by 11 people / $m^3$ in the month of January of 2017. On the other hand, the highest total number of zooplankton was recorded in the duration of the study in S3 and the registered number was 25036.9 ind /$m^3$ Figure 1. This may be attributed to the high density of *keratella quadrata long spin*, which amounted to 8933.6 Ind / $m^3$ in this station, as well as the fact that this station is rich in nutrients [12], while the lowest total number of zooplankton in the study period was recorded in S1 and reached 16125 ind / $m^3$, It may be due to the fact that the water of this station is exposed to human pollution and also the water transparency is few in this station because of the presence of algae that cover the surface of the water, which reduces the access of lighting to it ,also to the boats movement in this station, which is a factor working to reduce the presence of zooplanktons that prefer quiet environments [13].

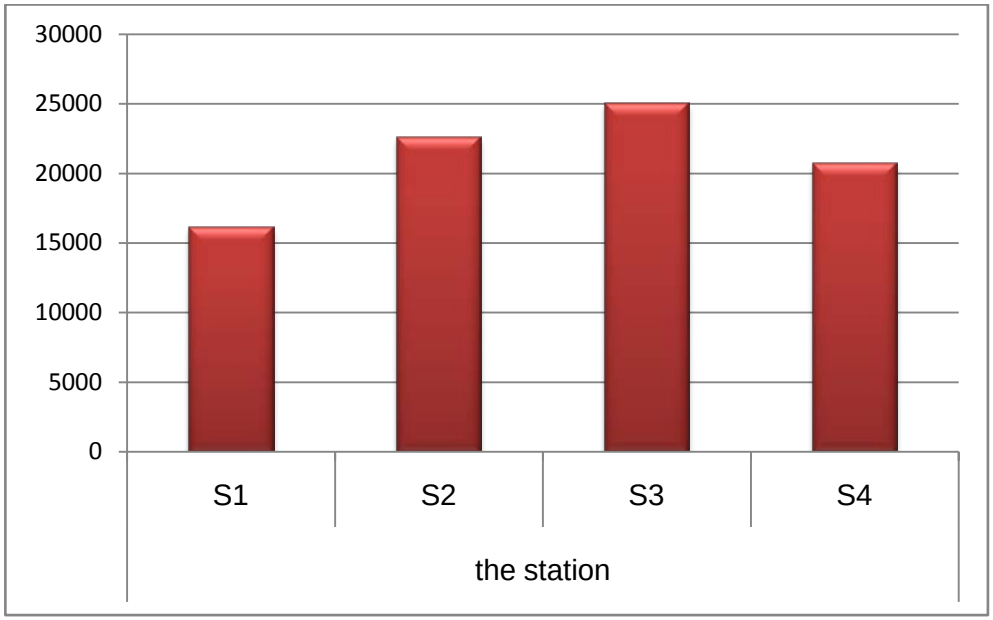


**Figure 1.** The Total number of zooplankton (individual / $m^3$) recorded in the study stations during the period from October 2016 to July 2017.

The seasonal changes showed that most of the increases in the total density of zooplankton were during the winter and spring months, which may have been associated with temperature change. There was a negative correlation between the total density of zooplankton and water temperature in the collection study stations, also Zooplankton requires sufficient time to adapt to changing temperatures in aquatic environments. the study recorded decline in the number of zooplankton in the summer and this may be attributed to the predation by fish with its larval and adults stages and also to predators of other invertebrates, as well as to the water turbidity due to the high proportion of solid materials suspended, which reduce the permeability of light and affect the presence of zooplanktons in the surface of water [14,15].

The current study recorded the dominance of the group of Rotifer with 84.9% of the total density of zooplankton at S1, 86.04% at S2, 88.79% at S3 and 82.96% S4, The results in this study indicated that Rotifer was the dominant group in all study sites Table 2.

**Table 2. Percentages of zooplanktons group at study stations in the study period from October 2016 to July 2017**

| Groups | The station | | | | LSD |
|---|---|---|---|---|---|
| | S1 | S2 | S3 | S4 | |
| Rotifer | 84.9 | 86.04 | 88.79 | 82.96 | 9.52 NS |
| Cladocera | 2.38 | 1.48 | 2.07 | 2.011 | 1.07 NS |
| Copepod | 12.7 | 12.47 | 9.13 | 15.03 | 7.41 NS |
| LSD | 8.61 * | 9.39 * | 9.55 * | 9.72 * | --- |
| *P<0.05 ،(NS) | | | | | |

The reason for the dominance of Rotifers over the rest of the zooplankton groups is due to their rapid reproduction, small size and short life cycles, and their tolerance to a wide range of environmental factors [16].

The third station was characterized by the highest intensity of the rotifer of the studied stations, with a total monthly densities of 22232.4 person/$m^3$ Figure 2, and this due to the nature of physical and chemical factors of water in S3 that clearly affect the abundance of species and population density. The results showed that there were no significant differences in locational changes of the density of the registered species of Rotifers during the study period, The monthly changes showed that the highest density of Rotifers was in January during the winter season and this increase due to the negative correlation between temperature and rotifer density, also Most of the increases in density of rotifers in this study coincided with a decrease in the number of other registered zooplankton groups (which may have helped to reduce predatory pressure and led to increased numbers of rotifers) [17], while The decrease in their numbers during the summer season is due to high temperatures and low oxygen values [18].

It is clear from Figure 3 that S3 recording the Highest Density for cladocera and it was estimated at 184 persons/$m^3$ in January of 2017 and It was observed that the density of the cladocera was small in the study stations and did not exceed 2% of the total number of the zooplankton and this ratio may be due to the fact that this group prefers plants with aqueous environments that provide an environment suitable for the living of members of cladocera [19]. In addition, that the collection of samples in this study was in areas far from the banks of the river and a have few vegetation and the large size of cladoceran species compared to other groups make them more vulnerable to prey than other zooplankton groups, and also because the cladocera produce static eggs under not suitable conditions [20], and this what we collect during the time of collection due to it daily migration in water column. The study recorded the highest values of cladocera in the winter because they are increased in water with high ratios of dissolved oxygen, and the study recorded increase in DO values during the winter season, with a maximum value of 10.25 mg / l.

The lowest numbers of cladocera density were recorded in the summer because their numbers decreased as the temperature increased as it was negatively correlated with temperature, This decrease was also accompanied by an increase in the number of copepod group and This was statistically significant in this study, due to the negative correlation between them and the copepoda which consider a good food for a group of copepod [21].

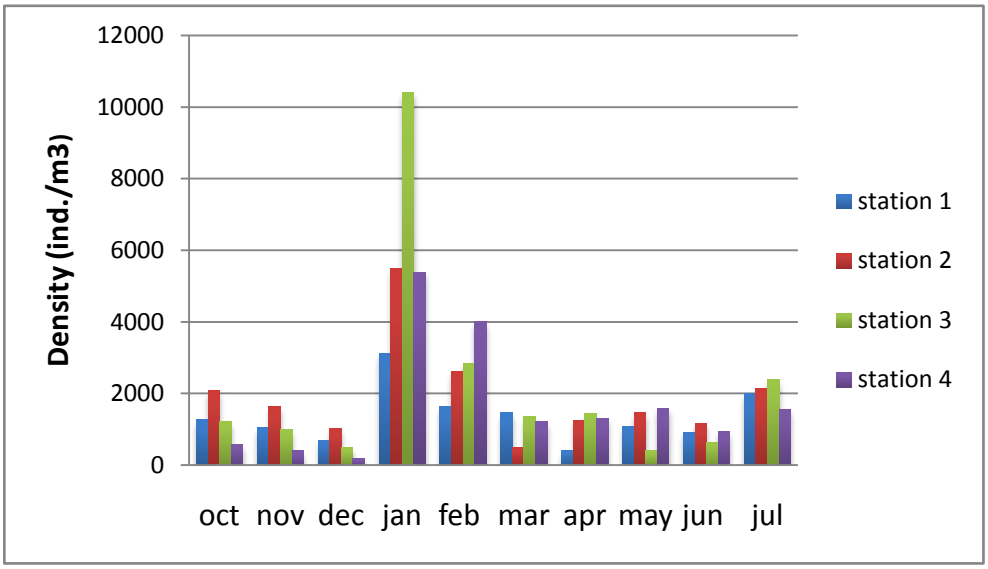


**Figure 2.** Effect of stations and months in the densities of rotifers during the period from October 2016 until July 2017

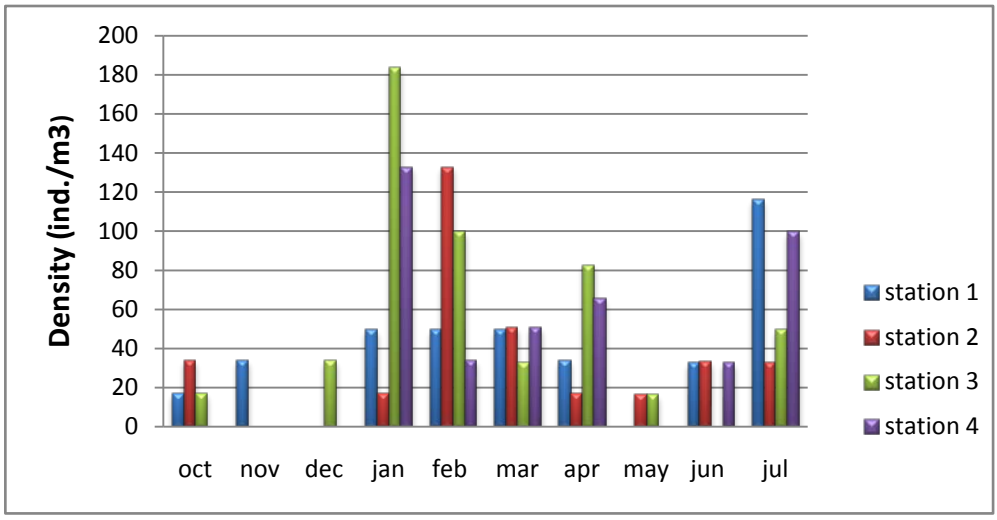


**Figure 3.** Effect of stations and months in the densities of cladocera during the period from October 2016 until July 2017

While the study recorded a total number of copepoda in S1 estimated at 2045.5 Ind / $m^3$ and at S2 estimated at 2817.9 Ind / $m^3$, at S (3) 2286.9 Ind / $m^3$ and at station (4) 3115.9 Ind / $m^3$. S4 recorded the highest density of 884 persons / $m^3$ in the summer in April, while it was less dense, which is zero in S2 and S4 during the fall and winter seasons in (December, October, and November). The highest densities of copepoda were recorded at S4 Figure 4, which may be accompanied by the availability of high numbers of Rotifers as food for, where the density of the rotifer in this region is 17203.3 Ind/$m^3$. The study recorded the dominance of Napuli of copepoda because it can adjust itself to various environmental conditions such as high or low temperature or lack of nutrients and predation and it stages tend to hibernate [22]. The study recorded The low densities in winter and some autumn months and this due to to the low density of phytoplankton, as well as the fall of rain, which reduces nutrient by dilution and transport contaminants to the water that cause change in water properties (physical and chemical) also. The relative abundance of this group is affected with Predation by fish, while the high summer rates may return to the abundance of phytoplankton that Flourish in the spring, which is the main food for this group. In addition, copepoda grow and develop better in warmer periods of the year [23].

## 3.2. Biodiversity Indices

The current study recorded values of Species Richness Index (D) at S1 ranging from the highest values of 8.103 in July to the lowest values of 4.426 in March and in S2 ranged from its highest value of 9.15 in July to its lowest value of 4.17 in March while it was ranged in S3 between the highest value of 7.673 in July to the lowest value of 3.641 in June, while the values of this index in S4 was ranged between the highest value of 7.888 in April and the lowest value of 3.083 in November and December (Table 3), The results of the present study recording high values of the species richness index(D) in some spring months and some of the autumn and summer months. This may be due to the availability of nutrients and the increase of the initial productivity of phytoplankton and this lead to the increase of the zooplankton, and thus providing a suitable environment to increase the index of species richness, and This prove The existence of a positive relationship between the abundance of species and physical and chemical determinants [24]. The high values of the index Indicates that water is rich in nutrients and indicates the stability of physical and chemical factors [25].

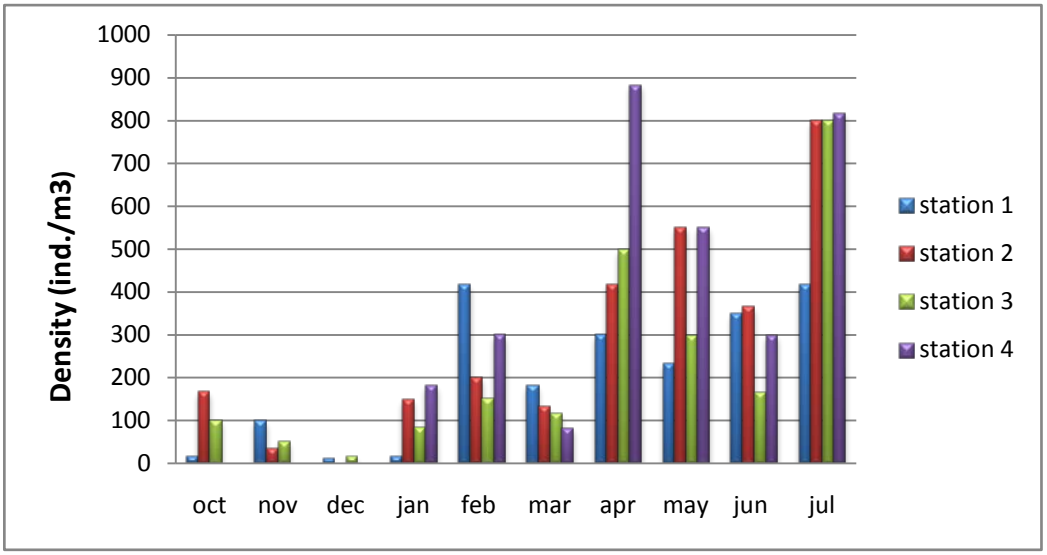


**Figure 4.** Effect of stations and months in the densities of copepoda during the period from October 2016 until July 2017

**Table 3. Effect of the station and months in the values of Species Richness Index(D) in the study stations during the period from October 2016 to July 2017**

| months | The station | | | | LSD |
|---|---|---|---|---|---|
| | S1 | S2 | S3 | S4 | |
| Oct | 6.419 | 7.455 | 7.017 | 3.641 | 2.46* |
| Nov | 6.793 | 7.888 | 6.568 | 3.083 | 2.51 * |
| Dec | 5.409 | 6.793 | 5.647 | 3.083 | 2.09 * |
| Jan | 4.926 | 7.017 | 7.237 | 4.673 | 1.96 * |
| Fe | 6.793 | 6.114 | 7.673 | 7.237 | 1.55 NS |
| Mar | 4.426 | 4.17 | 4.426 | 4.426 | 1.25 NS |
| Apr | 4.926 | 6.341 | 6.341 | 7.888 | 1.82 * |
| May | 5.882 | 4.926 | 5.882 | 6.568 | 1.37 * |
| Jun | 5.647 | 5.882 | 3.641 | 6.568 | 2.06 * |
| Jul | 8.103 | 9.15 | 7.673 | 6.405 | 1.86 * |
| LSD | 2.36 * | 2.95 * | 2.41 * | 2.07 * | --- |
| P<0.05 ،(NS) | | | | | |

Table 4 show the values of the Shannon-Weiner diversity index(H) in the Tigris river stations : S1 recorded the highest value for the diversity of 2,697 bits / person in November 2016 and The lowest values for the index were 1.40 bits/person in March, The S2 recorded 2.716 bits/person for diversity in November 2016 and the lowest value was 1,662 bits / person In January, the S3 recorded the highest value of 2.685 bits / person in December and the lowest value for diversity is 1.13 bits / person in June. When the S4 recorded the highest value for diversity, which is 2.625 bits / person in April and the lowest values for diversity is 1.525 in the month of March 2017. The value of the index in the study area ranged between the lowest value of 1.13 bits / person in the third station and the highest value of 2.716 bits / person in the second station. According to the values of the Index in the current study, the river has a high diversity and for all the stations, the values is more than 1 bit / individual. The study considered the Tigris River in the study area is (moderate organic pollution) depending on the values of the index [26]: -

More than 3 bits / individual = clean water

1- 3 bit / individual = Moderate Pollution Moderately polluted

Less than 1 bit / individual = Heavy pollution heavily polluted.

The values of the index were the highest in S2 and this may be due to the availability of certain environmental conditions such as high dissolved oxygen concentrations and abundance of phytoplankton as a result of nutrient enrichment through the effluent sewage that increased the nutrients from Medical city Hospital and the reduction of some important factors such as turbidity that lead to the increase in the diversity of rotifera, which form the highest percentage of zooplankton in all study stations [27].

The study recorded the height values of the index in summer and autumn, which may be due to the phytoplankton blooming and high temperatures degrees which reached in the current study to 31°C which favored by the smallest rotifers because it causing the increase in the process of molting and increase in breathing more than digestion [28]. The low diversity in the cold months is due to the low temperature, which reached 11.95°C in the present study.

**Table 4 . Effect of the station and months in the values of the Shannon-Weiner diversity index (H) in the study stations during the period from October 2016 to July 2017**

| months | The station | | | | LSD |
|---|---|---|---|---|---|
| | S1 | S2 | S3 | S4 | |
| Oct | 2.604 | 2.597 | 2.611 | 1.779 | 0.643 * |
| Nov | 2.697 | 2.716 | 2.665 | 1.733 | 0.755 * |
| Dec | 2.449 | 2.708 | 2.685 | 1.772 | 0.702 * |
| Jan | 1.552 | 1.662 | 1.381 | 1.593 | 0.563 NS |
| Fe | 2.09 | 2.041 | 2.03 | 2.033 | 0.415 NS |
| Mar | 1.40 | 1.831 | 1.447 | 1.525 | 0.498 NS |
| Apr | 2.127 | 2.367 | 2.392 | 2.625 | 0.588 NS |
| May | 2.143 | 1.803 | 2.416 | 2.148 | 0.602 NS |
| Jun | 2.415 | 2.066 | 1.13 | 2.335 | 0.751 * |
| Jul | 2.539 | 2.605 | 2.64 | 2.493 | 0.447 NS |
| LSD | 0.773 * | 0.831 * | 0.724 * | 0.721 * | --- |
| *P<0.05 ،(NS). | | | | | |

**Table 5. Effect of the station and months in the values of Species Uniformity Index (E) in the study stations during the period from October 2016 to July 2017**

| months | The station | | | | LSD |
|---|---|---|---|---|---|
| | S1 | S2 | S3 | S4 | |
| Oct | 0.855 | 0.807 | 0.833 | 0.81 | 0.261 NS |
| Nov | 0.872 | 0.824 | 0.875 | 0.891 | 0.207 NS |
| Dec | 0.883 | 0.876 | 0.948 | 0.911 | 0.244 NS |
| Jan | 0.588 | 0.53 | 0.435 | 0.489 | 0.261 NS |
| Fe | 0.676 | 0.693 | 0.623 | 0.64 | 0.195 NS |
| Mar | 0.563 | 0.763 | 0.582 | 0.614 | 0.278 NS |
| Apr | 0.806 | 0.79 | 0.798 | 0.796 | 0.186 NS |
| May | 0.741 | 0.683 | 0.836 | 0.705 | 0.216 NS |
| Jun | 0.853 | 0.715 | 0.514 | 0.767 | 0.244 * |
| Jul | 0.762 | 0.745 | 0.81 | 0.832 | 0.261 NS |
| LSD | 0.206 * | 0.218 * | 0.251 * | 0.225 * | --- |
| *P<0.05 ،(NS) | | | | | |

Species Uniformity Index (E) refers to the pattern of distribution among species [29], the study recorded the highest values the index in S1 during the month of December is 0.883 of the year 2016, while the lowest value of the index is 0.563 during the month of March 2017, while for the S2 ranged between 0.876 in December and 0.53 during the month of December The third station recorded the highest value of the index of 0.948 during the month of December and the lowest value of 0.435 during the month of January, the value of the index in the fourth station ranged between 0.911 in December of 2016 and 0.489 in January of 2017 Table 5. The recording of high values of the index shows that there is no environmental pressure, and this leads to stability of the zooplankton species in Tigris River. The values in this study were close to 1 and exceeded 0.5 in most months of study. The recording of low of values for the index during the winter may be due to the high water level in this season due to high rainfall with high nitrate During the winter and spring which explains The low homogeneity of species due to the increase in the organic content of water to the degree of abundance of food Eutrophication, which allows the sovereignty of a few species and high densities [30].

## 4. Conclusions

1. The sovereignty of rotifer group in the community of zooplankton in Tigris River.

2. The study showed the great effect of the city of Baghdad on the quality of the water of the Tigris River where the study showed the effect of existing restaurants and hospitals in the quality of water.

3. The species richness index (D) indicated that the group of rotifera recorded agood abundance in the study stations and followed by the copepoda, which contained a numerical abundance exceeded its types and the least is cladocera group which recorded a low number of species and density. The Species Uniformity Index (E) has shown a high recording in this study, that indicating the absence of environmental pressure.

4. According to the values of of the Shannon-Weiner diversity index (H) in the current study, the river has a high diversity and for all the stations. The study considered the Tigris River in the study area is (moderate organic pollution).

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