

## Environmental Assessment of Copepod Biodiversity Community – A Case Study of Hilla River in Iraq

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### ABSTRACT

This investigation of the biodiversity of copepods was carried out in the Hilla River. From January 2021 to December 2021, monthly samples of water and copepods were taken at three different locations in the river for this investigation. Water's temperature, turbidity, pH, salinity, dissolved oxygen, biological oxygen demand, total hardness, nitrate, and phosphate are some of the physical and chemical characteristics taken into account. A study was undertaken using biological indicators such the Shanon-Weiner index, Species Uniformity Index, and Species Richness Index. There were 24 copepod taxonomic units found. Copepoda had a maximum density of 1453 ind/m<sup>3</sup> in April and a lowest density of 80 ind/m<sup>3</sup> in February. The statistical study's findings revealed a statistically significant positive association between density, all of pH, BOD<sub>5</sub>, Nitrate, and Phosphate, as well as a statistically significant negative correlation with each of dissolved oxygen and total hardness. The Shanon-Weiner index recorded its greatest value in May, 3.33 bits/ind, and its lowest value in December, 0.08 bits/ind. The greatest value of the Species Uniformity Index (E) was 0.99 in March, while the lowest values of 0.1 were reported in July. Species homogeneity index and each of Turbidity have a substantial negative association and a strong positive connection, respectively. The Species Richness Index reached its greatest point in April (6.13), while it reached its lowest point in January (1.46). According to the statistical study, there is a strong positive association between Index values and a strong negative correlation with overall hardness.

**Keywords:** copepod, Hilla River, biodiversity.

### INTRODUCTION

While some, like Rabie (2008), define biodiversity as the total number of species present in the community and the relative density of these species in their studied environments, Sharma et al. define biodiversity as the variability in all life forms—from species to genera to the ecosystems in which they live—is more widely accepted. The abundance of species in freshwater ecosystems is comparatively higher than that in marine and terrestrial ecosystems, indicating that it is an important part of the Earth (Allen et al., 2011). Additionally, freshwater ecosystems are among the most threatened or endangered ecosystems on the planet. The exposure of these habitats to pollutants results in the direct killing of aquatic creatures or reduces

the environment necessary for development and reproduction, placing pollution at the top of the list of significant issues that endanger biodiversity in freshwater (Sterner, 2002). Because diversity in the community is strongly correlated with the type and nature of vital relationships with various environmental factors, it became the primary goal to observe the organisms in the living communities that live in direct contact with water and study the composition of their communities and their biological diversity. Conserving biodiversity and sustaining and maintaining ecological processes that depend on this diversity are both essential components of managing any ecosystem (Smith, 1999). More than 7,500 species of tiny crustaceans belong to the Copepod class. They have elongated, split bodies that are covered in exoskeletons. In general,

they are omnivorous and exist in a nutritional niche between plankton, big and small carnivores, and bacteria, algae, and protozoa (Cheng et al., 2001). The copepod, on the other hand, has distinct sexes and the great majority of them reproduce sexually (Srivastava, 2013). Fertilized eggs develop into larvae known as Nanpluis stage, which goes through six larval stages before transitioning into the last six stages, known as the Copepodia stage, which are the adult animals. Copepods are one of the most significant groups of invertebrates used as evidence in the biological monitoring of the aquatic ecosystem to detect and identify changes in water quality caused by pollution or eutrophication (Hassan, 2008). This is because of their morphological, functional, and genetic characteristics, the most significant of which is their close relationship to environmental factors and their rapid response to changes in environmental quality (Mukhopa) (Jones and Kaly, 1996). The goal of this research was to classify and assess environmentally the copepod biodiversity in the Hilla River.

## MATERIALS AND METHODS

### Area of study and sampling

At the Hindiya Dam, the Euphrates River splits off into the Hilla River. The river is considered the primary supply of water for the Babylon Governorate's drinking, agricultural, and industrial needs. It is around 97 kilometers long. Uses (Abdullah et al., 2020 and Abdullah et al., 2020). Three locations were chosen to collect study samples from the waters of the Hilla River, as shown in Figure 1. The Hilla River is exposed to many pollutants through passes of many villages and cities, the most significant of which is the city of offal- Hilla, the capital of the Babylon Governorate. These pollutants include pesticides, agricultural fertilizers, numerous chemicals used in the field of agriculture, medical waste, and domestic sewage in the center of the Hilla city. After the Al-Hindiya Dam, Site 1 was situated on the Hilla River. The flora on this location has increased, notably *Typha domingensis* and *Fragmite australis*, as well as submersible plants like *Ceratophyllum demersum* and *Potamogeton pectinatus*. Site 2 is situated beside the river as it flows through the heart of Hilla. The river is distinguished by its lack of

vegetative cover, its small length, and its exposure to several contaminants brought on by human and industrial activity. At the tip of the governorate of Babylon, before the river enters the governorate of AL-Qadisiyah, is where Site 3 is situated on the river. The expansion of submersible aquatic plants like *C. demersum*, *P. pectinatus*, and *Lemna Minor* along with the enlargement of the river section describe this region as being active in agriculture. For a full year, from January to December 2021, research samples were gathered on a monthly basis. The method outlined by (APHA, 2003) was used to measure the physical and chemical parameters. The samples were concentrated to 10 ml and stored in special bottles after being treated with formalin at a concentration of 4% using a special chip (Sedwerk Rafter Champer Holds a volume of 1 ml of sample Concentrated to 10 ml for the purpose of diagnosing the copepods). The samples were collected monthly for each site with an amount of 40 liters of water and passed through a network type (Hydro-Bios with diameter 55 microns).

### Statistical analysis

#### Calculation of Shanon-Weiner diversity index ( $H$ )

The values for this index were determined each month using the methodology detailed in (Floder and Sommer, 1999).

$$H = -\sum \frac{ni}{N} \ln \frac{ni}{N} \quad (1)$$

where:  $ni$  – number of individuals of one species in the station;

$N$  – the total number of individuals at the same station.

#### Calculation of species uniformity index ( $E$ )

For the zooplankton groups included in the research, the values of this index were determined monthly using the method outlined in (Neves et al, 2003).

$$E = H/\ln S \quad (2)$$

where:  $\ln S$  – equal to the largest theoretical value for diversity ( $H_{max}$ );

$H$  – value of Shannon-Wiener criterion;

$S$  – number of species in the station.

Values greater than 0.5 were considered equivalent or homogeneous in their appearance (Porto-Neto, 2003).

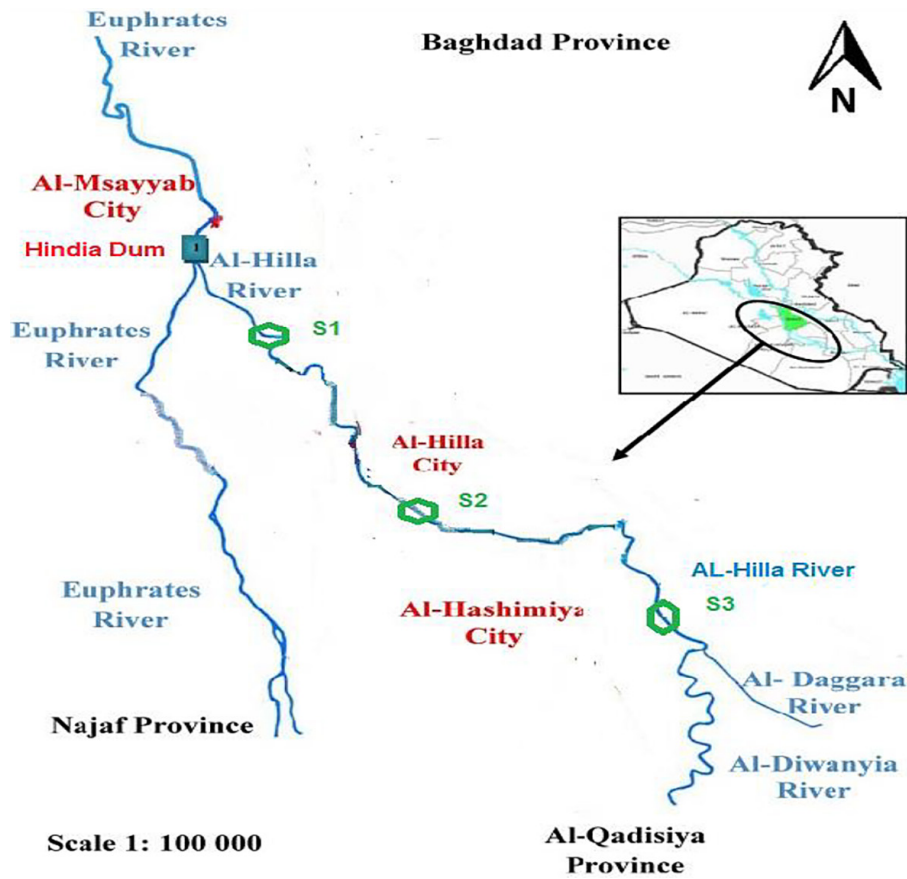


Figure 1. Study area

Table 1. Physical and chemical characteristics of Hilla River

Characteristics	Site 1	Site 2	Site 3
Water temperature, T	33–9 19.65±7.54 A	32–10 22.156±7.97 A	35–12 25.136±7.88 A
Turbidity, NTU	21.65–2.1 10.507±6.52 A	56.77–3.95 18.896±14.94 B	45.78–1.99 14.211±11.98 B
pH	7.7–7.2 7.545±0.33 A	8.8–7.4 8.175±0.37 A	8.5–7.7 7.85±0.34 A
Salinity, ppt	0.55–0.77 0.651±0.07 A	0.56–0.78 0.722±0.14 AB	0.71–1 0.788±0.14 AB
Dissolved oxygen, mg/L	13.12–7.1 9.55±2.11 A	11.9–5.9 8.55±1.96 A	12.6–6.3 8.33±1.91 A
BOD <sub>5</sub> , mg/L	3.9–0.8 1.68±0.95 A	6.9–1.9 3.16±1.24 B	5.3–1.8 3.44±0.88 B
Total hardness, mg/L	233.17–466.7 366.02±57.66 A	384.6–488 386.66±42.29 B	319.1–593.3 436.31±72.11 B
Nitrates, µg/L	25.11–4.23 11.88±7.61 A	4.22–30.55 14.33±9.58 A	4.61–38.44 15.33±11.46 A
Phosphate, µg/L	0.17–1.37 0.561±0.422 A	0.19–2.66 0.822±0.766 A	0.18–2.99 0.998±1.102 A

Note: \*Similar letters mean there are no significant differences.

Calculation of species richness index (D)

The formula provided in (Sklar, 1985) was used to derive the values of this index on a monthly basis.

$$D = \frac{(S - 1)}{\log N} \tag{3}$$

where: S – number of species;  
N – total number of people.

RESULTS AND DISCUSSION

Physical and chemical appearances

The physical and chemical properties of the water in the Hilla River are shown in Table 1. The range and (standard deviation average) are the first and second indicators in Table 1, respectively. The water temperature in Site 3 reached a maximum of 35 °C in August and a minimum of 11 m in February (2). The turbidity readings at Site 2 in January were 56.77 NTU and Site 3 in July were 1.99 NTU, respectively (2). Site 2 had a pH value of 8.8 in April, while site 1 had a pH value of 7.2 in February (Table 2). The salinity levels varied from the lowest value of 0.55 at site 1 in March to the highest value of 1ppt at site 3 in August (2). The dissolved oxygen varied from a maximum of 13.12 mg/L at site 1 in April to a minimum of 5.95 mg/L in site 2 in August. At Site 2, the (BOD5) value peaked at 6.9 mg/L in July, whereas at Site 1, the value peaked at 0.8 mg/L in February.

The total hardness values ranged from 233.17 mg/L at Site 1 in August to a maximum value of 593.3 mg/L at Site 3 in January. The greatest

concentration of nitrate was found at Site 3 in March, while the lowest concentration was found at Site 1 in May. The phosphorus varied from a maximum of 2.99 g/L in Site 3 in January to a

Table 2. The taxonomic units recorded of copepod in the Hilla River

No.	Taxa	Site 1	Site 2	Site 3
1	<i>Diaptomus alaskaensis</i>	+	-	-
2	<i>Diaptomus gracilis</i>	+	-	+
3	<i>Cyclops gigas</i>	-	-	-
4	<i>C. viridis</i>	-	+	-
5	<i>Cyclops vicinus</i>	+	-	-
6	<i>Ectocyclops sp.</i>	+	+	+
7	<i>Eucyclops. agalis</i>	+	+	+
8	<i>E. speratus</i>	+	+	+
9	<i>Eucyclops sp</i>	-	-	+
10	<i>Haliocyclops sp</i>	+	-	-
11	<i>Marocyclops ater</i>	+	-	+
12	<i>M. fuscus</i>	-	-	+
13	<i>M. hylanus</i>	+	+	-
14	<i>Mesocyclops sp .</i>	-	-	-
15	<i>Paracyclops affinis</i>	+	+	+
16	<i>P. Fimbriatus</i>	+	+	+
17	<i>P. Fimbriatus poppei</i>	+	-	-
18	<i>Tropocyclops prasinus</i>	+	+	+
19	<i>Paradactylopodia brevicornis</i>	+	-	-
20	<i>Nitocra cacustrus</i>	+	+	+
21	<i>Onychocamptus mohammed</i>	+	-	-
22	<i>Ergasilus sp</i>	+	-	+
23	<i>Lernaea</i>	+	-	-
24	<i>Nauplii of Copepoda</i>	+	-	-

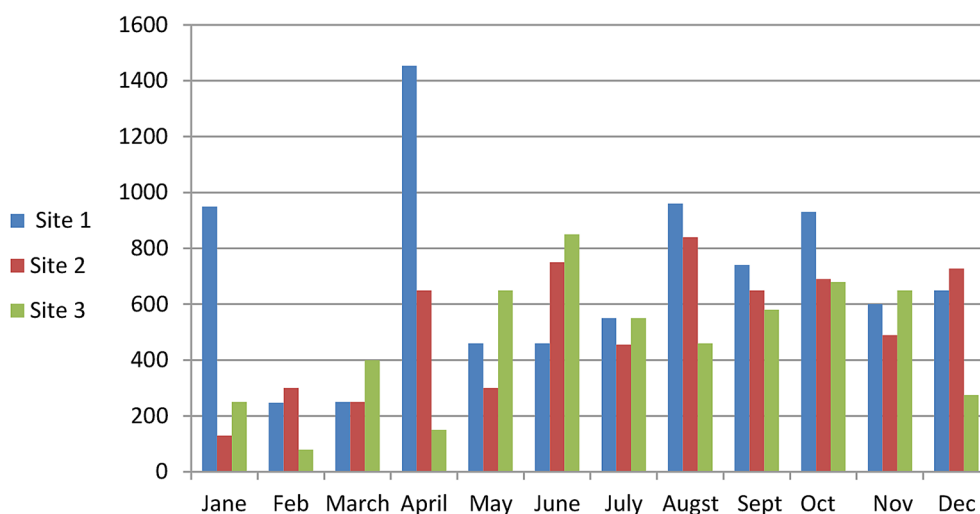


Figure 2. Monthly changes of the total densities of the copepod

minimum of 0.17 g/L in Site 1 in May. In the current study, the copepod density varied between Site 1's greatest value of 1453 ind/m<sup>3</sup> in April and Site 3's minimum value of 80 ind/m<sup>3</sup> in February. The statistical analysis revealed significant differences between the sites ( $p < 0.05$ ), as well as a significant positive correlation between density and pH, BOD<sub>5</sub>, nitrate, and phosphate at  $p < 0.05$  ( $r = 0.668$ ,  $r = 0.655$ ,  $r = 0.585$ ,  $r = 0.555$ ), and a significant negative correlation with dissolved oxygen and total hardness ( $r = -0.645$  and  $r = -0.775$ ), respectively.

According to numerous local and international studies, the copepod can adapt to a variety of environmental conditions, including high or low temperatures, a lack of nutrients, and predation. Copepodid stages and adults also tend to hibernate, which accounts for their periodic disappearance, and their numbers are influenced by the concentrations of salts and organic matter in the water (Al Douri, 2009 and Claps et al., 2004). As a result, the loss of these species in aquatic habitats is strong indication that the plants there are receiving excessive quantities of nutrients (Schmoltdt and Anderson, 2001). Due to the fact that their density is influenced by the water temperature and the availability of food, the high densities of copepods observed in the current study during the month of April may be the cause (Kulkarni and Surwase, 2013). Copepod growth and development are positively correlated with temperature, suggesting that warm climates are best for their growth and development (Winkler, 2002). The study's findings concur with those of Al-Lami and Abbas (2001), Al-Namrawi (2005), and Ibrahim (2005), all of

which demonstrated that an increase in suitable nutrients and the absence of predators from vertebrates and aquatic invertebrates, where they select for certain sizes, are related to an increase in copepod density in the spring (Mangalo and Akber, 1988). The lowest copepoda populations in winter may be a result of rain, increased river drainage, and an increase in turbidity, which results in a decline in phytoplankton abundance. According to Watezel (2001), inorganic turbidity and fish predation have an impact on the relative abundance of copepods, whereas Hashemzadeh and Venkataramana (2012) believed that rainfall, high river discharge, and a low abundance of phytoplankton caused by increased turbidity are the key factors influencing the presence and distribution of copepods. According to Hvel and Rhods (2001), Site 1 had the largest numerical abundance of copepods, which may be related to the amount of algae, the primary food source for this group. Site 3 had the lowest values. According to Jafari et al. (2011), the decrease in copepods in the Haraz River in Iran is caused by an increase in turbidity that kills juvenile copepods and inhibits their growth by reducing the amount of food accessible to them, which promotes the growth of rotifers and their domination in the river. According to Neves et al. (2003), the larval stages of the copepod account for a large portion of their density. In the copepod community, the dominance of small forms, especially (Nuaplilii), is caused by the copepod's ongoing multiplication and lack of invertebrate predation (Edmonson, 1959), and the predation of cladocera copepods provides food for copepod larvae in the form of algae (Sabri et al., 1989).

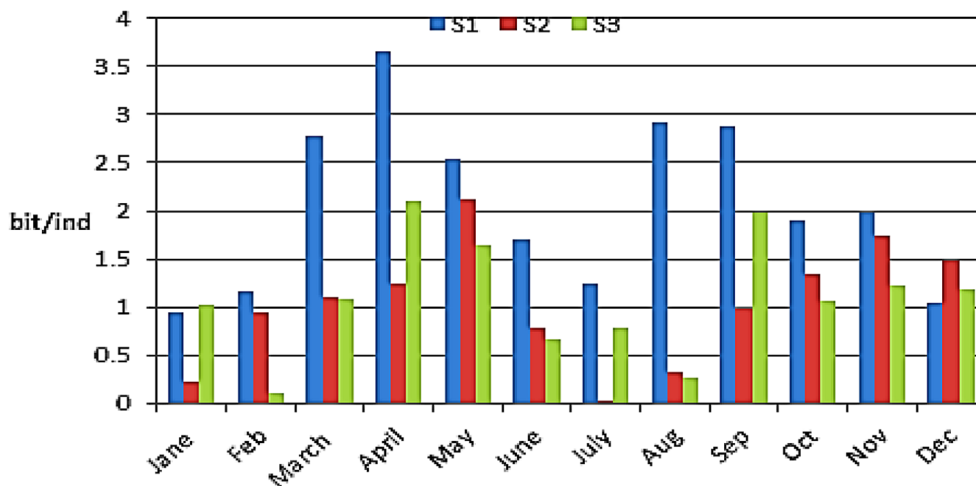


Figure 3. Monthly changes of the Shannon-Weiner Index of the copepoda

### Shanon-Weiner diversity index (H)

Site 1 reported a maximum Shannon Wiener Index value of 3.33 bits/ind in May, whereas site 2 recorded a minimum value of 0.08 bits/ind in December (Figure 3) The statistical analysis found that there were significant differences between the sites ( $p < 0.05$ ), as well as a significant positive correlation between the Shanon-Weiner Index and all of the water temperature, pH, and DO at  $p < 0.05$  ( $r = 0.768$ ,  $r = 0.755$ , and  $r = 0.768$ , respectively), and a significant negative correlation with each of the total hardness ( $r = -0.64$ ).

The high Shannon-Wiener Index values in the spring and fall are caused by their high densities, which may be primarily caused by an increase in transparency, dissolved oxygen content in the water, and phytoplankton density, which serves as a food source (Jose and Sanalkumar, 2012). Regarding the low values in summer and winter, they are caused by a variety of factors, such as an increase in turbidity and suspended particles (Neves et al., 2003), a dearth of aquatic plants, or a low concentration of dissolved oxygen, which has an impact on the richness and abundance of species (Shah and Pandit, 2013). Regarding the local alterations, site 1 reported high Shannon-Wiener Diversity Index values, which may be attributable to the presence of suitable environmental factors such a wealth of food and a high oxygen content. Site 2 recorded the lowest Shannon-Wiener index value, which may be related to the site's location in the city center of Hilla, where it receives a lot of pollutants, which results in a decline in some crucial elements like

transparency, dissolved oxygen, and pH, in addition to the absence of vegetation cover (Kumar, 2001). The Shannon-Wiener Diversity Index values for sites 2, 3, which were recorded at very low levels in the months of July and February, almost indicate a lack of biodiversity in those two sites during those two months. This is a sign of how serious organic pollution is and how it affects the presence of these organisms in those two regions, which works to reduce biodiversity (Al-Jizani, 2005). The hilla River has a significant degree of variety, as evidenced by the Shannon's index values in the current research, which surpassed 1 bit/ind. Given the following values of this evidence, the hilla River water in the research region and throughout the study period may be regarded as having mild organic contamination. More than 3 bits/ ind can considered clean water, Moderately polluted (1-3) bits/ind and Less than 1 bit/ ind will be Heavily polluted (Goel, 2008).

### Species uniformity index (E)

The Site 1 recorded the highest value of the Species uniformity index in March, was 0.99, while the lowest values of 0.1 were recorded during July in site 2. Figure (4) The results of the statistical analysis recorded significant differences between the sites ( $p \leq 0.05$ ) as well as a significant positive correlation between Species uniformity index and,all of DO, Nitrate and Phosphate at  $p \leq 0.05$  ( $r = 0.678$ ,  $r = 0.666$ ,  $r = 0.575$ ) respectively and a significant negative correlation with each of Turbidity, and total hardness ( $r = -0.545$   $r = -0.575$ ) respectively.

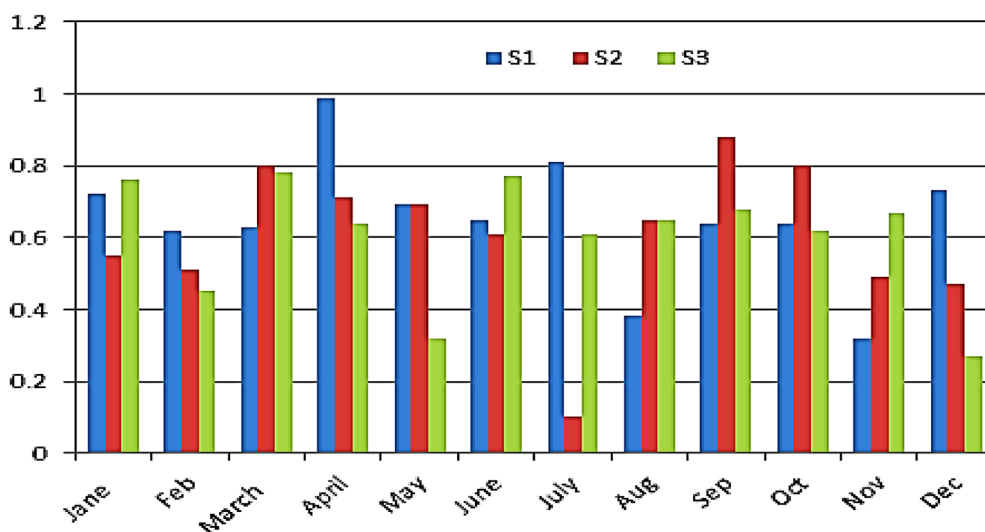


Figure 4. Monthly changes of the Species uniformity index of the copepod

The Species Uniformity Index (E) measures how individuals are distributed throughout species, and the closer individuals are to one another in terms of density, the closer the index value is to 1. (Ricotta and Avena, 2002). The high values of this index in the study sites show that the species were homogeneous in their appearance because there was no environmental stress or pressure, which creates a suitable environment for the stability of the copepoda community and allows greater dominance of the species. This is what happened at site 1 because the values exceeded 0.5 throughout the study period, and the species is therefore considered homogeneous in their appearance. While the low values of this index show the dominance of a few species at high densities, which is proof of environmental pressure, this is consistent with what was stated by (Green, 1993) that the low Species uniformity index shows the presence of pressure that prevents the dominance of many species, which is what happened in stations 2 and 3, where the decrease in this index due to the rise in the organic content and the decline in the deposition of inorganic matter occurred.

### Species richness index (D)

Site 1 had the greatest value of the Species Richness Index in April (6.13), while Site 3 recorded the lowest value (1.46) in January (Figure 5) The statistical analysis revealed significant differences between the sites ( $p < 0.05$ ), as well as a significant positive correlation between the Index values and all of the water temperature, pH, nitrate, and phosphate at  $p < 0.05$  ( $r = 0.565$ ,  $r =$

$0.775$ ,  $r = 0.685$ ,  $r = 0.555$ ), and a significant negative correlation with total hardness ( $r = -0.655$ ).

One of the greatest ways to track changes in the environment is to measure the richness of taxonomic units. The biological community's health and the environment in which it lives are associated with an increase in taxonomic unit abundance (Barbour et al., 1999) and a variety of variables, including as primary productivity, water depth, alkalinity, and plant nutrients, have an impact on species abundance. Competition and predation (Cottenie and Meester, 2003). Changes in temperature and light transmittance, as well as other chemical parameters including salinity, the quantity of dissolved oxygen, and pH, affect the abundance of some zooplankton species, as well as their rise or difference from one station to another (Al Douri, 2009). Recording high values of the species richness index during the spring season in the current study may be attributable to an increase in phytoplankton diversity and density, which creates an environment that is conducive to increasing species diversity and abundance (Yakub, 2004). Recording high values of the species abundance index also indicates an environment that is conducive to the growth and success of specific species (Badsı et al., 2010). According to Annalakshmi and Amsath (2012), the low values in summer and winter may be caused by the zooplankton's low density during these two seasons, which is mostly due to a lack of algae and aquatic plants, as well as the increased environmental stress brought on by the rise in solids. There may be a connection between salinity and melt for the summer's low species abundance

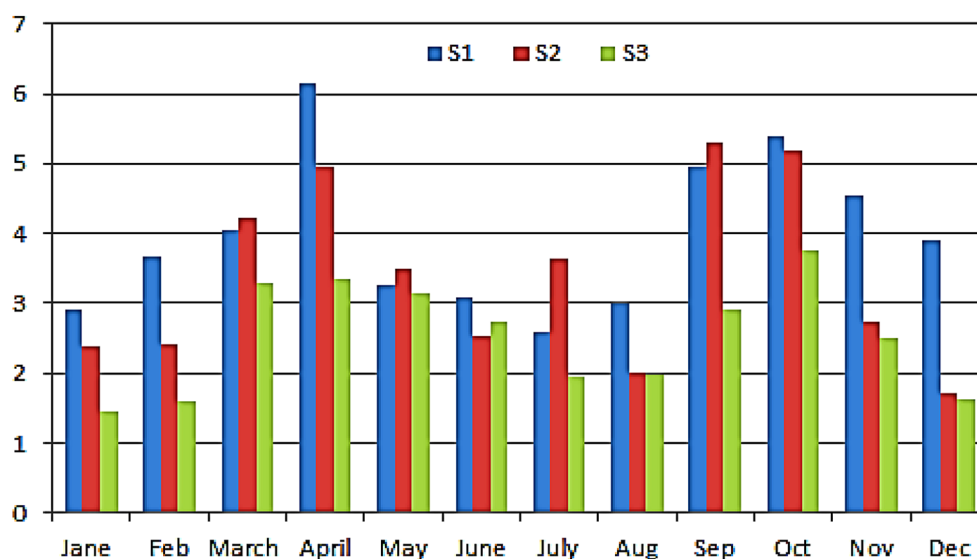


Figure 5. Monthly changes of the species richness index (D) of the copepod

(Ivanova and Kazantseva, 2006). Regarding the local changes, Site 1 reported high values for the Copepoda species abundance index. This may be because the area is bordered by agricultural fields with an abundance of aquatic plants, which is a favourable setting for their development and reproduction (Edmondson, 1959).

## CONCLUSION

The alkalinity of the water is caused by bicarbonate, and the Hilla River's water has good aeration and a pH that tends to be alkaline. Additionally, because it recorded values that fell below the lower limit of the brackish water range, the river water is extremely hard and approaches the lower limits of brackish water. Copepoda's density ranged from 80 ind/m<sup>3</sup> in February to a high of 1453 ind/m<sup>3</sup> in April. Numerous variables, the most significant of which are temperature and food availability, have an impact on copepod density. The most prevalent taxonomic unit related in the ecosystem of the Hilla River is the copepod larvae (nauplii). When it comes to copepod species appearance, high values of the species uniformity index show that there was no environmental strain on the river environment throughout the research period. The Hilla River's waters have a healthy level of biodiversity, which speaks to the environmental stability of the river. Additionally, it was discovered that the spring and fall seasons are ideal for fostering variety.

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