Impact of Physicochemical Parameters on Macroinvertebrates distribution attached to aquatic plants

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Abstract

The nutrients especially nitrate and phosphate have proven the main factor that affected the density of macroinvertebrates in the ecology of river. Four sites in two seasons (Spring and Summer) of 2020 have been selected to address the question of how the density of different aquatic macroinvertebrates attached to aquatic plants is correlated with physicochemical variables in the Euphrates river/Kufa city that considered the first study in Iraq. 19 taxa were diagnosis of macroinvertebrates attached to four aquatic plants (Ceratophyllum demersum, Hydrilla verticillata, Potamogeton crispus and Phragmites australis) during the study period. The Chironomidae genus was recorded in all aquatic plants. High diversity species appearance was recorded in an aquatic plant (Phragmites australis). The high density of macroinvertebrates recorded in spring than summer. temporal and spatial significant differences were found. Apparently, these spatial and temporal differences to be associated with variations in anthropogenic pressure, which differs in each area of the river. We observed a positive relationship between the PO4, NO3 and the density of macroinvertebrates attached with Phragmites australis and negative relationship between TDS and density of macroinvertebrates attached with Potamogeton crispus and found a negative relationship between BOD and density of macroinvertebrates attached with Hydrilla verticillata. These relationships suggest the physical and chemical variables affect the distribution of functional groups, abundance or biomass. There have been spatiotemporal variations in physical and chemical conditions of water associated with changes in the concentration of organic matter and nutrients.

Keyword: Aquatic plants, Euphrates, Macroinvertebrates, Physiochemical properties

Introduction

Seasonal invertebrate distributions are difficult to generalize in some areas. There are differences in seasonal distribution in general, moreover, little is known about seasonal succession in warm areas (Westveer et al.,2018). This study will help describe the dynamics of invertebrate attached to aquatic plants Euphrates river and provide an overview of the differences in the seasonal succession of invertebrate in warm regions. Here, we will study invertebrate to analyze its seasonal dynamics and investigate potential environmental factors for changes in its population.

Diverse invertebrate communities exist among submersible pond plants. The abundance of invertebrates (phytophilous) may be related to several factors, including surface texture, plant morphology, community formation, saturated algal growth, presence of defensive chemicals, and nutritional content of plant tissues, (Bogut et al.,2007). These plants provide shelter for invertebrates and serve as a protective cover against predators (Diehl 1992; Grutters et al.,2015), and are reproductive and attachment sites. (Wangensteen et al.,2016).

Invertebrates probably eat part of the plant or the surrounding portion associated with it (Van Soest,2018). Infeed water, pastoral Invertebrates may inhibit algal blooms, giving the chance to large submerged plants to continue (Weber et al. 2020). Numerous submerged plants within the pond make many delicate habitats that must give rise to different invertebrate groups. Phytophilic
invertebrates are not found equally in all plants and it associations with particular plant species are frequently studied in lakes (Thomaz, & Cunha, 2010).

Some species may be adapted for such tiny micro-organisms to separate resources into society. Other studies show association between large invertebrates and macrophytes, especially insects (Chilton 1990; Ptatscheck et al., 2020). Organisms also varied in density depending on the plants type, however, the formation of invertebrates in general was similar for all larger plants (Gerrish and Bristow 1979). The invertebrates of a group and the preferred association may play an important role in determining the morphology of plants. The invertebrates may depend on the form and the degree of the anatomy of the leaf, depending on the type of plant. (Graça, 2001).

Leaf deformed plants may have more invertebrates than wide-leaved plants per unit of biomass or area (Chilton 1990). Plants with dissected leaves can supply more periphyton substrates (Grutters et al., 2017). Thus, the food availability of plant-connected invertebrates is increased. While the hypothesis that the surface of the plant increases with the level of leaf anatomy is strongly supported, other studies were unclear (Peeters, 2002). Plants with complex leaves can provide better shelter than plants with shredded leaves (Taniguchi et al. 2003). Although the diversity of different varieties varies with the different plant species, large plants such as Myriophyllum spp and Ceratophyllum demersum. Invertebrates per unit did not support plant biomass more than broadleaf plants (Cyr and Downing 1988). Submerged plants support dense communities of large invertebrates (Tolonen et al. 2001)

The study of the abundance and preferences of individual populations of the invertebrate (including the zooplankton) in Lake Nasser was found to be closely correlated with aquatic plant and open water substrates. The findings show that the total suspended solids (TSS),d NO2 and TH are the most important variables in water on the distribution of large aquatic plants and invertebrates adherent to them. The study also indicates that water variables affect larger aquatic plants more than their associated invertebrates. The most influential aqueous variables were P, NO3, Na, K, Mg, Cl and DO which determined the distribution of open-water invertebrate groups. (Ali et al., 2007).

In a study (Strayer, 2007) The dominance of the macroinvertebrates community in plant beds was Chironomid, oligochaete worms, gastropods, water worms and amphipods. Several species of macroinvertebrates are found mainly in submerged plants, which indicates that plant beds are essential to support Hudson's biodiversity. Large invertebrates were more numerous in families with high biomass of plant and in the inner parts of the beds, whereas bed position nor size along the estuary did not affect the density of the macroinvertebrates.

Macrophytes influence animal populations and enhance biodiversity through a set of mechanisms, related to habitat complexity, which include feeding sites and shelter availability. Invasive macrophyte species may alter habitat structure thus influence associated organisms. (Thomaz & Cunha, 2010). The (Kelly et al., 2015) explain the Elodea nuttallii had small but significant impacts on plant, invertebrate and algal species. The richness of algal periphyton was lower on E. nuttallii than on native macrophytes.

The questions this study is trying to answer are 1) Any the aquatic plants that contain a high diversity of invertebrates? And 2) How the relationship between the density of different macroinvertebrate attached to aquatic plants is correlated with physicochemical variables in the Euphrates?

**Study area**
The Euphrates is one of the large rivers in Southwest Asia. The river originates in Turkey and flows southeast across Syria and through Iraq. The length of the Euphrates River from its source in Turkey to its mouth in the Shatt al-Arab in Iraq is about 2786 km, and drains an area of about 440000 km² (Figure 1), including 1176 km in Turkey, 610 km in Syria and 1160 km in Iraq, and its width ranges between 200 to more than 2000 meters at the estuary in Iraq. Kufa is a city found in An Najaf, and is approximately 170 kilometers south of Baghdad and 10 kilometers north of Najaf city, it is located 32°02'06.0"N latitudes, 44°24'10.8"E 32.05 longitudes and it is situated at elevation 24 meters above sea level (Al-Khafaji, 2012). Four site were selected to collect of samples during two seasons (spring and summer) of 2020 distribute as in map 1.

Map 1: study site on Euphrates River

Material and methods

Water samples were collected from the Euphrates river from four sites on the extension of the Euphrates river at Kufa city, where three samples repeated of each site from the surface water (about 30 cm from the surface), in the morning hours (7am-1pm) for two seasons (spring and summer), using polyethylene packages previously cleaned with distilled water and marking them, then store these samples cool at (4 °C) to study some physical and chemical properties. For the measuring of dissolved oxygen and biological oxygen demand (BOD) were used transparent and Dark bottles (Winkler bottles) according to (APHA, 2005). TSS was calculated according to (APHA,2005).-

Nitrite (NO2) was determined according to method modification of Strickland and Parsons (1968), Nitrate (NO3) determination was according to the method of Morris and Riley (1963) and updated by Strickland and Parsons (1968), Phosphate (PO4) was determined according to (Sletten, & Bach,1961).

Plants were collected in bags at each site to study invertebrate adhered to and classified, after being transferred to the laboratory. The coordinates of the locations of the sampling points were determined by GPS (Table 1). - Macroinvertebrate was identification after collecting aquatic plants
from the river and placing them in bags, they are brought to the laboratory for the purpose of studying adherent zooplankton and knowing its distribution, classification and species, where the plant part (200 gm) was cut and placed in a special bag and we add warm water to it with quiet shaking in order to separate the zooplankton from the plant, after which the water is poured warm in a filter with a diameter of (120µm) for the purpose of separating the zooplankton, and then we add a little ethanol to collect the zooplankton attached to the filter and collect it in a package of (50 ml) and save it and install it with (70%) ethanol, after several days the sediment comes down and we remove the water in the upper part by the siphon process and repeat it several times to get the sediment that contains macroinvertebrate by precipitation method (TCEQ, 2014). One ml of subsample was taken with a pipette, and then poured into a counting cell, examined and counted under a dissecting microscope where the different macroinvertebrate individuals were identified depend on [Edmondson (1959); Ahmed (1973); Kabat and Hershler (1993)].

| No | Location name                      | North          | East           |
|----|------------------------------------|----------------|----------------|
| 1  | Old Zarka plant                    | 32° 05' 10"   | 44° 22' 56"   |
| 2  | Old Kufa Bridge                    | 32° 02' 16"   | 44° 24' 45"   |
| 3  | Northern puncture station          | 32° 00' 09"   | 44° 26' 25"   |
| 4  | Cement factory bridge              | 31° 59' 10"   | 44° 27' 00"   |

Statistical Analysis

Complete Randomized Design (C.R.D) design was used for statistical analysis, used $P \leq 0.05$ and $0.01$ to showed result significantly, as well as the correlation coefficient between number individual of invertebrate with physical and chemical parameters according to SPSS program version 26.

Results and Discussion

The results of the current study indicated that air temperature was recorded between (33-45) for the two sites (1,4) during the spring and summer seasons (Table 2). This is related to the climatic nature of Iraq. Surface water temperature is highly correlated with air temperature as confirmed by the positive correlation between air and water temperature were 0.98 ($p <0.01$) as clear in (Table. 4), so the difference in water temperature is related to many environmental factors such as water depth, exposure to direct sunlight, and temperature Inlet water and shading (Bartram & Balance, 1996). Local variation of water temperature due to a difference in the time of measurement. Similar conclusion was made by other authors in this field (Salman, 2006 and Al-Zurfi, et al.,2018), and they observed that temperature is very important in water quality and directly affects the amount of dissolved oxygen, the solubility of minerals and some solids. Lingering, as a result, it controls the distribution of aquatic organisms (Shah et al., 2017).

The results of the current study recorded high concentrations of total dissolved solids (TDS) during the summer season, especially in the site (3), which is (785)mg/l, due to the leakage of large wastewater near the station. The total suspended solids (TSS) were high especially during the spring (9)mg/l during the station (1) due to the lack of water imports during the spring and the slow flow of water during this season (Table 2). A similar conclusion was made by (Mohammed, 2012).

The pH concentration was recorded for the summer and spring seasons, where the lowest value (7.59) was at the site (1) in the summer season, but the highest value (8.13) at the site(3) in the spring season (Table 2). The pH concentrations recorded in this study were within a limited range and tended to be slightly alkaline because it is common in Iraqi inland waters. This is due to
the temporary storage capacity of Iraqi natural waters that contain a high percentage of calcium bicarbonate. The results are consistent with other studies in this area (Hassan et al., 2007; Salman, 2006; Al-Haidarey, 2009). One of the most important factors limiting entry into an aquatic ecosystem through the water-air interface and through photosynthesis of aquatic plants is oxygen. Thus the amount of dissolved oxygen (DO) in an aquatic ecosystem depends on the rate at which these processes occur (Morgan and Iwama., 1996). The solubility of oxygen in water is affected by several factors such as temperature, the partial pressure of the gas, dissolved salts in addition to organic matter. (Morgan and Iwama., 1996; Wetzel and likens, 2000). The result indicated the presence of high concentrations of dissolved oxygen recorded in the spring season due to the low temperatures, as well as the lack of activity of microorganisms (decomposers), as the highest values were recorded in the spring season in the station (1,2) which are (7.2) mg/l (Table 2).

The BOD5 values ranged between (1.60-2.63)mg/l during the stations (4,1) for the spring and summer seasons respectively (Table 2). The variation in BOD values may be related to the organic matter loads discharged daily into the river from wastewater. BOD is a measure of the amount of dissolved oxygen that aerobic organisms such as bacteria and yeasts consume by breathing during the analysis of organic matter (Samer, 2015).

Plant nutrients (NO3, NO2, PO4) are essential elements for phytoplankton and other aquatic plants that stimulate them to grow (Neill, 2005). Human and industrial activities are essential sources of nitrates and nitrites in freshwater (Gassara et al., 2016). Through the study, it was found that the highest value of nitrates was in the spring season which was (30.4) in station (3) and the lowest value in the summer season was (6.5) in station (4) (Table 2), due to good ventilation and increased concentrations of dissolved oxygen that increase oxidation Nitrite to nitrate, (Philips et al., 2002), or because of the nitrogenous substances that are added by rain to the river by washing the lands adjacent to it (Adeyemo, 2008), and also for nitrite, the highest value was recorded in the spring and the lowest in the summer season (Table 2). While the reason for the high concentration of nitrates in summer is due to the high temperature and the increase in organic decomposition, and this leads to a decrease in the concentration of dissolved oxygen, this leads to the reduction of nitrates to nitrite (Rantanen et al., 2018). As for the site changes and the increase in nitrate and nitrite values in Station 3, they are caused by the flow of sewage into the river, the erosion of agricultural land, the incorrect use of fertilizers and residential waste (Khatri & Tyagi, 2015). The concentrations of phosphates in the river water depend on the lands that the river passes through and the household, agricultural and industrial wastes that are discharged into the river and which contain phosphate deposits, which are one of the most important sources of phosphates in the water (Aloe et al., 2014). The high concentration of phosphates in the site (3) in the summer season and reaches (0.55)mg/l as a result of what is discharged from various sources such as residential complexes, treated water, industrial wastewater (raw), tributaries, agricultural dumpsites, urban waste, groundwater, animal wastes, the process of decomposition and nitrogen fixation in Atmosphere(Ashraf et al., 2014). The value of phosphates in the site (4) decreases in the spring and reaches (0.16)mg/l (Table 2), due to the spread of phytoplankton and other aquatic plants that consume phosphate in large quantities and store it inside their bodies (Khan & Ansari, 2005).

With regard to invertebrates, 19 taxa were diagnosis of macroinvertebrates attached to four aquatic plants (Ceratophyllum demersum, Hydrilla verticillata, Potamogeton crispus and Phragmites australis) during the study period(Table 2) after collecting plants from the study sites of the Euphrates River/Kufa city, and the frequency of invertebrates for each plant and for all sites were studied. During the study period the Chironomidae genus were recorded more frequency on all plants show in a table (3), as its number of Chironomidae reached to 465 individual /gm in the Ceratophyllum demersum plant, and 505 individual /gm in the Hydrilla verticillata plant, and 200 individual /gm in the Potamogeton crispus and 400 individual /gm in the Phragmites australis plant. Differences in taxa numbers are attributed to differences in taxonomic aspects related to non-diagnosis of some taxonomic levels of genera and species or differences in environmental conditions and the nature of the studied ecosystems (Menezes et al., 2010).
The highest density of invertebrates during study period on *Phragmites australis* was 825 individuals/gm, and the lowest density of invertebrates in a plant *Potamogeton crispus* was 450 individuals/gm, shown in figure (2).

Invertebrates play an important functional role in aquatic systems by consuming phytoplankton and bacteria then releasing nutrients into the ecosystem or by acting as prey to transport nutrients to higher trophic levels. The formation of the invertebrate community in shallow water systems is not affected by predation only (Hampton and Gilbert, 2001), But also through the water cover and the hydrochemistry are major factors responsible for the formation of different environmental communities (Shurin, 2000). In this study, the distribution of invertebrate's adherent to each plant differed from one station to another, and this is due to the different environmental conditions such as nutrient availability, dissolved oxygen, salinity, and temperature, and these affect the population density of invertebrate communities. This confirms in the current study that there is a significant relationship ($P \leq 0.05$) between the nutrients (nitrites, nitrates and phosphates) with the number of invertebrates attached to the *Phragmites australis* plant, as it was recorded (0.96, 0.95, 0.98) respectively (Table 3) and recorded significant negative relation ($P \leq 0.05$) between TDS and number of invertebrates attached to the *Potamogeton crispus* plant was (-0.99) (Table 4) as recorded significant negative relation ($P \leq 0.05$) between BOD with a number of invertebrates attached to the *Hydrilla verticillata* was (-0.98) (Table 5).

| Station | Season | AT. | WT. | pH | TDS (mg/L) | TSS (mg/L) | BOD (mg/l) | DO mg/l | NO3 mg/l | NO2 mg/l | PO4 mg/l |
|---------|--------|-----|-----|----|------------|------------|------------|---------|----------|----------|----------|
| St.1    | Spring | 33.3| 26.8| 8.0| 332        | 9.0        | 1.70       | 7.2     | 20.9     | 0.15     | 0.19     |
|         | Summer | 35.3| 30.0| 7.5| 705        | 6.3        | 2.63       | 6.2     | 13.1     | 0.12     | 0.34     |
| St.2    | Spring | 35.3| 27.2| 7.7| 321        | 7.7        | 1.73       | 7.2     | 23.0     | 0.18     | 0.18     |
|         | Summer | 37.17| 30.2| 7.6| 725        | 5.0        | 1.87       | 5.3     | 7.0      | 0.04     | 0.21     |
| St.3    | Spring | 35.10| 27.5| 8.1| 347        | 7.0        | 1.93       | 6.3     | 30.4     | 0.27     | 0.20     |
|         | Summer | 40.17| 33.2| 7.6| 785        | 5.0        | 2.23       | 5.8     | 14.0     | 0.04     | 0.55     |
| St.4    | Spring | 40.7| 28.1| 7.8| 338        | 8.3        | 1.60       | 6.4     | 20.0     | 0.26     | 0.16     |
|         | Summer | 45.13| 39.1| 7.6| 784        | 6.7        | 2.53       | 5.5     | 6.5      | 0.14     | 0.21     |

Table 2. Physiochemical Parameters of Euphrates river / kufa city during study period (AT= Air Temperature, WT=Water Temperature).

Table 3. Density of macroinvertebrates attached with aquatic plants for spring and summer seasons (individual /gm)

| Plant         | Taxa                  | Spring | Summer | Total |
|---------------|-----------------------|--------|--------|-------|
| *Ceratophyllum demersum* | Chironomidae    | 50     | 195    | 70    | 100   | 25    | 25    | 465   |
|               | Cranefly nymph (mischederus) | 15     |        |       |      |       | 5     |       | 20    |
|               | Damselshy nymphs     |        | 20     |       | 10    |       |       | 30    |
|               | Diptera              | 5      |        |       |       |       |       |       | 5     |
|                        | larvae                  | Lymnaea auricularia | 35 | 20 | 55 |
|------------------------|-------------------------|--------------------|----|----|----|
|                        | Mysidiae                |                     | 15 | 15 |    |
|                        | Nymph                   |                     | 15 | 15 |    |
|                        | Odonata larvae          |                     | 15 | 15 | 30 |
|                        | Physa acuta             |                     | 10 | 60 | 15 | 85 |
|                        | Trychoptera spp.        |                     | 15 |    |    |
| **Hydrilla verticillata** |                         | Chironomidae       | 35 | 15 | 240| 110| 105| 505|
|                        |                         | Damselfly nymphs   | 5  | 5  | 10 |
|                        |                         | Lymnaea auricularia| 5  |    | 5  |
|                        |                         | Physa acuta        | 20 | 20 |    |
|                        |                         | Skimmer dragonfly nymph |       | 10 | 10 |
|                        |                         | Trychoptera spp.   | 5  | 5  |    |
| **Potamogeton crispus** |                         | Brachionidae       | 10 |    | 10 |
|                        |                         | Chironomidae       | 60 | 115| 25 | 200|
|                        |                         | Copepod asp.       | 5  |    | 5  |
|                        |                         | Cranefly nymphs    | 10 | 10 | 30 |
|                        |                         | (miscchederus)     |    |    | 5  |
|                        |                         | Damselfly nymphs   | 20 | 10 | 55 |
|                        |                         | Lymnaea auricularia| 15 | 25 | 15 | 55 |
|                        |                         | Odonata larvae     | 10 | 10 | 20 |
|                        |                         | Physa acuta        | 70 | 40 | 10 | 120|
| **Phragmites australis** |                         | Bivalve shalls     | 20 |    | 20 |
|                        |                         | Bosmina spp         | 20 |    | 20 |
|                        |                         | Brachionidae        | 10 |    | 10 |
|                        |                         | Brachionus spp      | 15 | 10 | 25 |
|                        |                         | Chironomidae       | 40 | 300| 15 | 45 | 400|
|                        |                         | Copepods           | 15 |    | 15 |
|                        |                         | Damselfly nymphs   | 10 |    | 10 |
|                        |                         | Diptera            | 10 | 10 | 80 |
|                        |                         | Lymnaea auricularia| 60 | 20 | 5  |
|                        |                         | Mosquito larvae     | 5  |    | 5  |
|                        |                         | Nymphus            | 20 |    | 20 |
|                        |                         | Ostracoda          | 40 | 40 |    |
|                        |                         | Physa acuta        | 10 | 85 | 30 | 125|
Figure 2: Density of Macroinvertebrates attached with plants during study period

Table 4: Correlation factor between Nutrients and density of Macroinvertebrates attached with aquatic plants during study period.

|        | Density C | Density H | Density P | Density Ph | PO4 | NO3 | NO2 |
|--------|-----------|-----------|-----------|------------|-----|-----|-----|
| Density C | Pearson Correlation | .1 | -.845 | -.669 | .348 | .165 | .034 | .916 |
| Sig. (2-tailed) | .155 | .331 | .652 | .835 | .966 | .084 |
| Density H | Pearson Correlation | -.845 | 1 | .358 | -.491 | -.375 | -.246 | -.564 |
| Sig. (2-tailed) | .155 | .642 | .509 | .625 | .754 | .436 |
| Density P | Pearson Correlation | -.669 | .358 | 1 | -.637 | -.500 | -.445 | -.707 |
| Sig. (2-tailed) | .331 | .642 | .363 | .500 | .555 | .293 |
| Density Ph | Pearson Correlation | .348 | -.491 | -.637 | 1 | .981 | .949 | .096 |
| Sig. (2-tailed) | .652 | .509 | .363 | .019 | .051 | .904 |
| PO4 | Pearson Correlation | .165 | -.375 | -.500 | .981 | 1 | .990 | .101 |
| Sig. (2-tailed) | .835 | .625 | .500 | .019 | .010 | .899 |
| NO3 | Pearson Correlation | .034 | -.246 | -.445 | .949 | .990 | 1 | .210 |
| Sig. (2-tailed) | .966 | .754 | .555 | .051 | .010 | .790 |
| NO2 | Pearson Correlation | .916 | -.564 | -.707 | .096 | -.101 | -.210 | 1 |
| Sig. (2-tailed) | .084 | .436 | .293 | .904 | .899 | .790 |

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).
Table 4: Correlation factor between some physical properties and density of invertebrate that attach with aquatic plants during study period.

|       | Density C | Density H | Density P | Density Ph | pH | WT | AT | TSS |
|-------|-----------|-----------|-----------|------------|----|----|----|-----|
| Density C | Pearson Correlation | 1 | -.845 | -.669 | .348 | .504 | .758 | .627 | .498 |
|         | Sig. (2-tailed) | .155 | .331 | .652 | .496 | .242 | .373 | .502 |
| Density H | Pearson Correlation | -.845 | 1 | .358 | -.491 | -.652 | -.294 | -.115 | -.595 |
|         | Sig. (2-tailed) | .155 | .642 | .509 | .348 | .706 | .855 | .405 |
| Density P | Pearson Correlation | -.669 | .358 | 1 | -.637 | -.651 | -.695 | -.670 | .302 |
|         | Sig. (2-tailed) | .331 | .642 | .363 | .349 | .305 | .330 | .698 |
| Density Ph | Pearson Correlation | .348 | -.491 | -.637 | 1 | .980 | .059 | -.135 | -.399 |
|         | Sig. (2-tailed) | .652 | .509 | .363 | .020 | .941 | .865 | .601 |
| pH | Pearson Correlation | .504 | -.652 | -.651 | .980 | 1 | .036 | -.071 | -.216 |
|         | Sig. (2-tailed) | .496 | .348 | .349 | .020 | .964 | .929 | .784 |
| WT | Pearson Correlation | .758 | -.294 | -.695 | -.059 | .036 | 1 | .983 | .246 |
|         | Sig. (2-tailed) | .242 | .706 | .305 | .941 | .964 | .017 | .754 |
| AT | Pearson Correlation | .627 | -.115 | -.670 | -.135 | -.071 | .983 | 1 | .123 |
|         | Sig. (2-tailed) | .373 | .885 | .330 | .865 | .929 | .017 | .877 |
| TSS | Pearson Correlation | .498 | -.595 | .302 | -.399 | -.216 | .246 | .123 | 1 |
|         | Sig. (2-tailed) | .502 | .405 | .698 | .601 | .784 | .754 | .877 |

Table 5: Correlation factor between some chemical properties and density of invertebrate that attach with aquatic plants during study period.

|       | Density C | Density H | Density P | Density Ph | TDS | DO | BOD |
|-------|-----------|-----------|-----------|------------|-----|----|-----|
| Density C | Pearson Correlation | 1 | -.845 | -.669 | .348 | .672 | -.238 | .737 |
|         | Sig. (2-tailed) | .155 | .331 | .652 | .328 | .762 | .263 |
| Density H | Pearson Correlation | -.845 | 1 | .358 | -.491 | -.637 | -.264 | -.984 | -.9 |
|         | Sig. (2-tailed) | .155 | .642 | .509 | .699 | .736 | .016 |
| Density P | Pearson Correlation | -.669 | .358 | 1 | -.637 | -.990 | .772 | -.245 |
|         | Sig. (2-tailed) | .331 | .642 | .363 | .010 | .228 | .755 |
| Density Ph | Pearson Correlation | .348 | -.491 | -.637 | 1 | .524 | -.139 | .523 |
|         | Sig. (2-tailed) | .652 | .509 | .363 | .476 | .861 | .477 |
| TDS | Pearson Correlation | .672 | -.301 | -.990 | .524 | 1 | -.831 | .171 |
|         | Sig. (2-tailed) | .328 | .699 | .010 | .476 | .169 | .829 |
DO Pearson Correlation 
- .238 - .264 - .772 - .139 - .831 - 1 - .402
Sig. (2-tailed) .762 .736 .228 .861 .169 .598
BOD Pearson Correlation
.737 .984 * .245 -.523 .171 .402 1
Sig. (2-tailed) .263 .016 .755 .477 .829 .598

Conclusion:

We observed a positive relationship between the PO4, NO3 and the density of macroinvertebrates and pH and Phragmites australis density and negative relationship between TDS and Potamogeton crispus density and negative relationship between BOD and Hydrilla verticillata density. These relationships suggest the physical and chemical variables affect the distribution of functional groups, abundance or biomass. There have been spatiotemporal variations in physical and chemical conditions of water associated with changes in the concentration of organic matter and nutrients. The concluded of current study the Chironomidae genus can able to live on all aquatic plants under study.

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