Structure of Bacterial Communities Associated with Some Aquatic Plants

Sadiq kadhum Iafta alzurfi$^1$ and Israa latif Katia$^1$

$^1$Departments of Ecology and pollution –Collage of Science/ University of Kufa, Iraq
sadiq.alzurfi@uokufa.edu.iq

Abstract

This study was the first of its kind on the Euphrates river in Iraq to study the composition of the epiphytic bacterial community of an three aquatic plants (Hydrilla verticillata, Phragmites australis and Eichhornia crassipes) was investigated. The study was conducted to how are bacterial assemblages in the rhizosphere for sediment different from those in bulk and surface sediments and aquatic plant during 2020 two sites in Kufa river were chosen. Total organic material, pH and EC of sediment were measured. Eighteen taxon were found in current study. The bacterial communities on three aquatic plants were distinct, such that Aeromonas sobria, Pseudomonas putida, Enterobacter cloacae and Acinetobacter baumannii were found on H. verticillata and in the sediment, while Acinetobacter woffi, Enterobacter cloacae ssp cloacae, Escherichia coli and klebsiellapneumoniae spp pneumonia on E. crassipes in site 2. Either on P. australis and sediment the Enterobacter cloacae, Pseudomonas aeruginosa, and Pseudomonas putida were found in site 1 and Granulicella elegans, Proteus penneri, and Pseudomonas putida in site 2. While the Escherichia coli, Klebsiella pneumonia and Serratiamarcescens were found in water at site 1. Aeromonassobriadominance in sediment of H. verticillata and in the sediment, while Escherichia coli dominance in sediment of E. crassipes, either Pseudomonas putidawas dominated in P. australis root. Number of bacteria were recorded in sediment of P. australis higher proportion was 28% than other. The indexes of diversity were recorded in sediment of P. australis higher than other except Domancy index recorded in sediment of E. crassipes was 0.025 higher than other. Our results indicated differences between the epiphytic bacterial community on the three plants and the water column at the species level, but an even representation of the most abundant phylogenetic taxa in sediment of P. australis was revealed. Statistical comparison of the retrieved sequences confirmed that the three libraries did differ significantly at the community level.

Keyword: Aquatic, Bacterial, Diversity, Shannon index.

1. Introduction.

Bacterial populations play a key role in the processing and demineralization of nutrients in aquatic ecosystems (Azam et al., 1983). To maintain the flow of energy, especially in the rivers it was play an important role in biodegradation (Costerton et al., 1987).

Aquatic bacteria play a vital and essential role in the preservation of natural water systems by various activities related to fundamental biogeochemical processes, such as respiration, the cycling of nutrients and reduced biological and chemical pollutants in water environments (Zeglin, 2015). In some circumstances, however, under extreme stress, these bacteria, for example, could have a detrimental impact on the
ecosystem or, even worse, cause serious health conditions (waterborne pathogens) for both humans and animals (Saxena et al., 2015; Kulinkina et al., 2016).

The majority of plants have intimate relationships with microorganisms, from mutual to a parasite. Plant-bacterium and plant fungus symbiosis is extremely common and well-studied in the terrestrial environment. (Alexopoulos and Mims, 1979).

Roots of plant represent one of the richest microbial ecosystems in the world between the soil and multicellular organisms (Bulgarelli et al. 2012). Various microbiotas are connected to their macrophyte host and act as an integrated functional unit in the microenvironment (Ofek-Lalzar et al. 2014), identified as the paradigm of the holobiont (Margulis and Fester 1991). Several soil microbes and plants have been detected in the holobiont paradigm. Soil rhizosphere microbes can convert nutrients for plants into easily assimilated forms (Zhang et al. 2009), and contribute to plant pathogen resistance (Berendsen et al. 2012). In exchange, plants supply carbon metabolites for rhizosphere microbes as root exudates (Bais et al. 2006). Such mutual interactions in the rhizosphere are ubiquitous because it is described in semi-arid soils (Aguirre-Garrido et al. 2012) to habitats of wetland (Hong et al. 2015). As they can extract resources from sediments, water, and air, Emergent macrophytes are considered especially productive organisms (Westlake 1965). They extend outward stems from under the surface of the water and carry out photosynthesis in the air. Aquatic macrophytes are rooted usually found in submerged especially in anoxic sediments, unlike terrestrial plants. Macrophytes like Zizania latifolia and P. australis characterize themselves by strong fistulous stems that work in tissue ventilation. The roots of emerging macrophytes are thus able to release oxygen and other primary and secondary metabolites into the rhizosphere (Herrmann et al. 2009; Toyama et al. 2011).

Microbial assemblage as a biofilm commonly occurs on the leaves of submerged plants, rhizosphere, especially on rhizoplane and on the solid surfaces of sediments. Several environmental conditions, such as excessive nutrients (eutrophication) their availability (Giaramida et al. 2013) and presence of toxic substances in the water affect biofilm and their structure (Calheiros et al. 2009).

Soil microorganisms are omnipresent, but only when water is reachable do they flourish. A low water content in the soil affects its microbial population by not only influencing the availability of water, but also of nutrients. Thus, in the formation of soil microbial communities water content is a major selective pressure in soil. The richness of the soil microbiota has recently been shown to correlate relative soil humidity positively with (Lau and Lennon, 2012; Blazewicz et al., 2014; Jonas et al., 2015; Taketani et al., 2017). This study was the first of its kind on the Euphrates river in Iraq to study how are bacterial assemblages in the rhizosphere for sediment different from those in bulk and surface sediments and aquatic plant, with respect to community composition, community structure, and diversity?

2. Material and Methods. The study site for this investigation was the Euphrates River, located in Kufa city, Iraq. The Euphrates is one of the largest rivers in Southwest Asia. The length of the Euphrates River from its source in Turkey to its estuary in Shatt al-Arab in Iraq is about 2786 km, and it drains an area of about 440000 km2 including 1160 km in Iraq. Kufa is a city in Najaf, and is approximately 170 kilometers south of Baghdad and 10 kilometers north of Najaf city. It is located at 32°02'06.0"N latitudes, 44°24'10.8"E 32.05 longitudes and is situated at an elevation 24 meters above sea level (Fig.1)(Al-Khafaji, 2012).

Two sites were selected to collect of samples during December of 2020 distribute as in map 1. The coordinates of the locations of the sampling points were determined by GPS the Site 1 ( 32.04188N 44.40660E)and Site 2 ( 32.03512N 44.41315 E) (Fig. 2). The two sites selected have the site 1 of them is far from pollution source and site 2 near of pollution source (Table 1). The water temperature of the water was measured on site using a thermometer instrument, while water pH and Electrical conductivity by multimeter instrument (WTW, German) was determined in the site.
The aquatic plants were collected from two sites after cut the part of roots were transferred to sterile plastic bags containing river water from the collection site. Water samples (three replicates) were collected in sterile bottles. In addition, sediment samples were samples collected in sterile bags. Total organic material analysis was analyses according to (Odeh and Shamsham, 2007). Water, sediment and plant samples were immediately transported on ice to the laboratory where roots of aquatic plants (*H. verticillata, P. australis and E. crassipes*) were sectioned into small pieces (approximately 1 cm). Sediment samples were taken to a depth of maximum penetration 20 cm for each aquatic plant. Sediment samples were taken to Away from every site 30 cm for each aquatic plant. Roots from the selected aquatic plants were manually shaken to remove loose sediment. For the analysis of bacterial diversity, 1 g of the sediment and root sample (fresh weight) and 1 ml of water was used to culture in nutrient media and incubate at 37°C for 24-48 hours. To identified of bacteria taxon was used Vitek 2 (Biomeriux /France). Diversity Index in current study the Shannon-Winer were used according to (Porto-Neto, 2003). The H max index was Calculated according to Shannon and Weaver (1949). And Evenees index (J) was calculated depending on the equation described in (Neves et al., 2003). While the Index of Simpson was calculated according to (Magurran, 2004). Either richness index was measured according to Margalef's (1969). Menhinick's index was calculated in current study. Agree with their findings, our study revealed that the different rhizosphere-associated sediment communities of *H. verticillata, P. australis* and *E. crassipes* were more diverse than bulk sediment communities. Maybe due to the pronounced “effects of rhizosphere,” which have been identified in rhizosphere of terrestrial microbiome (Berg and Smalla 2009; Philippot et al. 2013).
Table (1). Measurements of water physical and chemical variables at the two sampling sites in Kufa river with standard deviation (±)

| Water parameter | Site 1 | Site 2 |
|-----------------|-------|-------|
| Temperature     | 15.2±0.2 | 16±0.4 |
| pH              | 7.4±0.1 | 7.2±0.05 |
| EC              | 753±45 | 866±41.6 |
| TDS             | 552±31.6 | 666±30.5 |

2. Statistical Analysis. For statistical analysis at P ≤ 0.05 the Complete Randomized Design (C.R.D) was used to reveal significant results. In addition, the ANOVA test between the total number of bacteria using SPSS version 26.

3. Results and Discussion. Water and sediment variables. Water physical and chemical variables (Table 1) were differ at the two sites were recorded site 2 higher than site 1 as for as sediment physical and chemical properties were differing in two site were recorded site 2 higher than site 1 due to the site 2 near to household waste drainage. The physical and chemical properties of water increase in areas that are under the influence of agricultural and domestic activity. The increase in organic matter in site 1 (Table 2) due to the density of aquatic plant at this site, especially the prominent ones such as Phragmites. The most important source of organic matter in river sediments comes from the decomposition of the biomass of aquatic plants (Alzurfi, 2010).

Table (2). Measurements of sediment physical and chemical variables at the two sampling sites in Kufa river with standard deviation (±)

| Sediment parameter | Site 1 | Site 2 |
|--------------------|-------|-------|
| pH                 | 8.2±0.2 | 8.6±0.2 |
| EC                 | 1806±14 | 1904±21.6 |
| TDS                | 850±10 | 896±14.6 |
| Total organic material | 17.6±0.83 | 10.21±0.43 |

Table 3 clear the bacterial species identified among the plant species and the water column and sediment of plants were the Acinetobacter baumannii, Aeromonassobria, Enterobacter cloacae and Pseudomonas putida were detected in the H. verticillata root in site 1 only, and Aeromonassobria participate in appearance in sediment of Hydrilla and sediment of P. australis in site 1, while Acinetobacter lwoffii, Enterobacter cloacae ssppcloacae, Escherichia coli and klebsiellapneumoniaespppneumoniae were retrieved in E. crassipes root at site 2. Where the Enterobacter cloacae, Pseudomonasaeruginosa, and Pseudomonas putida in P. australis root at site 1 and Granulicattelaegans, Proteus peneri and Pseudomonas putida in site 2. Serratiamarcescens was participated in both sites in water column, while Escherichia coli and Klebsiellapneumoniae were detected in site 2 only Acinetobacter lwoffii and Escherichia coli were detected in sediment of E. crassipes in site 2, Alloiococcus otitis, Burkholderia mallei, Citrobacterbraakii and Pseudomonas putida were founded in sediment of P. australis.
There were more species of bacteria and diversity in the rhizosphere communities compared with the surface sediment communities. The most abundant genera were found within rhizosphere compare than surface sediment communities. These results agree with previous findings of rhizosphere communities associated with the terrestrial plants (Philippot et al. 2013; Mendes et al. 2014; Zhang et al. 2017). and rhizosphere communities associated with the aquatic plants (Huang et al., 2020). Recently, several studies have highlighted the distinction between the bulk and rhizosphere sediment communities associated with rooted macrophytes, including the freshwater macrophyte Phragmites (Borruso et al. 2014; Behera et al. 2017; Huang et al., 2020) and marine seagrasses (Cúcio et al. 2016; Hurtado-McCormick et al. 2019).

| Bacteria species                      | Site 1 | Site 2 | Site 3 | Site 1 | Site 2 | Site 3 | Water | Site 1 | Site 2 | Site 3 | Site 1 | Site 2 | Site 3 | Site 1 | Site 2 | Site 3 |
|--------------------------------------|--------|--------|--------|--------|--------|--------|-------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| Aeromonas sobria                     | 100%   | 100%   | 100%   | 0%     | 0%     | 0%     | 100%  | 0%     | 0%     | 0%     | 44.5%  | 44.5%  | 44.5%  | 0%     | 0%     | 0%     |
| Escherichia coli                     | 41%    | 41%    | 41%    | 39%    | 39%    | 39%    | 36%   | 36%    | 36%    | 36%    | 36%    | 36%    | 36%    | 36%    | 36%    | 36%    |
| Pseudomonas putida                   | 44.5%  | 44.5%  | 44.5%  | 36%    | 36%    | 36%    | 36%   | 36%    | 36%    | 36%    | 36%    | 36%    | 36%    | 36%    | 36%    | 36%    |
| Pseudomonas aeruginosa               | 44.5%  | 44.5%  | 44.5%  | 36%    | 36%    | 36%    | 36%   | 36%    | 36%    | 36%    | 36%    | 36%    | 36%    | 36%    | 36%    | 36%    |
| Pseudomonas putida                   | 44.5%  | 44.5%  | 44.5%  | 36%    | 36%    | 36%    | 36%   | 36%    | 36%    | 36%    | 36%    | 36%    | 36%    | 36%    | 36%    | 36%    |
| Pseudomonas putida                   | 44.5%  | 44.5%  | 44.5%  | 36%    | 36%    | 36%    | 36%   | 36%    | 36%    | 36%    | 36%    | 36%    | 36%    | 36%    | 36%    | 36%    |
| Pseudomonas putida                   | 44.5%  | 44.5%  | 44.5%  | 36%    | 36%    | 36%    | 36%   | 36%    | 36%    | 36%    | 36%    | 36%    | 36%    | 36%    | 36%    | 36%    |
| Pseudomonas putida                   | 44.5%  | 44.5%  | 44.5%  | 36%    | 36%    | 36%    | 36%   | 36%    | 36%    | 36%    | 36%    | 36%    | 36%    | 36%    | 36%    | 36%    |

The relative abundance index of bacteria community is set out in the table (4). The *Aeromonas sobria* and *Escherichia coli* recorded the highest percentage with 100% in sediment of Hydrilla and Eichhornia respectively followed by *Pseudomonas putida* 44.5% in Phragmites root and *Escherichia coli* with 41% in water column followed by *Escherichia coli* 39% in Eichhornia root and Serratiamarcescens with 36% in Phragmites root. shows that dominant a few species of epiphytic bacteria in aquatic plant may be due to decrease of temperature in December that affected bacteria species existence in Euphrates river. Increased
precipitation may decrease surface water pathogen levels due to dilution (Lucas et al. 2014). in the study Yadav et al (2019) mention among all the bacterial strains, Pseudomonas putida was found to be the most predominant microorganism residing in the water samples in all the seasons.

**Table (4): The Relative abundance index (Ra index) of bacterial community in three aquatic plants in Euphrates river.**

Where (R) rare less than 10%, (La) less abundant 10-40%, (A) abundant species appearing 40 - 70% and dominant species (D) more than 70%.

| Taxon                           | E.crassipes | Water | H.verticala | P.australis | S | E | H | S | P |
|--------------------------------|-------------|-------|-------------|-------------|---|---|---|---|---|
| Acinetobacter baumannii        |             |       |             |             | La|   |   |   |   |
| Acinetobacter lwoffii          | La          |       |             |             |   |   |   |   |   |
| Aeromonas sobria               |             |       | La          |             |   | D|   | La|   |
| Alloccoccus otitis             |             |       |             |             | La|   |   |   |   |
| Burkholderia mallei            |             |       |             | La          |   |   | La|   |   |
| Citrobacter braakii            |             |       |             |             |   |   |   |   | La|
| Enterobacter cloacae           |             |       |             |             | La|   |   |   |   |
| Enterobacter cloacae ssp. cloacae | La  |       |             |             |   |   |   |   | La|
| Escherichia coli               | La          | A     |              |             | D |   |   |   |   |
| Granulicatella elegans         |             |       |             |             | R |   |   |   |   |
| Klebsiella pneumoniae          |             | La    |              |             |   |   |   |   |   |
| klebsiella pneumonaeus pneumo niae | La  |       |             |             |   |   |   |   |   |
| Kocuria varians                |             |       |             |             |   |   |   |   | R |
| Proteus penneri                |             |       |             |             | R |   |   |   |   |
| Pseudomonas aeruginosa         |             |       |             |             | La|   |   |   |   |
| Pseudomonas putida             |             |       | La          |             | A |   |   | La|   |
| Serratia marcescens            |             | La    |             |             |   |   |   |   |   |
| Staphylococcus pseudintermedius |             |       |             |             |   |   |   |   | La|

Eighteen species were identified of epiphytic bacteria on three aquatic plants, water column and sediment; 7 species on sediment of *P. australis*, 5 species on *P. australis* root, 4 species on *H. verticala* root and *E. crassipes*, 3 species on water column and 1 species on sediment of *H. verticala* and *E. crassipes* during the study period (Table 5; Fig. 5). The site 2 was recorded more number than site 1 of bacteria was 403 CFU in site 2 and 303 CFU in site 1. *Escherichia coli* was recorded higher number was 133 CFU in site 2 while *Aeromonas sobria* was 117 CFU in site 1. *H. verticala* not recorded in site 2 and *E. crassipes* in site 1 due to loss these plants in site. Aeromonas isolation from aquatic environments has
been reported by several studies (Nishikawa and Kishi, 1988; Chacon et al., 2003) but these contained little data on the proportion of various component species. These species can be found in environments in which water has become eutrophic due to photosynthesis of phytoplankton, fertilizer or other reasons (Martin-Carnahan and Joseph, 2005). *E. coli* lives naturally in the intestines of humans and animals and is at the same time opportunistic bacteria causes urinary tract infections (Hadi et al., 2014). It has multidrug resistance (Laird, 2016). The presence of a high percentage of environmental E. coli in site 2 and no presence in site 1 due to site 2 was located near sewage waste draining that they may have derived from waste effluents and other nonpoint sources (Anastasi et al., 2012).
| Species                        | Sites          | E. crassipe CFU/ml | Water CFU/ml | H. verticillata CFU/gm | P. australis CFU/gm | S E CFU/gm | S H CFU/gm | SP CFU/gm |
|-------------------------------|----------------|-------------------|-------------|------------------------|---------------------|------------|------------|-----------|
| Acinetobacter baumannii       | Site 1         | 0                 | 0           | 0                      | 0                   | 1          | 6          | 1         |
| Acinetobacter lwoffii         | Site 1         | 0                 | 0           | 0                      | 0                   | 1          | 0          | 1         |
| Aeromonas sobria              | Site 1         | 35                | 52          | 30                     | 17                  | 3          | 0          | 3         |
| Alloiococcus otitis           | Site 1         | 0                 | 0           | 0                      | 0                   | 0          | 0          | 0         |
| Burkholderia malti           | Site 1         | 0                 | 0           | 0                      | 0                   | 0          | 0          | 0         |
| Citrobacter braakii           | Site 1         | 0                 | 0           | 0                      | 0                   | 0          | 0          | 0         |
| Enterobacter cloacae          | Site 1         | 13                | 23          | 6                      | 6                   | 3          | 3          | 3         |
| Enterobacter cloacae ssp cloacae | Site 1       | 0                 | 0           | 0                      | 0                   | 0          | 0          | 0         |
| Escherichia coli              | Site 1         | 0                 | 0           | 0                      | 0                   | 0          | 0          | 0         |
| Granulicatellaelegans         | Site 1         | 0                 | 0           | 0                      | 0                   | 0          | 0          | 0         |
| Klebsielapneumoniae           | Site 1         | 0                 | 0           | 0                      | 0                   | 0          | 0          | 0         |
| Klebsielapneumoniae ssp pneu moniae | Site 1      | 0                 | 0           | 0                      | 0                   | 0          | 0          | 0         |
| Kocuria varians               | Site 1         | 18                | 8           | 1                      | 1                   | 1          | 1          | 1         |
| Proteus penneri               | Site 1         | 0                 | 0           | 0                      | 0                   | 0          | 0          | 0         |
| Pseudomonas aeruginosa        | Site 1         | 40                | 4           | 4                      | 4                   | 4          | 4          | 4         |
| Site 2 | Acinetobacter baumannii | Acinetobacter hofii | Aeromonas sobria | Alloiococcus otitis | Burkholderia mallei | Citrobacter braakii | Enterobacter cloacae | Enterobacter cloacae ssp. cloacae | Escherichia coli | Granulicatella elegans | Klebsiella pneumoniae |
|--------|--------------------------|--------------------|-----------------|-------------------|-------------------|-----------------|----------------------|--------------------------|----------------|------------------------|------------------------|
| Pseudomonas putida | 30 | 33 | | | | | | | | | |
| Serratia marcescens | 21 | | | | | | | | | | |
| Staphylococcus pseudintermedius | | | | | | | | | | | |
| Total | 0 | 21 | 94 | 96 | 0 | 52 | 68 | | 31 | | |

Note: The table shows the counts of various bacterial species at Site 2.
| Species                        | Count | ID 1 | ID 2 | ID 3 | ID 4 | ID 5 |
|-------------------------------|-------|------|------|------|------|------|
| klebsiella pneumonia             | 30    |      |      |      |      |      |
| Kocuria varians                 |       |      |      |      |      | 0    |
| Proteus penneri                |       |      |      |      |      | 8    |
| Pseudomonas aeruginosa         |       |      |      |      |      | 0    |
| Pseudomonas putida             |       |      |      |      |      | 14   |
| Serratia marcescens            |       |      |      |      |      | 25   |
| Staphylococcus pseudintermedius|       |      |      |      |      |      |
| Total                         | 104   | 107  | 0    | 32   | 39   | 121  |

The highest density of bacteria during study period was on sediment of \textit{P. australis} 121 CFU/gm in site 2, and the lowest density of Bacteria in a water column was 21 CFU/ml, as shown in fig. (3). The statistical analysis showed significant differences between site and all treatments at the $P \leq 0.05$ show in table (6). It is becoming apparent that aquatic angiosperms hold on their surfaces unique and potentially mutual microorganism assemblings. Recent research in several aquatic angiosperms has shown that bacteria attached to the root differ from bacteria sediment from rhizosphere (Jensen et al., 2007; Kusel et al., 2006). A number of different microbe metabolism processes on plant surfaces are enhanced, including sulfide oxidation, methane oxidation, reduction of iron, reduction of sulphate and fixation of nitrogen, all of which are affected by plant activity (Lee, 1999; King, and Garey, 1999; Nielsen et al., 2001; Sorrell et al., 2002). In addition, aquatic plants produce antimicrobials that limit bacterial and fungal colonization of vegetation surfaces, including zosteric acid, and allow only certain microbes to be established (Bushman and Ailstock, 2006; Newby et al., 2006).

![Fig (3): Mean of total number of bacteria in three aquatic plant, water column and sediment in Euphrates river /Kufa city.](image-url)

![Table (6): ANOVA test between sites and three aquatic plant, water column and sediment in Euphrates river /Kufa city.](table-url)

| Tests of Between-Subjects Effects |
|----------------------------------|
| Dependent Variable: Number       |
| Source | Type III Sum of Squares | df | Mean Square | F | Sig. | Partial Eta Squared |
|--------|-------------------------|----|-------------|---|------|---------------------|
| Corrected Model | 80368.2 | 13 | 6182.17 | 112.696 | .00 | .981 |
| Intercept | 115447.714 | 1 | 115447.714 | 210.4516 | .00 | .987 |
| Site | 1110.85 | 7 | 1110.85 | 20.250 | .00 | .420 |
The percentage of bacteria species on three aquatic plant, water column and sediment were recorded the highest value in sediment of *P. australis* was 28% while *P. australis* root recorded 20% and *H. verticillata* root and *E. crassipes* recorded 16% followed water column 12% during study period (Figure 4).

![Fig.(4): Percentage of species of bacteria in three aquatic plant, water column and sediment in Euphrates river /Kufa city.](image)

Shannon-Weiner Diversity Index (H) from the obtained results of epiphytic bacteria, water column and sediment showed that the minimum value of (H) recorded on sediment of *H. verticillata* and *E. crassipes* was (0.00) while the higher value of (H) was recorded on sediment of *P. australis* (1.92) (Table 7). While the estimated species richness (Hmax) of epiphytic bacteria showed no value for sediment of *H. verticillata* and *E. crassipes* was (0.00) and the higher value of (H max) was recorded in sediment of *P. australis* was 1.94 and higher value of epiphytic bacteria was 1.6 in *P. australis* root (Table 7). The obtained results of epiphytic bacteria showed that the minimum value of Pielou evenness recorded sediment of *H. verticillata* and *E. crassipes* was (0.00) while the higher value of evenness was recorded on water column was 1.1 (Table 7). Estimated species Dominance (D) of epiphytic bacteria showed a clear decrease on sediment of *P. australis* was (0.004) while the higher value of Dominance was recorded on sediment of *E. crassipes* (0.025) (Table 7). The obtained results of epiphytic bacteria showed that the minimum value of Simpsons index recorded on
sediment of *E. crassipes* (0.97) while the higher value of Simpsons index was recorded on sediment of *P. australis* (0.99) (Table 7). Estimated species richness index of epiphytic bacteria showed no value for sediment of *H. verticillata* and *E. crassipes* was (0.00) while the higher value of richness index was recorded on sediment of *Phragmites australis* (2.6) (Table 7). The obtained results of epiphytic bacteria showed that the minimum value of Menhinick Index recorded on sediment of *Hydrilla verticillata* (0.13) while the higher value of Menhinick Index was recorded on sediment of *Phragmites australis* (0.51) (Table 7).

The Shannon diversity index showed the sediment of *P. australis* to have the greatest diversity and abundance of bacteria. This should not be surprising because sediment is more likely to accommodate a higher diversity of bacteria due to the many various sources through which bacteria can be introduced into the river. In contrast, the bacterial community on the phyllosphere of the three plants is expected to be more established and stable (Delmotte et al., 2009).

The distinctions between epiphytic bacterial communities might be due to the geographic locations and individuality of the plant species being studied. Other known aquatic classes as Planctomycetes, Cyanobacteria, Basil and Actinobacteria, but not Hydrilla have been found only in the eelgrass and water column. One of them is Planctomycetes in numerous habitats (Brümmer et al., 2000). Enterobacter cloacae was found only in the *H. verticillata* root and *P. australis* root, but not in *E. crassipes*, water column and sediment these results disagree with (Gordon-Bradley et al., 2014; Crump, and Koch, 2008).

Table 7: biodiversity index of different bacterial species found in three aquatic plant, water column and sediment in Euphrates river / Kufa city.

| Taxon        | *E. crassipes* | Water | *H. verticillata* | *P. australis* | SP | SE | SH | SP |
|--------------|----------------|-------|------------------|---------------|----|----|----|----|
| Indivdual    | 104            | 128   | 94               | 128           | 39 | 52 | 189|    |
| Richness index | 1.49          | 0.95  | 1.52             | 1.99          | 0.0| 0  | 2.63|    |
| H            | 1.29           | 1.22  | 1.31             | 1.41          | 0  | 0  | 1.92|    |
| H max        | 1.39           | 1.1   | 1.39             | 1.61          | 0  | 0  | 1.94|    |
| Pieloueveness| 0.93           | 1.11  | 0.94             | 0.88          | 0  | 0  | 0.99|    |
| Dominance    | 0.009          | 0.008 | 0.01             | 0.007         | 0.0| 0  | 0.0| 0.04|
| Simpsons     | 0.99           | 0.99  | 0.99             | 0.99          | 0.9| 81 | 0.996|
| Menhinick    | 0.39           | 0.265 | 0.41             | 0.44          | 0.1| 6  | 0.51|    |
4. Conclusion. Although in one of the first studies comparing the epiphytic bacterial communities on some aquatic plants, and the water column, differences were found at the species level between the epiphytic bacterial community on the two plants and the water column. However, the current study concluded the distribution of bacterial species was similar in *E. crassipes* and differed in *P. australis*, *H. verticillata* and sediment. The diversity index of bacteria was higher in the sediment of *Phragmites* and to provide greater insights into the ecological impacts of *Hydrilla* and *Eichhornia* introduction into aquatic systems. Also, further work on the chemical composition of *Hydrilla*, *Eichhornia*, and other aquatic plant species may provide additional information as to the factors that select the bacterial communities on the two plant species. The results of this study serve as a segue to future studies in this area.

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