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RESEARCH ARTICLE

BIODIVERSITY OF BENTHIC MACROINVERTEBRATES IN Al-RAZZAZA LAKE AT KARBALA PROVINCE/ IRAQ

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Abstract

This study was conducted to assess the biodiversity of benthic macroinvertebrates with assessing the water quality of Al-Razzaza Lake by chemical and physical analysis in addition to The Shannon – Wiener biological diversity index. The samples were collected each month from January 2013 to March 2014, from three sits. The chemical and physical analysis includes: water temperature (15 – 31) ^{0}C, DO (4.05 – 7.3) mg/l, salinity (1.98 – 2.52) ppt., TSS (4748 – 8157) mg/l, pH (5.11 – 8.7) & organic matter in sediment (1.8 – 13.6) %. Arthropods recorded in the present study were Crustacea and Hexapoda (Insects). Crustacea were including Decapoda *Metapenaeus* spp. (shrimp); Amphipoda *Gammarus* spp. (scud) and *Balanus amphitrite* (sessile genera). Insects consist of two genera including: Midge larvae and Damselfly Nymph. Mollusca that found during the study period were consisting of ten genera, including seven genera of gastropods and the remaining three genera are bivalves. Gastropods are *Melanopsis costata; Melanoides tuberculata; Cerithidea cingulata; Theodoxus jordani; Hydrobia ventrosa* (first time record in Iraq); *Lymnaea auricularia* and *Physa acuta*. Bivalves are *Laevicardium flavum; Corbicula fluminea* and *Unio tigridis*. The Shannon – Wiener biological diversity index revealed a value of diversity between 1.22 in winter 2014 to value of 1.95 in autumn.

INTRODUCTION

Al-Razzaza Lake location in Karbala and Anbar, the Eco-region were in Arabian Desert and East Sahara. The directional information of this area is located approx (20 km) northwest of Karbala, and (50 km) southeast of Ramadi. The coordinates are: N 32’ 41” E 43’ 40” and the altitude around 30m.

Benthic invertebrates can be differentiated by the position they occupy on or in bottom sediment (Hyman, 1967):

- Infauna: animals that live in sediments, almost all worms and bivalves.
- Epifauna: organisms that live on the surface of the bottom sediment, including many crustaceans and gastropods.

Benthic invertebrates play an important role in transitional ecosystem, filtering phytoplankton's and then acting as a food source for large organisms such as fish, there by linking primary production with higher trophic levels. They also structure and oxygenate the bottom by reworking sediment and play a fundamental role in breaking down organic materials before bacterial remineralization (Tagliapietra & Sigovini, 2010).

Molluscs are soft – bodies, bilaterally symmetrical, unsegmented, coelomata animals; usually shelled having a mantle, ventral foot, anterior head, and dorsal visceral mass (Van Damme, 2014).

Arthropods are bilaterally symmetrical, triploblastic, body covered with thick chitinous cuticle forming an exoskeleton, body segmented usually bear paired lateral and jointed appendages, segmented animals with coelom which is reduced and modified (Meglitch, 1972).

Crustacea are mainly aquatic, generally marine but few freshwater and few live in moist places, generally free – living but few are parasitic forms head often fused with thorax to form cephalo-thorax covered dorsally by carapace, head bears a pair of compound eye and five pairs of appendages, thorax and abdomen often bears with a pair of appendages (Goodfriend, 1986).

Insects are air breathing invertebrates, mostly terrestrial and rarely aquatic arthropods. Their life cycle in aquatic habitats including egg then larval stage; nymph which is a stage with no metamorphosis such as dragonfly, or naiad which is a stage with hemi-metabolic metamorphosis, then adult stage which live on the surface water or aquatic plants or flying in surrounding environment (Patton, 1963).

Materials and Methods:

This study includes three sites for sampling water; sediments and invertebrates located in Karbala. The stations were located by using GPS to determine the N and E value in addition to latitude, as described below:

	N	E	Latitude
S 1	32.64'785"	043.87'912"	17 m
S 2	32.58'579"	043.82'956"	12 m
S 3	32.59'175"	043.81'784"	15 m

The three sites of sampling showed in the lake as represented in figure (1).

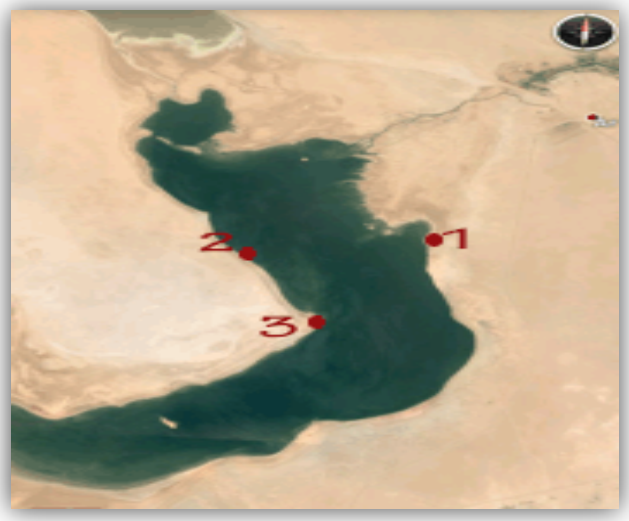

Figure 1: the sampling sites of study area in Al-Razzaza Lake (Google Earth)

Sediments and invertebrates samples were collected by using Ekman dredge 15x15x15, and sieves No. 30 of (500µm) mesh size was used to collect the Benthic invertebrates, all samples were kept in polyethylene bags and then kept in bottles and the samples preserved by adding formaldehyde (5%) to be classified later.

Invertebrate's identification and estimation for benthic invertebrates including Arthropods (Crustaceans and Insects) and Mollusca (Gastropods and Bivalves) examined under dissecting microscope and identified by using (Ahmed, 1973); (Kabat & Hershler, 1993); (Hershler & Ponder, 1998) and (Edmondson, 1959), the results were expressed by Individual/m^2.

The Shannon – Wiener diversity index was measured according to the equation below as described By Shannon and Wiener, (1949).

$$H = -\Sigma\ ni / N\ Ln\ ni / N$$

n_i: Number of Species individuals in the Site

N: Number of all Species individuals in the same site

The results explained by the following:

1 < Low Diversity

(1 – 3) Moderate Diversity

3 > High Diversity

Results and Discussion:

Study results showed that the minimum values of water temperature was 15°C were recorded in January 2013. While the maximum value of water temperatures were 31°C recorded in August 2013. As showed in Tables (1, 2 & 3).

In previous study on Al-Razzaza Lake, Hassan (1998) measured the water temperature of the lake finding that it's ranges between (11.9 – 34) ^{0}C.

The present study results showed that the lowest pH value was (5.11) in May which acidic, while the highest value of pH was (8.7) in June that considered slightly alkaline, the other months of study period were around neutral pH (Tables: 1, 2 & 3).

The obtained data showed that the lowest value for salinity was 1.982 ppt. in January 2013, while the highest value was in August at 2.528 ppt. (Tables: 1, 2 & 3).

Salinity is affected primarily by the geology of the area through which the water flows and the presence of naturally occurring salts (Behar and Cheo, 2004).

Present study findings revealed that the DO had the lowest value of 4.05mg/l in August, while the highest value was 7.3mg/l in January 2014 (Tables: 1, 2 & 3).

WFD UK (2006) standards for water quality, considered that DO concentration between (4 – 6) mg/l is moderate water, while (7 – 9) mg/l considered good water quality. The CCME (1999) guide line for the protection of freshwater aquatic life is between 5.5 to 6.0 mg/l, but UNESCO and WMO (1992) mentioned that DO concentration of 9 mg/l is the optimal concentration for aquatic life, while 7-8 mg/l considered acceptable, and 3.5-6 mg/l considered poor.

Study results showed that the lowest value for TSS was 4748 mg/l in January 2013, while the highest value was 8157 mg/l in August (Tables: 1, 2 & 3).

Suspended Particulate Matter is defined as the dry weight of all particulate matter in a sample, including clay, silt, sand, mineral particles; phytoplankton, heterotrophic plankton (bacteria), and particulate organic detritus. It absorbs heat from sunlight and increases water temperature. (MIDEQ, 2000). Therefore, phytoplankton and the heterotrophic community it supports contribute to what is measured by SPM (Gallegos, 2004).

Study results showed the higher content of organic matter was in January 2013 at 13.6%, while the lowest value 1.8 % in July (Tables: 1, 2 & 3).

The temperature controls the rates of important biological processes, such as organic matter decomposition and accumulation of peat in the wetlands. In the case of high water temperature during summer the decomposition rate of organic matter increases leading to the reduction of dissolved oxygen in the water column (Bij de Vaat and Pavluk, 2004).

Table 1: Mean ± Standard deviation of water samples collected from site1 of Al-Razzaza Lake during study period (2013 – 2014).

Water Parameters	Mean ± standard deviation				
	Site 1				
	Winter2013	Spring 2013	Summer2013	Autumn2013	Winter2014
Water temperature (^{0}C)	17.0±1.6	22.33±2.49	30.0±1.8	26.0±2.92	17.0±1.41
DO (mg/L)	7.13±0.03	7.98±0.655	5.537±1.00	6.479±0.341	6.8±0.74
pH	7.6 ±0.17	8.0±0.0	8.43±0.104	7.77±0.386	7.2±0.18
Salinity (ppt.)	2.115±0.004	2.379±0.06	2.251±0.287	2.583±0.431	2.06±0.058
TSS (mg/L)	4354.5±495.21	6362.33±188.42	6789.0±579.32	7194.0±384.794	7332.0±469.93
Organic Matter (%)	13.35±0.54	11.6±1.00	7.83±2.269	9.47±0.377	10.6±0.787

Table 2: Mean ± Standard deviation of water samples collected from site 2 of Al-Razzaza Lake during study period (2013 – 2014).

Water Parameters	Mean ± standard deviation				
	Site 2				
	Winter 2013	Spring 2013	Summer 2013	Autumn 2013	Winter2014
Water temperature (^{0}C)	16.5±0.408	21.67±2.625	29.33±1.70	25.33±1.7	16.33±1.247
DO (mg/L)	7.255±0.184	7.426±0.280	5.941±1.233	6.502±0.4	6.607±0.722
pH	7.4±0.88	7.9±0.216	8.47±0.06	7.9±0.374	7.23±0.08
Salinity (ppt.)	2.062±0.064	2.372±0.072	2.205±0.229	2.34±0.058	2.146±0.114
TSS (mg/L)	5817.0±108.594	6039.3±369.37	7119.0±734.86	7464.3±450.64	7264.0±367.36
Organic Matter (%)	10.0±0.0	8.2±1.499	4.33±2.655	7.0±1.1775	8.73±1.68

Table 3: Mean ± Standard deviation of water samples collected from site 3 of Al-Razzaza Lake during study period (2013 – 2014).

Water Parameters	Mean ± standard deviation				
	Raz'za 3				
	Winter 2013	Spring 2013	Summer 2013	Autumn 2013	Winter 2014
Water temperature (^{0}C)	16.5±0.408	21.67±2.625	29.33±1.699	25.67±2.054	16.33±1.247
DO (mg/L)	7.195±0.075	7.911±0.336	5.538±1.06	5.688±1.172	6.416±0.619
pH	7.4±0.1	7.867±0.189	8.2±0.141	7.87±0.33	7.27±0.05
Salinity (ppt.)	1.9965±0.0445	2.257±0.066	2.286±0.198	2.292±0.084	2.100±0.038
TSS (mg/L)	5720.0±73.84	6360.3±233.687	7255.3±616.9	7354.3±361.63	7046.7±335.24
Organic Matter (%)	9.75±0.204	8.1±1.273	4.7±2.747	6.97±0.957	8.63±0.499

Benthic Macroinvertebrates community of Al-Razzaza Lake:

Arthropods that recorded in present study were Crustacea and Hexapoda (Insects). Crustacea consist of Decapoda *Metapenaeus* spp. (shrimp); Amphipoda *Gammarus* spp. (scud) both is swimmers and *Balanus amphitritis* (sessile genera). The insects consist of three genera including: Midge larvae; Damselfly Nymph. Decapods, *Metapenaeus* spp.(shrimp) and amphipods *Gammarus* spp. (scud) were recorded in the present study as the biological community of Al-Razzaza Lake. The shrimp found in fresh and brackish waters, open and closed water ecosystems beside estuaries and gulfs (Stephenson, 1983).

Shrimp recorded in marshes of southern Iraq, the shrimp (*Metapenaeus* spp. and scud were recorded in Abu Zirig marsh (Al- Saffar, 2006). Sebtie (2009) recorded the presence of the two orders (decapods and amphipods) in the three marshes (Al – Hawizah; Al – Chibaysh and Al – Hammar) and Garma River.

The species *Balanus amphitritis* is a corn barnacle species, found in warm and temperate waters worldwide. Its common in coastal and estuarine, found attached to hard surfaces such as bed rocks; boulders; mollusks' shells as well as hulls of ships (Boudreaux & Walters, 2005).The species *B. amphitritis* was also recorded in the southern marshes by Sebtie, (2009), in the three marshes were (Al – Hawizah; Al – Chibaysh and Al – Hammar) beside Garma River.

The Chironomids family known as "lake flies" in parts of Canada, called "sand flies" in various regions of the USA great lakes area and called "bay flies" in areas near the bay of Green Bay, Wisconsin (Amitage *et al.,* 1995).

The midge larvae, some of their species are known as "blood midge" because they contain a red blood pigment (hemoglobin). Midge larvae development pass through four stages, the first stage is usually planktonic, floating in the water column. Later stage descends to the bottom and is usually benthic (Merritt & Cummins, 1996). The midge larvae were reported in many studies in Iraqi southern marshes (Al- Saffar, 2006 and Sebtie, 2009). As well as the Iraqi rivers, Tigris and Euphrates (Al- Nimrawee, 2005).

Mollusca which were found during the study period composed of ten genera, including seven genera of gastropods and the three remaining genera for bivalves. Gastropods are *Melanopsis costata; Melanoides tuberculata; Cerithidae cingulata; Theodoxus jordani; Hydrobia ventrosa* (first record in Iraq)*; Lymnaea auricularia* and *Physa acuta.* Bivalves are *Laevicardium flavum; Corbicula fluminea* and *Unio tigridis.*

Gastropods are symmetrical molluscs that underwent torsion, the body is generally divided into two main regions: head – foot and mantle (including shell) (Goodfriend, 1986).

Cerithidae cingulata is a medium sized snail, called mud snail, found in marine and brackish water (Houbrick, 1984). The snail *C. cingulata* was previously recorded from Arabian Gulf and Shatt Al-Arab by Ahmed (1973). But it seems there is no accuracy for this species neither marshes nor Tigris and Euphrates rivers.

The second species recorded in this study was *Melanoides tuberculata* is a freshwater, found in North Africa and Asia. This snail normally found in freshwater but is very tolerant to brackish water and recorded in water with salinity of 32.5 ppt. it is warm – climate species prefer a water temperature range of (18 – 30) ^{0}C. (Duggan, 2002). The species recorded in Shatt Al- Arab and Arabian Gulf by Ahmed (1973). Beside the findings of Khalaf (2011) who recorded the snail in all studied stations (Al- Salhiyia; Abu Alkaseb; and Al- Qurna) of Shatt Al- Arab. Also the snail was found in southern marshes of Iraq (Al- Saffar, 2006 and Sabtie, 2009).

Melanopsis costata is a species of freshwater snail, found in southern Europe, North Africa, Asia and New Zealand (Powell, 1979). The snail is ribbed: the ribs almost extend the entire height of each whorl. The snail is wide spread in wide variety of aquatic habitats, found on stones; or aquatic plants and sometimes on silty mud (Bilgin, 1983). This species is widely distributed throughout Syria, Palestine and Jordan Valley and Iran (Mansoorian, 1994).

Theodoxus jordani snail have been recorded during all the study period from all sites, the snail known as small water snail that is live in both freshwater and brackish water. This species is highly variables in sized and color pattern with semi-ovular shell. Live on stones and under stones (Zettler *et al.,* 2004). This species *Th. jordani* was recorded in southern marshes of Iraq including (Al- Hammar; Al- Ghibayish; Al- Hawiezah and Abu Zirig), and also in Garmmat Ali river and Shatt Al- Arab as well as Arabian Gulf. Also the snail was reported in (Al- Husseinis; Al- Duwania and Al- Ahunaidai) creeks (Ahmed, 1973; Al- Taee, 2011; Al- Saffar, 2006; Sebtie, 2009 and Khalaf, 2011).

Hydrobia ventrosa (Montagu, 1803) snail that recorded in the present study is considered to be the first record to Iraqi fauna. It is characteristic by being white in color, very small mud snail, live in brackish water, ranged in size from (1.5 – 3.0) mm commonly 1.7 mm with smooth, medium – thick, ovate – conic shell with (4 – 6) whorls (Hershler & Ponder, 1998). Fig. (2).

Fig. (2): Photograph of the snail *Hydrobia ventrosa* (8x).

The *Hydrobia ventrosa* is a brackish water species found in estuarine, lagoon and marine environments. *H. ventrosa* are deposit feeders, ingesting sediment particles and grazing on solid surfaces such as aquatic macrophytes, assimilating the associated micro-organisms (Van Damme. 2011). In Kysing Fjord estuary / Denmark, the two species *Hydrobia ventrosa* and *H. neglecta* were recorded by Siegismund (1982). While in Turkey there are three species of *Hydrobia* which reported in coastal brackish water, including *H. ventrosa, H. acuta* and *H. ulva*. The species *H. ventrosa* is located in Turkey at two lakes (Sarikum and Derbent Dam) and found in Mediterranean coast (Demir, 2003). *The H. ventrosa* was also reported in Mediterranean brackish lagoon and Ichkeul Lake in Tunisia (Casagranda *et al*., 2005). The *H. ventrosa* snail widely distributed in the coast of Iceland, Great British, Ireland, France, Baltic Sea and Black Sea (Kabat & Hershler, 1993).

Lymnaea auricularia is a species of small sized, air – breathing, freshwater pond snail. This snail is found in freshwater lakes, ponds, and slow – moving rivers with mud or silt bottoms, this species prefer very lentic waters in lakes. And can tolerate anoxic conditions (Mackie *et al*., 1980). The species *L. auricularia* was earlier recorded in some studies on Iraqi southern marshes, the marshes were the snail reported are (Al – Hawizah; Al – Chibaysh; Al – Hammar and Abu-Zirig) (Al- Saffar, 2006 and Sebtie, 2009).

Physa acuta is a species of left – handed snails (sinistral), air – breathing, freshwater snail, called European *Physa* and bladder snail. Distributed in Mediterranean, North America and Europe. Live in rivers, lakes, ponds, and swamps, with occurring in warm water (Dillon *et al.*, 2002). The species *Ph. acuta* was also recorded in the findings of Sebtie (2009) in southern marshes, as well as in Abu Zirig marsh (Al- Saffar, 2006). This species was not recorded in studies done about benthic community of Shatt Al- Arab or Arabian Gulf.

Bivalves include clams, oysters and mussels. Comprise a class of marine and freshwater molluscs. They have laterally compressed bodies enclosed by a shell consisting of two hinged parts, they have no head. The shell composed of calicium carbonate, the two parts usually similar, called valves (Runnegar & Bentley, 1983).

Laevicardium flavum is a clam with solid shell, inflated oval, beaks in the middle and have creamy color. The margins are serrated. The clam *L. flavum* recorded in the present study; beside it is reported in the Arabian Gulf, Jazirat – Hecham coast and Umm Qaser area (Ahmed, 1973).

Corbicula fluminea is a species of freshwater clam. In southern Asia called good luck clam, and found in many parts of the world including North America and Europe. Found in rivers and lakes. Characters of the species, have amount of ribs on the shell are (7 – 14) rib/cm (Beran, 2000). The species *C. fluminea* was reported in southern marshes (Al – Hawizah; Al – Chibaysh; Al – Hammar and Abu-Zirig) (Al- Saffar, 2006 and Sebtie, 2009). Beside Shatt Al- Arab and Arabian Gulf (Ahmed, 1973). As well as in both Iraqi rivers (Tigris and Euphrates) (Al-Nimrawee, 2005 and Hashim, 2010).

Unio tigridis is a freshwater clam, found very rare frequent in the present study. This species found in higher numbers in other studies in Iraqi marshes, rivers and Shatt Al- Arab (Ahmed, 1973; Al- Nimrawee, 2005; Al- Saffar, 2006; Sebtie, 2009 and Hashim, 2010).

Benthic Macroinvertebrates densities and seasonal variations:

The benthic community that recorded in this study was: gastropods; molluscs; crustaceans and insects.

The density variation through the study seasons of sessile arthropods, *B. amphitritie* which found in all sites and collected from rocks, aggregated on shells or even found on tin soda. The highest density was on autumn at 2775 Ind./m^2, while the lowest density recorded in winter 2014 at 313 Ind./m^2. Tables (4, 5 & 6) showed the mean density± SD for each site in all study period. The barnacle *B. amphitritie* spread in warm - waters with temperature between (18 – 25) ^{0}C for the larval development (nauplii stage), while the high temperature above 29^{0}C well affect the nauplii

development and less attached ability to the adults (Thiyagarajan *et al.,* 2003). *B. amphitritie* showed direct correlation with water temperature were (r= 0.908), beside direct correlation with DO concentrations (r= 0.592), the salinity had also direct correlation (r= 0.534) and strong correlation with TSS (r= 0.935).

The snail *C. cingulata* had a highest density in spring at 3914 Ind./m^2, while the lowest density found in autumn at 55 Ind./m^2 in site 1, Tables (4, 5 & 6). *C. cingulata* found in brackish and marine waters, prefer water temperature among (20 – 28) ^{0}C and the largest density collected in April month on marshes (Smith & Ruiz, 2004). This agrees with the study findings that the highest density in spring. The snail showed a lower density in site 1 comparing with the other two sites (2 & 3), which may be due to the sediment structure of site 1 that had more silt and clay particles than the other sites. The snail showed a direct correlation with water temperature at (r= 0.969) and inverse correlation with DO (r= - 0.809).

M. tuberculata found in the present study with highest density at 10,512 Ind./m^2 in autumn at site 1, while the lowest density at 3943 Ind./m^2 in winter 2013. *M. tuberculata* wide spread in Asia and other parts of the world as North America and Europe. Found dominant when the soil are muddy and silty, with water temperature at (18 – 30) ^{0}C. This species are freshwater snail, although is very tolerant to salinity and recorded in water with salinity of 32.0 ppt. (Duggan, 2002). The correlation showed a strong bond between the snail and water temperature (r= 0.886), while correlation with salinity was no correlation (r=- 0.193) and correlation with DO concentrations was inverse correlation (r= -0.928). The snail *M. tuberculata* found to be recorded in Iraq in different aquatic habitats (Lotic and Lentic) with different salinity and sediments texture.

M. costata this species found in higher density at the two sites 2 & 3. The highest density recorded in spring at 7583 Ind./m^2, while the lowest density in site1 at winter 2013 with 100 Ind./m^2. The optimal water temperature for growth and reproduction was around 21 ^{0}C (Harzhauser *et al.,* 2011). Correlation analysis showed the species correlation with water temperature was (r= 0.90), while correlation with organic matter in sediment were strong direct at (r= 0.919).

The snail *Th. jordani* had the higher density found to be in sites 2 & 3. The highest density found in spring at 2188 Ind./m^2, while the lowest density found in winter 2014 at 45 Ind./m^2. The species *Th. jordani* live in both fresh and brackish waters, found abundant in littoral zone of hard water (Kirkegaard, 2006). In the present study showed an inverse correlation with salinity (r= -0.772) and the correlation with water temperature was (r= 0.671). The *Th. jordani* snail dominate in spring season due to the growth of filamentous algae, the diatoms are food item for juveniles of the snail (Skoog, 1978). In field observations, in spring months found the water color changed from brown in winter to greenish color with large amount of floated algae on the lakes edges.

H. ventrosa found in the lake at all study sites. The highest density recorded in site 1 at 7818 Ind./m^2 in autumn, while the lowest density found in summer at 393Ind./m^2. *H. ventrosa* is a mud sail, increased in growth and reproduction when the water temperature ranges from (15 – 25) ^{0}C and any increase in temperature above 25^{0}C will lead to significant reduction in the life span of cercaria (Mouritsen, 2002). In semi – natural lagoons of Spain, the *H. ventrosa* was seemed to be the most numerous species in spring and summer seasons (Drake & Arias, 1994). While in controlled laboratory conditions, the *H. ventrosa* had a maximum egestion rate at water temperature of 25 ^{0}C and salinity of 2.0 ppt. (Hylleberg, 1975). The statistical analysis showed the correlation between the snail and water temperature was strong inverse at (r= -1.0).

The best salinity of water for the growth and reproduction of *Hydrobia* was under 20‰ (Hylleberg, 1975). The correlation that found between the water salinity and the snail was strong direct correlation at (r= 0.823). The species found in samples that collected only from sediments with very fine sand (Anderson *et al.,* 2010).

L. auricularis and *Ph. Acuta* had the lowest density among all other collected species. The two species found only in site 1 at all study period, except spring season, which showed an appearance of both species in site 2 & 3 at density of (15 & 14) Ind./m^2, respectively. *L. auricularis* had the highest density in spring at 66 Ind./m^2 and the lowest density in winter 2013 at 23 Ind./m^2. *L. auricularis* best life cycle is in soft water compared with hard to medium hardness and the most affective chemistry variable was magnesium (Dussart, 1979). As earlier the results revealed that water hardness of the present study was very hard (more than 300 mg/l), which is not suitable for the growth and reproduction of the snail. The snail showed an inverse correlation with water hardness at (r= -1.0). The optimal water temperature for growth and reproduce is around 20 ^{0}C and pH ranges from (6.0 – 7.1) (Karimi *et al.,* 2004).

Ph. acuta had the highest density in autumn at 117 Ind./m^2 and the lowest density found to be in winter 2013 at 22 Ind./m^2. *Physa* is a snail live in freshwater and have the ability to adapt to extreme environmental conditions, the snail found in ponds but not in dominant density (De Witt, 1955).

The bivalves that found in the present study were composed of three species, which are: *Laevicardium flavum* collected from all study sites, the highest density was summer at 941Ind./m^2, while the lowest density found in winter 2013 at 69 Ind./m^2. The clam density was higher in sites 2 & 3 more than site 1, which may be due to the sediment structure and organic matter contents. The statistical analysis showed an inverse correlation between the clam and organic matter at (r= -0.567). The clam *L. flavum* is a very wide ranging species in the indo – west Pacific and

extremely variable species (Barash & Danin, 1986). This species was reported in Shatt Al- Arab and Arabian Gulf in wide spread (Ahmed, 1973). But no accuracy of the species in Southern marshes of Iraq.

The second clam was *C. fluminae* found in all study sites but in most study period, the highest density was in summer at 68 Ind./m^2, while the lowest density in winter 2014 at 6 Ind./m^2. The species recorded at higher density in both Iraqi rivers and marshes. The statistical analysis showed the correlation between the clam and water temperature was direct at (r= 0.55) while inverse in correlation with DO and organic matter at (r= -0.904 and r= -0.681) respectively.

U. tigridis collected only in two seasons, spring and summer at (14 – 15) Ind./m^2 and absents in the other seasons of study period. Most of the collected clam was damaged or the shell without the animal soft tissue.

The Arthropods that collected in the study period were decapods, amphipods and insects larvae, which all considered as epi-benthic fauna.

Decapoda the genera *Metapenaeus* spp. (shrimp) was found during the study period. The highest density was recorded in spring at 470 Ind./m^3, while the lowest density in winter 2013 at 8Ind./m^3. The shrimp reported in many previous studies on the wetlands in Iraq, including Tigris and Euphrates rivers, marshes and Arabian Gulf.

Amphipods the genera *Gammarus* spp. (scud) had the highest density during spring at 240 Ind./m^3, while the lowest density was recorded at 4 Ind./m^3 during winter 2014. The water hardness above 250 mg/l affected the growth and size of *Gammarus* spp. beside that the best water temperature ranges from (7 – 15) ^{0}C (Stephenson, 1983). The water hardness of Al-Razzaza Lake was much higher around 2500 mg/l and water temperature was ranges from (16 – 30) ^{0}C, which considered as unfavorable conditions for the growth of *Gammarus* spp. which reflect the low density of the scud that collected during the present study period.

The insects which collected from the lake were midge larvae and damselfly nymph. The midge larvae collected only from the months of two seasons: spring and autumn. Spring season had the higher density with 23,883 Ind./m^3, while in the autumn season the density was the lowest at 500 Ind./m^3. The other seasons showed absolute absent of the larvae. The high density of midge larvae in anoxic conditions due to the presence of hemoglobin, which allow them to absorb oxygen from the water, so they can survive with very low levels of oxygen including very polluted area (Merritt & Cummins, 1996).

Damselflies nymph as well as midge larvae collected from Al-Razzaza Lake only in two seasons: spring and autumn. The spring season had the highest density with 1500 Ind./m^3, while autumn had lower density at 67 Ind./m^3. The remaining seasons, winters and summer showed that the nymphs were vanished from all collected samples. Damselfly nymph usually found in shallow clean water, as well as found in running water but they prefers the marshes, ponds and lakes (lentic systems) (Brusca & Brusca, 2003). This agrees with present study that the collected nymphs found in shore side near the aquatic plants and low water waves.

Table 4: Mean ± Standard deviation of total number of benthic macroinvertebrate species found in water samples collected from site 1 of Al-Razzaza Lake during study period

Species	Seasons				
	Winter 2013	**Spring 2013**	**Summer 2013**	**Autumn 2013**	**Winter 2014**
	Mean ± SD	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**
B. amphitrite	542.0± 15.77	956.0± 44.92	1767. 0± 528.6	2775.0± 1028.35	605.0± 233.2
C. cingulata	753.0± 64.82	966.0± 16.26	467.0± 124.35	55.0± 10.42	148.0± 53.92
M. tuberculata	3943.0± 984.7	6583.0± 1384.7	10037.0± 4620.6	10512.0± 6314.6	5302.0± 2008.3
M. costata	100.0± 4.76	579.0± 218.4	509.0± 312.68	593.0± 142.37	106.0± 26.8
Th. jordani	57.0± 28.48	377.0± 99.16	224.0± 86.92	392.0± 71.18	45.0± 11.77
H. ventrosa	3789.0± 967.35	5626.0± 1206.8	5851.0± 1524.3	7818.0± 2111.4	4000.0± 1983.6
L. auricularia	22.5± 11.8	66.0± 19.88	50.0± 14.22	58.0± 13.31	30.0± 8.69
Ph. acuta	22.0± 13.62	45.0± 20.22	49.0± 11.34	117.0± 44.32	79.0± 13.66
L. flavum	69.0± 27.14	74.0± 13.66	331.0± 86.46	180.0± 37.61	110.0± 32.61
C. fluminea	0.0±0.0	15.0± 8.84	32.0± 10.18	15.0± 7.88	6.0±0.0
U. tigridis	0.0±0.0	14.7±9.11	0.0±0.0	0.0±0.0	0.0±0.0

Midge Larvae	0.0±0.0	11934.0± 3652.6	0.0±0.0	500.0± 208.63	0.0±0.0
Damselfly Nymph	0.0±0.0	1500.0± 818.65	0.0±0.0	100.0± 15.35	0.0±0.0
Decapods (Shrimp)	8.0± 3.68	390.0± 109.7	295.0± 76.81	62.0± 9.87	11.0± 5.77
Amphipods (Scud)	6.0± 0.0	197.0± 53.44	13.0± 5.62	32.0± 8.44	5.0± 2.89
Total	9311.5	29322.7	19625	23209	10447

Table 5: Mean ± Standard deviation of total number of benthic macroinvertebrate species found in water samples collected from site 2 of Al-Razzaza Lake during study period

Species	**Seasons**				
	Winter 2013	**Spring 2013**	**Summer 2013**	**Autumn 2013**	**Winter 2014**
	Mean ± SD	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**
B. amphitrite	445.0± 14.62	711.0± 408.33	844.0± 401.22	1034.0± 882.61	400.0± 298.64
C. cingulata	1793.0± 712.6	2388.0± 1098.43	555.0± 137.51	875.0± 437.5	554.0± 332.7
M. tuberculata	1900.0± 105.39	6363.0± 2648.35	7117.0± 3425.82	1128.0± 618.2	1790.0± 886.7
M. costata	1288.0± 96.44	6647.0± 3008.24	3196.0± 1984.5	3110.0± 1357.1	1161.0± 925.3
Th. jordani	202.5± 58.26	1732.0± 864.27	1781.0± 998.26	2177.0± 988.5	579.0± 325.8
H. ventrosa	570.0± 138.92	700.0± 158.37	393.0± 121.0	1959.0± 759.4	741.0± 369.1
L. auricularia	0.0±0.0	15.0±6.88	0.0±0.0	0.0±0.0	0.0±0.0
Ph. acuta	0.0±0.0	15.0± 5.98	0.0±0.0	0.0±0.0	0.0±0.0
L. flavum	115.5± 9.84	628.0± 246.13	941.0± 529.4	330.0± 162.41	250.0± 105.88
C. fluminea	10.0± 8.68	58.0± 14.29	68.0± 33.66	45.0± 11.55	14.0± 7.18
U. tigridis	0.0±0.0	14.0±4.55	14.0± 9.33	0.0±0.0	0.0±0.0
Midge Larvae	0.0±0.0	23833.0± 1628.5	0.0±0.0	550.0± 333.3	0.0±0.0
Damselfly Nymph	0.0±0.0	887.0± 369.13	0.0±0.0	67.0± 28.51	0.0±0.0
Decapods (Shrimp)	0.0±0.0	470.0± 205.82	273.0± 94.08	128.0± 74.23	9.0± 6.42
Amphipods (Scud)	0.0±0.0	240.0± 88.97	844.0± 401.22	43.0± 11.48	4.0± 3.28
Total	6324	44701	15192	11436	5502

Table 6: Mean ± Standard deviation of total number of benthic macroinvertebrate species found in water samples collected from site 3 of Al-Razzaza Lake during study period

Species	**Seasons**				
	Winter 2013	**Spring 2013**	**Summer 2013**	**Autumn 2013**	**Winter 2014**
	Mean ± SD	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**
B. amphitrite	357.0± 44.68	663.0± 312.63	858.0± 411.7	996.0± 531.7	313.0± 135.7
C. cingulata	2152.0± 396.81.	3914.0± 1436.7	682.0± 294.51	1024.0± 753.9	2207.0± 1008.3
M. tuberculata	3807.0± 1860.5	6518.0± 3084.7	4549.0± 2306.83	1817.0± 1006.5	2258.0± 1444.7
M. costata	769.0± 122.55	7583.0± 3751.3	5207.0± 3366.7	1633.0± 998.7	652.0± 324.16

Th. jordani	716.0± 153.66	2188.0± 824.6	836.0± 264.8	959.0± 793.18	944.0± 437.7
H. ventrosa	616.0± 284.24	758.0± 300.7	493.0± 222.7	2508.0± 1306.7	1209.0± 731.6
L. auricularia	0.0±0.0	14.0± 5.66	0.0±0.0	0.0±0.0	0.0±0.0
Ph. acuta	0.0±0.0	14.0± 4.82	0.0±0.0	0.0±0.0	0.0±0.0
L. flavum	146.0± 72.72	663.0± 298.67	857.0± 506.7	353.0± 192.2	260.0± 159.7
C. fluminea	11.0± 11.9	59.0± 26.84	67.0± 33.3	47.0± 13.5	14.0± 8.62
U. tigridis	0.0±0.0	15.0± 6.67	15.0± 9.84	0.0±0.0	0.0±0.0
Midge Larvae	0.0±0.0	22317.0± 9642.7	0.0±0.0	563.0± 369.7	0.0±0.0
Damselfly Nymph	0.0±0.0	853.0± 579.3	0.0±0.0	67.0± 26.28	0.0±0.0
Decapods (Shrimp)	0.0±0.0	453.0± 200.5	232.0± 202.12	145.0± 78.43	10.0± 0.0
Amphipods (Scud)	0.0±0.0	240.0± 152.8	12.0± 4.88	40.0± 20.84	4.0± 3.56
Total	8574	46252	13808	10152	7871

Seasonal variation of benthic macroinvertebrates varies from season to another and varies among sites. The abiotic factors that influencing invertebrate's abundance and distribution on aquatic environment are: substrate, temperature, DO, pH and salinity (Ward, 1992).

Winter 2013 showed a high variation in benthic density among species. In site 1 the two species *M. tuberculata* and *H. ventrosa* the both snails showed the highest percentage among all benthos near 45%, while the other benthos showed a percentage lower than 10%. In sites 2 & 3 the two species *M. tuberculata* and *C. cingulata* had the highest percentage at (40 and 20) %, respectively. The other species of the benthic community showed a percentage closed to 10%. As described in fig. (2).

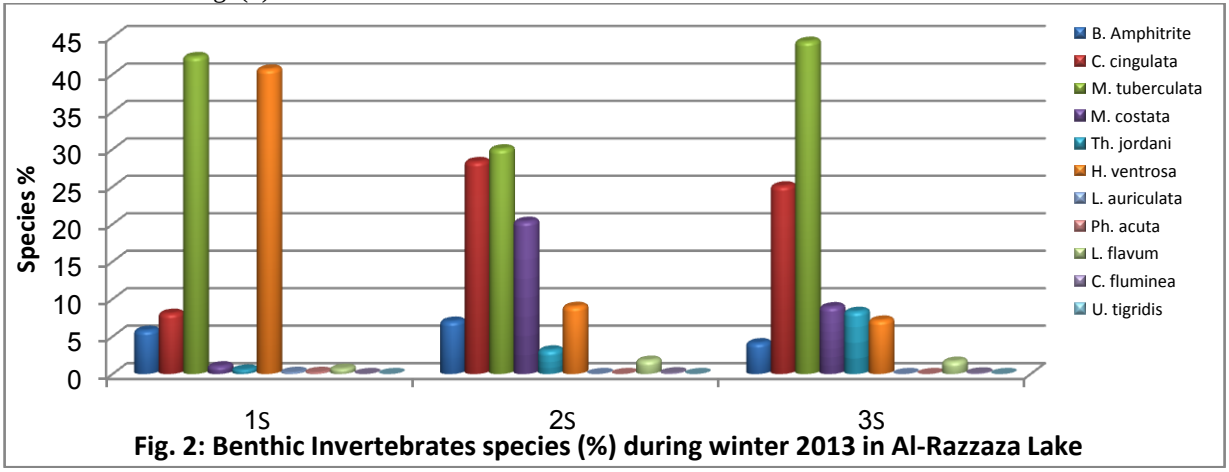

Fig. 2: Benthic Invertebrates species (%) during winter 2013 in Al-Razzaza Lake

The water parameters in winter, for water temperature, salinity, pH and others are suitable for the density of the three species *M. tuberculata; H. ventrosa* and *C. cingulata*. These had the highest density among all other benthic species. The water temperature around 17 ^{0}C is not the perfect temperature for reproduction of the adults as well as their larvae. As showed in the figure (2) the density of both species *M. tuberculata* and *H. ventrosa* were higher in site 1 comparing to the other two sites 2 & 3 and that due to the structure of the substrate which showed more silt and clay content in site 1 than the other sites with no gravel content, they prefer mudy silty sediment.

Spring season showed that the remain two species (*M. tuberculata* and *H. ventrosa*) at higher density than the other species of snails which had density around 5%. While the clams had the increase in the density of *L. flavum* to reach 5%, and the two clams less than 0.3%. As showed in figure (3).

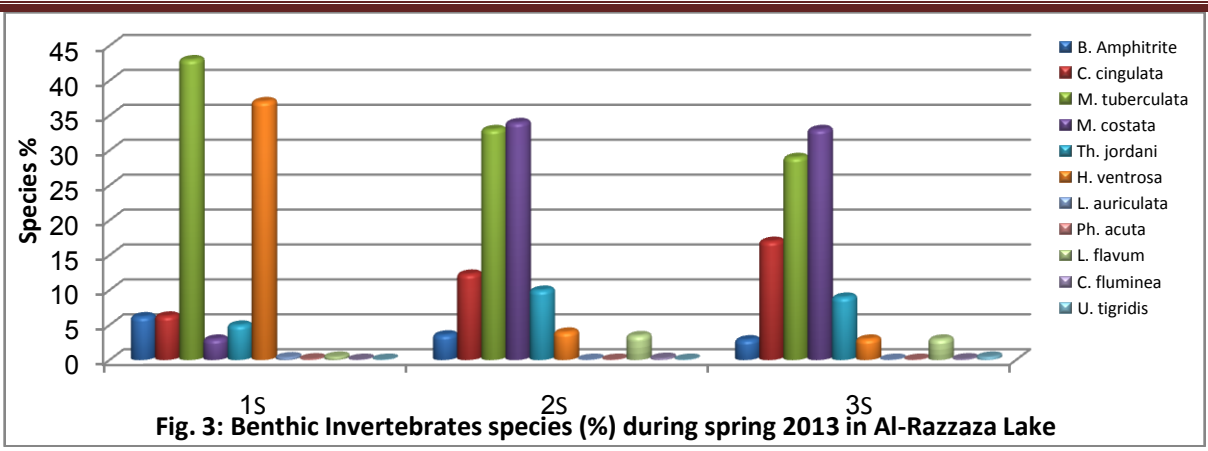

Fig. 3: Benthic Invertebrates species (%) during spring 2013 in Al-Razzaza Lake

In general all the species of snails and clams had increased in density in this season at study sites, the water temperature around 22^0C that considered the best temperature for microfauna growing and the growth of phytoplankton increased that considered the food item for molluscs, that reflect the raising of all species in spring than winter.

In summer season the DO concentration reach its lowest value around 4.0 mg/l with the salinity that reaches its highest value above 2.5 ppt. beside the peak of water temperature to reach 30 ^{0}C. These factors leading to the decrease of density for all species, except the species *M. tuberculata*. Fig. (4).

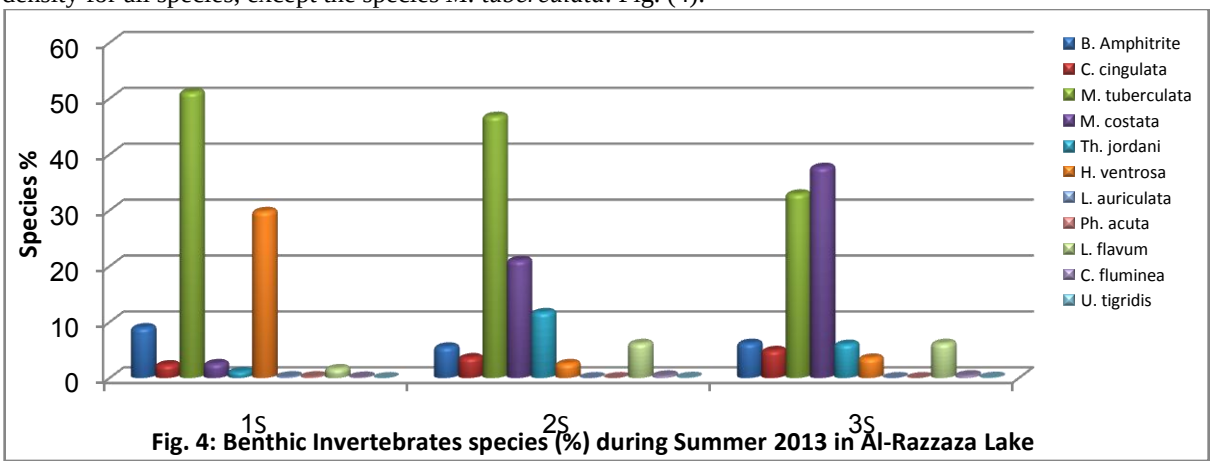

Fig. 4: Benthic Invertebrates species (%) during Summer 2013 in Al-Razzaza Lake

M. tuberculata increased to more than 50% in the summer, due to the snail ability to survive in severe conditions with high temperature and high salinity.

Autumn season revealed a raise up in density for the benthic community. The *M. tuberculata* and *H. ventrosa* still the highest density among all gastropods in site 1. While in the two other sites 2 & 3, the gastropods density were close to each other with small differences, as showed in fig. (5). for the clams, the *L. flavum* remain in the higher density than the other two clams, as well as higher in the sites 2 & 3 than site 1.

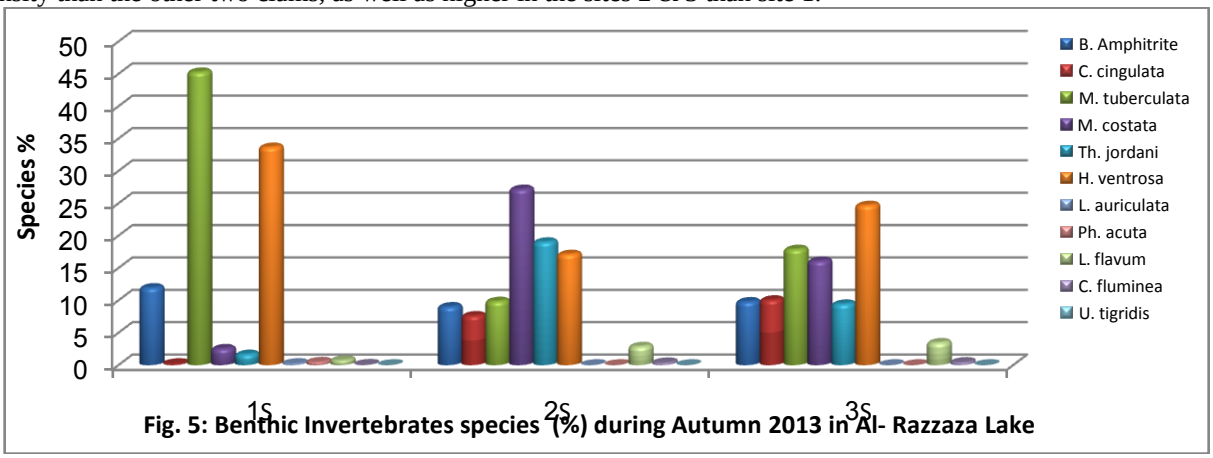

Fig. 5: Benthic Invertebrates species (%) during Autumn 2013 in Al- Razzaza Lake

Winter 2014, the mollusc's community returns to the situation of winter 2013. For site 1 the *M. tuberculata* and *H. ventrosa* had the highest density above 40%. While the other species were less than 5%. As showed in fig. (6). While in the sites 2 & 3, the gastropods species where closed to each other between (10 – 30) %. For the clams, *L. flavum* had higher density of 4% and the remained two clams less than 0.25%.

In all study period the *M. tuberculata* had a higher density than *M. costata* at all study sites, this agrees with findings of Al- Salman (1996) when study the benthic community of Garmatt Ali and found that the *Melanoides* had a higher density than the *Melanopsis* around all months of his study.

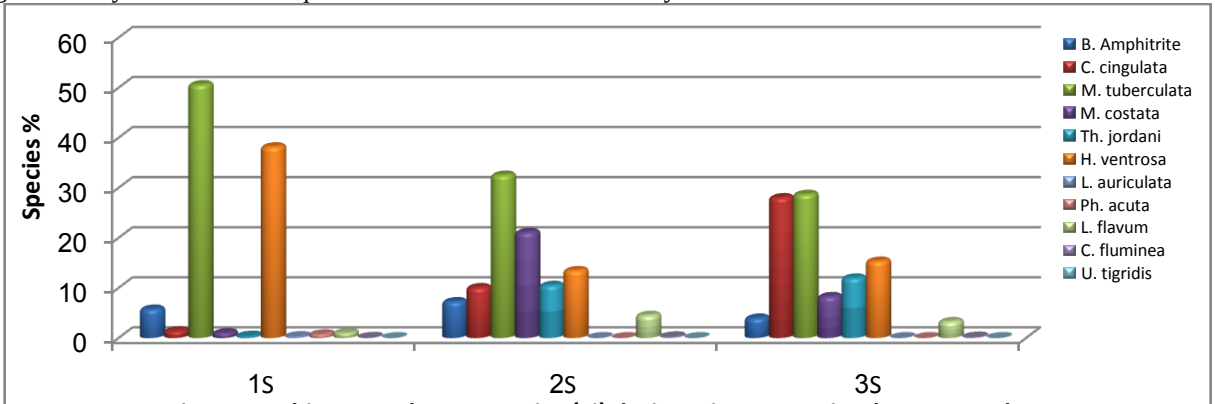

Fig. 6: Benthic Invertebrates species (%) during winter 2014 in Al-Razzaza Lake

Shannon – Wiener Diversity Index (H):

Benthic macroinvertebrates revealed a value of diversity between 1.22 in winter 2014 to value of 1.95 in autumn (table 7). Normal H index values are (0 – 4), the values less than one indicating poor water quality, while values between 1 to 3 reflect moderate water quality, and above 3 considered as good water quality for the studied environment. According to this classification the water quality of Al-Razzaza Lake is moderate water quality.

In some previous studies of Iraqi marshes, Al- Saffar (2006) recorded diversity with range of zero to 2.083 for Abu Zirig marsh. While the other southern marshes (Al – Hawizah; Al – Chibaysh and Al – Hammar) the diversity index values were (0.194 – 1.083) (Sebtie, 2009).

Diversity index of some lakes around the world was less than 3. This agrees with the present study as well as the marshes in Iraq; although these lakes and the Iraqi marshes with Al-Razzaza Lake were different form each other in their water parameters and ecological conditions. The Huron Lake had H value among (0.82 – 1.2) (Bruno *et al.* 2007). While Varana – Beloslav Lake in Belgaum have the diversity values (1.2 – 1.7) (Thorp & Covich, 2001). Veli and Kadinamkulam Lakes in India were (0.27 and 2.33) respectively (Latha & Thanga, 2010).

Many factors influence the community structure of benthic macroinvertebrates including: water temperature, light penetration, TSS and humus content (Reeves *et al.*, 2008). Beside the findings of Remple *et al.* (2000) that sediment particles size affected the benthic structure and density. This agrees with present study, when the species *H. ventrosa* found in higher density in site 1 (loamy soil) comparing to the other sites 2 & 3 (sandy soil).

Table 7: Shannon – Whiner Diversity Index (H) for Benthos species of Al-Razzaza Lake during study period

	S 1	S 2	S 3
Winter 2013	1.37	1.74	1.64
Spring 2013	1.48	1.60	1.65
Summer 2013	1.38	1.63	1.67
Autumn 2013	1.35	1.90	1.95
Winter 2014	1.22	1.88	1.83

Conclusion:

1- The only source of water input to the lake is Karbala trocar.

2- The water of Al-Razzaza Lake during the study period was cool to warm water. The pH is slightly acidic to slightly alkali. The lake water salinity is slightly brackish water. The dissolved oxygen content in acceptable limits. And the lake water is very hard.

3- The benthic macroinvertebrates includes: (A) Mollusca includes gastropods (*Melanopsis costata; Melanoides tuberculata; Cerithidae cingulata; Theodoxus jordani; Hydrobia ventrosa; Lymnaea auricularia* and *Physa acuta)* and bivalves *(Laevicardium flavum; Corbicula fluminea* and *Unio tigridis*). (B) Arthropods are two groups; the crustaceans (Decapoda *Metapenaeus* spp. (shrimp); Amphipoda *Gammarus* spp. (scud) and *Balanus amphitritis*). The insects are (midge larvae & damselfly nymphs).

4- The benthic macroinvertebrates species varied in their density from species to species, as well as from season to season. The *M. tuberculata; H. ventrosa* and *M. costata* had the highest density among all benthos.
5- Al-Razzaza Lake had a moderate diversity according to Shannon – wiener diversity index.
6- In general the invertebrates of the lake are not submitted to high environmental stressors according to uniform index.
7- Al-Razzaza Lake water quality is fair to mid – quality water.

Recommendations:

1) Create a monitoring program for Al-Razzaza Lake, to continuous the evaluation of water quality and invertebrates content of the lake, beside other vertebrate's that inhabiting the lake.
2) Make a manual containing all types of living organisms that inhabit the lake dominantly and temporary.

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