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Seasonal variation in physico-chemical properties and zooplankton biomass in Greater Zab River -Iraq

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Abstract

Seasonal variation of zooplankton biomass has been carried out at two selected sites on Greater Zab River. Monthly samples of water were collected during period from January to December 2008. Some physico-chemical properties of water were studied including water temperature (from 8 to 30.5 °C), hydrogen ion concentration (from 6.3 to 8), EC (from 255 to 821 $\mu s.cm^{-1}$), turbidity (10- 85 NTU), dissolved oxygen (from 4.2 to 12.35 $mg.l^{-1}$), BOD_5 (from 0.6 to 24 $mg.l^{-1}$), COD (from 15 to 294 $mg.l^{-1}$), ammonium level (from 0.51 to 1.66 µg NH_4-$N.l^{-1}$), nitrite (from 29.1 to 71.3 µg $NO_2^-N.l^{-1}$), nitrate (from 112.9 to 327.4 µg $NO_3^-N.l^{-1}$), reactive phosphate (from 195.7 to 558 µg PO_4-$P.l^{-1}$) and calcium concentration (from 24.7 to 72 $mg.l^{-1}$). Concerning planktonic communities, the results showed that the total zooplankton number was ranged from 100 $individuals.l^{-1}$ to 6650 $individuals.l^{-1}$ and the total phytoplankton population was 18773 $cell.l^{-1}$ to 269448 $cell.l^{-1}$. Statistical analysis showed that there was a positive correlation between total count of zooplankton and total count of phytoplankton during studied period with r = 0.38 in site (1) and r = 0.31 in site (2). However, the results of water quality of Greater Zab River showed that the values of WQI were 66.15% and 64.61% respectively in both studied sites which can be considered as fair according CCME (2001) and medium according EU (1975).

الملخص

تم دراسة التغيرات الفصلية لمجتمع الهائمات النباتية و الحيوانية في موقعين على نهر زاب الكبير. جمعت العينات شهرياً خلال فترة كانون الثاني الى كانون الاول 2008. وقد تم دراسة بعض الصفات الكيمياوية والفيزياوية للماء وكانت النتائج على النحو التالي: درجة حرارة الماء (تراوحت من 8 الى 30.5)، تركيز ايون الهايدروجيني (تراوحت من 6.3 الى 8)، التوصيل الكهربائي (تراوحت من 255 الى 821 ميكروسمنز/سم)، عكورة المياه (10 الى 85 وحدة عكورة)، الاوكسجين المذاب (4.2 الى 12.35 ملغم/لتر)، المتطلب الحيوي للاوكسجين (0.6 الى 24 ملغم/لتر)، المتطلب الكيمياوي للاوكسجين (15 الى 294 ملغم/لتر)، امونيا (0.51 الى 1.66 ميكرو غرام NH4-N/لتر)، نتريت (29.1 الى 71.3 ميكرو غرام NO2- N/لتر)، نترات (112.9 الى 327.4 ميكرو غرام NO3- N/لتر)، الفوسفات (195.7 الى 558 ميكرو غرام PO4- P/لتر) وتركيز ايون الكالسيوم (24.7 الى 72 ملغم/لتر). اما بالنسبة الى دراسة كتلة الهائمات، فان النتائج اوضحت بان مجموع الهائمات الحيوانية كانت تتراوح بين 100 فرد/لتر الى 6650 فرد/لتر ومجموع الهائمات النباتية كانت تتراوح بين 18773 خلية/لتر الى 269448 خلية/لتر، كما ظهرت احصائيا بان هناك علاقة موجبة بين اعداد الهائمات الحيوانية والنباتية حيث كانت قيمة r= 0.38 للموقع الاول و r= 0.31 للموقع الثاني. كما ان نتائج اختبار نوعية المياه اعتماداً على (EU, 1975) و (CCUM, 2001) اوضحت بان قيمة تقيم نوعية المياه كانت 66.15% و 64.61% على التوالى في كلا من محطتي الدراسة كوركوسك و جمة دبس.

Keywords: Zooplankton, Phytoplankton, Physico-chemical properties, Water quality, Greater Zab River.

1. Introduction

Zooplankton is tiny animals found in all aquatic ecosystems, particularly the pelagic and littoral zones in the ocean, also in ponds, lakes, and rivers. They are classified by size and/or by developmental stage. Size categories include: **picoplankton** that measure less than 2 micrometers, **nanoplankton** measure between 2 - 20 micrometers, **microplankton** measure between 20 - 200 micrometers, **mesoplankton** measure between 0.2 - 20 millimeters, **macroplankton** measure between 20 -200 millimeters, and **megaplankton**, which measure over 200 millimeters (Lynn, 2007).

The zooplankton community is composed of both primary consumers (which eat phytoplankton) and secondary consumers (which feed on the other zooplankton). They provide a direct link between primary producers and higher trophic levels such as fish. Nearly all fish depend on zooplankton for food during their larval phases, and some fish continue to eat zooplankton in their entire lives (Madin *et al.*, 2001).

Many studies on zooplankton community and grazing with phytoplankton were conducted in different parts of the world. Merrick and Ganf (1988) made a study on effects of zooplankton grazing on phytoplankton communities in Mt Bold Reservoir in Australia. Zooplankton grazing on bacteria and phytoplankton in

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Nakdong River was carried out by Kim *et al.* (2000) in Korea. However, Tan *et al.* (2004) made an investigation on seasonal variation in zooplankton composition and grazing impact on phytoplankton in Pearl River estuary in China. The present investigation aimed to study the seasonal variations of zooplankton and its relations to phytoplankton, in addition to study of some physio-chemical properties and water quality of Greater Zab River.

2. Material and Methods

2.1. Study area

Greater Zab River is a large river (392 km) in Iraq. This river is one of the main tributary of the Tigris. It is originated mainly from mountainous area of Iran and Turkey. It is situated between 36°-37° north latitudes and 43°-44° east longitude (Susa, 1960). During this study samples were collected in two sites; the first was located near Kaurgosk village and second was located at Chamadbz village about 20 Km from site one (Fig. 1).

2.2. Sampling

Samples for physical, chemical and biological variables were performed from two sites during period extended from the January to the December 2008. Water samples were collected for chemical and biological analysis using pre-washed polyethylene bottle by water sample twice before filling.

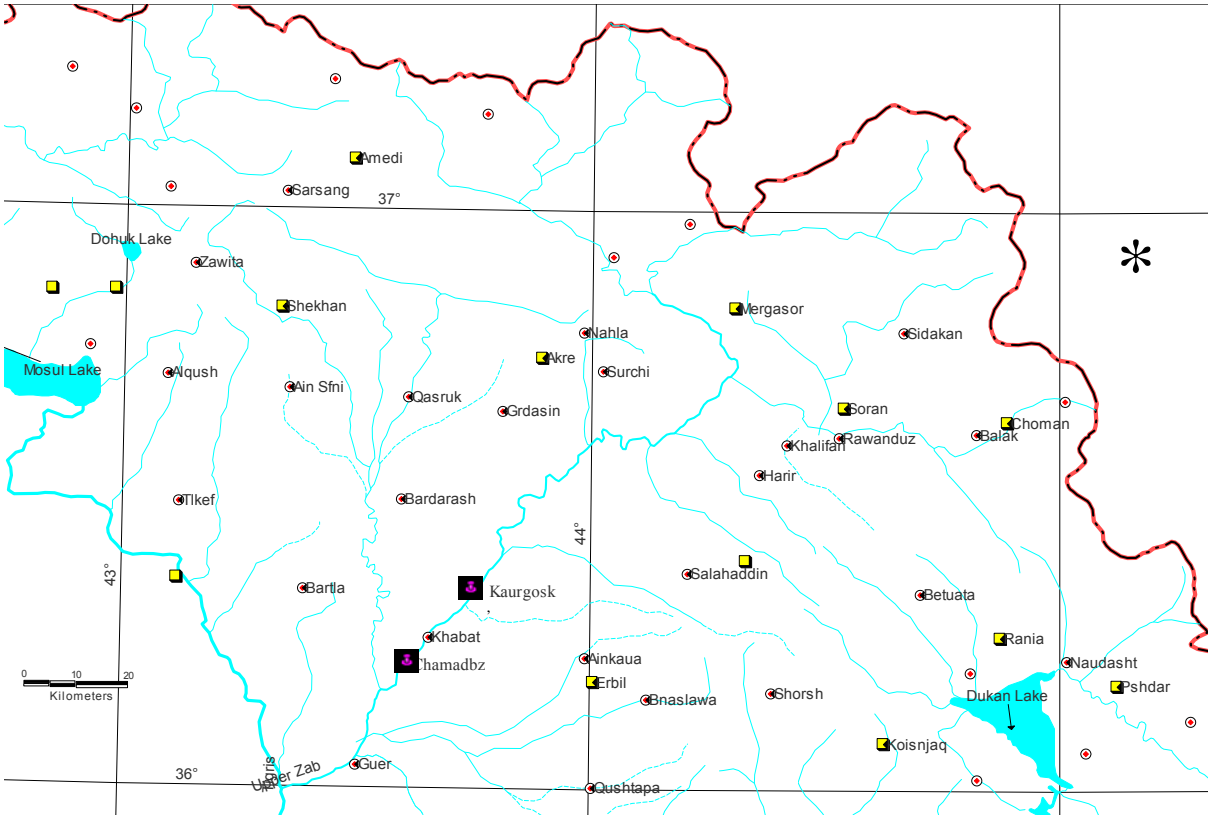

Fig. (1) Map of Iraq showing the studying sites on Greater Zab River

The studied physico-chemical parameters:- water temperature (by using precise mercury thermometer), hydrogen ion concentration (by using pH-meter), electrical conductivity (by using EC-meter), turbidity level (by using turbidity-meter), dissolved oxygen (titrimetric methods), biological and chemical oxygen demand (titrimetric methods), ammonium, nitrite and nitrate-nitrogen, reactive phosphate (by using spectrophotometric methods) and calcium ion content(by using titrimetric methods) were measured according to A.P.H.A. (1998).

Empirical equation was described by (Sanchez *et al.*, 2007) were used for water quality index evaluation:-

$$WQI = k\frac{\sum_i CiPi}{\sum_i Pi} \quad (1)$$

Where:

K= is a subjective constant

Ci= is the normalized value of the parameter

Pi= is the relative weight assigned to each parameter.

The obtained results of the equation were compared with the Canadian and European standard for surface water quality.

Enumeration of phytoplankton was conducted based on a modification of the membrane filtration technique of McNabb (1960), Hinton and Maulood (1979). The phytoplankton was counted by using Olympus compound

microscope, the number of algal cell per liter was calculated by the following formula:

Total No. of phytoplankton (cell/l) =
(D * area of filter)/(area of 30 fields * liter of sample filtered)
D = total count of 30 fields

Zooplankton sample were collected by filtering 30 liter of the river water using plankton net (55 µm mesh size), concentrated sample were fixed with 5% formalin.

Counting of zooplankton samples was undertaken in the laboratory using a compound microscope and the following references were used:-Edmondson (1959), Scourfield and Harding (1966) and Smith (2001). The results expressed as individual.l^{-1}.

2.3. Statistical analysis:

Statistical analysis of physico-chemical data was done using Completely Randomized Design (CRD) to study the effect of different site and date of sampling, and LSD values were calculated to compare between each of ecological data. Also, simple correlation analysis was done between total count of zooplankton and total count of phytoplankton (Snedecor and Cochran, 1980).

3. Results:-

In this study, a number of phisco-chemical parameters were studied (Table 1). Water temperature of studied sites during studied period was ranged between 8 to 30 ˚C, and statistically the regional and monthly variation showed non significant differences ($p< 0.05$).

Hydrogen ion concentration of studied river in studied sites was ranged from 6.3 to 8. Statistical analysis showed that pH value was significantly different ($P< 0.05$) between studied sites and date of sampling.

Electrical conductivity of studied sites ranged between 255 to 821 µs.cm^{-1}, and the results showed that there was a significant difference ($P< 0.05$) between studied sites and time of sampling.

Turbidity levels revealed that they were obviously significant differences ($p<0.05$) during studied period it was ranged between 10 to 85 NTU.

Dissolved oxygen concentrations were ranged from 4 to 12.35 mg.l^{-1} . The statistical analysis showed that there was no significant differences ($p< 0.05$) were observed between studied sites.

The results were revealed that the BOD_5 in both studied sites was ranged between 0.6 to 24 mg.l^{-1}. While, COD value was ranged from 15 to 294 mg.l^{-1}, and the statistical analysis showed that there was a significant differences ($p<0.05$) between studied site and sampling date.

Data of ammonia, nitrite and nitrate nitrogen indicated significant differences ($p< 0.05$) between studied sites and sampling date. Ammonia level was ranged from 0.51 to 1.66 µg NH_4-N.l^{-1}. While, nitrite was ranged between 29.1 to 71.3 µg NO_2-N.l^{-1} and nitrate ranged between 112.9 to 327.4 µg NO_3-N.l^{-1}.

Phosphate content of studied river was ranged from 195.7 to 558 µg PO_4-P.l^{-1}, and statistically the results showed significant differences ($p< 0.05$) between the studied sites.

Table (1): Physico-chemical properties of Greater Zab River, data represented as mean ± S.E., with minimum and maximum value from January to December 2008.

Studied parameters	Kaurgosk	Chamadbz
Water Temperature (C°)	19.54 ± 0.71 10-26.5	19.06 ± 0.905 8-30.5
Hydrogen ion concentration	7.31 ± 0.007 6.3-8	7.16 ± 0.004 6.74-7.89
Electrical conductivity	1127.08 ± 65.9 283-821	442.5 ± 35.7 255-711
Turbidity level (NTU)	40.08 ± 13.21 10-85	48.16 ± 7.40 16-80
Dissolved oxygen (mg/l)	9.54 ± 0.25 6.5-11.34	9.36 ±0.34 4-12.34
BOD_5 (mg/l)	3.71 ± 1.98 0.6-23	3.80 ± 1.96 0.8-24
COD (mg/l)	91 ± 28.1 15-280	98 ± 26.7 15-294
NH_4 (µg NH_4-N/l)	0.92 ± 0.09 0.51-1.06	0.98 ± 0.09 0.7-1.66
NO_2 (µg NO_2-N/l)	50.2 ± 3.60 29.1-65	50.8 ± 3.58 29.1-71.3
NO_3 (µg NO_3-N/l)	208.4 ± 25.1 112.9-327.4	233.7 ± 26.2 135.4-293.5
PO_4 (µg PO_4-P/l)	424.21 ± 26.58 212.1- 515.5	393.1 ± 25.37 195.7- 558
Calcium concentrations (mg/l)	38.45 ± 3.78 27.4-72	42.4 ± 4.27 24.7-67

Calcium concentration of studied Zab was ranged from 24.7 to 72 mg.l^{-1}, and it is variations showed significant differences ($p< 0.05$) among studied sites and sampling date.

Concerning to biological study, the results showed that the total count of phytoplankton ranged between 18773 to 269446 cell.l^{-1}. Higher number of phytoplankton was observed in site (2) during September 2008, while lower number was recorded in the same site during June 2008. However, the total count of zooplankton was ranged from 100 to 6650 individual.l^{-1}. Higher number of zooplankton was recorded in site (1) during November 2008, whereas lower number was observed in site (2) during January 2008. From the statistical analysis observed that there is a positive correlation between total count of zooplankton and total count of phytoplankton with $r =0.38$ and $r = 0.31$ in both site respectively.

The result of water quality assessment showed that the value WQI were 66.15% in site (1) and 64.61% in site (2).

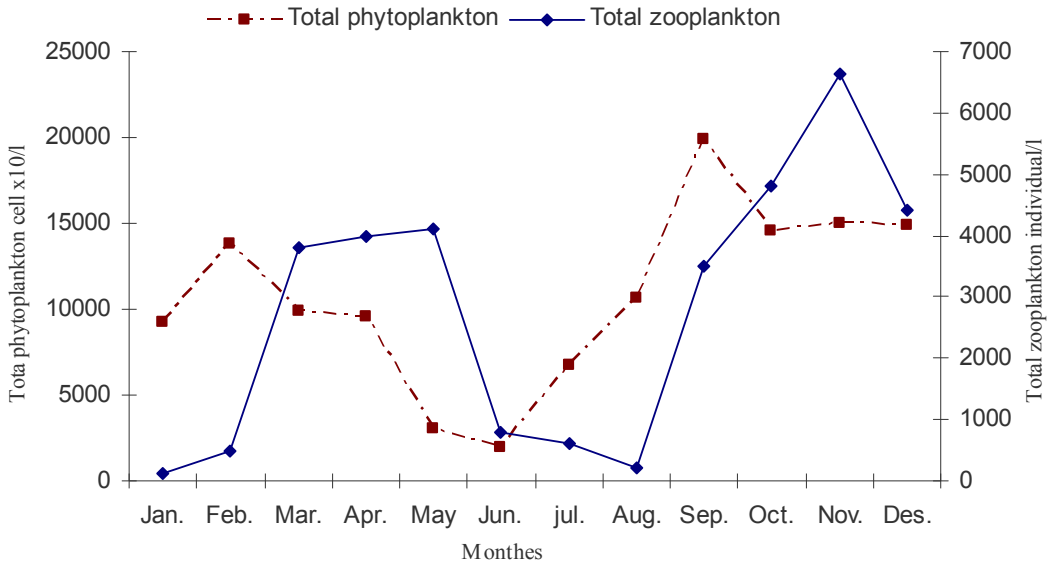

Fig. (2)Relationship between total zooplankton and total phytoplankton in site (1) during study period

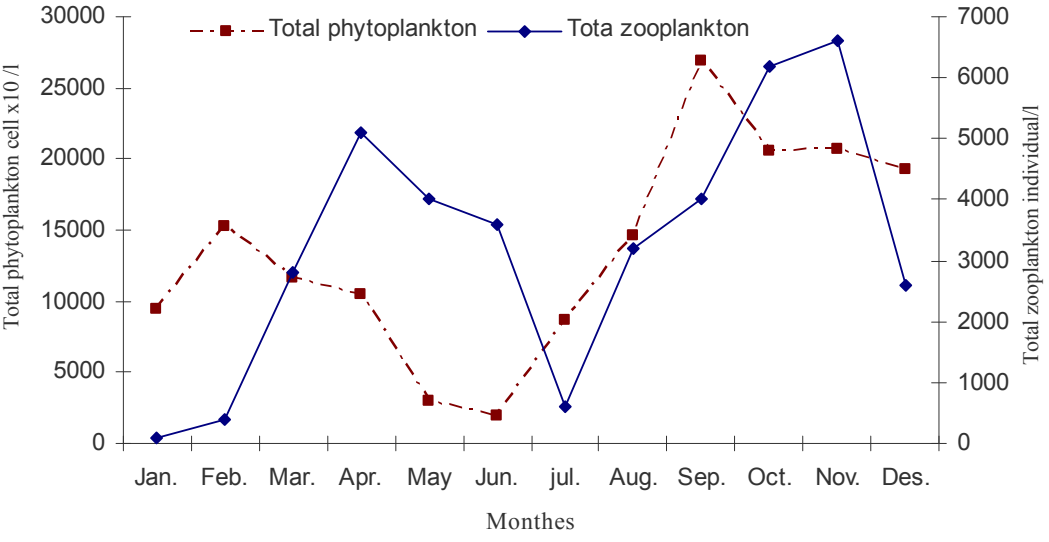

Fig. (3)Relationship between total zooplankton and total phytoplankton in Chamadbz during study period

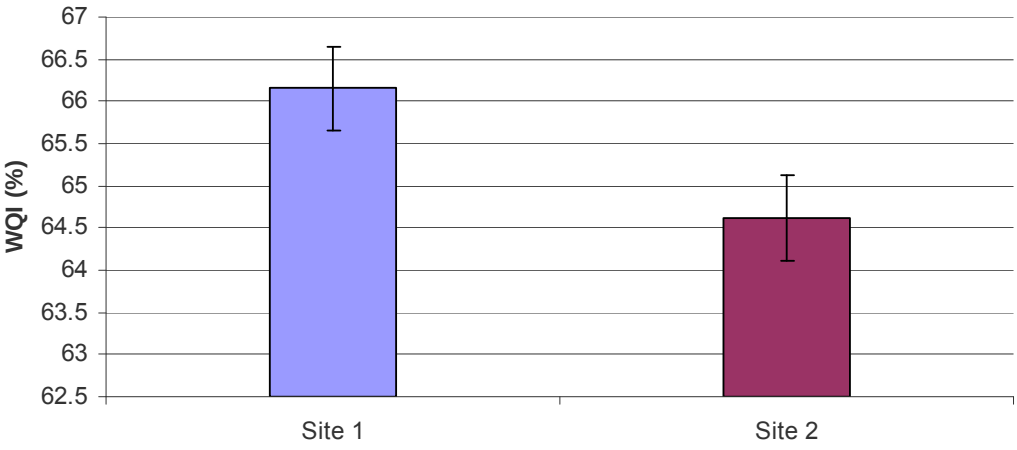

Fig. (4) Water quality index in Greater Zab River (value as mean)

4. Discussion:-

Water temperature is an important factor in any aquatic environments affecting on biological processes, in this study it was ranged between 8 to 30.5 ˚C. This variation may be due to changes in air temperature, and this result was similar to previous studies done by Ali (2007) and Shekha (2008). The pH value of Greater Zab River in study sites during of most studied period was alkaline side above 7, and this result agreed with Maulood *et al.* (1980) they reported that Iraqi inland water is regarded to be on the alkaline side of neutrality, reflecting geological formations of the area and the results are agree with the finding that recorded by Ali (2007) and Shekha (2008) in the same river. Electrical conductivity used as an indicator of water quality based on total dissolved salts (Rasheed, 1994). Generally, EC value was less than 500 µs.cm^{-1} in most of studied period in both sites and the results came in accordance with the known EC value for Iraqi inland water (Al-Naqshbandi, 2002). On the other hand, lower level of turbidity was 10 NTU recorded in June, while the higher level was observed during september 2008 which may be due to the increase of planktonic algal growth (Antoine and Alsaadi, 1982).

Oxygen content of water is one of the important factors, and it is very necessary for all living organisms (WHO, 2006). The DO content of studied river was ranged between 4 to4- 12.35 mg.l^{-1}. However, BOD_5 and COD values were ranged between 0.6 – 24 mg.l^{-1} and 15 – 294 mg.l^{-1}, respectively. Generally, high value of BOD_5 and COD were observed during the warm sommer months (July and August) which coincided with a high water temperature and low DO. These results were slightly lower than that reported by Shekha (2008) at the same river.

Ammonium nitrogen is commonly used as an indicator for organic matter content, while nitrite is another source of inorganic nitrogen and concerning as an indicator of water pollution. The high level of nitrite may be due to domestic sewage input to the river from the surrounding village. Nitrate is the stable form of combined nitrogen and it is an important factor which might limit growth of phytoplankton (ref.…). The results of ammonia, nitrite and nitrate nitrogen are agreed with those of Ali (2007) and Shekha (2008). Phosphorus is essential to the growth of algae and other biological organisms. The reactive phosphate concentration in studied river was ranged between 195.7 to 558 µg PO_4-P.l^{-1}. The high concentration of phosphate may be due to sewage water effluent and fertilizer application in surrounding agricultural area. This result was close to that reported by Shekha (2008). Calcium concentration in the studied Zab was ranged from 24.7 72 mg.l^{-1}. The present result was similar to that reported by Ali (2007), and it was lower than that reported by Al-Kubasi (1996).

Concerning to phytoplankton community, the results showed that the range of total phytoplankton population was 18773 cell.l^{-1} to 269448 cell.l^{-1}. Diatoms were the most dominant group of phytoplankton in the studied river, with dominancy of ***Cyclotella*** *sp.* in both sites. The total zooplankton population was from 100 individual.l^{-1} to 6650 individual.l^{-1} with mean value of 3266.7 ± 95.24x10^3 individuals.l^{-1} in site (1) and 2782.1 ± 102.01x10^3 individual.l^{-1} in site (2), which was lower to the value reported by Ahmed *et al.* (2004) and Chowdhury *et al.* (2007). Crustacea was dominant group among zooplankton especially Copepods with the dominancy of ***Eucyclops*** *sp.* in both sites during studied period. Similarly Patra and Azadi (1987) reported same result in Hulda River and Ali (2007) and Shekha (2008) also reported similar results in the greater Zab River. In site (1) zooplankton showed two main peaks, one extended from March to May and another one in November. In site (2) the first peak was in April to June the other one from October to November. The lower value of zooplankton was 100 individual.l^{-1} observed in site (2) during January 2008, and this may be due to decrease of phytoplankton number in which zooplankton grazing on it, in addition to low temperature during cold winter months. These results agreed with those results reported by Das and Srivastava (1956) in a pond in India and Chowdhury *et al.* (2007) in Borobila beel. Razzaque *et al.* (1995) reported that the zooplankton showed two peaks, one in the May and another in the October in Halti Beel. Both zooplankton and phytoplankton showed direct

grazing relationship with r = 0.38 in Kaurgosk and r = 0.31 in Chamadbz (Fig. 2, 3). Similar relationship was also reported by Ali *et al.* (1985) in a Lucknow pond in India, Patra and Azadi (1987) in Halda River, Chowdhury *et al.* (2007) in Borobila Beel.

The results of the seasonal variation in zooplankton population suggest that the most favourable period for growth is from the August to the November, and this may be due to increase of phytoplankton population. The same phenomenon was reported by Razzaque *et al.* (1995) and Ehshan *et al.* (2000).

Regarding to the evaluation of the water quality with using of WQI, the results showed that the values of WQI were 66.15% in site (1) and decreased to 64.61% in Chamadbz. Taking in to account both the points sampled, the water from Greater Zab River may be classified as fair (Grade D) depending on the classification of CCME (2001), meanwhile according to EU (1975) classification of water of both sites can be regarded as medium (Fig. 4).

Further study should be conducted on seasonal variation of zooplankton and phytoplankton in relation to some other parameters as water temperature, nutrients and pollution should be taken in Greater Zab River.

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