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Research Article

Physio-chemical Propreties and Rotifera Population Density of Darbandikhan Lake, Kurdistan-Iraq

Sherko A. Muhammad and Ahmed F. Ali
Biology Department, College of Science, University of Sulaimani, Kurdistan Regin, Iraq

Abstract: Water samples were collected at regular monthly interval periods beginning in November 2009 to June 2010. The study of Rotifera community has been carried out at five sites including: downstream of the Darbandikhan Lake (Lake Outlet), near the dam (500 m), left shoreline of the Lake, Sirwan River and Tangero River. The physical and chemical properties of water were studied including: water temperature (from 11.9 to 25.5ºC), pH (from 6.55 to 8.60), EC (from 289 to 683 µs/cm), T.D.S (from 184.90 to 437.10 mg/L), DO (9.5 to 1.8 mg/L), BOD_5 (from 0.20 to 8.50 mg/L), Turbidity (from 0.70 to 68.90 NTU) and Total hardness (from 120.10 to 355.5 mg/$CaCO_3$/L). While 14 genus of Rotifera were recorded, the density of Rotifera in the studied sites showed wide fluctuations in their occurrence. It was ranged from 4 to 134 ind/m^3. The lower value was recorded in site 5 during January and the higher number was recorded in site 2 during May 2010.

Keywords: Darbandikhan Lake, physico-chemical properties, rotifera density

INTRODUCTION

The rotifers are among the most common inhabitants of freshwater everywhere. Some also live in brackish water and few in the ocean or on land in damp sites (Jordan and Verma, 2009). Rotifers are obligate aquatic animals that are reputed to have particularly efficient mechanisms to survive extreme or prolonged periods of drought, in the form of inconspicuously small resting stages, hidden between plant litter and sediment (Segers and Shiel, 2008). Rotifers have been known for about 300 years. Approximately more than 400 species have been identified worldwide, but less than 5% are found in marine and brackish water and they occur in variety of aquatic and semiaquatic habitats, on all continents including Antarctica (Ried, 1961).

An important feature of the life cycles of rotifers is the presence of resting egg stage. Resting eggs are easily transported by birds, water and wind and for this reason many rotifers are considered to be potentially cosmopolitan in distribution (Hutchinson, 1967).

As components of the zooplankton, because rotifers are small (40 µm-2mm long), they generally have less individual biomass than micro crustaceans. However because they can reproduce rapidly, rotifers can account for (15-67%) of total zooplankton production (Muhammad, 2004). Rotifers play a significant role in the ecology of some lakes as grazers suspension feeders, bacteriovores, detritus feeder and predators (Aronovich and Spektova, 1974).

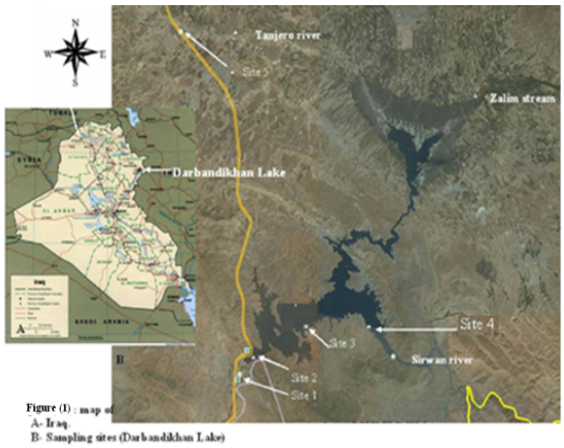

Fig. 1: Map of: A- Iraq, B- sampling sites (Darbandikhan Lake)

Most planktonic rotifers feed on algae or particles less than 20 µm long, although some species can ingest cells up to 48 µm long, algivorous rotifers can be highly selective feeders (Erdugan and Guher, 2005).

MATERIALS AND METHODS

Study area: Darbandikhan dam is located about 65 km southeastern of Sulaimani city, Kurdistan region, in the north of Iraq and 230 km northeast of Baghdad. It is situated between 35º-36º north latitude and 45º- 46º east longitudes (Fig. 1). Darbandikhan dam is located on the

Corresponding Author: Sherko A. Muhammad, Biology Department, College of Science, University of Sulaimani, Kurdistan Regin, Iraq

Table 1: Some physical-chemical properties of water samples (according to the site of sampling), data represented as (mean±S.E.) with minimum and maximum values, during study period

Variables	Site 1	Site 2	Site 3	Site 4	Site 5
Water temperature (ºC)	14.06±0.300^{c}	14.05±0.300^{c}	17.90±0.300^{b}	13.75±0.300^{c}	21.94±0.300^{a}
	11.90-17.000	13.00-14.900	125.00-19.000	13.00-15.000	18.80-25.500
pH	7.02±0.132^{b}	7.08±0.132^{b}	7.13±0.132^{b}	7.51±0.132^{b}	8.15±0.132^{a}
	6.55-7.200	7.00-7.200	7.00-7.500	7.20-7.800	7.80-8.600
EC (µs/cm)	326.75±12.437^{d}	358.25±12.437^{cd}	362.25±12.437^{cd}	373.62±12.437^{c}	495.00±12.437^{b}
	289.00-381.000	300.00-482.000	299.00-427.000	311.00-411.000	348.00-683.000
T.D.S (mg/L)	209.00±7.990^{d}	229.24±7.990^{cd}	231.79±7.990^{cd}	233.36±7.990^{c}	316.76±7.990^{b}
	184.90-243.800	192.00-308.400	191.30-273.200	199.00-263.000	222.70-437.100
DO (mg/L)	8.33±0.216^{a}	7.39±0.212^{b}	7.29±0.212^{b}	7.45±0.212^{b}	5.20±0.212^{c}
	7.80-9.500	7.00-8.000	7.00-7.500	6.50-8.300	1.80-7.000
BOD_5 (mg/L)	0.38±0.161^{d}	1.06±0.157^{c}	1.06±0.157^{c}	1.94±0.157^{b}	5.46±0.157^{a}
	0.20-0.550	0.80-1.500	0.75-150	1.00-2.750	3.50-8.500
Turbidity (NTU)	1.00±1.298^{b}	2.80±1.298^{b}	2.70±1.298^{b}	4.01±1.298^{b}	40.50±1.298^{a}
	0.70-1.800	1.00-8.200	1.20-7.400	2.70-5.500	22.10-68.900
Total hardness (mg.$CaCO_3$/L)	152.01±6.371^{c}	226.75±6.237^{b}	237.71±6.237^{b}	313.19±6.237^{a}	223.13±6.237^{b}
	120.10-199.00	198.00-255.000	211.00-305.670	280.00-355.500	143.00-295.000

Values in each row with different letters are significantly different at p<0.05; Values in rows with same letters are not significantly different

Table 2: Some physical-chemical properties of water samples (according to the date of sampling), data represented as mean±S.E. with minimum and maximum values, during study period

Variables	November	December	January	February	March	April	May	June
Water	17.20±0.740^{ab}	16.70±0.740^{ab}	15.02±0.740^{b}	15.00±0.740^{b}	15.37±0.740^{b}	16.10±0.740^{ab}	17.30±0.740^{ab}	18.07±0.740^{a}
Temperature (ºC)	13.60-24.500	12.80-24.000	11.90-22.000	12.50-19.000	13.00-18.800	13.80-19.200	14.50-22.500	14.00-25.500
pH	7.17±0.202^{a}	7.26±0.202^{a}	7.32±0.202^{a}	7.31±0.202^{a}	7.38±0.202^{a}	7.46±0.202^{a}	7.42±0.202^{a}	7.58±0.202^{a}
	6.60-7.800	6.70-7.900	6.70-8.000	6.65-8.000	6.55-8.300	6.70-8.500	6.70-8.100	6.60-8.600
EC (µs/cm)	429.33±21.440^{b}	400.66±21.44^{bc}	379.00±21.44^{bc}	352.16±21.44^{c}	371.50±21.44^{bc}	415.33±21.44^{bc}	423.83±21.44^{bc}	494.17±21.440^{a}
	380.00-527.000	311.0-533.000	299.00-542.000	289.0-511.000	299.0-501.000	311.0-611.000	311.0-611.000	381.00-683.000
T.D.S (mg/L)	274.73±13.880^{b}	256.38±13.88^{bc}	242.40±13.88^{bc}	255.35±13.88^{c}	237.72±13.88^{b}	265.77±13.88^{bc}	263.60±13.88^{bc}	316.22±13.880^{a}
	243.20-337.200	199.0-341.100	191.30-346.800	184.9-327.000	191.3-320.600	199.0-369.900	199.0-391.000	243.80-437.100
DO (mg/L)	6.46±0.342^{bc}	7.10±0.342^{ab}	7.96±0.342^{a}	7.68±0.342^{a}	7.82±0.342^{a}	7.46±0.342^{ab}	6.54±0.342^{bc}	6.02±0.342^{c}
	2.80-8.000	5.2-8.000	7.50-8.300	6.80-8.300	7.00-9.500	7.00-8.500	3.50-8.000	1.80-7.800
BOD_5 (mg/L)	2.31±0.511^{a}	1.99±0.511^{a}	1.40±0.511^{a}	1.64±0.511^{a}	1.58±0.511^{a}	1.84±0.511^{a}	2.26±0.511^{a}	2.83±0.511^{a}
	0.55-6.200	0.38-3.800	0.20-3.500	0.30-5.200	0.30-5.000	0.35-5.000	0.40-6.500	0.55-8.500
Turbidity (NTU)	7.60±4.355^{a}	7.39±4.355^{a}	5.78±4.355^{a}	7.84±4.355^{a}	12.42±4.355^{a}	10.91±4.355^{a}	13.59±4.355^{a}	16.10±4.355^{a}
	0.98-30.200	0.93-27.600	0.70-22.100	0.80-33.400	1.80-39.200	0.85-44.800	0.95-57.800	1.00-68.900
Total hardness	237.00±14.710^{abc}	233.1±14.71^{abc}	197.20±14.710^{c}	208.8±14.71^{bc}	222.2±14.710^{bc}	224.8±14.710^{bc}	252.4±14.710^{ab}	272.20±14.710^{a}
(mg.$CaCO_3$/L)	145.00-325.000	133.0-355.500	129.00-280.000	120.1-292.000	140.0-310.000	155.0-299.000	199.0-330.000	195.00-311.000

Values in each rows with different letters are significantly different at p<0.05; values in rows with same letters are not significantly different

Sirwan (Diyala) river in a narrow valley between (Baranan) mountains.

Sampling: Sampling of water for physical, chemical and biological properties usually started at 8 am and completed at 2 pm. All samples were analysis within 24 h (APHA, 1998). Rotifera samples were taken by passing 60 L of water sample through plankton net (25 µm pore size); concentrated samples were preserved in 4% formalin solution. For the identification, classification and counting of rotifera, compound microscope and digital camera (14 mega pixel) were used, as references: Edmondson (1959) used for identification, Jordan and Verma (2009) for classification, in addition to the Suthers and Rissik (2008). The result was expressed by individual/m^3.

Statistical analysis: Statistical analysis was performed using software program (SPSS version 12). All data were treated with the one-way ANOVA (Analysis of Variance), Post hoc test (Duncan) for detecting significant deference between variables at different locations (sites) and sampling time. All data are expressed as mean±S.E. A p-value of 0.05 was concerned as the limit for significance.

RESULTS

In this study, a number of physio-chemical property were studied (Table 1 and 2), the water temperature ranged between 11.9 to 25.5ºC. The minimum was recorded during Jan. 2010 in site 1, while the maximum was recorded during June 2010 in site 5. The water temperature showed monthly and local variation with significant differences (p<0.05) between all sites and seasons.

The pH value ranged from 6.55 to 8.60. The lowest value recorded during March 2010 in site 1 and the highest value was recorded during June 2010 in site 5. Non significant seasonal variation (p>0.05) was recorded, while significant difference (p<0.05) were observed between site 5 to other sites of sampling.

The minimum Electric Conductivity value in all studied water samples were (289 µs/cm) recorded in sit 1 during February 2010 and maximum value was (683 µs/cm) in site 5 during June 2010. The analysis of variance showed significant differences (p<0.05) between the sites and the seasons of sampling.

The lowest value of total dissolved solid was noted at site 1 during February 2010, while the highest value was observed at site 5 during June 2010 and it was ranging from 184.90-437.10 mg/L. Significant differences (p<0.05) were observed between the sites and the seasons of sampling.

The maximum dissolved oxygen concentration was 9.5 mg/L measured in site 1 during March 2010. While minimum value was 1.8 mg/L recorded in site 5 during June 2010. The highest value was recorded in the coldest months and the lower value during the warm

Table 3: List of rotifera recorded during studied period and their classification

Phylum: Rotifera	St. 1	St. 2	St. 3	St. 4	St. 5
Class: Monogonata					
Order: Ploima					
Family: Branchionidae					
Keratella sp.	+	+	+	+	-
Branchious sp.	+	+	+	+	-
Lepadella sp.	+	+	+	+	+
Family: Euchalnidae					
Euchlanis diltata (Ehrenberg)	+	+	+	+	+
Family: Lecanidae					
Lecane sp.	+	+	+	+	+
Family: Notommatidae					
Cephalodella auriculata (Muller)	+	+	+	+	-
Cephalodella gibba (Ehrenberg)	+	+	+	+	+
Family: Gastropidae					
Pedipartia gracilis (Myers)	+	+	+	+	-
Family: Proahadae					
Proales falicaciosa (Gosse)	+	+	+	+	-
Walfertia ornate (Donner)	+	+	+	+	-
Family: Epiphanidae					
Epiphanes sp. (Ehrenberg)	+	+	+	+	-
Trichotria tetraclis (Ehrenberg)	+	+	+	+	-
Class: Bdelloidea					
Order: Bdelloidae					
Family: Philodinididae					
Philodena roseola (Ehrenberg)	+	+	+	+	+
Rotaria sp. (Scopoli)	+	+	+	+	+

+: Present; -: Absent

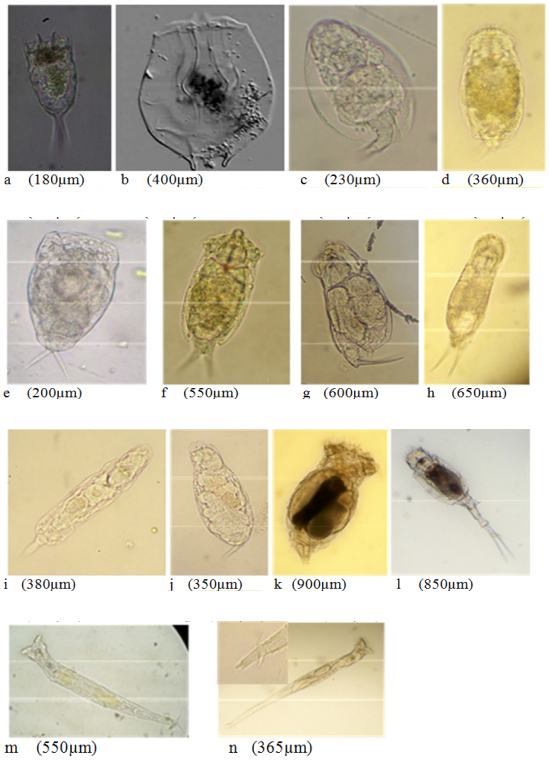

Plate 1: Rotifera (10xX40x)
a- *Keratella* sp. b- *Brachionus* sp.
c- *Lepadella* sp. d- *Euchlanis diltata* (Ehrenberg).
e- *Lecane* sp. f- *Cephalodella auriculata* (Muller).
g- *Cephalodella gibba* (Ehrenberg).
h- *Pedipartia gracilis* (Myers).
i- *Proales falicaciosa* (Gosse).
j- *Walfertia orn-ate* (Donner).
k- *Epiphanes* sp.
l- Trichotria tetraclis (Ehrenberg).
m- *Philodena roseola* (Ehrenberg). n- *Rotaria* sp. (Scopoli).

Table 4: Total number of rotifera (ind./m^3) recorded during study period

	Sites				
Months	St. 1	St. 2	St. 3	St. 4	St. 5
November	5	32	35	16	13
December	6	18	21	13	12
January	6	80	39	8	4
February	9	17	26	12	6
March	40	96	87	16	17
April	19	90	89	15	14
May	85	134	120	17	34
June	94	30	113	13	18

months. Significant difference ($p<0.05$) were found between winter and summer and sites of sampling.

The minimum Biological Oxygen Demand in all studied water samples were (0.20 mg/L) recorded in site 1 during January 2010 and maximum value was (8.50 mg/L) in site 5 during June 2010. No Significant differences ($p>0.05$) were observed between months of studies and significant differences ($p<0.05$) were recorded between sites.

The turbidity values were ranging from the minimum value of (0.70 NTU) observed in site 1 during January 2010 and the maximum value (68.90 NTU) recorded in site 5 during June 2010. No Significant differences ($p>0.05$) were found between months of studies and site 5 differs significantly ($p<0.05$) from other sites.

The total hardness ranged from the minimum value (120.10 mg.$CaCO_3$/L) recorded in site 1 at February 2010 to maximum value (355.5 mg.$CaCO_3$/L) in site 4 during December 2009. The results showed clear seasonal variations ($p<0.05$) in total hardness levels were observed throughout the entire sampling periods and sites.

Concerning to biological study, the results showed that Fourteen genera of Rotifera (Table 3) (Plate 1) were identified, from which twelve genere belong to Monogonata *Keratella* sp., *Brachionus* sp., *Lepadella* sp., *Euchlanis diltata*, *Lecane* sp., *Cephalodella auriculata*, *Cephalodella gibba*, *Pedipartia gracilis*, *Proales falicaciosa*, *Walfertia ornate*, *Epiphanes* sp. *and Trichotria tetraclis*; and two genera belong to Class Bdelloidea *Philodena roseola* and *Rotaria atrinus*.

The density of Rotifera in the studied sites showed wide fluctuations in their occurrence. It was ranged from 4 to 134 ind./m^3 (Table 4). The lower value was recorded in site 5 during January and the higher number was recorded in site 2 during May 2010.

DISCUSSION

There are differences in water temperature between stations for example the minimum water temperature was 11.9ºC during January, at the St. 1, while the maximum was in the St. 5 (wastewater) during June which was 25.5ºC. This result comes in accordance with those of Muhammad (2004) in some water body of Sulaimani, while the maximum temperature in the present study recorded in site 5 Qaragol waste water

lower than this recorded by Shekha (2008) in Erbil wastewater channel.

The pH (hydrogen ion concentration) is an important quality parameter of both natural water and wastewater. pH value for all water and wastewater samples were in the optimum range of pH (6.5-9.5) according to WHO (2006).

Electrical Conductivity varied from 289 µs/cm in winter to 683 µs/cm in summer, this result comes in accordance with the result of Muhammad (2004) during his ecological study on aquatic life of some spring and streams water of Sulaimani-Iraq. While it was relatively lower than those found by Shekha (2008) who studied the effect of Erbil wastewater discharges on water quality of Greater Zab River. The highest EC value during summer time is possibly due to evaporation and low flows when the capacity of the spring or the stream is at its lowest, while, the lowest EC values in winter months might be related to dilution factor and highest flows (Ried, 1961).

The present study showed (TDS) ranged between 184.9-437.1 mg/L that come in accordance to the result of Muhammad (2004) in some Sulaimani water body. (TDS) in water supplies originate from natural sources, sewage, urban and agricultural run-off and industrial wastewater.

The Dissolved Oxygen concentration of Darbandikhan water was often high and at all sites, except the (St. 5) which is polluted water that has the minimum dissolved oxygen of (1.8 mg/L). The highest value was recorded in the coldest months and the lower value during the warm months. This comes in accordance to that of Muhammad (2004) in some Sulaimani water bodies; Mohammad (1980) on wastewater channel in Baghdad area, while the maximum DO value recorded in the present study is lower than that of Ali (2007) in Greater Zab River. But it was higher than Shekha (2008) in Erbil waste water channel.

The Biological oxygen demands are the indicators of the amount of organic matter in a water system (Hammer, 1986) and they are delayed mirror image of oxygen profile (Lester, 1975).

Levels of BOD_5 from 0.20 to 8.5 mg/L reflect the relatively low organic matter content in all the water systems in the present study, because rain season was more than the years before and this lead to increase in the water level compared to the years before. On the other hand our study was performed in 8 months (November 2009 till June 2010), but the months of (July, August and September) will be the amount of the BOD_5 and other parameters will be altered because of two reasons, first the amount of the water will decreased and second the water and air temperature will be more and this will lead to more decomposition of organic matter and more change in BOD.

Turbidity throughout the period of the study was low, for example minimum turbidity was 0.70 NTU recorded at the St. 1 during January because the amount of the water was high, while the maximum belonging to the St. 5 which was 68.90 NTU during June, because the amount of the water was very low in addition to the domestic wastes that enter into the water in different ways.

Total Hardness ranged between (120.1-355.5) mg $CaCo_3$/L, so the study water considered being very hard. This result comes in accordance with that of Muhammad (2004) in Sarchnar-Sulaimani and very lower than that of Al-Saadi *et al.* (2008), who demonstrated that the Sawa Lake (Iraq) water was very hard with total hardness of more than 9000 mg $CaCO_3$/L.

Aquatic's life can have a hard time, water that has a lot of rotting organic material in it, especially in summer, for example all Stations of the study area except (St. 1) suffering the decrease of the water and this lead to changes in all types of organisms populations and also food chain will affected, some species dominated and others dead and eaten by others.

Site number (5) has different habitat and different populations because the Tanjero River contains the industrial wastes and also the source of pollutant's will be differ by villagers and their animals, also there were places for washing cars and vehicles and specially lorries that carry cattles, at this water wide distribution of organisms are recorded from protozoa to molluscs, Site (5) was the polluted water, this water contains the sewage water and also a branch of the Sarchnar spring water, according to the maximum BOD_5, at the present study this sites showed that the pollution levels were low compared to other sewage water. The analysis clearly showed extensive pollution impact to the Tanjero River particularly after the river has passed the city. Other small rivers, carrying somewhat cleaner water, feed into the Tanjero as it approaches Darbandikhan Reservoir, but the waters of the Tanjero are still in an unhealthy state as they enter the lake (Nature Iraq Newsletter, 2008).

The lower Rotifera population density was recorded in site 5 during January with the dominance of two genus *Philodena roseola and Rotaria atrinus* belonging to the Class: Bdelloidea and the higher density was recorded in site 2 during May 2010 that contained all 14 identified taxa of rotifer, with the dominance of *Lepadella* sp., *Pedipartia gracilis*, *Proales falicaciosa* and *Walfertia ornate.* Total number of Rotifera recorded in studied sites during the studied period was lower than that recorded by Shekha (2008) during his study of the effect of Erbil wastewater discharge on water quality of Greater Zab River.

The population densities reached maximum numbers during May and minimum during January (Table 4). This result is similar to that found by Mangalo and Akbar (1986) and Erdugan and Guher (2005).

Mangalo and Akbar (1986) attributed these variations in the population densities to many factors such as, the effluent disposal from the sewage treatment plant, temperature, DO, pH and EC.

Erdugan and Guher (2005) demonstrated that species diversity of rotifera increased gradually from spring to summer months. On the other hand, when the weather began to be colder, that is the end of autumn, a decrease occurred, this diversity patterns greatly depend on the water temperature and the food supply provided within the water. In spring, when the heat of the water started to increase, an increase was observed in the phytoplankton population which is food for rotifera.

Rotifer species composition varied with seasons, rotifers can be classified according to temperature as perennial, summer and winter species. Rotifer composition can be related to conductivity, since salinity is a chemical limitation of rotifer communities (Modenutti, 1998).

On the other hand, Feike *et al*. (2007) stated that *Brachionus calyciflorus*; *B. plicatilis* and *Keratella cochelaris* are mainly responsible for the rotifer mass development in summer and also had a preference to high pH value.

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