International Journal of Botany Studies
ISSN: 2455-541X; Impact Factor: RJIF 5.12
Received: 20-12-2020; Accepted: 19-01-2021: Published: 02-02-2021
www.botanyjournals.com
Volume 6; Issue 1; 2021; Page No. 365-369

Seasonal dynamics of cladocerans diversity with reference to physico-chemical conditions in selected water bodies of Udaipur, Rajasthan

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Abstract
A study of seasonal dynamics of zooplankton diversity with reference to physico-chemical conditions (water quality) of three water bodies (Hiratalai, Swaroop Sagar and RCA nursery pond) in Udaipur, Rajasthan was made in winter (January), summer (May) and late monsoon (September) to determine their ecological health. Zooplankton as a cosmopolitan community is vital ecological indicator for assessment of water quality and biodiversity, as they are strongly affected by environmental conditions and respond quickly to changes in water quality. Zooplankton constitutes a vital intermediate link between phytoplankton and fish in the food chain. Seasonal changes in zooplankton species are related to the physico-chemical parameters of aquatic ecosystem. These parameter analysis helps to evaluate the impact of anthropogenic activities on water bodies. As per the approved technical programme, studies were conducted using the laboratory facilities of limnology and fisheries department of MPUAT, Udaipur and Zoology Department of MLSU, Udaipur. While the field studies were conducted at three different seasonal ponds of Udaipur district.

Keywords: limnology, eutrophication, cladocerans

Introduction

Lakes and ponds are an important source of freshwater for the mankind. They prove to be of great ecological value for the surrounding environment as these water bodies pose a direct and indirect effect on the weather conditions, habitat, community and underground water levels of the catchment areas. Lakes and ponds have known to be filtering surface water as it percolates down to the water tables. These harbor a diverse variety of micro-organisms and macro-organisms forming the lake community a dynamic ecosystem. Phyto planktons and zooplanktons constitute the micro community in the lakes and ponds.

The zooplankton populations undergo natural seasonal fluctuations which can be expressed by various quantitative parameters such as population density, biomass and biochemical compounds. Seasonal changes in zooplankton species are related to the physico-chemical parameters of aquatic ecosystem (Basawarajeshwari & Ramakrishna Reddy, 2015) [1]. But due to anthropogenic interferences in these aquatic bodies like sewage disposal, agricultural runoffs, industrial discharges and other such polluting activities, there is a severe effect on the physico-chemical parameters of water. These parameters have a significant effect on the composition of lake communities as has been seen in this study also. Every parameter emphasizes a certain characteristic, which should be known in order to evaluate the role of zooplankton in that particular ecosystem. In India, considerable work has been done on ecology and seasonal distribution of zooplankton than other tropical and subtropical countries. Because of their heterotrophic activity, zooplanktons play an important role in the cycling of organic materials in aquatic ecosystems and are used as bioindicators of environmental quality. The present paper deals with the zooplankton diversity with reference to physico-chemical conditions (water quality) of three water bodies (Hiratalai, Swaroop Sagar and RCA nursery pond) in Udaipur, Rajasthan

Materials and Methods

Study Area

Climate of the study area

Udaipur (Rajasthan) experiences a subtropical climate with an average rainfall ranging between 76-89 cm and relative humidity between 75 to 95% during the monsoon period. The summers are hot having an average range of maximum temperature between 38 to 41 degree centigrade and winters are cool minimum temperature between 1 to 5 degree centigrade. The elevation of Udaipur is at 559.6 metre MSL.

Ponds and nursery

a. **Swaroop Sagar (Latitude: 24° 35' 11" N; Longitude: 73° 40’ 56" E)**

It is a small lake with spread of water area of 58.3 hectare only. This is situated along the western waterfront of Udaipur with a connection with Pichola. Swaroop Sagar is relatively polluted and shallow lake. The basin of the lake is 'U' shaped and is surrounded by thickly populated area. Real separation of Swaroop Sagar from Pichola lake takes place during summer when water level of both the lake get reduced. The maximum length, width and depth of the lake are 583 metre, 291 metre and 6.98 metre respectively.

b. **Nursery pond (Latitude: 24° 34' 57" N; Longitude: 73° 42’ 26" E)**

Nursery pond is situated at animal farm of RCA located in the heart of Udaipur city. The water spread area of the tank is 0.015 hectare with maximum depth of 5 feet.

c. **Hiratalai (Latitude: 24° 30' 45" N; Longitude: 73° 40’ 12" E)**

Hiratalai is a small seasonal pond located near Udaipur-Ahmedabad road at Balicha. During summers the water body gets dry or has very less water level. The water spread area of the pond is 1.10 ha with maximum depth of 7 feet.

Water sample collection

The water and zooplanktons samples from all the three water bodies were collected during the month of September 2003, January 2004 and May 2004 to cover all the three seasons. The water sample were collected from 1m depth in sterilized glass bottles during morning hours. The physico-chemical characteristics such as dissolved oxygen, temperature, pH, alkalinity and depth of visibility were determined at the sampling stations whereas, other parameters such as phosphates and nitrates were determined in the laboratory following standard method of APHA (1989). The samples of zooplankton were analyzed for their qualitative and quantitative estimation using C Z inverted microscope and S-R counting cell.

Water quality parameters

Water samples were analyzed to determine their physico-chemical characteristics during the study.

1. Water temperature: water temperature was measured using a standard thermometer having precision up to 0.1 degree centigrade.
2. Depth of visibility: A 20 CM diameter Secchi disc with alternately painted white and black quadrants was used for measuring transparency of pound and nursery waters. Herein, mean of disappearance and reappearance depth for the disk has been recorded as visibility depth in centimeter. All the observations for this purpose were made between 10 to 11 a.m.
3. pH: The hydrogen ion concentration (pH) of experimental water was determined with an electronic digital pH meter.
4. Dissolved oxygen: The basic unmodified Winkler's method was followed for the determination of dissolved oxygen (DO). The water samples were collected in 125 ml capacity amber coloured glass stoppered bottles and immediately winklered using 1 ml each of winkler A and b solutions. The samples were then acidified using 1 ml of concentrated H_2SO_4 and then treated against an N/80 sodium thiosulphate (Hypo) to a colorless end point using starch and as an indicator. Dissolved oxygen was calculated by following formula:

Dissolved Oxygen = (100 × B × F) / A

Where:
A = ml of sample titrated
B = volume of Hypo used
F = Calculated factor value (F= 25/ T × 0.08), 0.08= conversion factor for O_2
T = Titre reading for Hypo.

5. Alkalinities: 50 ml of water sample was titrated against 0.02 N H_2SO_4 using phenolphthalein and methyl orange indicator for carbonate and bicarbonate alkalinities respectively. The results were derived using the formula equation:
   a. Carbonate alkalinity (mg/l) = (ml of titrant × 1000)/ ml of sample
   b. Bicarbonate alkalinity (mg/l) = (ml of titrant × 1000)/ ml of sample
   The sum of carbonate and bicarbonate alkalinity was computed as total alkalinity.
6. Nitrate Nitrogen: Nitrate nitrogen (NO_3-N) was estimated following phenol disulphonic acid method. For this, 50 ml of water sample was evaporated to dryness (after removing chloride by dissipating with 5% Ag_2SO_4) on a hot plate. After cooling to ml of phenol disulphonic acid was added to the residue and the content was mixed thoroughly with the help of a glass road. The volume was then raised up 250 ml using double distilled water. This was followed by the addition of 6 ml of liquid ammonia, which imparts yellow colour to the solution. The colour intensity of the sample and a series of standard were measured from UV-108 spectrophotometer at 410 nm against the reagent blank as a reference solution. The concentration of nitrate nitrogen in sample was determined from the calibration curve.
7. Phosphate: For the estimation of phosphate, 50 ml of filtered sample was taken in a conical flask and 2- 3 drops of phenolphthalein solution was added. On appearance of pink colour, standard sulfuric acid (0.02 N) was added drop by drop until the colour disappeared. Then 2 ml of acidified ammonium molybdate solution and five drops of stannous chloride solution were added. The blue colour developed by the presence of phosphate was measured at 690 nm on a digital spectrophotometer using reagent blank as the reference solution. Concentration of phosphates in the samples was determined as follows:
   Phosphate (mg/l) = (concentration of standard solution/ absorbance of standard solution) × (absorbance of sample/ volume of sample) × 1000

Zooplankton (Cladocerans) analysis

Systematic identification of zooplanktons was done after Needham and Needham (1966), Sharma and Durve (1985) and Edmondson (1959).

The zooplanktons were collected along with the sampling of water. For the sample collection an appropriate quantity of experimental water (i.e. 30 ml from culture system and 50 litre from natural water body) was filtered through bolting silk No. 16 and the zooplanktons obtained were preserved in 4% pure neutralized formalin. For qualitative analysis of zooplanktons, Hensen's standard plankton net was towed in seasonal ponds and nursery. The sample of zooplanktons were analysed using a sedgewick Rafter counting cell (Pennak, 1978; APHA, 1989) [6, 2] with the help of CZ inverted microscope. Strip counting was done and the zooplanktons were estimated using following formula:

Zooplankton (No. /l) = A × (B/C) × (l/d) × 10^3

Where
A = total number of individuals in observed strips
B = volume of sample in cell
C = volume of observed strips
d = concentration factor

Results

Physico-chemical parameters

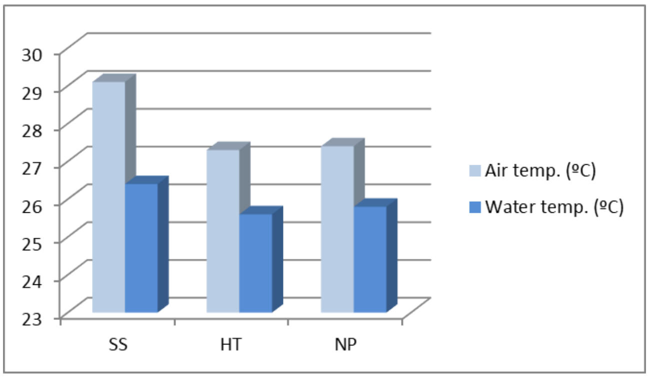
The results of the physico-chemical parameters are presented in the Table 1.
The minimum being noted during winter in nursery pond while the maximum being recorded in Swaroop Sagar during summer months. Further the mean values of water temperature ranged from 25.6 to 26.4 degree centigrade with minimum in Hiratalai and maximum in Swaroop Sagar (Table 3.2). The Nursery pond had higher depth visibility than Swaroop Sagar and Hiratalai with less seasonal variations (60.3 to 69.9 cms). However, in Swaroop Sagar and Hiratalai the transparency values were fluctuated significantly. The lower values of transparency in these waters were during monsoon season. The transparency is in this water body is increased from September to January and subsequently decreased from January to May (Table 1). The mean values of transparency are depicted in figure show that the highest level of transparency was in nursery pond followed by Hiratalai and Swaroop Sagar. The water reaction was alkaline (pH 7.3- 8.9) with minimum value at Hiratalai during winter month and maximum was also at Hiratalai during monsoon. No definite trend in seasonal fluctuations of PH was found. However significantly higher (8.56) mean value was noticed in Swaroop Sagar than nursery pond (7.86) and Hiratalai (7.96). The minimum (5.0 mg/ l) and maximum (8.6 mg/l) values of dissolved oxygen were recorded from Swaroop Sagar and Hiratalai respectively. The dissolved oxygen content may be considered as conducive for aquatic habitat. However, poor dissolved oxygen content (5.0 mg/litre) was noted during summer from Swaroop Sagar, where city sewage enters with moderate organic load. The seasonal fluctuations were significantly higher in Swaroop Sagar and Hiratalai compare to Nursery pond. Further the mean dissolved oxygen level ranged from 6.44 to 7.16 mg/litre with minimum in nursery pond and maximum in Hiratalai (Table 1).

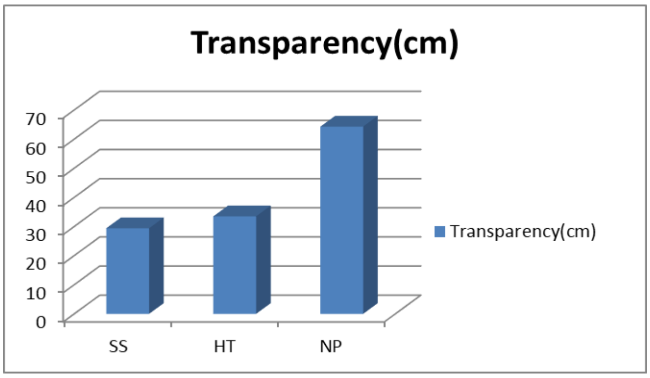
The minimum (126 mg/l) and maximum (220 mg/l) values of Total alkalinity were recorded during monsoon from Hiratalai and Swaroop Sagar respectively. Significantly higher (198 mg/l) mean value of total alkalinity was noticed in Swaroop Sagar while the lowest (157 mg/l) being in nursery pond (Table 1).
In general, the Nursery pond had low EC (0.046- 0.050 mMho) than Hiratalai (0. 080 – 0.118 mMho) and Swaroop Sagar (0.135-0.152mMho). Further the seasonal variation of EC was also less in nursery pond than Swaroop Sagar and Hiratalai. The EC values are significantly higher just after the monsoon which gradually decreased further. Further, the lowest (0.04mMho) and highest (0.14 mMho) mean values of EC were recorded from Nursery pond and Swaroop Sagar respectively (Table 1).
Phosphate content was very low in both Nursery pond (0.005-0.013 mg/l) and Hiratalai (0.060-0.090 mg/l), while significantly higher values were recorded in Swaroop Sagar (0.15- 0.72 mg/l). The highest values of phosphate were noticed during summer in both Swaroop Sagar (0.72 mg/l) and Hiratalai (0.09 mg/l). These higher levels of phosphate in Swaroop Sagar and Hiratalai coincident with lowest water level. The seasonal fluctuations were less in Nursery pond. Further, the lowest (0.008 mg/l) and highest (0.346 mg/l) mean value of phosphate contents were recorded from Swaroop Sagar and Nursery pond respectively (Table 1).
Like phosphate, the concentration of NO_3-N was less in Nursery pond (0.27-0.31) and Hiratalai (0.20-0.28) but higher in Swaroop Sagar (1.05-1.42 mg/l). The seasonal fluctuation in nitrate nitrogen had also the same trend as phosphate. In general, the highest and lowest value of 1.42 mg/l and 0.20 mg/l were obtained from Swaroop Sagar and Hiratalai. The highest and lowest mean value of NO3-N were also noticed in Swaroop Sagar and nursery pond (Table 1).

Table 1: Comparative water quality status of selected water bodies of Udaipur

Para	Swaroop Sagar				Hiratalai				Nursery Pond			
	Mon	Win	Sum	Avg.	Mon	Win	Sum	Avg.	Mon	Win	Sum	Avg.
AT	28.2	21.9	37.2	29.1	29.3	20.6	32.1	27.3	28.2	19.9	34.1	27.4
WT	26.0	20.4	32.8	26.4	27.5	18.8	30.5	25.6	26.4	18.5	32.5	25.8
VIS	23.5	39.7	26.0	29.4	29.5	37.0	34.0	33.5	62.8	69.9	60.3	64.3
pH	8.6	8.8	8.1	8.56	8.9	7.3	7.7	7.96	7.6	8.2	7.8	7.86
EC	0.152	0.138	0.135	0.140	0.118	0.107	0.080	0.100	0.049	0.046	0.050	0.040
DO	6.48	8.30	5.00	6.59	7.08	8.60	5.82	7.16	6.62	7.10	5.60	6.44
TA	220.0	218.0	156.0	198.0	126.0	187.0	168.0	160.3	134.0	174.0	163.0	157.0
NIT	1.30	1.05	1.42	1.25	0.28	0.20	0.21	0.23	0.31	0.29	0.27	0.29
PHP	0.170	0.150	0.720	0.346	0.060	0.070	0.090	0.073	0.005	0.013	0.007	0.008

AT = Air temp. (ºC), WT= Water temp. (ºC), VIS= Visibility (cm), EC = Electric conductivity (mMho), DO = Dissolved oxygen (mg/l), TA= Total Alkalinity (mg/l), NIT= Nitrate (mg/l), PHP= Phosphate (mg/l), Mon= Monsoon, Win= Winter, Sum= Summer and Avg. = Average





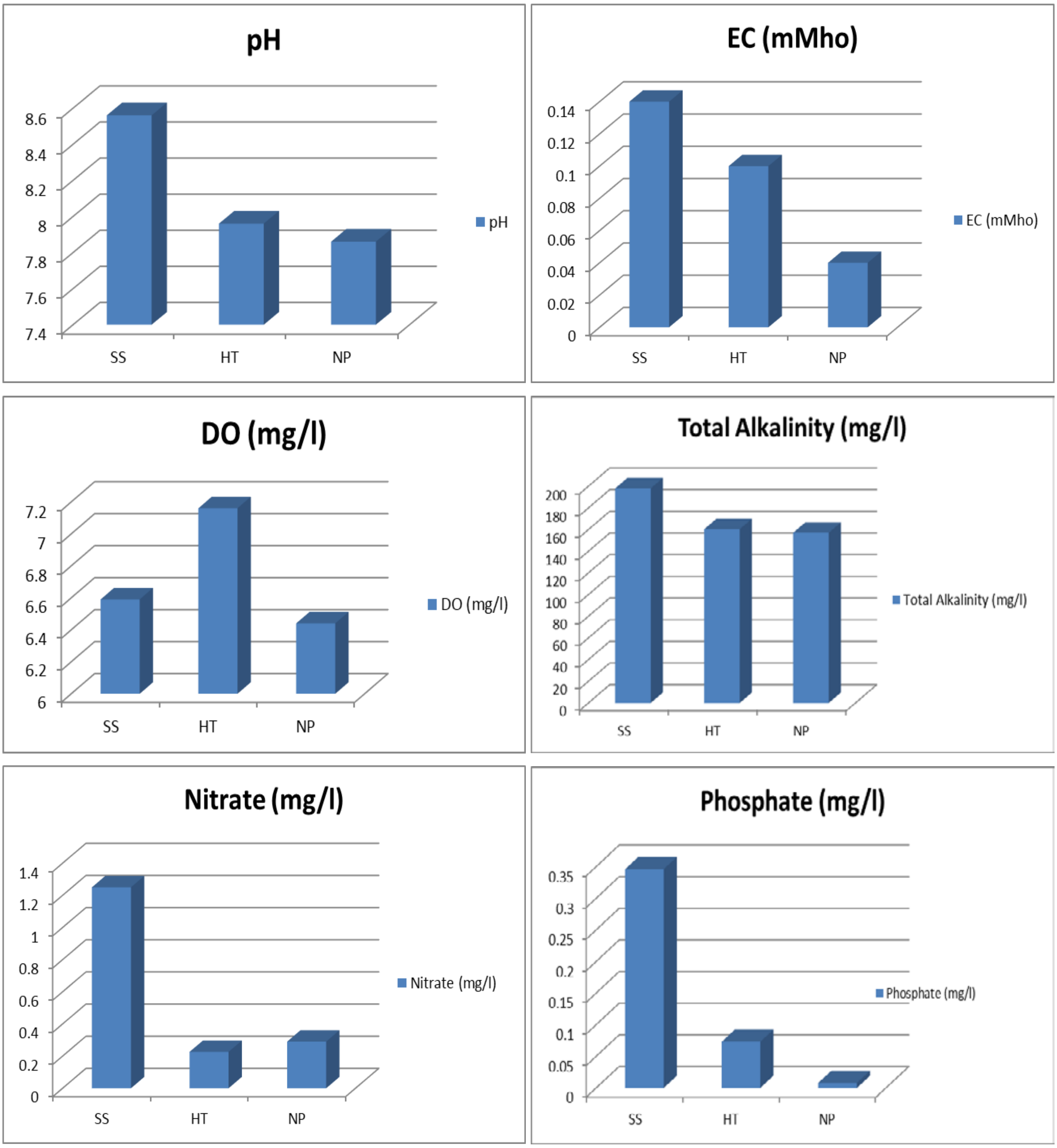


Fig 1: Mean value of selected water quality parameter from three water bodies of Udaipur

Cladocerans study

A total of 5 genera belonging to zooplanktonic group Cladocerans was recorded from these three water bodies of Udaipur (Table 2). In general, the diversity was higher in Swaroop Sagar.

Table 2: Cladocerans with total biomass recorded from three water bodies of Udaipur

	Swaroop Sagar			**Hiratalai**			**Nursery Pond**		
CLADOCERA	MON	WIN	SUM	MON	WIN	SUM	MON	WIN	SUM
Daphnia sp.	+	+	+	+	+	+	+	+	+
Ceriodaphnia sp.	+	+	+	-	+	-	-	-	-
Moina sp.	+	-	+	-	+	-	+	+	-
Simocephalus sp.	+	-	-	-	-	-	-	+	-
Bosmina sp.	-	+	-	+	+	-	-	-	+
Total Biomass (No./l)	106	123	82	13	35	15	9	12	6

+ = Present, - = Absent, MON= Monsoon, WIN= winter and SUM= summer

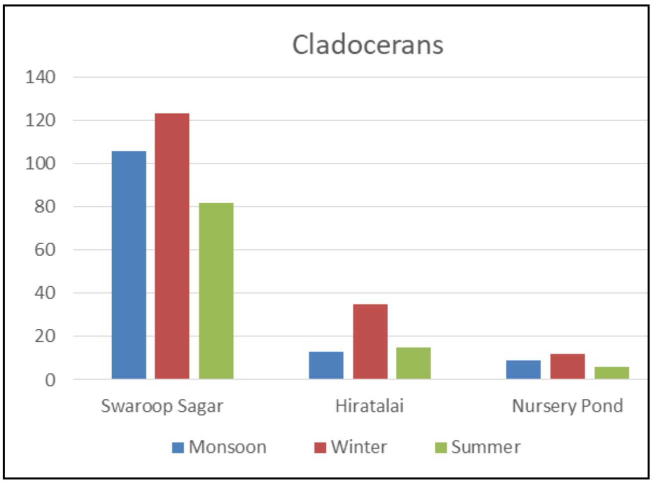


Fig 2: Average Cladocerans production (No./l) in three water bodies of Udaipur

It is evident from the fig 2 that the population of Cladocerans was highest in Swaroop Sagar followed by Hiratalai and nursery pond. The higher diversity in all the three water bodies was noticed during winter as compared to summer and late monsoon (fig.2)

Discussion

Fluctuation of zooplanktons is controlled by a combination of physico-chemical and biological factors (Dijk and Zanten, 1995) [7]. Present data shows that in all the three water bodies, air and water temperature was found to go hand in hand. This may be due to their small water spread area, as small water bodies with less depth react quickly to the changes in atmospheric temperature (Welch, 1952) [8].

In the present study, a distinct relationship between temperature and Cladocerans diversity have been observed. Winter months had higher species diversity than summer months. Thus, variation pattern in zooplankton species diversity with temperature was in accordance with Sinha and Islam (2002) [9].

Nursery pond was more transparent than Swaroop Sagar. This may be due to the discharge of large amount of domestic sewage and cattle waste in Swaroop Sagar and Hiratalai respectively. Goldman (1977) has also suggested less transparency in waters affected by sewage or by other organic contamination.

Dissolved oxygen along with transparency could provide information about the nature of an aquatic ecosystem better than any other chemical parameters (Hutchinson, 1975). It has been observed that dissolved oxygen concentration of more than 5 mg/l favour good growth of flora and fauna. Seasonal variations in dissolved oxygen were significant in all the three water bodies ranging from 5 to 8.6 mg/l. Swaroop Sagar being a polluted and highly eutrophic water body showed low dissolved oxygen in summer months due to higher rate of biodegradation of organic matter at higher temperature (Table). Roule (1930) [12] rightly pointed out that the largest aqua crops are usually obtained in alkaline water in between 7 to 8 pH. Ohle (1934) [13] opined that pH above 10 or less than 4.8 have a detrimental effect. Water from all the three water bodies is basically alkaline in nature with pH in the range of 7.3 to 8.9; which would be considered good for the growth of aquatic animals.

It is worth mention here that the level of nitrate-nitrogen and phosphorus were well within the prescribed range for good aquaculture except in nursery pond (Moyle 1946) [14]. The higher Cladocerans production in Swaroop Sagar coincided with higher NO3-N and phosphate levels which might have favoured the higher zooplanktons crop from this water body as compared to nursery pond.

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