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Diurnal variations of plankton diversity and physico-chemical characteristics of Rewalsar Wetland, Himachal Pradesh, India

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Abstract

The contemporary examination signifies diurnal variations in various physico-chemical parameters of Rewalsar wetland during summer and winter. Fluctuations in the intensity and duration of solar radiations, temperature, photosynthesis, respiration and decomposition were the major factor responsible for diel fluctuations in the physico-chemical factors. Water temperature showed increment from 24.82°C to 29.20°C in June and from 9.15°C to 12.95°C in January. Minimum and maximum values of temperature were recorded at 06.30 hrs and 14.30 hrs respectively. Secchi disc transparency was low in the wetland due to abundance of phytoplankton. It ranged from 0.00-121.00 cm during summer and 0.00-131.00 cm during winter. Oxygen percentage saturation values were minimum (summer 26% and in winter 58%) in the morning at 06.30 hrs and reached maximum (70% in summer and 100% in winter) in the afternoon at 14.30 hrs. Free carbon dioxide was present only at 06.30 a.m. in winter. The pH of water remained alkaline and increased from 10.30 hrs to 14.30 hrs, thereafter it decreased again. Carbonates were present only in January (0.00-5.80 mg L^{-1}). Bicarbonates were 132.52-152.50 mg L^{-1} in June and 92.35-121.23 mg L^{-1} in January. The values for chloride, hardness and electrical conductance were higher during summer as compared to winter. Total hardness showed fluctuations from 163.45 to 181.24 mg L^{-1} in summer and 121.45 to 140.72 mg L^{-1} in winter, chloride. Phytoplankton were composed of members of Bacillariophyceae, Chlorophyceae, Cyanophyceae, Euglenophyceae and Cryptophyceae. Phytoplankton showed up movements during day time and down movement after sunset. Zooplankton were composed of Rotifera, Cladocera and Copepoda. They showed up migration during night hours and down migration during day.

Keywords: Rewalsar; Phytoplankton; Diurnal-variations; Zooplankton.

INTRODUCTION

Many aquatic organisms exhibit diurnal rhythms in their activities. Although factors such as light, temperature, food, sex and size have been attributed as probable causes for such behaviour of planktonic organisms, subsurface illumination for the 24-hour period has been found to be the most essential stimulus. It is with this respect that Odiete (1993) disclosed that plankton (phytoplankton) growth and distribution depend on the carrying capacity of the environment and on the nutrients concentration both intracellular and extracellular. Physico-chemical parameters also affect plankton distribution, sequential occurrence and species diversity (Raymond, 1983). Plankton distribution and abundance are affected by season (Ezra and Nwankwo, 2001). Seasonal variations affect the physico-chemical variables thus causing variation in abundance and diversity of plankton. Human activities (agricultural runoff) going on along introduce wastes into it which could affect the physico-chemical variables from season to season. These therefore cause seasonal variation in phytoplankton populations. The environmental variables such as temperature, pH and phosphate play a decisive role in altering the phytoplankton density. The diversity and seasonal fluctuation of phytoplankton observed in Rewalsar wetland during the study period. The present study attempts to provide such vital information for future references. Diurnal fluctuations of fresh water bodies have been studied by various workers Ganapati 1955, George, 1961, Verma, 1967, Mishera et al. 1975,1976, Vasisht and Sharma,1975, Nasar,1977, Bohra,1978, Dobriyal and Singh, 1981, Malhotra, *et.al.*,1984 and Jindal, 2005. During present investigation, an attempt has been made to study the diel fluctuations in physico-chemical and biological parameters of Rewalsar wetland in district Mandi (Himachal Pradesh). This wetland is eutrophic in nature and receives organic matter through anthropogenic activities.

Description of Study Area

Rewalsar wetland (31° 37' 30'' N; 76° 49' E) is situated on the eastern slopes of the lesser Himalayas at an altitude of 1360 m above msl. It is located in the North-West part of the Mandi district of Himachal Pradesh (Fig.1 & 2). Rewalsar falls in the western Himalayas and can be approached from the Mandi town (Himachal Pradesh). The area of the wetland is 2.6 ha and its maximum depth is 6 m.

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Source: Google Earth.

Fig 1. Satellite view of Rewalsar Wetland.

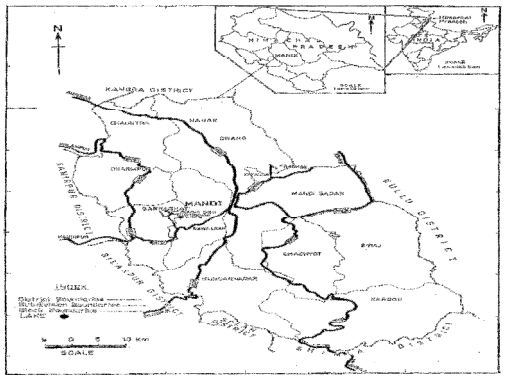

Fig 2. Map of different freshwater lakes in Mandi District (Himachal Pradesh)

MATERIALS AND METHODS

Water samples for physico-chemical and biological analysis were collected at 4 hrs interval for 24 hrs, i.e. 06:30 hrs, 10:30 hrs, 14:30 hrs, 18:30 hrs, 22:30 hrs and 02:30 hrs. The study was made twice, i.e. during summer and winter. Physico-chemical parameters of the water were analyzed following standard methods (APHA, 2005). Parameters like temperature, pH and electrical conductance measured with the help of Multi 340i/set water analysis kit, penetration of light with Secchi disc, free carbon dioxide by titrimetric method and fixation of dissolved oxygen were done on the spot. For the rest of the parameters, 500 ml lake water was collected and analyzed in the laboratory. For the collection of biota, the samples were collected with the help of plankton net made up of blotting silk No. 25 (0.3 mm mesh) and fitted with a wide mouthed bottle. 50 L of water was sieved through the net. The collected samples were preserved in 4% formaldehyde solution.The books consulted for the identification of phytoplank and zooplankton are: Smith (1950), Edmondson (1959), Pennak (1978), Koste (1978), Kudo (1986) and (Smirnov, 1992; 1996).

RESULT AND DISCUSSION

Physico-chemical Characterstics

Diel fluctuations in physico-chemical characteristics during the period of study have been given in Table 1 and Fig.5. Well marked diurnal variations have been recorded in most of the physico-chemical parameters. Water temperature showed a definite diurnal trend of increment during day time. Water temperature varied from 24.82°C to 29.20°C in June and from 9.15°C to 12.95°C in January. Minimum and maximum values of temperature were recorded at 06.30 hrs and 14.30 hrs respectively during both the seasons. The highest (4.38°C) and lowest (3.80°C) diel fluctuation in the months of June and January respectively were due to variations in solar radiations. Further, as suggested by (Welch, 1952) smaller water bodies reacted more quickly to change in temperature. Free carbon dioxide was present only at 06.30 a.m. in winter. Total absence of free carbon dioxide during most of the collections could be attributed to relatively less in number of organisms and decomposition of oxidizable organic matter at low temperature. It started appearing after 10.30 hrs and reached at its maximum in the morning hours at 06.30 a.m. in summer (Vasanthkumar and Vijaykumar, 2011). The pH of water remained alkaline and increased from 10.30 hrs to 14.30 hrs, thereafter a decrease was noticed. A similar pattern has earlier been reported by (George, 1966, Khan *et al*., 1970). This increase during the sunshine hours might be due to high rate of algal photosynthesis. Higher value in diel variation (0.72) in summer was due to luxuriant growth of blue greens and longer period of solar radiation, while the low variation (0.50) in winter was due to decrease in the sunshine hours and decline in the abundance of phytoplankton. During present investigations, carbonates were totally absent in summer and were present only in winter (0.00-5.80 mgL^{-1}). Bicarbonates fluctuated from 132.52 to 152.50 mg L–1 in June and 92.35 to 121.23 mg L^{-1} in January. Carbonates, bicarbonates and free carbon dioxide were found to be interrelated Secchi disc transparency was low in the wetland due to abundance of phytoplankton. It ranged from 0.00-121.00 cm during summer and 0.00-131.00 cm during winter. Water transparency showed maximum value at 14.30 hrs in both seasons and then there was a decline in the afternoon; with relatively less values were noticed (Vasanthkumar and Vijaykumar, 2011). This could be attributed to up movements of blue-green algae. Oxygen percentage saturation values were minimum (summer 26% and in winter, 58%) in the morning at 06.30 hrs, and reached maximum (summer 70% and winter 100%) in the afternoon at 14.30 hrs. Contrary to the findings of (Verma, 1967) a positive correlation has been noticed between dissolved oxygen and temperature. This was due to fact that under tropical eutrophic conditions and in the presence of high illumination during the day, the rate of photosynthesis increased rapidly, thus liberating more oxygen in water (Hutchinson, 1957, Patil *et al.*, 1984 Jindal, 2005, Vasanthkumar and Vijaykumar, 2011). It was also noticed that in the month of June, depletion in the oxygen value (2.18 mg L^{-1}) during early hours was more as compared to those in the January (8.82 mg L^{-1}). This was because of higher respiratory consumption of oxygen by the biota and higher rate of decomposition of oxidizable organic matter at higher temperature. This was because of higher respiratory consumption of oxygen by the biota and higher concentration of free carbon dioxide was present only at 06.30 a.m. in winter. Total absence of free carbon dioxide during most of the collections could be attributed to relatively less in number of organisms and decomposition of oxidizable organic matter at low temperature. It started appearing after 10.30 hrs and reached at its maximum in the morning hours at 06.30 a.m. in summer (Vasanthkumar and Vijaykumar, 2011). The pH of water remained alkaline and increased from 10.30 hrs to 14.30 hrs, thereafter a decrease was noticed. A similar pattern has earlier been reported by (George, 1966, Khan *et al.*, 1970 and Malhotra, *et al.* 1984). This increase during the sunshine hours might be due to high rate of algal photosynthesis. Higher value in diel variation (0.72) in summer was due to luxuriant

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Biotic Factors

Phytoplanktons were composed of members of Bacillariophyceae, Chlorophyceae, Cyanophyceae, Euglenophyceae and Cryptophyceae. In general, they showed upward movements during day time and downward movement after sunset. However, Singh *et al.* (1996) did not notice any significant diel fluctuations in phytoplankton while working on a lake in Bihar.

Among Cyanophyceae, *Microcystis aeruginosa*, *Phormidium* sp. and *Oscillatoria* sp. showed their peaks at 16.30 hrs and *Merismopedia* sp. and *Spirulina gomontii* at 18.30 hrs. Upward movement of these plankters, as suggested by Singh (1977) could be attributed to the presence of gas vacuoles which helped these plankters in floating on the surface of water. Bacillariophyceae, *Melosira* sp. showed its abundance at 06.30 hrs, *Nitzschia* sp. at 10.30 hrs and *Synedra ulna* at 10.30 hrs in summer and 14.30 hrs in winter. Similar observations have been made by Khan and Siddiqui (1976), Fischer *et al.* (1977) and Singh (1990). The rapid cell division during early morning could be the probable factor responsible for the abundance of diatoms (Fischer *et al.*, 1977). Euglenoids, *Euglena acus* (6870 in June and 12875 individual L^{-1} in January) showed its abundance at 10.30 hrs., whereas *Trachelomonas armata* after its peak at 06.30 hrs, showed down migration during the day. Green algae showed a clear picture of diurnal variation with a remarkable preference to the bright hours of the day. *Pandorina morum* (10.30 hrs), *Scenedesmus dimorphus* (18.30 hrs) and *Closterium acerosum* showed their abundance at 14.30 hrs, whereas *Chlorella vulgaris* and *Chlamydomonas reinhardi* at 14.30 hrs. These observations are in confirmity with the findings of Singh (1990). Diurnal variations in Phytoplankton have been given in Table 2 and Fig.3.

Zooplankton were composed of Rotifera, Cladocera and Copepoda. In general, they showed up migration during night hours and down migration during day. This trend was also reported by other workers (Vass and Sachlan, 1953; Singh, 1990; Chandrasekhar and Kodarkar, 1997). Maximum number of zooplankton (4184 individual L^{-1} at 10.30 hrs in summer and 2938 individual L^{-1} at 22.30 hrs in winter) was noticed at mid-night and minimum (2544 individual L^{-1} in summer and 1405 individual L^{-1} in winter at 14.30 hrs) in the afternoon. In summer, *Asplancina brightwelli* showed abundance at 10.30 hrs., whereas *Brachionus calyciflorus* and *Filina terminalis* showed maxima at 22.30 hrs, and *Brachionus angularis* and *Rotaria rototaria* at 10.30 hrs. *Epiphane senta* and *Lecane* sp. showed their abundance at 14.30 hrs.

Midnight abundance of rotifers had also been reported by Vass and Sachlan (1953), Chandrasekhar and Kodarkar (1997). However, Singh (1990) has reported the abundance of rotifers at 06.30 hrs. *Mesocyclops* sp. and *Eucyclops* sp. showed their abundance at 22.30 hrs, whereas *Ceriodaphnia* sp., *Daphnia pulex* and *Moina brachiata* showed their abundance at 02.30 hrs. Many workers have related light intensity to zooplankton distribution. During present studies, distribution of certain species of plankton during day showed positive phototactic behaviour and during night showed negative phototactic behaviour. However, evening and morning abundance of certain species could be attributed to be an effect of endogenous rhythm (Pennak, 1978; Jindal, 2005). Diurnal variations in Phytoplankton have been given in Table 3 and Fig.4.

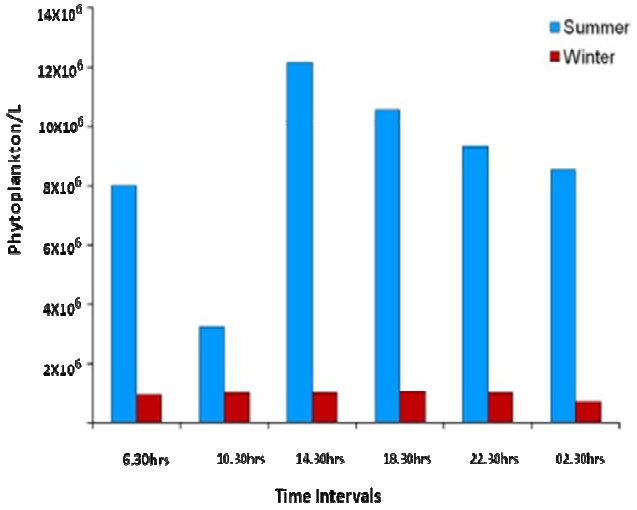

Fig 3. Diurnal variations in Phytoplankton during summer and winter in Rewalsar Wetland

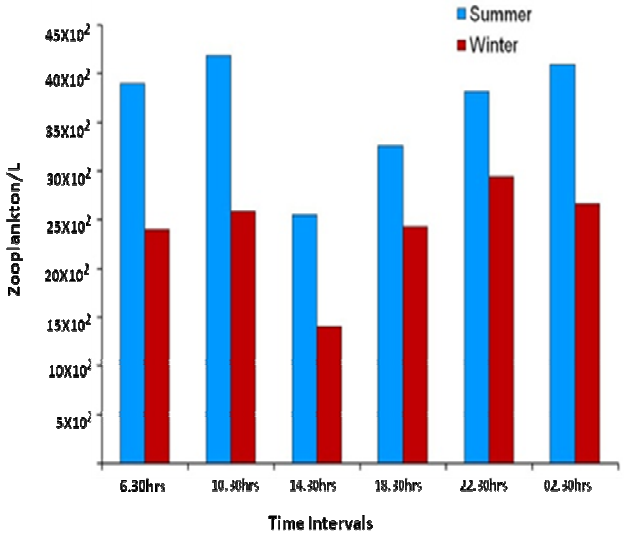

Fig 4. Diurnal variations in Zooplankton during summer and winter in Rewalsar Wetland

Table 1. Diurnal variations in Physico-chemical factors during summer and winter in Rewalsar Lake.

Parameter	Time and Season											
	06.30 hrs		10.30 hrs		14.30 hrs		18.30 hrs		22.30 hrs		02.30 hrs	
	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter
Water temperature (° C)	24.82	9.15	26.83	18.82	29.20	12.95	28.40	12.16	27.20	11.34	25.63	10.78
Conductivity (μS cm^{-1})	415	188	425	208	436	226	446	220	435	213	428	201
pH	7.20	8.30	7.72	8.60	7.92	8.80	7.82	8.70	7.60	8.60	7.52	8.40
Penetration of light (cm)	55	18	92	112	121	131	64	0	0	0	0	0
Dissolved oxygen (mg L^{-1})	2.18	8.82	3.65	9.80	6.23	11.40	5.67	10.80	4.82	10.00	3.45	9.32
Free carbon dioxide (mg L^{-1})	19.63	5.80	16.05	0	14.82	0	16.13	0	17.60	0	18.40	0
Carbonate (mg L^{-1})	0	0	0	6.80	0	14.20	0	13.25	0	9.82	0	11.00
Bicarbonate (mg L^{-1})	152.50	121.23	148.50	105.00	132.52	92.35	136.70	96.53	141.52	101.00	146.73	108.15
Total alkalinity (mg L^{-1})	152.50	121.23	148.50	111.80	132.52	106.55	136.70	109.78	141.52	112.00	146.73	117.95
Total Hardness (mg L^{-1})	181.24	140.72	174.50	116.23	168.67	121.45	163.45	129.68	171.24	131.24	178.68	138.53
Chloride (mg L^{-1})	49.60	26.40	46.45	28.50	44.25	26.10	42.34	25.30	43.57	25.00	47.50	25.60

Table 2.Diurnal variations in Phytoplankton during summer and winter in Rewalsar Lake.

Phytoplankton	Time					
	06.30 hrs	10.30 hrs	14.30 hrs	18.30 hrs	22.30 hrs	02.30 hrs
Summer						
Navicula cuspidata	244010	164810	118355	147600	138350	113510
Diatomy vulgare	44270	50135	54110	58428	51810	46365
Synedra ulna	182405	228705	187026	201700	163204	152900
Chlorella vulgaris	63025	65010	73115	10680	64260	60135
Scenedesmus bijugatus	64630	68310	71410	82410	78190	70285
Chlamydomonas reinhardi	61262	6530	91604	81005	86077	74872
Pandorina morum	58581	62430	60682	54568	50281	47341
Euglena acus	6208	6870	6025	6410	6085	5332
Trachelomonas sp.	58568	45140	40312	46085	50295	52780
Lepocyclis fusiformis	79210	82510	76255	78970	75080	72605
Microcystis aeruginosa	6235505	845020	9293118	8043215	7280350	6862410
Spirulina gomontii	833535	1050118	1348200	1658005	1233405	928410
Phormidium subfuscum	54540	548020	702118	63660	44138	38595
Oscillatoria limosa	7220	11230	15108	13405	10289	8135
Total Phytoplankton	7992969	3234838	12137438	10546141	9331814	8533675

Table 3. Diurnal variations in Zooplankton during summer and winter in Rewalsar Wetland.

Zooplankton	Time					
	06.30 hrs	10.30 hrs	14.30 hrs	18.30 hrs	22.30 hrs	02.30 hrs
Summer						
Colpoda sp.	85	40	32	56	48	61
Epistylis sp.	82	135	92	98	86	73
Stylonychia sp.	97	110	82	128	120	101
Vorticella sp.	58	58	37	71	60	52
Asplanchna sp.	678	970	605	708	620	510
Brachionus angularis	151	215	88	117	126	101
Epiphane senta	212	180	162	208	232	245
Rotaria rototaria	402	505	460	410	370	325
B. rubens	418	305	205	218	238	392
Ceriodaphnia sp.	205	132	82	104	255	278
Daphnia pulex	162	152	80	125	220	268
Moina brachiate	745	905	235	610	832	1133
Cyclops sp.	120	102	72	88	132	41
Mesocyclops sp.	182	165	141	162	205	200
Nauplii	305	210	171	155	270	315
Total Zooplankton	3902	4184	2544	3258	3814	4095
Winter						
Colpidium sp.	135	205	88	282	171	105
Colpida sp.	70	95	73	132	108	88
Alona pulchela	305	280	109	283	315	343
Daphnia pulex	305	205	93	225	280	385
Brachionus calyciflorus	110	125	88	92	141	128
Filinia longiseta	805	1020	682	983	1182	878
Lecane sp.	290	265	110	288	308	333
Eucyclops sp.	378	390	162	141	433	405
Total Zooplankton	2398	2585	1405	2426	2938	2665

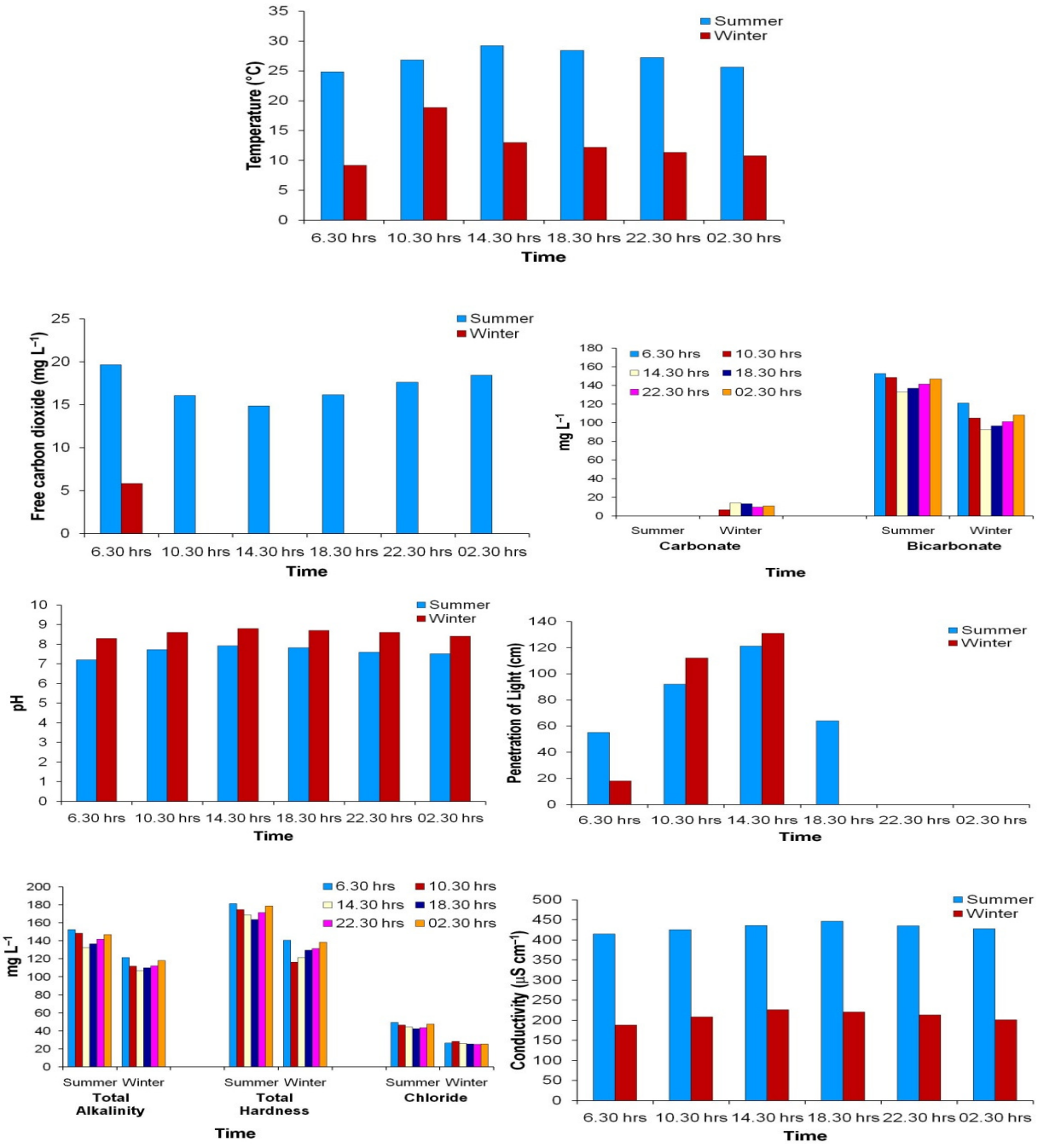

Fig 5. Diel fluctuations in Physico-chemical characteristics during summer and winter seasons at different time.

CONCLUSION

During present studies, distribution of certain species of plankton during day showed positive phototactic behaviour and during night showed negative phototactic behaviour. However, evening and morning abundance of certain species could be attributed to be an effect of endogenous rhythm.

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