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Study of the Physico-Chemical Parameters from the Baigul Reservoir of Distt - Udham Singh Nagar, Uttarakhand, India

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A B S T R A C T

The present study was undertaken to collect baseline data on the Physico-chemical parameters from the Baigul reservoir of district - Udham Singh Nagar, Uttarakhand located in the Tarai region of Uttarakhand. The ecology of reservoir plays a vital role in biological productivity. The nutrient status of water and soil plays the most significant role in governing the production of planktonic organisms. Various physical factors of water, such as temperature and light, play important role in metabolic activities in the water bodies while chemical characteristics such as pH, dissolved gases, carbonates and bicarbonates, nitrogen, phosphorus, silicon, calcium, magnesium, iron, chloride etc. largely govern their productivity. Thus, above said parameters were recorded from June 2014 to May 2015. Both lotic and lentic sites were selected for the study. Differential analysis was also drawn on the basis of diurnal variation, monthly variation. Analysis was also drawn on the basis of sampling sites.

Introduction

The fisheries sector contributes to the national income, exports, food and nutritional security and employment generation. As per the estimates of the Central Statistical Organisation of the Government of India, the total fish production during 2011-12 is at 8.67 million tonnes with a contribution of 5.30 million tonnes from inland sector and 3.37 million tonnes from marine sector respectively. In same year fisheries sector contributes 4.47 per cent to the agricultural GDP and 0.78 per cent to the total GDP (DAHD&F, 2013). During 2013-14, the volume of fish and fishery products exported from India was 9, 83756 tonnes worth 30, 213.26crores and during 2013-14 for the first-time export earnings have crossed USD 5 Billion (MPEDA, 2014).

The reservoirs can play a vital role in increasing fish production of the country, provided these vast resources are developed for fisheries on the scientific lines. Reservoirs are not only one of the most potential fishery resources for future fisheries development but will play pivotal role man power resources development and management for generating the source from employment of India Vass

(2002). Among edaphic factors physic-chemical characteristic water and soil are the major intervention determining the productivity of the reservoir. The soil quality and fertility influence the productivity of reservoir, the factors of mean depth, erosion, damage and the overall development of the shore land of the reservoirs. Natarajan and Pathak (1983) studied water transparency is one such physical variable significant to production. The poor light penetration may be due to suspended matter like silt and clay which retard the productivity. The important physical parameters are dissolved oxygen having the main source in water from air and through photosynthesis. The dissolved oxygen of the reservoir is removed through respiration of fauna and purification of organic matter. Thus the available dissolved oxygen in water depend on the balance of its utilization and availability the other edaphic factors include CO_2 profile, Alkalinity, nitrate, phosphate are the riders responsible either for maintenance of purity and pristine condition of ecosystem in reservoirs but also highly influence nutritionally the biological and fish productivity from the reservoirs (Welcomme, 1976; Singh and Swarup, 1980; Jhingran, 1988; Cornett, 1989; Sommer, 1989; Tarapchak and Russel, 1990; Jhingaran, 1991; Potapova and Charles, 2003).

Uttarakhand, the hill state of India has only fresh water resources having river and tributaries (2,686 km.) reservoirs (20,075 ha) and flood plain (628 ha) which have 64 species in Garhwal region and 31 fish species in Kumaon region. The important reservoirs of Uttarakhand are the Nanaksagar, Sardasagar, Baigul, Tumaria, Dhaura, Baur, Haripura and Tehri. These reservoirs are mainly used for irrigation, hydroelectric power generation and fisheries (Gautam *et al.,* 2004). Among these reservoirs, Baigul reservoir which is situated at about 35 kms from the place of study centre: College of Fisheries, Pantnagar is taken as case study for the present investigation. The present study was proposed with the objective to study the physico-chemical parameters like water temperature, turbidity, transparency, pH, dissolved oxygen, CO_2 profile, total alkalinity, total nitrate, total phosphate etc.

Materials and Methods

Experimental site

The site chosen for the experiment for all the interventions of sampling and as a case study intending the improvement was Baigul reservoir. The fisheries activity of the dam began in 1973. The spread of the reservoir is about 2995km and the catchment area of 305 km^2. The geographical details and profile of the reservoir is given in Table 1.

Sampling stations

Four permanent sampling stations were identified in the reservoir. Stations I and II were located in the lentic sector whereas stations III and IV were located in the lotic or riverine sector of the reservoir (Fig. 1).

Collection of water samples

The water samples were collected at fortnightly intervals from June 2014 to May 2015 from the said location of the reservoir. The stations were approached with the help of a boat to collect the samples. Nansen's water sampler was used to collect the water samples from different depths.

The samples were used to determine the analysis of physic-chemical parameters viz., temperature, transparency, turbidity, pH, dissolved oxygen, Alkalinity, free CO_2, nutrients like nitrate, phosphate (According to standard guidelines of standard methods APHA, 1988).

Physical parameters of water

Water temperature

Water temperature was recorded with the help of an ordinary thermometer having range of 0-50^{0}C, with mark up to 0.1^{0}C. The surface water temperature was recorded by dipping the mercury bulb of the thermometer directly into the water. For determining the temperature of subsurface waters, the thermometer was immediately dipped into the water as soon as it was brought in the Nansen's bottle from a given depth. This method was found to be appropriate.

Transparency

Water transparency was measured by a standard Secchi disc having a diameter of 20.0 cm, with alternate quadrates of white and black colour and attached to a graduated rope. The disc was lowered in the water till it disappeared visually followed by its slow lifting till it became visible again. The depths of disappearance and reappearance of Secchi disc were noted and an average of the two readings was taken as secchi disc transparency.

Turbidity

The turbidity of water was measured by Jackson candle turbidity meter in terms of Jackson turbidity unit (J.T.U.). Water samples were shaken well and poured into the glass tube until the image of candlelight disappeared and the reading was noted from inside bottom of the glass tube.

Chemical characteristics

pH

The pH of the water samples was determined in the field using a 'Henna' electronic digital pH meter.

Dissolved oxygen

The dissolved oxygen was determined by Winkler's titrimetric method (APHA, 1998). Accordingly, the water samples were processed immediately at the site. Samples were collected in 250 ml sampling bottles carefully, avoiding air bubble formation. 1 ml each of manganese sulphate and alkaline potassium iodide solutions were added by dipping the pipette inside the bottle. Precipitate so formed was allowed to settle on the bottom and 1 ml of conc. H_2SO_4 was added to dissolve the precipitate. The bottle was inverted quickly and repeatedly until the precipitate dissolved. 100 ml of this solution was taken in a conical flask and titrated with N/40 sodium thiosulphate solution until the colour of sample became pale yellow. Then few drops of starch solution were added and mixed well to yield blue colour. The titration was continued until the blue colour completely disappeared.

Calculations

The DO content was determined using the following calculation:

Dissolved oxygen (mg/l) = N / 40 ml sodium thiosulphate used × 2

Total alkalinity

Alkalinity was assessed titrimetrically using phenolphthalein and methyl orange as indicators (APHA, 1998).

Phenolphthalein alkalinity

50 ml of water sample was taken in a conical flask and then 5- 6 drops of phenolphthalein indicator solution were added. If the sample remained colourless, phenolphthalein alkalinity was absent. The appearance of pink colour indicated the presence of phenolphthalein alkalinity (Plates1). The

sample with pink colour was titrated with 0.02N H_2SO_4 solution to a colourless end point.

Calculation

Phenolphthalein alkalinity was calculated by using the following expression.

Phenolphthalein alkalinity ($CaCO_3$ mg/l) = A × 1000/ ml sample

Where,

A = ml 0.02N H_2SO_4 used for titration.

Methyl orange alkalinity

The methyl orange alkalinity was analysed by adding 5-6 drops of methyl orange indicator solution in 50 ml of water sample in a conical flask. The solution became yellow in colour. Then it was titrated with standard 0.02N H_2SO_4 till pink colour developed.

Calculation

Methyl orange alkalinity (mg/l $CaCO_3$) = B × 1000/ ml sample

Where,
B = ml titrant used for sample to develop pink colour

Free carbon dioxide

The free carbon dioxide was estimated by standard titrimetric method using phenolphthalein as an indicator (APHA, 1998). 100 ml of the sample was taken in a Nessler's tube in which 5-10 drops of phenolphthalein indicator were added. Sample remaining colourless indicated the presence of free CO_2. It was titrated rapidly against N/44 NaOH until a faint but permanent pink colour appeared.

Calculation

Free CO_2 was calculated by using the following expression:

Free CO_2 (mg/l) = No. of ml of N/44 NaOH used × 10

Nitrate-nitrogen

Nitrate-nitrogen was determined by using "Phenol disulphonic acid" method (APHA, 1998). An aliquot of 50 ml of water sample was evaporated up to dryness in silica crucible and then dissolved in 1.0 ml of phenol disulphonic acid. The contents were diluted to 10 ml with ammonia free distilled water and transferred to a conical flask.

Then, 6-8 ml of strong ammonia solution was added into the flask to neutralize the resulting acidity. Optical density was read within 30 minutes at 410 nm using a spectrophotometer. The concentration of NO_3^- N was calculated from the calibration curve prepared with known concentrations of standard KNO_3 solution.

Results and Discussion

Water temperature

Lentic water

No particular trend of difference in temperature between the two stations could be noticed however for most months at all depths the slightly higher inclination in temperature was recorded at the surface in both the stations in lentic waters very less difference (about 1^oc) in temperature was seen in all the months except the maximum of 2^oc temperature difference was observed in the month of April. Seasonal difference in the temperature was apparent from the fact that in all the summer months at all depths the higher temperature was observed than winter months from both the stations (Table 2).

Among the summer months higher temperature was recorded in the months of June at all the depths from both the station. In winter months the lowest values of temperature was observed in the month of January at all the depth from both the stations.

Lotic water

The recorded temperature values for the lotic waters at two stations (station III and station IV) have indicated the following trend.

The temperature values of the lotic water at two depths (surface and 5 m) for the IVth station indicated lower values than station IIIrd for the months of August to February. The temperature values from the month of April to July have indicated higher values of temperature of both the depths for the VIth station than IIIrd station this summaries that for most of the winter monsoon months the temperature values were lower at the IVth station while the temperature values were at higher range for the summer months at the station IIIrd station (Fig. 2).

Transparency

It was noticed that the transparency values were highest during the winter month of December and January, varying between 124.0 cm to 274.0 cm at all the station of lentic and lotic waters. The months of July and August recorded the lowest values of transparency the value varying between 31.5 cm to 49.0 cm. The pattern of transparency values indicated that after the peak or high mark of transparency in winter months, the decreasing trend was observed from spring which continued till the lowest values recorded in the months of monsoon. The increased rate precipitation, sedimentation and erosion along the shore side due to violent condition may be the cause of lowest rate of transparency during monsoon months (Table 3).

Turbidity

The term turbidity directly related to the existence of any kind of suspended solids and inversely proportional to the nature of transparency in the water columns. It is therefore evidently the turbidity values were minimum during the winter months having the lowest values in the months of December and January varying between 28 to 51 J.T.U the turbidity values significantly started increasing from the onset of spring continued in all summer months reaching maximum during monsoon season in the months of July and August varying between 88 to 145 J.T.U no particular trend was observed between the turbidity values between lentic and lotic waters comparatively in the respective months, however the lowest and highest levels of turbidity were recorded at station IIIrd and station IVth of lotic waters of reservoir (Fig. 3 and Table 4).

pH

The fluctuations in pH were almost identical in the different stations with values ranging from 7.0 to 8.7. The minimum pH values at surface, 5.0 m and 10.0 m depths in lentic sector and surface and 5.0 m depths in lotic sector were obtained during June- July.

The maximal pH values were encountered during spring, autumn and winter seasons

In surface waters the maximum pH was recorded in January in lentic and November in lotic sector, respectively whereas in deep waters maximum pH values were obtained during winter and spring seasons (Fig. 4).

Table.1 Salient features of Baigul Reservoir

PARAMETERS	BAIGUL RESERVOIR
Latitude	28° 56^1 N
Longitude	79^0 40^1 E
Altitude (m)	211
District	Udham Singh Nagar
State	Uttarakhand
Feeder river	Sukhi or Baigul
Construction year	1967
Water spread area (ha)	2693
Type of foundation	Earthern
Total length of bundh (km)	15.3
Top width of the dam (m)	4.8
Maximum height of reservoir	13.71
Depth (m)	201.2 m during summer 207.8 m during monsoon
Spill way	Manual
Total catchment area (km^2)	305

Table.2 Seasonal variation of water temperature (^{0}C) of different depths and stations of Baigul reservoir (Year 2014-2015)

	Lentic						Lotic			
	Station I			Station II			Station III		Station IV	
Months	Surface	5m	10m	Surface	5m	10m	Surface	5m	Surface	5m
June	34.5	33.4	30	35	34.4	33.1	33	32.3	34.9	33.1
July	33	31.2	30.3	33.5	32	30.8	31.9	30.4	32	30.8
August	31.8	30.7	28.9	31	30.3	29.2	30	29.1	29.4	28.7
September	29.2	28.6	27.8	29.8	28.7	27.9	29	28.4	28.6	27.5
October	28.3	28	25.6	27.1	26.2	25	27.3	26	26.2	25.1
November	21	19.5	17.7	20	18.5	17.3	20.1	18.2	20	18.2
December	15.8	14.7	13.9	16.5	16.1	14.7	15.3	14.4	14	13.3
January	12.6	11.2	9.4	11.5	12.3	13.8	10.4	9.7	10.2	9.6
February	15	14.8	14	15.3	14.2	13.1	15.6	13.8	14	13.5
March	21	19.7	19.2	21.2	20.9	18	21	19.2	19	20.9
April	29	28.4	28.3	27	26.2	25.8	31	30.2	31.4	29.1
May	32.4	31	29.2	32.2	31.4	30	31.6	30.2	32.7	31.6

Table.3 Seasonal variation of transparency (cm) at different depths and stations of Baigul reservoir (Year 2014-2015)

	Lentic		**Lotic**	
Months	**Station I**	**Station II**	**Station III**	**Station IV**
	Surface	**Surface**	**Surface**	**Surface**
June	50	67	81	64.5
July	36.5	31.5	49	47
August	49	47.5	46.5	43
September	53	51	55	51.5
October	74.5	69.5	72	72
November	92.5	81	87.5	78.5
December	126.5	124	115	112
January	242	274	208	191
February	184	156	148	171.5
March	102	94	104	88
April	80	86	89	81
may	92	94	71.5	73

Table.4 Seasonal variation of turbidity (J.T.U) at different depths and stations of Baigul reservoir (year 2014-2015)

Months	**Lentic**		**Lotic**	
	Station I	**Station II**	**Station III**	**Station IV**
	Surface	**Surface**	**Surface**	**Surface**
June	82	86	80	91
July	88	98	104	96
August	130	124	92	145
September	65	86	58	56
October	62	52	48	43
November	48	45	52	62
December	42	51	32	46
January	36	41	28	31
February	64	76	72	98
March	67.5	69.5	80.5	70
April	65	67.5	73	63
May	71	76	79	66

Table.5 Seasonal variation of pH at different depths and stations of Baigul reservoir (year 2014-2015)

	Lentic						Lotic			
	Station I			Station II			Station III		Station IV	
Months	Surface	5m	10m	Surface	5m	10m	Surface	5m	Surface	5m
June	7.5	7.4	7.2	7.6	7.3	7	7.3	7.1	7.6	7.4
July	7.9	7.7	7.5	7.7	7.5	7.2	7.3	7.2	7.5	7.4
August	7.5	7.4	7.3	8	7.9	7.7	7.6	7.4	7.8	7.7
September	8.1	8	7.9	7.7	7.6	7.5	7.5	7.6	7.5	7.2
October	7.8	7.7	7.6	8.1	8	8.2	7.9	7.5	8.3	8
November	8.1	8	7.9	8	7.8	8.1	8.6	8.2	8.3	8.2
December	8	7.8	7.7	8.1	7.9	8.1	7.8	7.7	7.6	7.5
January	8.6	8.4	8.3	8.5	8.6	8.7	8	7.9	8.1	7.8
February	8.5	8.4	8.1	8.4	8.3	8.2	8.2	8	7.9	8
March	8.6	8.3	8.2	8.4	8.3	8.2	8.1	8	7.9	8
April	8.7	8.6	8.5	8	7.9	7.8	7.5	7.4	7.7	7.6
May	7.6	7.5	7.4	7.5	7.5	7.3	7.4	7.4	7.5	7.2

Table.6 Seasonal variation of Dissolved oxygen (mg/l) at different depths and stations of Baigul reservoir (year 2014-2015)

	Lentic						Lotic			
	Station I			Station II			Station III		Station IV	
Months	Surface	5m	10m	Surface	5m	10m	Surface	5m	Surface	5m
June	9.5	9.3	9.1	8.6	8.3	7.9	9.2	8	8.3	7.9
July	8.3	8.1	7.9	7.5	7.2	6.7	8.8	8.5	7.9	7.7
August	10.5	10.3	9.8	9.5	9.3	8.9	10.3	9.5	10.1	9.5
September	8.8	8.4	8.3	8.5	8.3	8	9.9	9.7	8	7.8
October	8.3	8	7.7	9.2	8.8	7.8	9.9	9.3	8.1	7.5
November	9.8	9.5	9.1	9.8	9.8	9.5	8.5	8.3	9.7	9.5
December	10.1	10	9.5	10.5	9.8	8.8	10.5	9.9	10	9.9
January	9.5	8.2	7.8	9.1	9	8.6	12.1	11.3	10.3	9.9
February	12.2	11.8	10	11.5	11.3	9.9	12.7	11.8	11.8	11.5
March	11.3	10.8	11.1	10.5	10.3	9.5	10.2	9.8	10.5	10.1
April	10.9	10.4	9.9	9.5	8.5	7.6	9.5	9	8.7	8.5
May	8.3	8.1	7.9	9.2	8.8	8.5	8.6	8.3	8.9	8.7

Table.7 Seasonal variation of free CO_2 (mg/l) at different depths and station of Baigul reservoir (year 2014-2015)

	Lentic						Lotic			
	Station I			Station II			Station III		Station IV	
Months	Surface	5m	10m	Surface	5m	10m	Surface	5m	Surface	5m
June	4.1	6.6	7.9	5	5.9	7.5	0	4	0	6.5
July	0	5.2	7.1	0	6.4	7	0	0	0	6
August	6.1	6.4	7	8	7.5	8.8	7.1	10	7.2	9.2
September	0	4.3	6	0	0	0	0	6	0	6.1
October	0	0	3.9	0	0	3.2	0	5.2	0	4
November	5	6	6.5	3	6	7.2	0	6	6.8	8
December	6.3	7.6	9	5.2	7	8.8	3	7	6	10
January	9	10	12	9.4	12	14	0	6.2	14	15
February	9.5	12	13.2	0	8.6	10.5	7	11.5	0	7.6
March	7.8	8	9	0	6	8.5	0	10	0	7.5
April	0	6.5	8.5	0	5	6	0	8	0	0
May	0	0	4	0	0	5	4.4	7.6	0	8.6

Table.8 Seasonal variation of total alkalinity (mg/l) at different depths and stations of Baigul reservoir (year2014-2015)

	Lentic						Lotic			
	Station I			Station II			Station III		Station IV	
Months	Surface	5m	10m	Surface	5m	10m	Surface	5m	Surface	5m
June	147	138	128	149	125	139	142	120	136.9	115.2
July	127	110	133	136	106	98	139	155	138	140
August	105	100	85	125	100	105	130	110	105	95
September	142	120	100	150	133	110	125	135	120	90
October	160	165	150	144.5	125	155	126	100	104	105
November	113	110	128	130	121	118	128	105	132	120
December	140.2	119	110	130	106	99	103	110	112	95
January	185	155	150	140	138	130	188	160	138	120
February	170	173	160	185	160	140	180	155	195	185
March	195	180	165	150	140	120	205	180	175	160
April	190	165	160	174	172	170	175	170	170	155
May	165	167	136	175	160	145	155	140	160	150

Table.9 Seasonal variation of Nitrate-Nitrogen (mg/l) at different depths and stations of Baigul reservoir (year 2014-2015)

	Lentic						Lotic			
	Station I			Station II			Station III		Station IV	
Months	Surface	5m	10m	Surface	5m	10m	Surface	5m	Surface	5m
June	0.015	0.02	0.026	0.016	0.023	0.027	0.06	0.077	0.035	0.045
July	0.011	0.023	0.032	0.018	0.022	0.03	0.038	0.0476	0.023	0.017
August	0.017	0.021	0.022	0.016	0.019	0.026	0.02	0.026	0.02	0.029
September	0.03	0.019	0.026	0.031	0.025	0.028	0.025	0.027	0.022	0.03
October	0.021	0.023	0.022	0.0192	0.024	0.031	0.022	0.021	0.02	0.032
November	0.02	0.015	0.031	0.022	0.025	0.029	0.023	0.032	0.027	0.03
December	0.01	0.013	0.02	0.014	0.018	0.02	0.018	0.024	0.021	0.028
January	0.004	0.006	0.02	0.004	0.008	0.016	0.013	0.018	0.01	0.015
February	0.004	0.005	0.011	0.006	0.008	0.014	0.006	0.009	0.009	0.008
March	0.011	0.016	0.023	0.007	0.012	0.02	0.004	0.009	0.011	0.018
April	0.013	0.02	0.023	0.015	0.019	0.026	0.017	0.021	0.028	0.049
May	0.02	0.024	0.032	0.02	0.023	0.029	0.034	0.048	0.027	0.037

Fig.1 Map showing sampling stations in Baigul reservoir

Fig.2 Seasonal variation of water temperature (^{0}C) of different depths and stations of Baigul reservoir (Year 2014-2015)

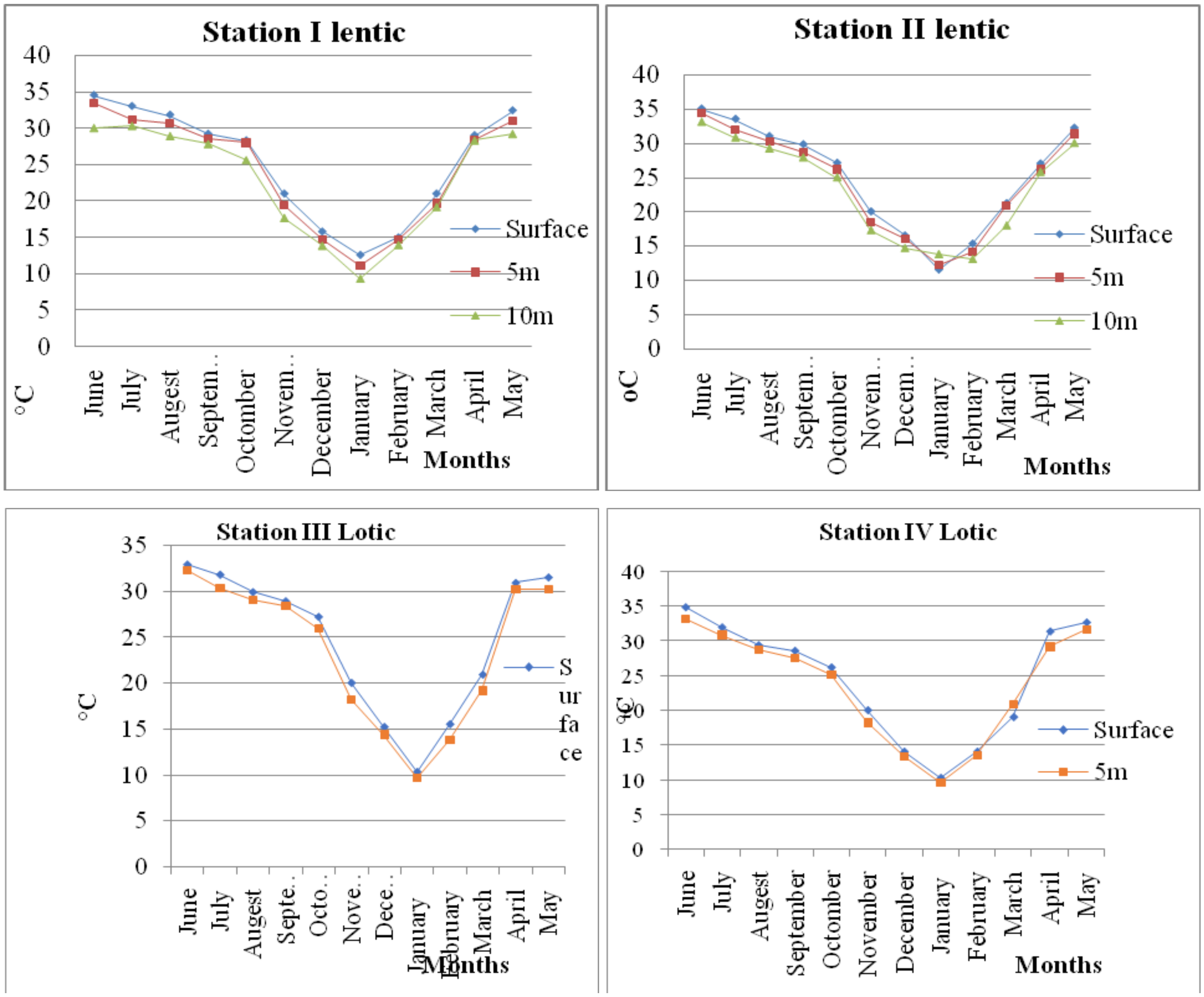


Fig.3 Seasonal variation of turbidity (J.T.U) at different depths and stations of Baigul reservoir (year 2014-2015)

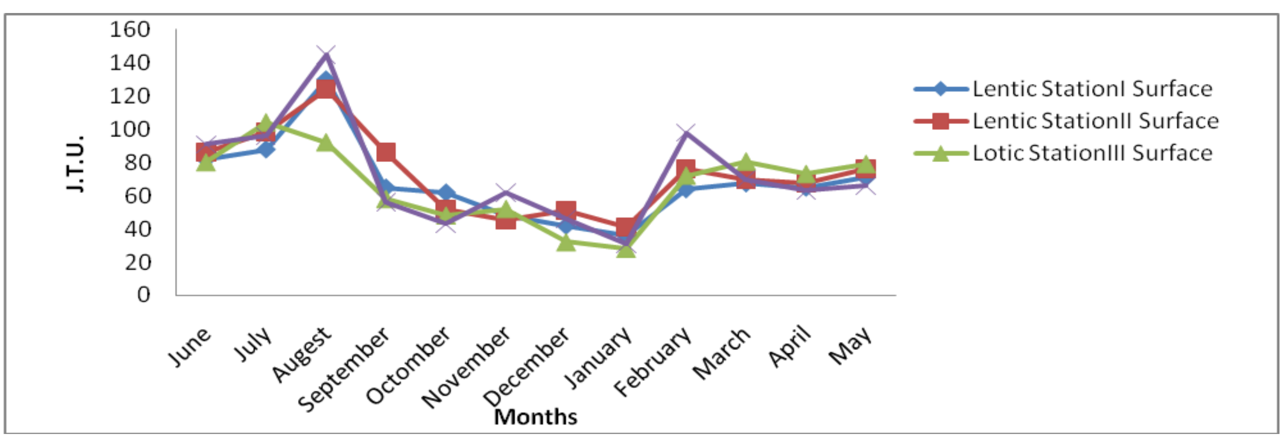


Fig.4 Seasonal variation of pH at different depths and stations of Baigul reservoir (year 2014-2015)

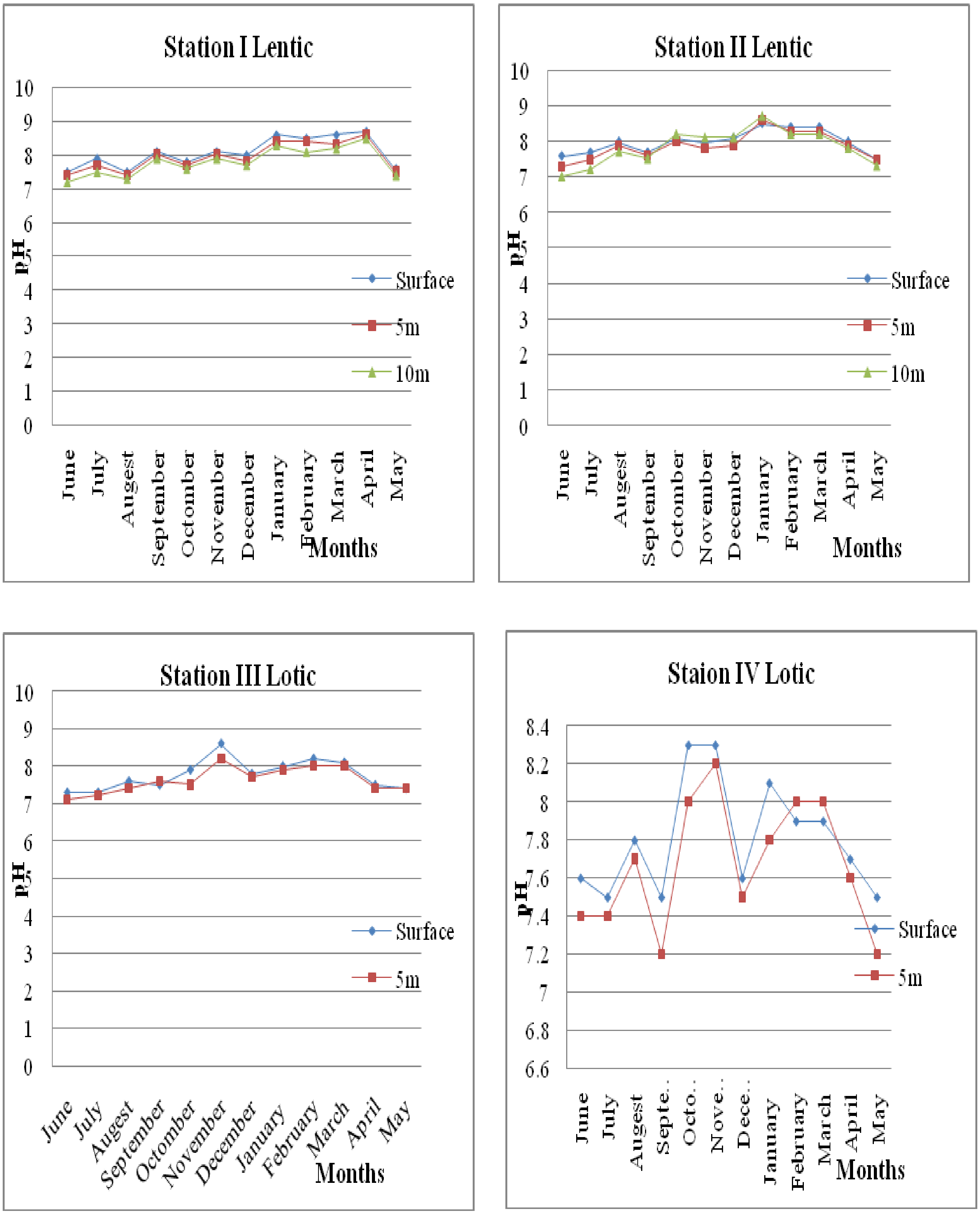


Fig.5 Seasonal variation of Dissolved oxygen (mg/l) at different depths and stations of Baigul reservoir (year 2014-2015)

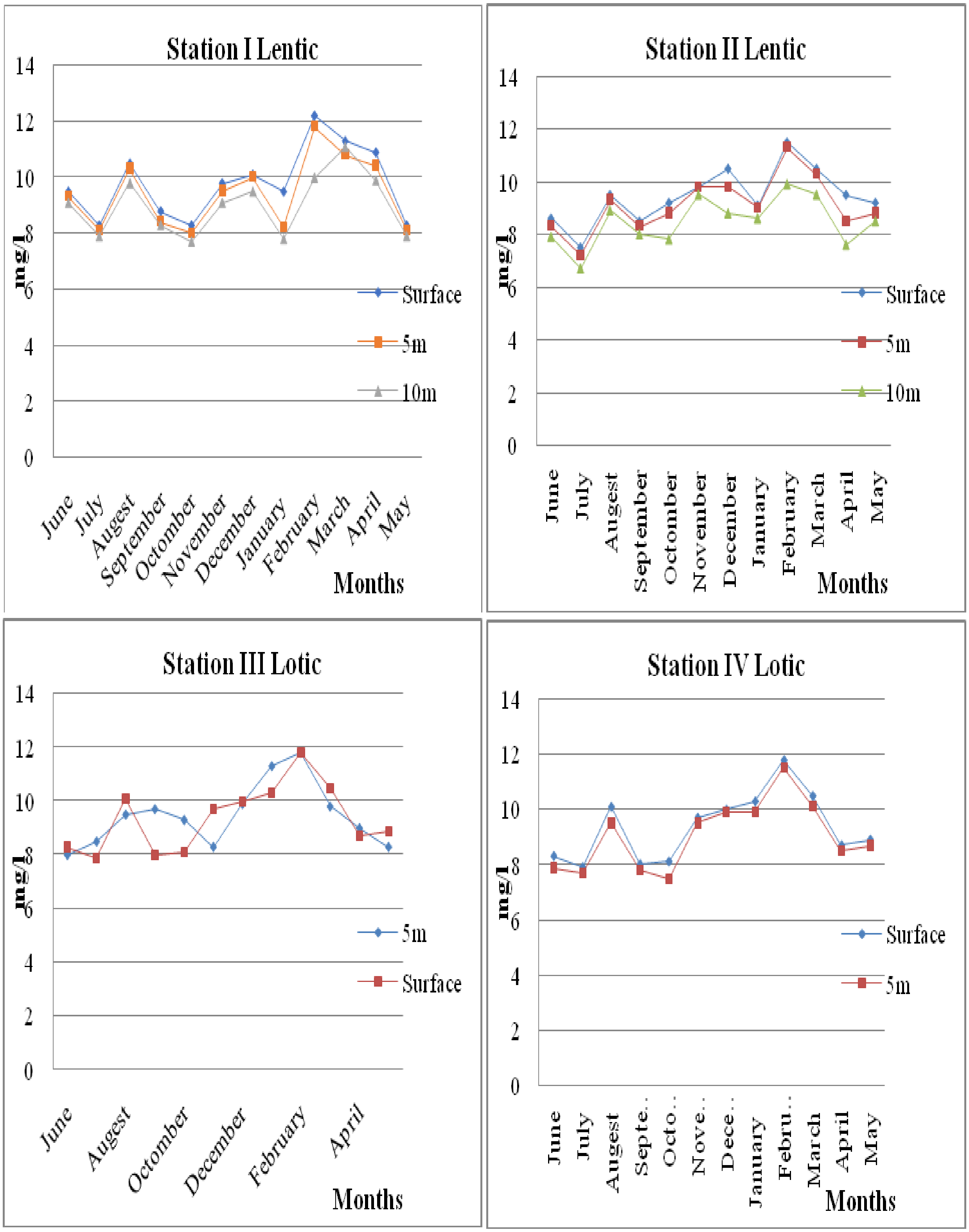


Fig.6 Seasonal variation of free CO_2 (mg/l) at different depths and stations of Baigul reservoir (year 2014-2015).

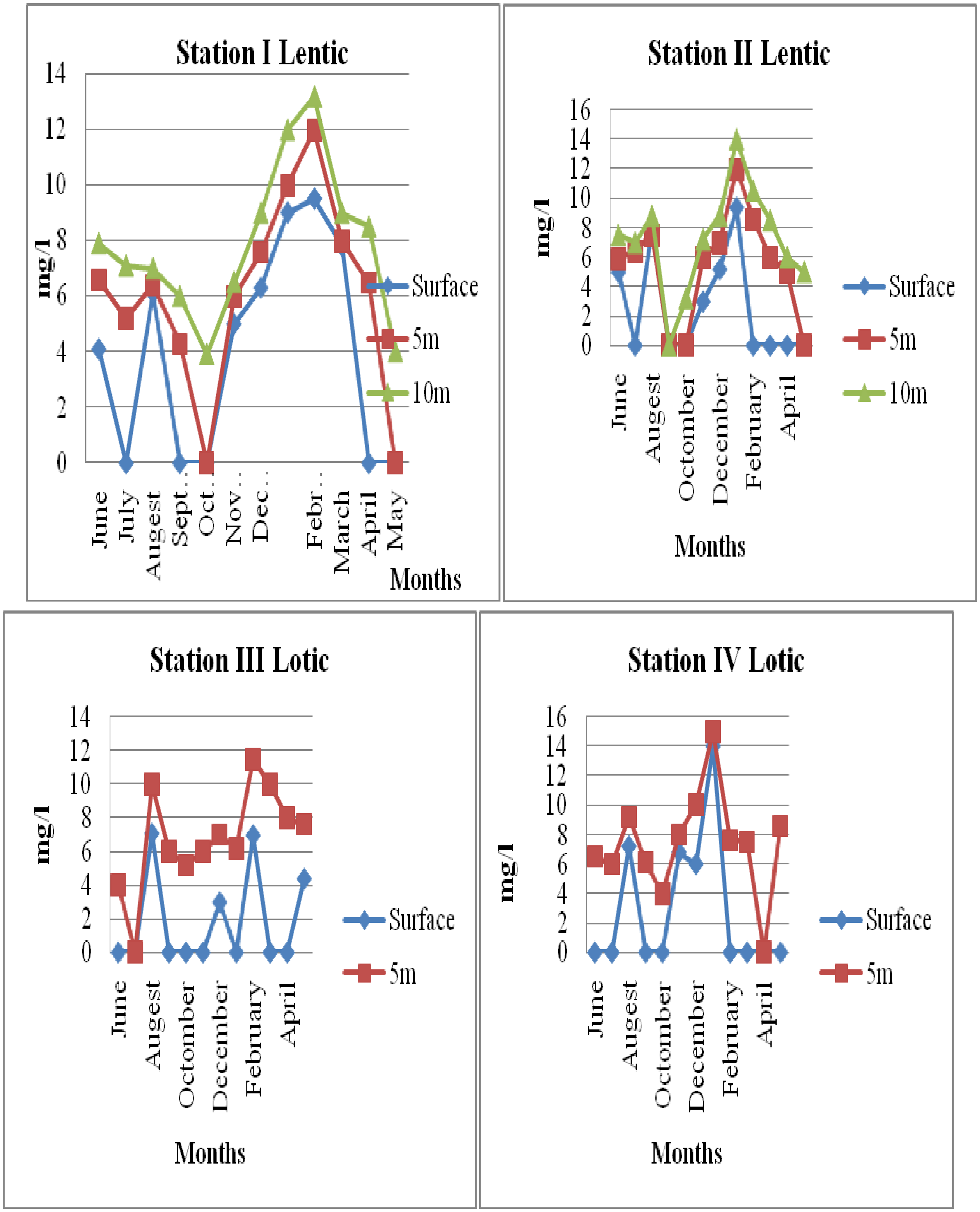
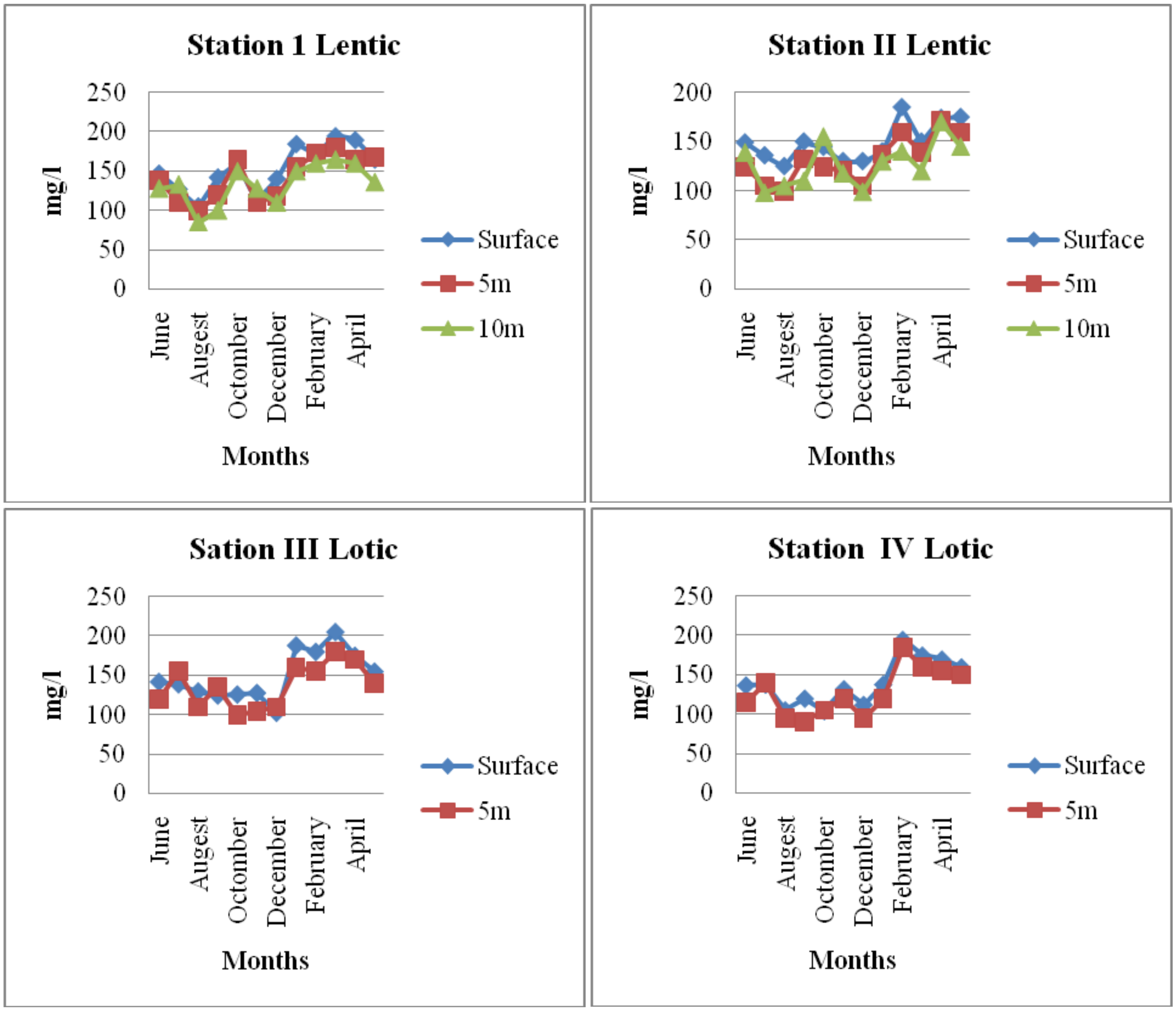


Fig.7 Seasonal variation of total alkalinity (mg/l) at different depths and stations of Baigul reservoir (year2014-2015)



Throughout the study period the pH of the water remained alkaline ranging from 7.5 to 8.7 in surface; 7.4 to 8.6 at 5.0 m and 7.0 to 8.7 units at 10.0 m depths of lentic sector; 7.2 to 8.5 in surface and 7.1 to 8.3 units at 5.0 m depths of lotic sector (Table 5). There were only minor differences between the pH values between surface and 10.0 m waters in both lentic and lotic sectors.

Dissolved oxygen

In the month of February, the highest values of dissolved oxygen were recorded in both the lentic and lotic waters at 12.2 mg/l and 12.7 mg/l respectively. The dissolved oxygen levels were high at all stations except at 10 m depth in station I. the lowest dissolved oxygen levels were recorded in the month of July at all the depths in all the stations with minimum 6.7 mg/l at 10 m in station II in lentic waters and 7.7 mg/l at 5 m depth in lotic waters. The values of dissolved oxygen started declining with the advent of spring reaching continuous low levels in the summer months, except the high levels of dissolved oxygen were recorded at all stations then the preceding month of May. The dissolved oxygen levels were high in winter months than summer months in all the stations of lentic and lotic waters. The dissolved oxygen levels after recording the lowest value in the month July significantly increased in the month of August at all the stations. Thereafter the declined in the month of September and October started increasing with the advent of winter month is November reaching maximum in the month of February (Fig. 5 and Table 6).

Free CO_2

In the course of investigation, the values of free CO_2 in the reservoir were found to vary between nil or 0 mg/l to 15 mg/l. High levels of free CO_2 were recorded during the winter months from December to February at 10 m depth in lentic waters and 5 m depth in lotic waters. The highest value of free CO_2 was recorded in the month of January at 10 m depth of station II (14 mg/l) in lentic waters and at 5 m depth of station IV (15 mg/l) in lotic waters (Fig. 6 and Table 7).

Total alkalinity

The high value of total alkalinity comparatively was recorded in the month of March with 195mg/l at surface in the lentic waters and 205 mg/l at surface in the lotic waters. The value thereafter started decreasing at surface and all depths significantly for the lentic waters for the entire duration summer months up to June and in the monsoon months of July and august thereafter the value of total alkalinity increased for the month of September and October (Fig. 7 and Table 8).

Nitrate–Nitrogen

The NO_3-N exhibited the regular trend of variations in both lentic and lotic sectors. In the lentic waters the maximum and minimum values were ranging between 0.032 mg/l and 0.004 mg/l respectively. The lotic waters it varied between high of 0.077 mg/l and low of 0.004 mg/l. The station wise range of NO_3-N values found to be 0.004 mg/l to 0.032 mg/l for station Ist, 0.004 mg/l to 0.031 mg/l for station IInd; 0.004 mg/l to 0.077 mg/l for station IIIrd and 0.009 mg/l to 0.049 mg/l for station IVth. The high values of nitrate was found in late summer months with the highest value at station IIIrd (5m) at lotic sector of reservoir. The late winter months of January and February accounted for low concentration of NO_3-N.The general trend exhibited the alternate levels of high and low NO_3-N levels. The comparatively high levels NO_3-N with the onset of autumn followed with the decrease in the level during late winter months and again increased during spring time to have higher level in the summer season (Table 9).

The physical factors like insolation, temperature, transparency had the direct impact on the existence of phytoplankton. The insolation was maximum during the summer months with high rise in temperature. After the winter months from the time of spring the insolation and temperature values started increasing and continued to reach this peak in June. The availability of higher solar energy and increased temperature resulted into fairly deeper recording of transparency starting from the month of February to May. The chemical parameter like nitrate nitrogen also after low values recording in the winter months started increasing from March and continued till its peak in June. The nitrate indicated high values all through late summer months.

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