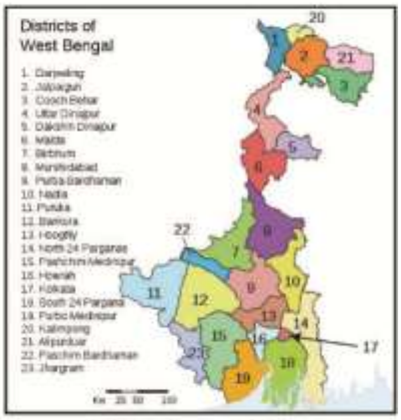

Chapter 04: Physico-chemical parameters of water

Location of pond

India Map



West Bengal Map

District Map of South 24 Pgs.

Photo plate no. I

Open View of the Culture Pond

Study sites of pond

Field work

Water analysis Institution

Photo plate no. II

Laboratory work

Chapter – 04

4.1 INTRODUCTION

Study areas of the ponds are located at Hotar, Magrahat, South 24-Parganas, West Bengal, India. The Length of the ponds are 548.17 ft, 520.12 ft, 492.15 ft and breadth 151.58 ft 142.48ft and 139.35ft. Water surface of the ponds are 480.50 ft, 465.90 ft, 380.27 ft area and the depth of 129.54 cm, 125.27 cm and 121.20 cm. It covers irrigation and pisciculture area of the local people. The healthy condition of an aquatic system depends upon its physico-chemical and biological characteristics which usually fluctuate with seasons. Different parameters of freshwater play a vital role of healthy fish production. Freshwater body includes lake, river, pond canals, reservoir and ditch, which are exclusively important directly and indirectly in our everyday life. Water quality provides current information about the abundance and distribution of the aquatic flora and fauna, indicating the ecological health of the natural water bodies. The study had been undertaking during the periods from November, 2014 to October, 2016. This research work data's were derived from the methods of some scientific information, field observations from the selected three cultural ponds. Analysis of physico-chemical parameters were made on seasonal basis APHA, (2005). The fish fauna were caught by direct method using gears. The economical importance and commercial value of the fishery resources were suggested by Sutton (1996). The ranges of different water parameters determine the quality of water body and acceptable limit recommended by, WHO (World Health Organization, 2004).

4.2 MATERIALS AND METHODS

Collection of water samples

Water samples were collected from the three sampling stations – pond-1, pond-2 and pond-3 in culture ponds. Monthly samples of subsurface water were collected during middle of the week of each month from November, 2014 to October, 2016 at 8 a.m. to 9 a.m. winter, summer, monsoon and post-monsoon seasons in clean plastic air tight bottles. Particularly for DO analysis, water sample was collected in clean 100 ml bottles of glass. The air and water temperature were recorded by minimum – maximum hydro-thermometer and thermometer respectively. pH by pH meter (Systronics Model-362), conductivity by conductivity meter (Labtronics model – LT16), dissolved oxygen by Winkler's volumetric method, photic depth by Secchi disc method, free CO_2, alkalinity, chloride, salinity, phosphorus, total inorganic nitrogen, calcium, magnesium and hardness are measured by APHA (2005). Each parameter and every of water samples were collected from three study sites and analysed the mean values were detected in (Table-3).

Analysis of water samples

The analysis of the water samples for physico-chemical parameters was made following the method of APHA (2005).

Temperature

Temperature of the air and water samples was checked on the spot during the sampling process. Other physico-chemical parameters were analysed in the laboratory. Air temperature was measured by graduated degree centigrade (°C) thermometer at the study ponds in each month during the study seasons. Water temperature was recorded by dipping the minimum-maximum hydro-thermometer of 0 °C to 50 °C ranges with 0.2 °C least count stated by Yang and Yeo (2004).

pH stands for the negative logarithm of hydrogen ions. It is the scale of intensity of acidity and alkalinity of water. It plays a major role in controlling the proper nutritional condition of water. The pH of water sample was measured using a pH meter at the sampling spot and then verified using a digital pH meter (Systronics Model - 362). For verification of water samples collected from the ponds were taken in a clean, sterilized bottle which was carried out to the laboratory and poured in a beaker where calibrated electrodes dipped into the water sample to obtain the pH value.

Transparency and photic depth (Secchi disc method)

Transparency is a measure of light penetration into the water body which is crowded by suspended matters, micro-organisms to the passage of light. It is measured by Secchi disc a circular metallic plate having 10 cm radius. The upper surface of the disc is divided into four quadrates painted alternately in black and white colours. A strong rope is fixed to the centre of Secchi disc.

Procedure

Transparency

The disc was gradually dipped down into the water with the help of a rope. The depth was noted when the upper surface of the disc just disappeared. Sequentially, the disc was lifted upward very slowly and the reappeared depth was noted.

Calculation

The depth of water at which the disc disappeared = d_1

The depth of water at which the disc re-appeared = d_2

Secchi disc transparency = $(d_1 + d_2)/2$ in cm

Salinity (APHA, 2005)

Salinity is the dissolved salt contents (such as sodium chloride, magnesium and calcium sulphates and bicarbonates) of a body of water and in soil. It plays an important role in the growth of culture organisms through osmoregulation of body minerals from that of the surrounding water.

Calculation

Salinity (ppt.) = Chlorinity (ppt.) × 1.805 + 0.03

Dissolved oxygen

Winkler's volumetric method was followed for estimation of dissolved oxygen.

The dissolved oxygen content of the samples was determined by the modified Winkler's titrimetric method, Strickland and Persons (1972) and expressed in mg/l. Collected water sample (in DO bottle) was mixed with 1 ml of manga-nous sulphate solution and then 1 ml of alkaline iodide solution at the sampling spot. The stopper was closed and inverted for a few times to ensure through mixing of water with reagents. Then it was carried out to the laboratory. 1 ml of concentrated H_2SO_4 was added to it and inverted the stoppard bottle for a few times to dissolve the precipitate. After that 50 ml of the sample solution was taken to a conical flask and titrated with freshly prepared N/40 Sodium Thiosulphate solution till the colour of the sample solution turned fade. Then 1 to 2 drops of starch indicator was added to it, blue colour was developed. Then the solution was titrated again carefully till the point-blue colour disappeared. The volume of Thiosulphate solution was noted for calculation.

Calculation

Concentration of DO (ppm) = ml of $^{N}/_{40}$ Sodium Thiosulphate used × 4

Optimum range = 5 to 10 ppm

Free Carbon dioxide (CO_2) (APHA, 2005)

The free CO_2 concentration was estimated titrimetrically against Sodium hydroxide solution using Phenolphthalein indicator 100 ml. It was titrated against $N/_{44}$NaOH with constant stirring till pink colour appears at the end point.

Calculation

Concentration of free CO_2 (ppm) = ml of $N/_{44}$NaOH required × 10

Alkalinity (APHA, 2005)

The amount of acid required to titrate the bases in water is a measure of alkalinity (Boyd, 1969).

Procedure

The procedure of total alkalinity was measured of 100 ml water sample. It was taken in a 250 ml conical flask and 3 drops of Phenolphthalein indicator was added. Water colour turned to pink and then it was titrated with 0.02 N H_2SO_4 until the pink colour just disappeared. The volume (ml) of used acid was noted. Then 3 drops of Methyl Orange (MO) was added to the same water sample. Water turned to yellow and then it was titrated with same acid until a faint orange end point was obtained. The volume (ml) of acid used during the titration was noted.

Calculation

Total volume of 0.02 N H_2SO_4 consumed during titration with both Phenolphthalein and Methyl Orange indicator was M. Total alkalinity as ppm of $CaCO_3$ in M × 10.

Total hardness (APHA, 2005)

In most of the freshwater, total hardness is mainly occupied by calcium and magnesium ions. The total hardness was determined by the titration with standard Ethylene Diamine Tetraacetic Acid (EDTA).

Factor = 5/V, where V = Volume of EDTA used.

(A) Determination of calcium (APHA, 2005)

5 ml of water sample was taken in a volumetric flask and the volume was made 25 ml by addition of distilled water. 5 ml of 4N NaOH was added to it and 25 mg of Murexide indicator was added to give an orange red colour. It was then titrated against 0.01N EDTA till on purple

colour appears**.**

(B) Determination of Ca + Mg (APHA, 2005)

5 ml of water sample was taken in a volumetric flask and the volume was made 25 ml by addition of distilled water. 1 ml of Ammonium chloride – Ammonium hydroxide buffer and 3 to 4 drops of EBT (Eriochrome Black T indicator) was added to give a wine red colour. It was then titrated against 0.01 N EDTA till blue colour appears.

Calculation

Concentration of Ca (ppm) = (ml of EDTA used × F × 40)

Concentration of Mg (ppm) = $\text{ml of EDTA used for Ca} + \text{Mg}) - (\text{ml of EDTA used for Ca}) \times F \times 24$

Total hardness (APHA, 2005)

(A) Observed ppm of Ca (as $CaCO_3$ equivalents) = ppm of Ca in water × 50.04 / 20.04

(B) Observed ppm Mg (as $CaCO_3$ equivalents) = ppm of Mg in water × 50.04 / 12.16

Total hardness of water = (Ca) + (Mg) ppm as $CaCO_3$

Phosphate

The solvable reactive phosphate content of water, termed as orthophosphate was determined spectrophotometrically by using strong acid ammonium molibate, stannous chloride (flash) and standard phosphate solutions. 25 ml of water sample taken in a glass flask, 1 ml of ammonium molibate solution and 3 drops of 0.12 ml stannous chloride solution were added.

Gradually a blue colour appeared. The observance reading was noted in a spectrophotometer at 690 nm after 10 minutes, before 15 minutes against blank. The value of phosphate was at estimated with the help of a calibration curve and expressed in mg/l.

Total inorganic nitrogen (APHA, 2005)

Importance of nitrogen in fish nutrition is well documented as was stated by many workers. Ammonium (NH_4^+) and nitrate (NO_3) forms of inorganic nitrogen remain dissolved in water.

The nitrate content was estimated by using phenol disulphuric acid, potassium hydroxide and stranded nitrate solution. In a casserole, 25 ml of water sample was taken which was evaporated to dryness on a hot plate. The residue was rapped thoroughly with 0.5 ml of phenol disulphuric acid regent by a glass spatula to dissolve all solids. Later 5 ml of distilled water and 1.5 ml of KOH were added one after another and then stirred that resulted in the development of yellow colour. The supernatant was taken and its absorbance was recorded in a spectrophotometer at 410 nm against distilled water blank. The value of nitrate was found out with the help of standard curve and expressed in mg/l.

Procedure

Firstly, 250 ml of water sample was taken in a Kjeldahl flask and fitted the flask with the distillation set along with condenser. Davarda's alloy and 10 ml of 40% NaOH solution was added to Kjeldahl flask. Then 20 ml of 4% Boric acid (H_3BO_3) in a 250 ml conical flask and placed it below the outlet of the condenser so that the tip of the outlet dipped into the Boric acid solution. Distillation was carried out upto Daverda's alloy and NaOH solution almost to dryness. Then the heating was stopped and taken out the conical flask. Thereafter the distillate was titrated with 0.1 N/H_2SO_4 solutions till pinkish colour appears**.**

Calculation – Nitrogen in form of NH_4^+ +NO_3 = A/V × 280 ppm

Where A= 0.1 N/H_2SO_4 solution required for titration.

V = Volume of water sample used.

Electrical conductivity (EC) (APHA, 2005)

Electrical conductivity (EC) value indicates the total concentration of ionized constituents of water sample. EC is reciprocal of electrical resistance and can be derived from the relationship C = I / R where I is current, R is resistance and C denotes conductivity. It was measured at 25 ℃ and μmho / cm unit.

Procedure

The cell of the conductivity meter in the standard KCl solution was immersed and noted the conductivity value in the meter. The cell constant from the relationship as was shown earlier using known specific conductance of the standard solution was calculated. Then the cell was rinsed with distilled water. After that it was immersed in the sample water and noted the conductivity value.

Calculation

EC of the water sample (μmho / cm) = measured conductivity × cell constant.

Chloride (APHA, 2005)

Concentration of ion varies widely depending upon the environmental condition. Most of the water soluble salts commonly remain in Cl^- form in the aquatic environment. So, therefore, the amount of Cl^- in the water body indicates very closely the total amount of soluble salts present in the ecosystem.

Procedure

Standardisation of $AgNO_3$ solution, 10 ml of standard NaCl solution was taken in a 250 ml conical flask. Then distilled water was added to make the volume around 100 ml, 0.5 ml of K_2CrO_4 solution was added and was titrated with $AgNO_3$ till appearance of a permanent red precipitation. The strength of $AgNo_3$ solution was standardized with the help of titrated value. F was the factor of $AgNO_3$ concentration and V is the volume required for titration, F = 10/V, where V is the volume of water sample (ml). Cl^+ estimation-5 ml of water sample was taken in a 250 ml conical flask. Then 0.5 ml K_2CrO_4 was added to it and titrated with $AgNo_3$ till the appearance of a red precipitation.

Calculation

$$\text{Concentration of } Cl^- \text{ (ppm)} = \frac{\text{Titrated value (ml)} \times F \times 1000}{V}$$

Where, F= Factor of $AgNO_3$ concentration, F= 10/V

V= Volume of water sample (ml)

Phosphorus

According to Jhingran (1975), the most critical nutrient element in the maintenance of pond productivity is phosphorus. It has the special significance in fish culture.

Procedure

Standard curve with different concentrations of phosphorus from the 2 ppm solution was prepared as follows:

ml of 2 ppm solution	conc. (ppm) of P in 25 ml vol. flask
0.25	0.02
0.5	0.04
1.25	0.1
2. 5.	0.2
5.0	0.4

Above mentioned volumes of 2 ppm phosphorus solution was taken in 25 ml of five volumetric flasks separately and was also run a blank in another flask without any P solution. Some amount of distilled water in each of the flask was added to reach the volume up to 10 ml. Then 5 ml of Ascorbic acid molybdate mixture to each flask was also added and made up the volume of 25 ml with distilled water. 30 minutes were waited for full blue colour development.

Optical density (OD) of a spectrophotometer at 660 nm wave length after setting OD with blank solution was noted. A standard curve by plotting concentrations (ppm) of P axis and respective OD in Y axis was prepared. 5 ml of water samples were taken in a 25 ml of volumetric flask depending on expected concentrations of P in water and blank flask were also taken. 5 ml of ascorbic acid molybdate mixture was poured into each flask and distilled water was added in each flask till up to the volume reached 25 ml OD was determined of the developed blue colour as before. OD value of unknown water samples on the standard curve was put on to get the concentration of P in the volumetric flask as stated earlier.

Calculation

The concentration of P in 25 ml volumetric flask = X ppm

The initial volume of water sample taken in the flask = V ml

Concentration of P in water sample = X × 25/V ppm

4.3 RESULTS

The present investigation has been carried out during the study period from November, 2014 to October, 2016. The first annual cycle is from November, 2014 to October, 2015 and the second annual cycle is from November, 2015 to October, 2016. The value of physico-chemical parameters of selected cultural ponds water show variations and the mean value obtained results are displayed in (Table-1, 2 & 3 and Fig.1 to 17).

Table- 1

Monthly values of physico-chemical parameters of culture ponds (November, 2014 to October, 2015)

Parameter (Unit)	Nov' 14	Dec' 14	Jan' 15	Feb' 15	Mar' 15	April' 15	May' 15	June' 15	July' 15	Aug' 15	Sept' 15	Oct' 15
Air Temperature O°C	26.3 ± 0.20	26.9 ± 0.23	27 ± 0.16	28.3 ± 0.08	34.3 ± 0.37	32.9 ± 0.98	32.7 ± 0.86	35.4 ± 0.84	33.9 ± 0.57	33.8 ± 0.57	32.8 ± 0.33	31.7 ± 0.49
Water Temperature O°C	26.2± 0.90	25.2± 0.82	26.3± 0.41	25.5± 0.73	28.6± 0.33	28.9± 0.49	30.7± 0.33	34.1± 0.33	34.8± 0.49	31.3± 0.65	30.1± 0.82	29.2± 0.37
pH	7.4± 0.73	7.2± 0.08	7± 0.16	6.9± 0.49	7.8± 0.49	7.12± 0.82	7.9± 0.33	6.5± 0.65	6.8± 0.73	7.3± 0.16	7.2± 0.26	7.6± 0.33
Transparency (cm)	182.7± 0.37	182.1± 1.31	187.19 ±0.15	251.05 ±0.83	172.17 ±0.08	60.35± 0.35	65.2± 0.73	32.25± 0.83	30.28± 0.08	269.25 ±0.82	141.7± 0.49	142.1± 1.14
Salinity (ppt.)	0.29± 0.03	0.12± 0.08	0.119± 0.03	0.372± 0.01	0.31± 0.08	0.342± 0.01	0.078± 0.05	0.148± 0.08	0.182± 0.01	0.99± 0.11	0.249 ± 0.05	0.251 ±0.05
DO (mg/l)	5.6± 0.21	5.8± 0.08	6.0± 0.24	6.1± 0.08	6.3± 0.24	6.0± 0.24	5.7± 0.47	5.3± 0.52	5.4± 0.08	5.6± 0.21	5.8± 0.08	6.5± 0.16
Free CO_2 (mg/l)	3.34± 0.91	3.48± 0.89	3.59± 0.93	5.66± 0.99	5.54± 0.88	1.45± 0.65	3± 0.77	3.79± 0.44	3.52± 0.87	3.63± 0.69	5.13± 0.32	2.4± 0.73
Alkalinity (mg//l)	52.6± 0.33	55.5± 0.90	60.41± 0.33	55.7± 0.33	60.15± 0.02	62.1± 0.82	59.4± 0.33	54.6± 0.98	45.5± 0.82	68.5± 0.73	67.6± 0.65	59.45± 0.37
Total Hardness (ppm)	86.55± 0.90	87.6± 0.98	88.5± 0.73	77.45± 0.82	68.7± 0.90	66.5± 0.90	67.71± 0.90	67.62± 0.90	65.5± 0.98	62.22± 0.82	72.52± 0.01	75.1± 0.82
Electrical conductivity (µmho/cm)	11.7± 0.73	11.54± 0.78	11.47± 0.08	11.45± 0.01	11.6± 0.01	12.34± 0.08	12.65± 0.08	12.6± 0.08	12.13± 0.82	13 ± 0.82	12.72± 0.77	12.32± 0.26
Chloride (mg/l)	150.12 ±0.01	150.1± 0.01	149.32 ±0.01	174.3± 0.41	119.2± 0.82	110.22 ±0.82	32.65± 0.09	67.27± 0.82	77.31± 0.82	38.13± 0.82	120.3± 4.08	143.36 ±0.88
Phosphate (mg/l)	0.047	0.044	0.038	0.037	0.02	0.019	0.119	0.125	0.134	0.131	0.121	0.053
Total Inorganic Nitrogen (mg//l)	1.29	1.37	1.41	1.44	0.26	0.29	0.59	1.32	1.87	1.52	1.89	2.27
Ca (mg/l)	19.23± 0.37	29.24± 0.37	24.72± 0.37	26.5± 0.90	18.2± 0.33	11.75± 0.74	24.27± 0.37	36.2± 0.73	38.42± 0.63	29.4± 0.01	17.2± 0.73	21.42± 0.74
Mg (mg/l)	11.63± 0.04	10.71± 0.78	13.69± 0.04	12.71± 0.04	16.74± 0.02	18.77± 0.01	13.51± 0.37	13.79± 0.04	15.6± 0.29	30.69± 0.04	17.18± 0.41	11.32± 0.04
Water level (ft)	370.32	370.65	370.65	370.7	365.3	362.32	288.65	289.65	290.68	298.58	315.6	374.33
Photic Depth (cm)	205.74 ±0.91	202.65 ±0.73	204.0± 0.82	218.6± 1.55	164.14 ± 0.81	129.54 ±0.85	109.6± 0.65	100.7± 0.08	119.25 ±0.81	160.35 ±0.87	162.4± 0.73	202.54 ±0.81

Table-2

Monthly values of physico-chemical parameters of culture ponds (November, 2015 – October, 2016)

Parameter (Unit)	Nov' 15	Dec' 15	Jan. 16	Feb' 16	Mar' 16	April' 16	May' 16	June' 16	July' 16	Aug' 16	Sept' 16	Oct' 16
Air Temperature O°C	30.1± 0.37	26.11± 0.81	32.15± 0.39	33.23± 0.37	34.46± 0.78	36.18± 0.79	34.36± 0.16	34.34± 0.81	35.28± 0.78	34.4± 0.73	35.12± 0.81	31.16± 0.57
Water Temperature O°C	23.12 ± 0.81	19.2± 0.73	20.17± 0.81	24.13± 0.81	26.2± 0.73	30.46± 0.80	29.66± 0.81	31.4± 0.73	31.45± 0.80	30.65± 0.73	30.68± 0.82	28.71± 0.81
pH	7.39± 0.08	7.6± 0.16	8.1± 0.08	7.59± 0.08	7.3± 0.16	7.55± 0.08	7.63± 0.07	7.62± 0.08	7.74± 0.07	7.26± 0.02	7.61± 0.09	7.47± 0.07
Transparency (cm)	179.5 ±0.73	159.4± 0.90	229.1± 0.08	301.5± 0.90	177.33 ±0.81	100.19 ±0.82	41.92± 0.78	103.18 ±0.79	141± 0.82	179.3± 0.73	177.14 ±0.80	185.5± 0.73
Salinity (ppt.)	0.3± 0.08	0.27± 0.01	0.3± 0.08	0.25 ± 0.04	0.5±0. 08	0.45± 0.09	0.27± 0.01	0.47± 0.08	0.35± 0.07	0.31± 0.01	0.29± 0.01	0.27± 0.01
DO (mg/l)	5.4± 0.16	5.8± 0.24	6.2± 0.41	6.5± 0.24	6.6± 0.65	6.1± 0.33	5.8± 0.16	5.0± 0.08	5.1± 0.16	5.5± 0.08	5.9± 0.44	6.3 ± 0.33
Free CO_2 (ppm)	4.59± 0.73	3.62± 0.07	8.56± 0.01	6.22± 0.02	3.33± 0.01	3.66± 0.10	3.36± 0.07	4.1± 0.24	3.36 ± 0.07	3.46 ±0.01	5.25± 0.81	6.69 ±0.73
Alkalinity (mg/l)	78.69 ±0.82	70.23± 0.74	68.24± 0.81	69.52± 0.82	57.31± 0.77	69.34± 0.81	86.22 ±0.80	79.13± 0.81	79.15± 0.81	63.14± 0.80	41.71± 0.82	69.61± 0.74
Hardness (ppm)	171.52 ±0.74	142.63 ±0.77	110.2± 0.73	111.2± 0.73	114.29 ±0.81	112.31 ±0.73	136.2± 0.73	172.26 ±0.81	178.23 ±0.81	183.26 ±0.72	158.23 ±0.73	130.31 ±0.73
Electrical conductivity (µmho/cm)	11.78 ±0.73	11.7± 0.65	13.34± 0.75	13.58± 0.74	15.68± 0.73	16.95± 0.82	16.65± 0.81	17± 0.82	16.02± 0.80	15.82± 0.74	12.3± 0.65	11.69± 0.73
Chloride (mg/l)	149.56 ±0.73	128.18 ±0.81	156.34 ±0.55	116.21 ±0.82	269.4± 0.65	165.18 ±0.80	130.2± 0.73	302.23 ±0.78	156.23 ±0.54	151.31 ±0.57	141.41 ±1.44	133.3± 0.90
Phosphate (mg//l)	0.06	0.051	0.043	0.033	0.013	0.027	0.021	0.039	0.176	0.185	0.102	0.097
Total Inorganic Nitrogen (mg/l)	1.2	0.86	0.68	0.8	0.85	0.81	0.53	1.1	1.3	1.72	1.69	1
Ca (mg/l)	46.16 ±0.79	27.37± 0.74	19.18± 0.81	30.19± 0.77	26.33± 0.78	20.71± 0.82	26.65± 0.76	39.67 ±0.80	33.41 ±0.81	40.26 ±0.75	31.67± 0.80	34.65± 0.65
Mg (mg/l)	10.42 ±0.78	18.9 ±0.82	16.44 ±0.51	18.6 ±0.16	13.6 ±0.73	14.4 ±0.73	15.86 ±0.82	52.69 ±0.80	24.29 ±0.73	23.23 ±0.77	21.72 ±0.81	11.76 ±0.80
Water level (ft)	374.33	374.1	370.24	367.2	360.34	360.35	360.35	373.21	374.33	380.4	381.38	376.24
Photic Depth (cm)	164.14 ±0.81	134.17 ±0.72	140.2± 0.73	130.1± 1.63	173.66 ±0.72	160.2 ±0.73	57.48 ±0.80	60.1± 0.81	45.52± 0.72	56.13± 0.81	205.1± 0.81	157.12 ±0.82

Table-3

Ranges of physico-chemical parameters and their suitability for pisciculture.							
	Nov. 2014 - Oct. 2015			Nov. 2015 - Oct. 2016			
Parameter (Unit)	**MIN**	**MAX**	**MEAN**	**MIN**	**MAX**	**MEAN**	**PISCICULTURE (ICAR/NRAE/SRAC/ Recommended values**
Air Temperature O℃	26.3	35.4	31.33	26.11	36.18	33.07	
Water Temperature O℃	25.2	34.8	29.24	19.2	31.45	27.15	sp. dependent 24-30 usually
pH	6.5	7.12	7.23	7.3	8.1	7.57	6.5 - 9.0 SRAC
Transparency (cm)	30.28	269.25	143.03	41.92	301.5	164.59	Species dependent
Salinity (ppt.)	0.078	0.372	0.29	0.25	0.47	0.34	< 0.5 - 1.0 for Freshwater Fish NRAC
DO (mg/l)	5.3	6.5	5.84	5.0	6.6	5.85	> 4 - 5 NRAC
Free CO_2 (mg/l)	1.45	5.66	3.71	3.33	8.56	4.68	< 10 NRAC
Alkalinity (mg/l)	45.5	68.5	58.46	41.71	86.22	69.36	50 - 150 SRAC
Hardness (ppm)	62.22	88.5	73.83	110.2	183.26	143.39	30 -180 ICAR
Electrical conductivity (µmho/cm)	11.6	13	12.13	11.7	16.95	14.38	
Chloride (mg/l)	32.65	174.3	111.02	116.21	302.23	166.63	> 100 SRAC
Phosphate (mg/l)	0.019	0.134	0.074	0.013	0.185	0.071	0.005 - 05 SRAC
Total Inorganic Nitrogen (mg/l)	0.26	2.27	1.29	0.53	1.72	1.05	(NH_3)0.1 Max., (NH3) 0.1 – 4.5, (NO2) 0.005 – 05, ICAR Tripura
Ca (mg/l)	11.75	38.42	24.71	19.18	46.16	31.35	> 20 SRAC
Mg (mg/l)	10.71	30.69	15.53	10.42	52.69	20.16	
Water level (ft)	288.65	374.33	338.95	360.34	381.38	371.04	
Photic Depth (cm)	100.7	218.6	164.96	45.52	205.1	123.66	
Water temperature, pH, salinity , DO, free CO_2, alkalinity, hardness, chloride , phosphate , total inorganic nitrogen, Ca ,ranges are eligible for fish culture (According to ICAR,SRAC,NRAC-Table-3) which induce the fish productivity.							

A) Air Temperature

Many workers opined that the temperature is an important driving force which in turn regulates the population of aquatic ecosystem. Air temperature indirectly impacts on abiotic as well as biotic components of this ecosystem.

The monthly variation of air temperature has been presented in Fig.1.

The maximum air temperature was recorded 35.4 °C in summer (June), 2015 and minimum temperature was 26.3 °C in winters (November), 2014 in 1st annual cycle whereas in 2nd annual cycle 26.11 °C was the minimum in December, 2014 and 36.18 °C was the maximum in April, 2016 in (Table-1 & 2). The mean values of both the year was 31.33 °C and 33.07 °C respectively table-3 and fig.1.

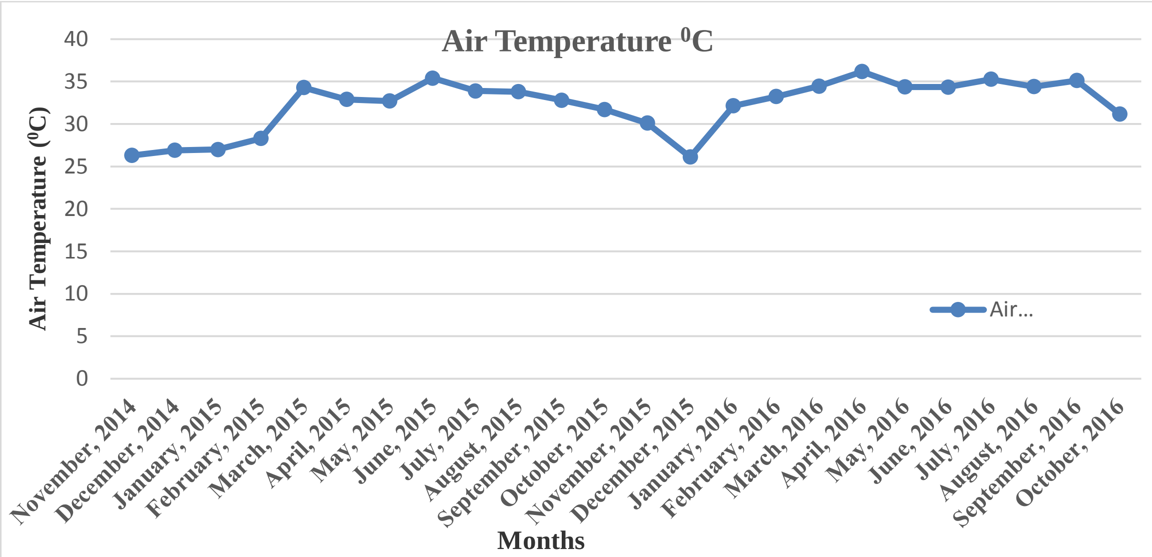


Fig. 1 Line diagram showing monthly variations of Air temperature during the study period (November, 2014 to October, 2016)

B) Water Temperature

Water temperature is direct and indirect influence many biotic and abiotic components of aquatic ecosystem. The water temperature of cultural ponds varies with climatic condition, sunlight penetration and depth. In the present study, water temperature range was in between 25.2 °C in December, 2014 to 34.8 °C in July, 2015 in 1st annual cycle while in 2nd annual cycle range was in between 19.2 °C in December, 2015 to 31.45 °C in July, 2016 in (Table-1 & 2).

The mean values of both the year was 19.2 °C and 27.15 °C respectively table-3 and fig. 2.

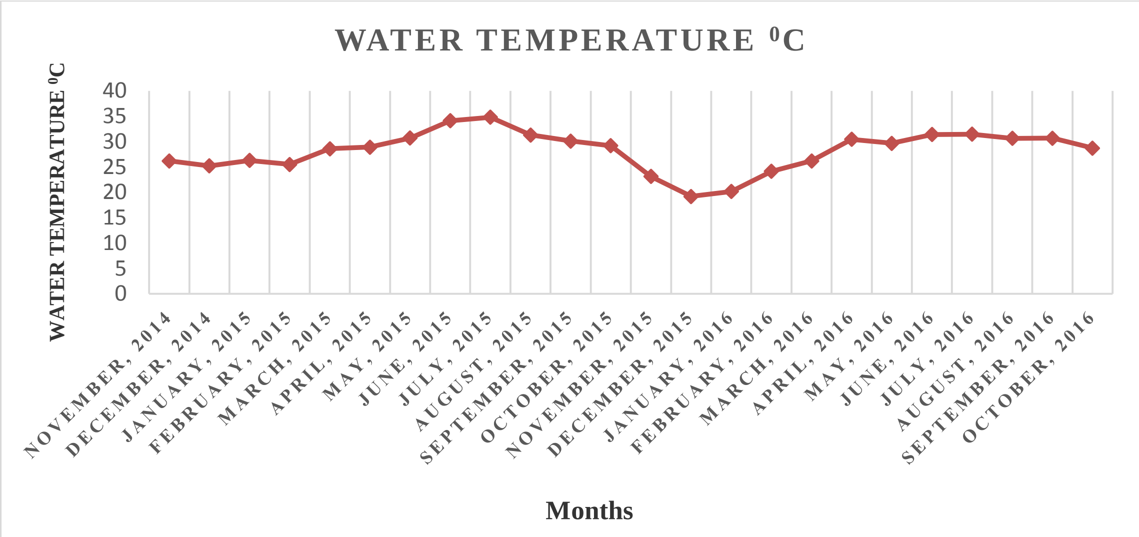


Fig. 2 Line diagram showing monthly variations of water temperature during the study period (November, 2014 to October, 2016)

C) pH

P^H is the scale of intensity of acidity and alkalinity of water and measure the concentration of hydrogen ions. In 1st annual cycle, variation of pH ranged from 7.12 to 6.5 in between April, 2015 to 7.12 in June, 2015 in (Table-1) whereas the 2nd annual cycle, variation of pH range from 8.1 in January, 2016 to 7.3 in March, 2016 in (Table-2). 7.23 and 7.57 were the respective mean values table-3 and fig. 3.

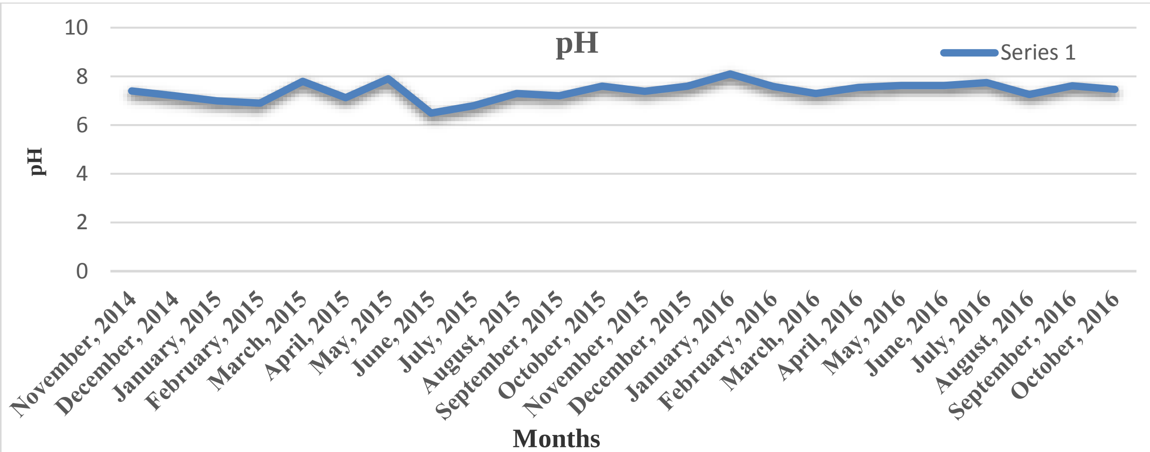


Fig. 3 Line diagram showing monthly variations of pH during the study period (November, 2014 to October, 2016)

D) Transparency

The measurement of light penetration into the water body: Penetration of sunlight might be interrupted by silt, clay, organic matter, plankton, macrophytes. The values of transparency range from 30.28 cm to 269.25 cm in between July, 2015 to August, 2015 in 1st annual cycle. In 2nd annual cycle, the lower value was recorded to be 41.92 cm in May, 2016 and higher value was 301.5 cm in February, 2016 in (Table-1 & 2). The mean values in both the year were 143.03 cm and 164.59 cm respectively table-3 and fig. 4.

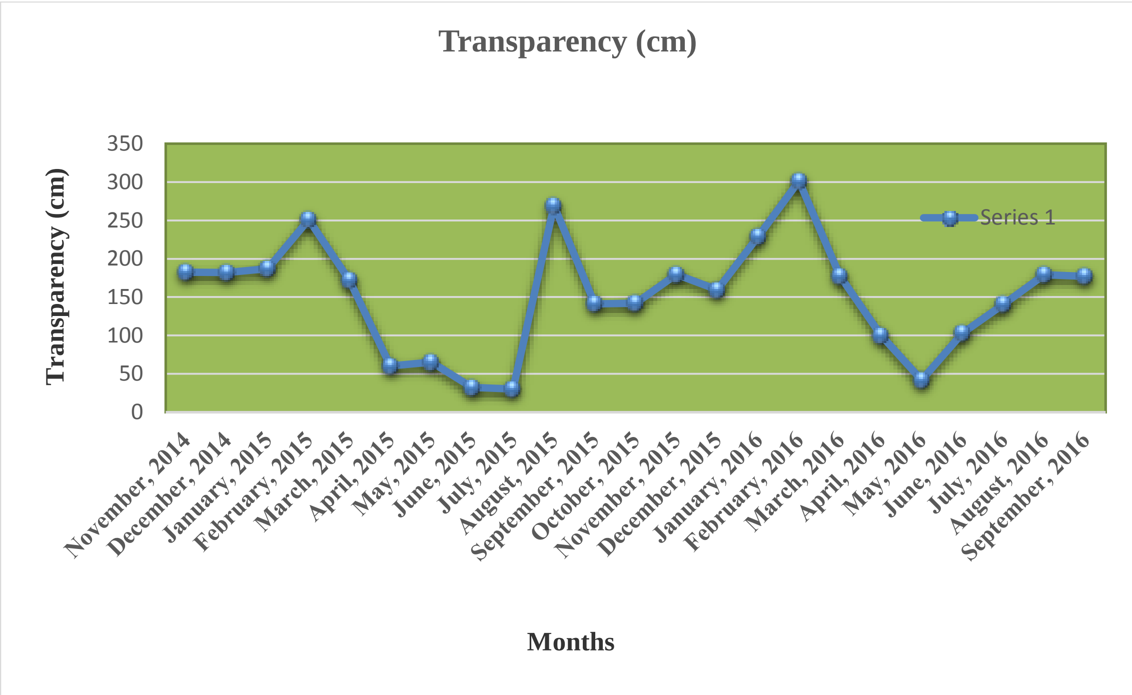


Fig. 4 Line diagram showing monthly variations of transparency during the study period (November, 2014 to October, 2016)

E) Salinity

It plays an important role in the growth of cultural organisms through osmoregulation of body minerals from that of the surrounding water and acts as a dynamic indicator of the nature of the exchange system. It expressed maximum value of 0.99 ppt. in August, 2015 and minimum value of 0.078 ppt. in May, 2015 in 1st annual cycle. On the contrary, maximum salinity value was 0.5 ppt. in March, 2016 and minimum was 0.25 ppt. in February, 2016 in 2nd annual cycle (Table-1 & 2). The mean values in both the year were 0.29 and 0.34 ppt. respectively table-3 and fig. 5.

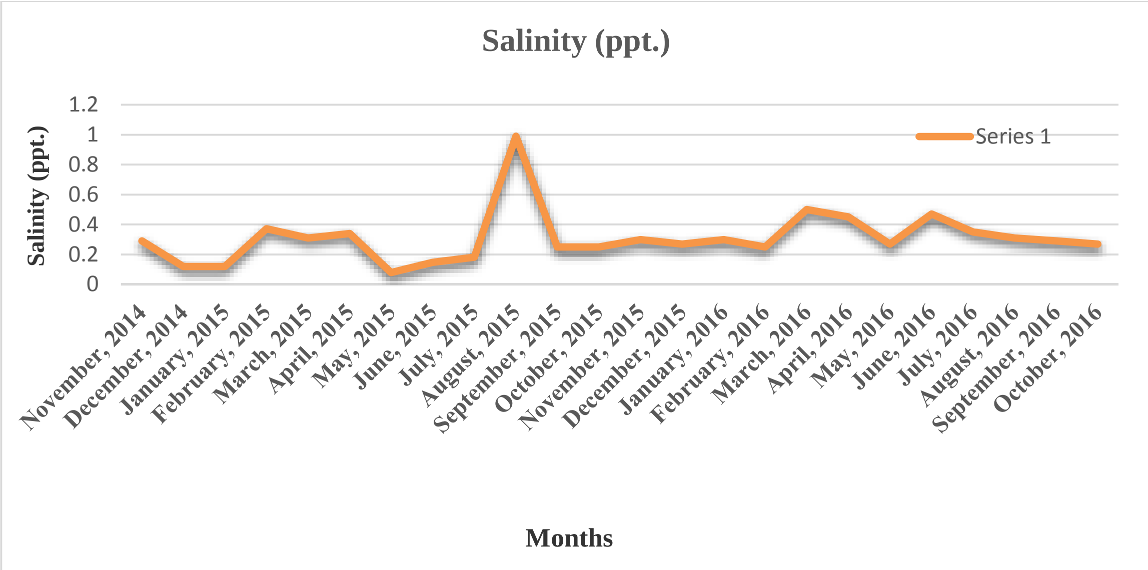


Fig. 5 Line diagram showing monthly variations of Salinity during the study period (November, 2014 to October, 2016)

F) Dissolved Oxygen (DO)

Dissolved oxygen is a very important parameter in water quality assessment. Its presence is highly effective for maintenance of biological life of aquatic system. The values of DO contents were observed to vary in between 5.3 mg/l in June, 2015 to 6.5 mg/l in October, 2015 during 1st annual cycle in (Table-1) of the study period. In 2nd annual cycle, DO value varied in between 5.0 mg/l in June, 2016 to 6.6 mg/l in March, 2016 in (Table-2). The mean values were 5.84 and 5.85 mg/l, in both the cycle respectively table-3 and fig. 6.

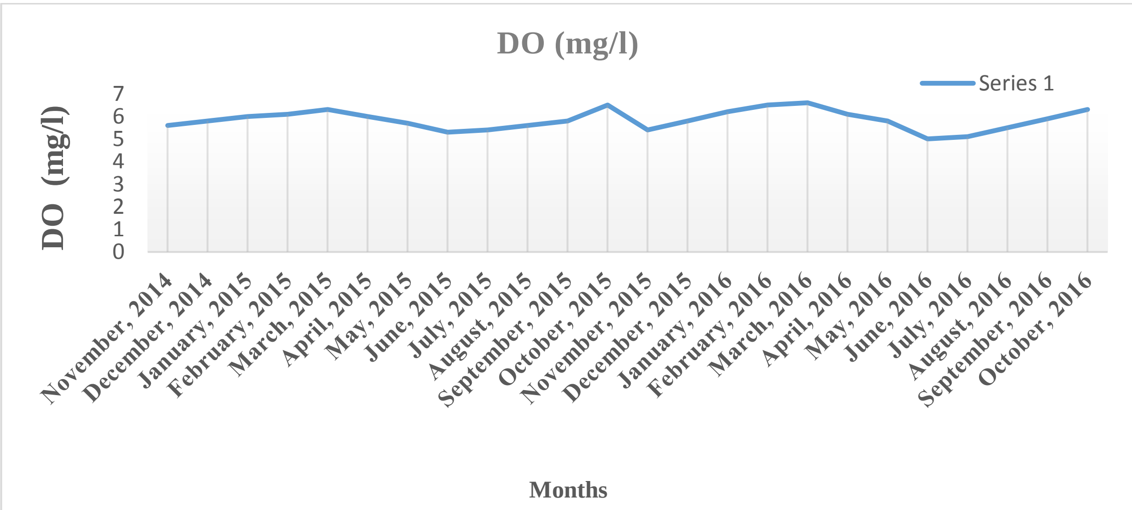


Fig. 6 Line diagram showing monthly variations of Dissolved Oxygen (DO) during the study period (November, 2014 to October, 2016)

G) Free CO_2

Free CO_2 range exhibited variability from 1.45 mg/l in April, 2015 to 5.66 mg/l in February, 2015 with mean values 3.71 mg/l in 1st annual cycle while 3.33 mg/l in March, 2016 to 8.56 mg/l in January, 2016 with mean values 4.68 mg/l in 2nd second annual cycle table-1, 2 and 3 and fig. 7**.**

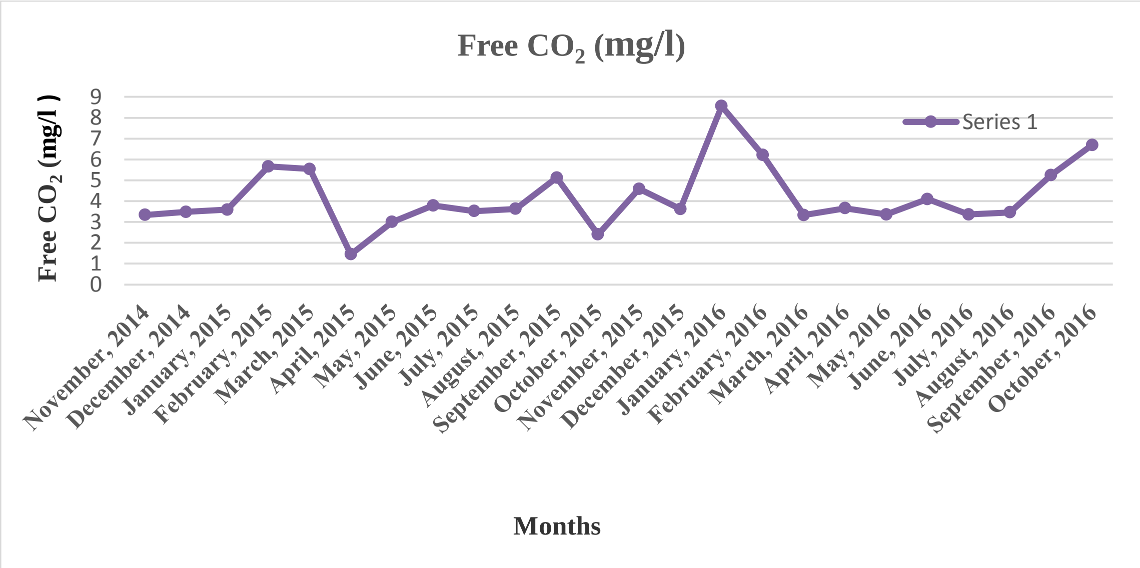


Fig. 7 Line diagram showing monthly variations of free CO_2 during the study period (November, 2014 to October, 2016)

H) Alkalinity

Alkalinity of water measures of its capacity to neutralize acids. Presence of hydroxide, carbonate and bicarbonate are usually considered for determination of alkalinity. The highest total alkalinity was recorded 68.5 mg/l in August, 2015 while the lowest value was 45.5 mg/l in July, 2015 with a mean values of 58.46 mg/l in 1st annual cycle in (Table-1 & 3). Similarly in 2nd annual cycle, the highest total alkalinity was recorded 86.22 mg/l in May, 2016 and the lowest value was 41.71 mg/l in September, 2016 with mean values 69.36 mg/l table-2 and 3 and fig. 8**.**

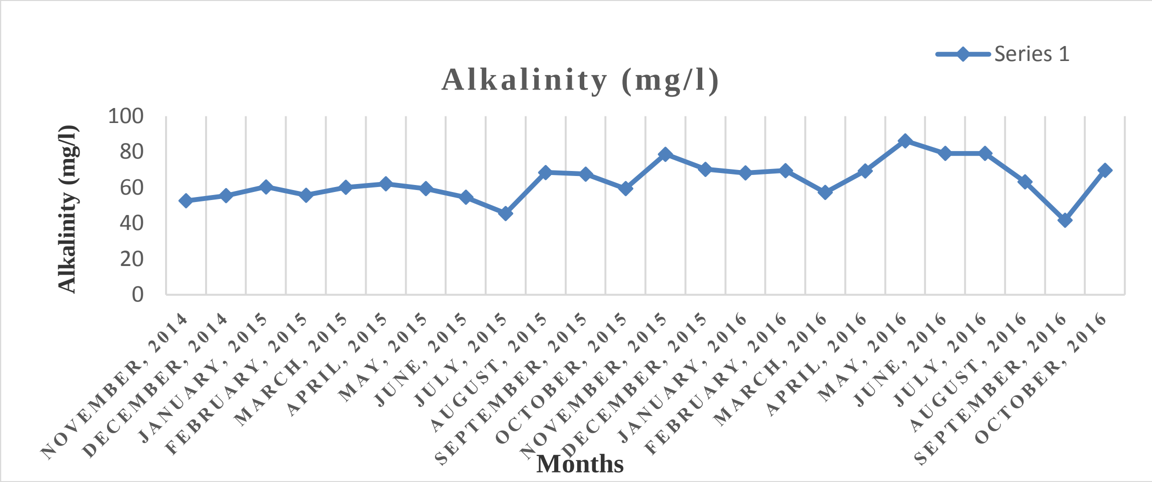


Fig. 8 Line diagram showing monthly variations of alkalinity during the study period (November, 2014 to October, 2016)

I) Total Hardness

In most of the freshwater, total hardness is mainly occupied by calcium and magnesium ions. Hardness varied from 88.5 ppm to 62.22 ppm from January, 2015 to August, 2015 in 1st annual cycle in (Table-1). Besides, highest value was 183.26 ppm in August, 2016 and lowest was 110.2 ppm in January, 2016 in 2nd annual cycle (Table-2). Whereas the mean values of both the years were 73.83 and 143.39 ppm respectively table-3 and fig. 9.

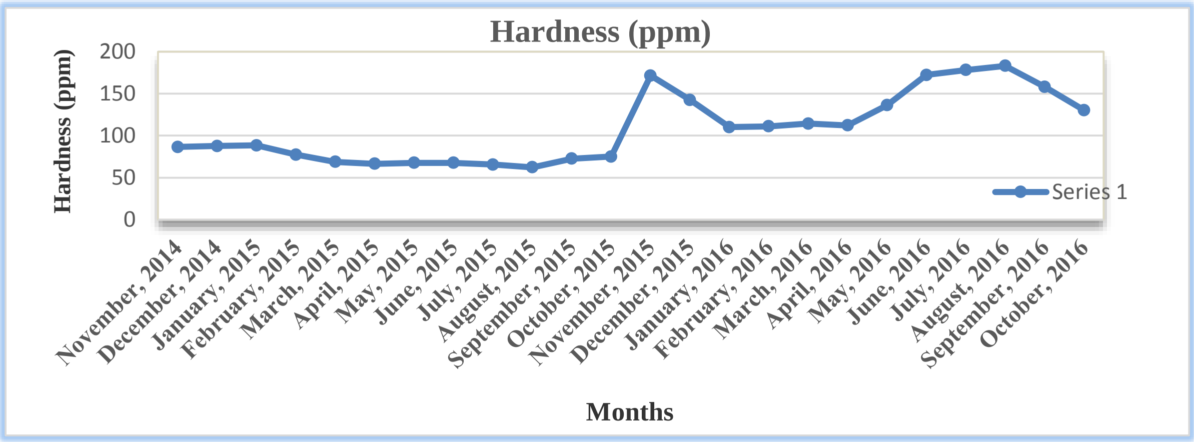


Fig. 9 Line diagram showing monthly variations of dissolved total hardness during the study period (November, 2014 to October, 2016)

J) Electrical conductivity

It is a measure of water capability to transmit electrical current and used as tool to assess the purity of water (Murugesan et al., 2000). EC value was marked through lower reading 11.6 µmho /cm in March, 2015 and higher reading 13 µmho / cm in August, 2015 in 1st annual cycle.

In 2nd annual cycle minimum value was 11.7 µmho / cm in December, 2015 and maximum value was 16.95 µmho /cm in April, 2016 in (Table-1 & 2). The mean values of both the years were 12.13 and 14.38 µmho/cm respectively table-3 and fig. 10.

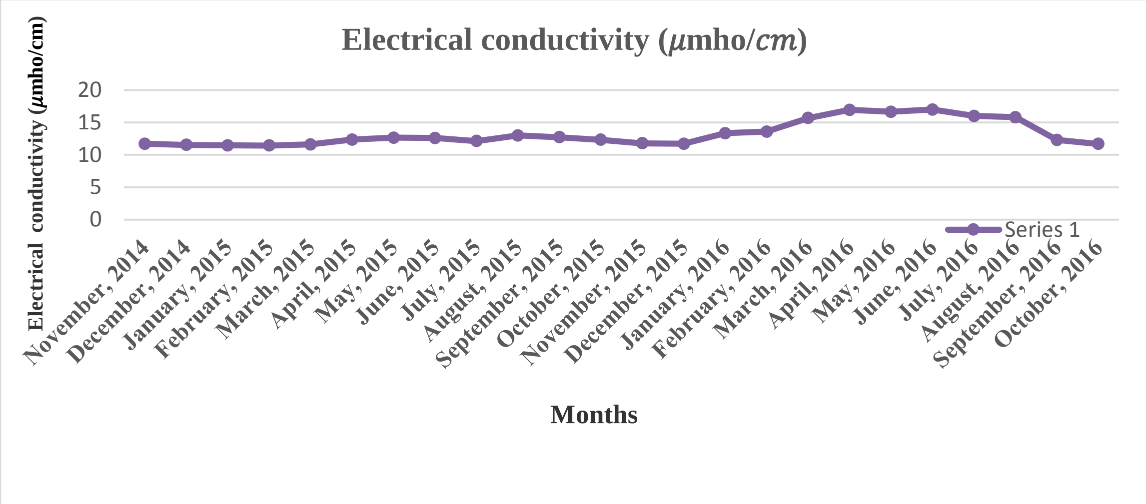


Fig. 10 Line diagram showing monthly variations of electrical conductivity during the study period (November, 2014 to October, 2016)

K) Chloride

The value of chloride was found to vary between 32.65 mg/l in May, 2015 to 174.3 mg/l in February, 2015 in 1st annual cycle whereas 116.2 mg/l in February, 2016 to 302.23 mg/l in June, 2016 in 2nd annual cycle in (Table-1 & 2). The mean values of both the year's ware 111.02 and 166.63 mg/l respectively table-3 and fig. 11.

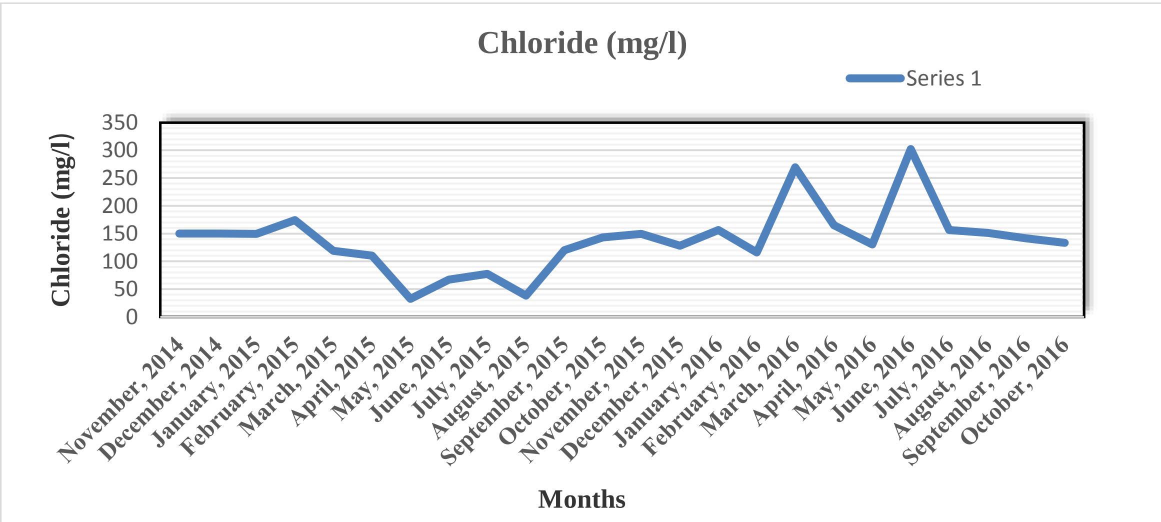


Fig. 11 Line diagram showing monthly variations of chloride during the study period (November, 2014 to October, 2016)

L) Phosphate

The amount of phosphate exhibits a wide fluctuation throughout the study period. Maximum value was 0.134 mg/l in July, 2015 and minimum was 0.019 mg/l in April, 2015 with mean values 0.074 mg/l in (Table-1 & 3) in 1st annual cycle. In 2nd annual cycle, maximum value was 0.185 mg/l in August, 2016 and minimum value was 0.013 mg/l in March, 2016 with mean values 0.071 mg/l showing table-2 and 3 and fig.12.

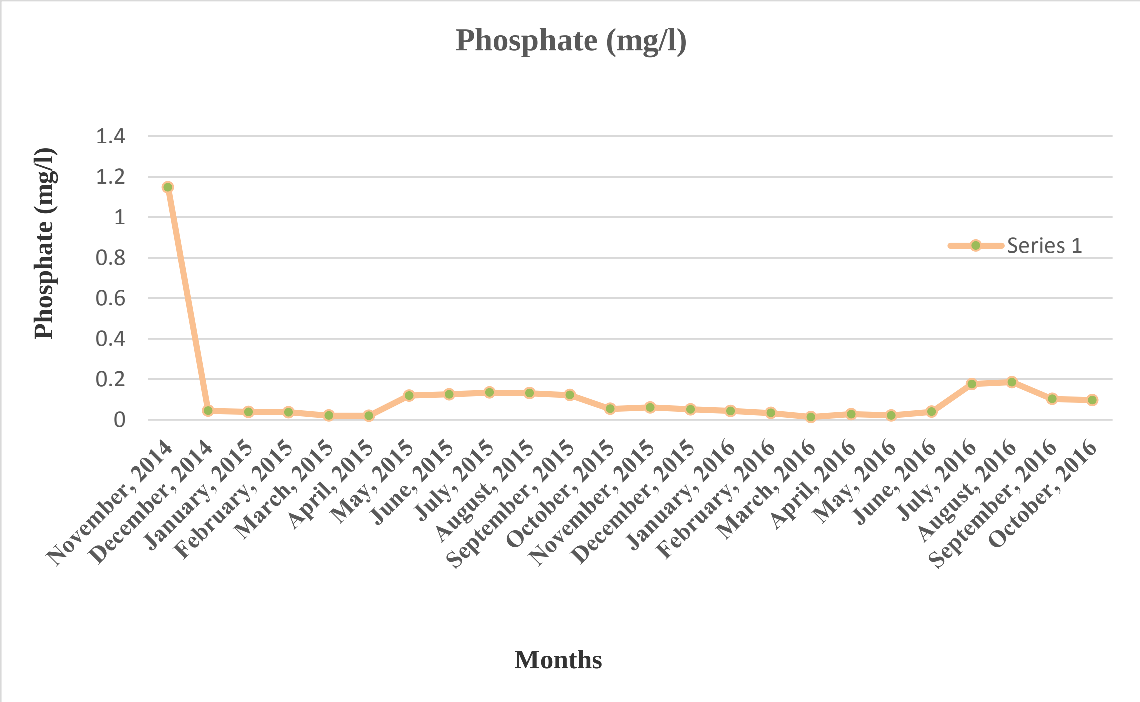


Fig. 12 Line diagram showing monthly variations of phosphate during the study period (November, 2014 to October, 2016)

M) Total inorganic nitrogen

The amount of total inorganic nitrogen (ammonia, nitrate and nitrite) observed that maximum 2.27 mg/l in October, 2015 and minimum 0.26 mg/l in March, 2015 with mean values 1.29 mg/l showing in (Table-1 & 3) 1st annual cycle. Consequently in 2nd annual cycle, it was observed maximum value 1.72 mg/l in August, 2016 and minimum value was 0.53 mg/l in May, 2016 with mean values 1.05 mg/l showing table-2 and 3 and fig. 13.

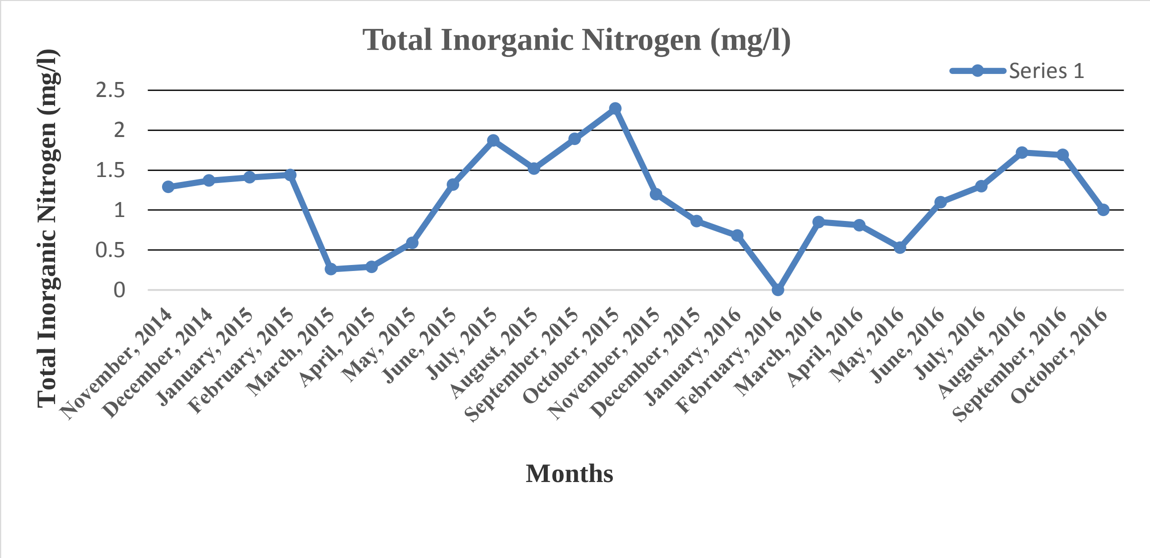


Fig. 13 Line diagram showing monthly variations of Total inorganic nitrogen during the study period (November, 2014 to October, 2016)

N) Calcium

The recorded calcium value fluctuated from 11.75 mg/l to 38.42 mg/l in between April, 2015 to July, 2015 in 1st annual cycle whereas highest recorded value was 46.16 mg/l in November, 2015 and lowest value was 19.18 mg/l in January, 2016 in 2nd annual cycle in (Table-1 & 2). The mean values in both the years were 24.71 and 31.35 mg/l respectively table- 3 and fig. 14.

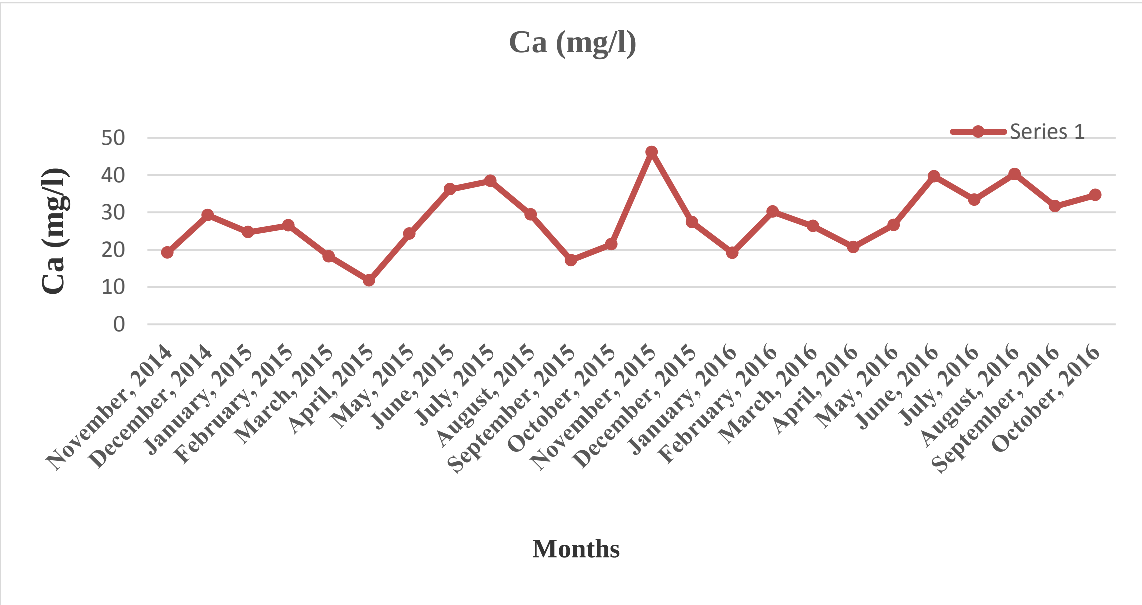


Fig. 14 Line diagram showing monthly variations of calcium during the study period (November, 2014 to October, 2016)

O) Magnesium

The magnesium content was detected with highest concentration of 30.69 mg/l in August, 2015 and lower concentration of 10.71 mg/l in December, 2014 in 1st annual cycle. In contrast, highest value was recorded 52.69 mg/l in June, 2016 and lower value was recorded 10.42 mg/l in November, 2015 in 2nd annual cycle in (Table-1 & 2). The mean values in both the years were 15.53 and 20.16 mg/l respectively table-3 and fig. 15.

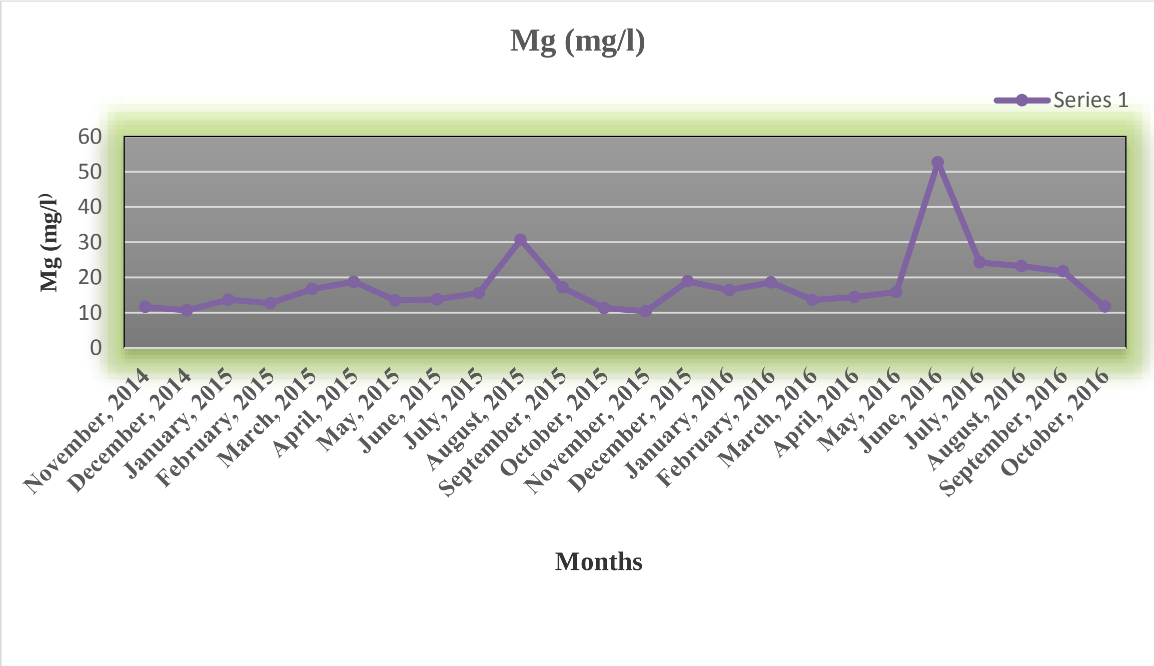


Fig. 15 Line diagram showing monthly variations of magnesium during the study period (November, 2014 to October, 2016)

P) Water level

Water level depends upon the rainfall of the concerned area. The water level remained low 288.65 ft in May, 2015 and high of 374.33 ft in October, 2015 with mean values 338.95 ft (Table-1 & 3) in the 1st annual cycle. In 2nd annual cycle, water level was high of 381.38 ft in September, 2016 and low 360.34 ft in March, 2016 with mean values 371.04 ft table-2 and 3 and fig.16.

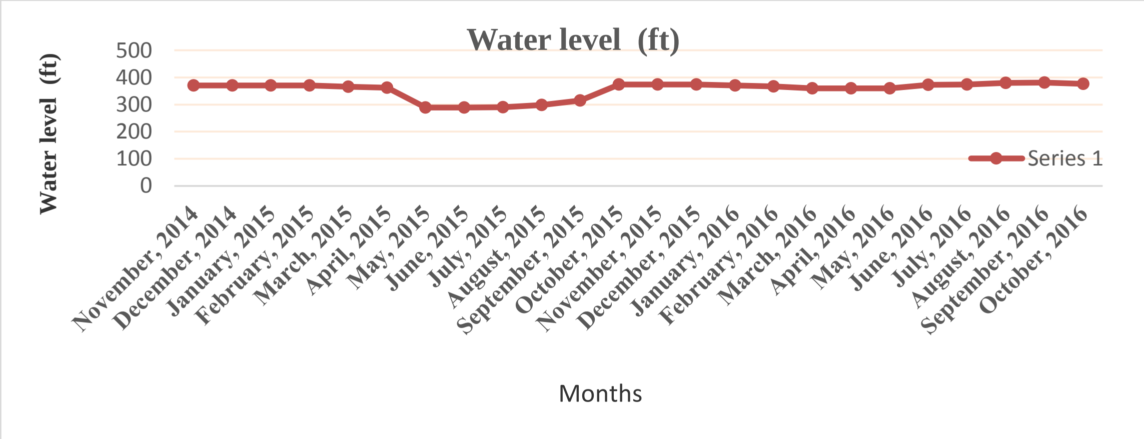


Fig. 16 Line diagram showing monthly variations of water level during the study period (November, 2014 to October, 2016)

Q) Photic depth

Photic depth expressed the range from 100.7 cm in June, 2015 to 218.6 cm in February, 2015 with mean values of 164.96 cm in 1st annual cycle whereas in 2nd annual cycle ranged from 45.52 cm in July, 2016 to 205.1 cm in September, 2016 with mean values of 123.66 cm table-1, 2 and 3 and fig. 17.

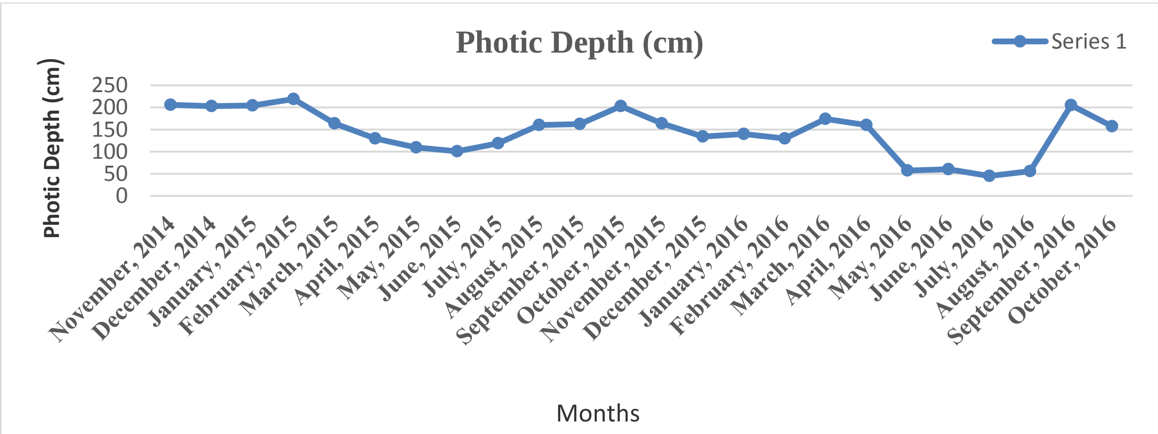


Fig. 17 Line diagram showing monthly variations of photic depth during the study period (November, 2014 to October, 2016)

4.4 DISCUSSION

Physico-chemical parameters of water samples collected from ponds during different seasons that reflect seasonal changes in water quality. Water quality has been observed that the water temperature was always less than air temperature. Significantly highest and lowest temperature was always less than air temperature. Significantly highest and lowest temperatures were recorded for all the seasons. Comparatively higher temperature is due to the low water level in the pond, clear atmosphere and high solar radiation in summer. On the other hand, lower temperature during the post-monsoon is due to lesser solar radiation, higher water level. Similar observation was recorded in the natural water bodies by Salve and Hiware (2010). The water temperature ranges from lower value of 19.2 ℃ in winter to higher value of 34.8 ℃ in summer. According to Jhingran (1968) temperature range of 28 to 34 ℃ in tropical water is congenial for optimal growth of fish. pH of the pond water fluctuated seasonally in between 6.5 (rain) to 8.1 (winter) throughout the study period. It is recorded to be slightly acidic and slightly alkaline in nature in various months. The highest pH recorded in the season summer was due to the low level of water. Similar trends are observed by Kadam et al., (2007) and Reddy et al., (2015). The water of the ponds becomes turbid due to suspend solid being washed off with rain water. Penetration of sunlight may be interrupted by silt, clay, organic matter and plankton. Salinity plays an important role in the growth of fishes through osmoregulation of body mineral from that of the surrounding pond water. Dissolved oxygen concentration varies from 7.5 to 12.2 mg/l. The maximum value of dissolved oxygen concentration is observed in summer whereas the minimum value found in the monsoon. Highest dissolved oxygen during summer may be due to photosynthetic activities of aquatic plants of the water body. DO showed inverse relationship with temperature which is also reported by Rani et al., (2004), Chattopadhyay et al., (2007). Recorded value of dissolved oxygen ranges documented by Boyd (1969), Alabaster and Lloyd (1980) as favourable water quality for fish culture. Chattopadhyay et al., (2007) also reported a negative correlation of temperature with CO_2 in Krishna Sayar Lake at Burdwan. The highest values of free CO_2 (8.56 mg/l) in January, 2016 and lowest values (3 mg/l) in May, 2015. The highest value of total alkalinity is recorded during monsoon (86.22 mg/l) whereas the lowest value is recorded during post monsoon (41.71 mg/l) probably due to rainfall. Similar result also expressed by Islam (2007) in a pond of Rajshahi University, Bangladesh.

Alkalinity was negatively correlated with total phytoplankton population. The maximum total hardness is due to the mixture of different chemicals. Seasonal estimate of total hardness showed significantly increase in the month of winter (88.5 mg/l) whereas declining trend with the minimum value in the season of monsoon (65.5 mg/l). The chloride content was highest value (302.23 mg/l) in the month of summer, 2016. Similar type of observation had been found in Ranjit Sagar reservoir by Kumar et al., (2006). Phosphate content remains very poor amounts throughout the study period. Phosphate was highest value (0.185 mg/l) during the rainy season and lowest value (0.013 mg/l) was in summer in its utilization by phytoplankton. Total inorganic nitrogen values were very low all over the study period except monsoon (1.87 mg/l) in July, 2015. Similar observation was seen by Das (2000). Nitrogen content is higher (2.27 mg/l) in rainy season, which can be attributed to the fertilizers leached from surrounding agricultural field of the ponds whereas lower value (0.26 mg/l) in March, 2015. In summer is due to utilization by plankton and aquatic plants. Similar results are seen by Sivakumar et al., (2008). The calcium and magnesium ions content released from dead mollusc and shell increase the concentration of total hardness (Bhatt et al., 1999). During rainy season hardness of water increases due to addition of Ca and Mg ions. These findings suggest that the water body is hard mainly in the transitional period of summer and rainy season. Jhingran (1963) also found direct relationship between hardness and plankton production.

Increase of water level on account of rainfall reduces the plankton population whereas plankton density is low other than winter season as because several parameters of water showed remarkable variation. Water temperature, pH, salinity, dissolved oxygen, free CO_2, alkalinity, chloride, phosphate, Ca, total inorganic nitrogen ranges are eligible for fish culture (According to ICAR, SRAC and NRAC) in (Table-3) which induce the fish productivity as well as fish fauna diversity.