

Study of “Trophic Status” of a Pond through Diurnal Profiling

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Abstract:

The purpose of the study was to ascertain the trophic status of the pond through significant correlation among the physico-chemical parameters in a 24 hr period.

The work involved a systematic study involving selected physico-chemical parameters of two ponds located in Patna, India. It was found out that the content of dissolved oxygen in the Secretariat pond varied with the depth of the pond. Higher value of Dissolved Oxygen (DO) at surface and at a depth of 0.5 meters, in comparison to the bottom, suggests that the diurnal variation of DO is mainly attributed to photosynthetic activities of the phytoplankton. The DO content begins to fall off with the decline of effective sunlight (16:00 hours). Thus, it is evident that the diurnal periodicity of the dissolved oxygen is an indirect reflection of the biochemical pulse of the system. However, at the Adalatgunj pond, clinograde distribution of DO was observed, suggesting water to be eutrophic.

The study also revealed the sharp diurnal variations of free CO_2 at the Adalatgunj pond. The bicarbonate alkalinity was maximum at 12:00 hours suggesting the dominance of HCO_3^- ions by that time. When photosynthetic demand of CO_2 increases, the required amount is furnished by distribution of bicarbonate ions. As a result, the bicarbonate alkalinity starts decreasing from 12:00 hours – 16:00 hours, and starts increasing when the photosynthetic activity ceases (beyond 20:00 hours). Low alkalinity and least variation at Adalatgunj pond is an indicative of eutrophic water.

This diurnal study gives information about the trophic status (oligotrophic, eutrophic) of a pond vis-à-vis the various parameters - alkalinity, DO, free CO_2 etc.

I. INTRODUCTION

Extensive studies on the diurnal profile of the physico-chemical parameters of the various aquatic ecosystems in India and abroad have been made [1] [2] [3]. However, few records are available on the diurnal profile of ponds exclusively used for pisciculture. The present study attempts to know the diurnal profile of some physico-chemical parameters in 24-hour study and to find out its correlation with the trophic status of the pond.

For the present study two ponds of Adalatgunj and Secretariat were selected. Both ponds are located in Patna (25°37'00"N lat. 85° 09' 45"E. long.) which is 60m above mean sea level. According to archival records in The District Gazetteer [4], Patna has been the playground of the laterally shifting Sone River. The

annual flooding of the river also served to fill up the natural depressions that are common throughout the alluvial plains of the state. Archaeological evidences and archives reveal the Sone as once flowing along the present-day Serpentine Road and draining into the Ganga in the north via the channel that today takes the form of the Main Drain Canal of Mandiri area. Both the Secretariat and the Adalatgunj ponds are interpreted as “Chharan” or remnants of ox-bow lakes formed by the meandering Sone in the historical past. These water bodies used to be subject to annual replenishment during floods and were also a receptacle of the sandy alluvium of the Sone. Investigations have revealed that beneath the first few feet of the pond beds lie hundreds of feet of Sone sand, and, perhaps, remnants of then existing aquatic life forms.

Recent past have witnessed filling up of most of such natural water-bearing depressions for urban constructions. As a result, the remaining water bodies, like that of Adalatgunj, have been reduced to shallow depressions receiving urban waste water, thereby altering drastically their ecological environment. Both the ponds are roughly of equal area having mean depth of 9 feet. The Secretariat pond is exclusively used for aquaculture and is maintained by the Department of Fisheries, Govt. of Bihar (India). In this pond, water is regularly filled after proper aeration (photographs 1 & 2). The Adalatgunj pond, on the other hand, is an ill-maintained pond where pisciculture is done through conventional methods. The pond receives discharge from adjoining domestic areas (photographs 3 & 4).



Photograph 1: Secretariat pond where water is regularly filled after proper aeration



Photograph 2: Secretariat pond maintained by Govt. of Bihar



Photograph 3: Adalatgunj pond showing Water Hyacinths



Photographs 4: Adalatgunj pond where water is filled through discharge from adjoining areas

II. METHODS AND MATERIALS

Four hourly samples of water were made for a period of 24 hours in the month of April for three consecutive years (2001 – 2003). The samples were collected from the surface, depth of 0.5metre and the bottom. The temperature was measured by mercury filled Celsius Thermometer and pH was recorded by Systronic double electrode pH meter (model no.- 335). Estimates of alkalinity, free carbon dioxide (CO_2) and Dissolved Oxygen (DO) were done on site. Total hardness and chloride were estimated in the laboratory. Standard methods of APHA, 1985 [5] was adopted for these tests. Correlation coefficient (r) among the physico-chemical parameters of surface water of the two systems were statistically calculated [6].

III. RESULTS AND DISCUSSION

Diurnal variations of physico-chemical parameters of both ponds were summarized in table 1 (a), (b), (c) and 2(a), (b), (c). Correlation coefficients (r) among the physico-chemical parameters of the surface water of the two ponds were shown in table 3 and 4. Temperature is one of the most important physical factors which influence the other parameters. Air and surface water temperatures in the pond at Adalatgunj varied between 29.0°C to 36.5°C , whereas the temperature at the depth of 0.5 m and bottom varied between 31.0°C to 35.5°C and 31.0°C to 35.0°C , respectively. Maximum air temperature was recorded at 12 am (12.00 hours) and relatively lower temperature during night hours. Surface water temperatures in both ponds followed the same trend. Marked variation in different zones at a time was not observed due to the lower volume of water. Diurnal variations of water temperatures were observed which are largely guided by variations in atmospheric temperatures.

Table 1 (a)
Diurnal variations in some Physico-chemical parameters of the Secretariat Pond at Patna on 20th April, 2001

Time Interval (h)		4	8	12	16	20	24
Parameters							
Atm. Temperature $^\circ\text{C}$		31	30	31.5	31.5	30	29.5
Water Surface		30	30	31.5	32	31	30
Temp. 0.5m		30	30.5	32	32.5	32.5	31
$^\circ\text{C}$ Bottom		30	30.5	32	31.5	31.5	31
pH Surface		9.2	9.3	9.5	10.2	10	9.9
0.5m		9.4	9.8	9.9	9.9	9.7	9.5
Bottom		9.3	9.5	9.9	9.9	9.8	9.5
DO Surface		9	9.5	10.1	15.8	12.3	10
(ppm) 0.5m		8.8	9.6	9.8	15.8	13.8	11.9
Bottom		8.9	9.4	9.6	9.8	9	7.9
Chloride Surface		33.4	33.3	33.3	33.5	33.6	33.7
(ppm) 0.5m		33.2	33.5	33.5	33.2	33.7	33.4
Bottom		33.1	33.6	33.4	33.6	33.6	33.5
Total Surface		66	68	65	72	72	71
Hardness 0.5m		71	72	70	71	71	71
(ppm) Bottom		70	71	71	70	70	71
Free Surface		Nil					
CO_2 0.5m							
(ppm) Bottom							
Bicarbo. Surface		61	57	67	85	67	63
Alkalinity 0.5m		57	56	97	45	46	53
(ppm) Bottom		59	61	85	67	57	59

The pH value was in alkaline range for all observations in both the ponds. This value was higher at 4.00 pm (16.00 hours) in both the cases. Decrease in pH was observed after 16.00 hours, which might be due to accumulation of phyto-respiratory CO_2 during the dark periods. pH shows a negative correlation with temperature ($r = -0.904$ at the Adalatgunj pond and $r = -0.930$ at the Secretariat pond), which is significant at 5% level.

Table 1 (b)

Diurnal variations in some Physico-chemical parameters of the Secretariat Pond at Patna on 18th April, 2002

Time Interval (h)		4	8	12	16	20	24
Parameters							
Atm. Temperature °C		30.5	30	31	31.5	30	29.5
Water Surface		30	30	31.5	32	31	30
Temp. 0.5m		30	30.5	32	32.5	32.5	31
°C Bottom		30	30.5	32	31.5	31.5	31
pH Surface		8.9	9.1	9.1	9.9	9.8	9.7
0.5m		9.1	9.5	9.6	9.7	9.5	9.3
Bottom		9	9.5	9.6	9.7	9.6	9.2
DO Surface		8	8.4	10.1	15.8	12.3	10
(ppm) 0.5m		7.9	8.6	9.4	15.8	13.8	11.9
Bottom		7.9	8.4	9.2	9.5	9.1	7.8
Chloride Surface		32.4	33.6	32.7	32.9	33.6	33.7
(ppm) 0.5m		32.3	33.6	32.7	32.8	33.7	33.4
Bottom		32.6	33.7	32.7	32.8	33.6	33.5
Total Surface		65	67	64	74	72	71
Hardness 0.5m		70	71	69	71	70	71
(ppm) Bottom		69	70	71	70	70	71
Free Surface		Nil					
CO ₂ 0.5m							
(ppm) Bottom							
Bicarbo. Surface		60	56	66	84	66	62
Alkalinity 0.5m		56	56	96	44	46	52
(ppm) Bottom		58	60	84	66	56	58

Table 1 (c)

Diurnal variations in some Physico-chemical parameters of the Secretariat Pond at Patna on 25th April, 2003

Time Interval (h)		4	8	12	16	20	24
Parameters							
Atm. Temperature °C		29	30.5	32	31.5	30	29.5
Water Surface		30	31	31.5	32	31	30
Temp. 0.5m		31	32	32	32.5	32.5	31
°C Bottom		31	32	32	31.5	31.5	31
pH Surface		9.4	9.82	9.88	10	9.8	9.7
0.5m		9.2	9.6	9.66	9.76	9.46	9.4
Bottom		9.1	9.6	9.64	9.73	9.7	9.3
DO Surface		8.2	8.6	10.2	14	12.6	10.2
(ppm) 0.5m		8	9	9.6	16	14	12
Bottom		8	8.2	9.6	9.44	9.3	8
Chloride Surface		33.6	35.5	32.6	37.6	36.6	34.3
(ppm) 0.5m		33.4	35.5	32.6	42.5	38.5	32.2
Bottom		30	30.5	32.6	35.5	35	32.2
Total Surface		66	68	64	76	74	70
Hardness 0.5m		71	72	70	72	70	71
(ppm) Bottom		70	70	72	70	70	70
Free Surface		Nil					
CO ₂ 0.5m							
(ppm) Bottom							
Bicarbo. Surface		64	60	70	88	70	66
Alkalinity 0.5m		60	60	100	48	50	56
(ppm) Bottom		62	64	88	70	60	62

Table 2 (a)

Diurnal variations in some Physico-chemical parameters of the Adalatgunj Pond at Patna on 20th April, 2003

Time Intervals(h)		4	8	12	16	20	24
Parameters							
Atm. Temperature °C		30.5	30.5	32.5	33.5	30	29
Water Surface		30.5	31	34	35	34.5	33
Temperature 0.5m		30.5	31.5	35.5	35	35	33.5
°C Bottom		30.5	31.5	35	35	35	33.5
pH Surface		8.2	8.6	8.7	9	8.8	8.6
0.5m		8.3	8.4	8.6	8.9	8.9	8.6
Bottom		8	8.1	8.5	8.5	8.6	8.3
DO Surface		4.9	7.8	7.9	8.8	5.6	5.2
(ppm) 0.5		3.7	6.1	6.2	6.4	4.2	3.8
Bottom		2.2	2.44	3.1	3.2	2.3	2.3
Chloride		129	130	133	132	131	132
(ppm) 0.5m		130	136	136	134	131	130
Bottom		131	131	130	138	138	132
Total Surface		250	251	258	256	270	266
Hardness 0.5		266	263	265	267	272	265
(ppm) Bottom		269	264	266	269	274	271
Free CO ₂ Surface		25.1	26.5	10.2	10.1	20.3	24.5
(ppm) 0.5		17.6	18.8	8.8	9.1	14.9	16.9
Bottom		24.9	26.6	12.8	14.9	22.1	24.5
Bicarbo Surface		14	15	11	11	12	12
Alkalinity 0.5		14	15	11	11	12	12
(ppm) Bottom		14	15	11	11	12	12

Table 2 (b)

Diurnal variations in some Physico-chemical parameters of Adalatgunj Pond at Patna on 19th April, 2003

Time Intervals(h)		4	8	12	16	20	24
Parameters							
Atm. Temperature °C		30	30.5	32	32.5	30	29
Water Surface		31.5	33.5	36	35	34.5	33
Temperature 0.5m		31	33.5	35.5	35	35	33.5
°C Bottom		31	32.5	35	35	35	33.5
pH Surface		8.5	8.6	8.9	9	8.7	8.6
0.5m		8.4	8.6	8.6	8.9	8.8	8.2
Bottom		8.1	8.3	8.5	8.5	8.7	8.2
DO Surface		5.1	8.1	8.1	8.9	5.7	5.1
(ppm) 0.5		4	6.2	6.4	6.5	4.2	3.9
Bottom		2.4	2.6	3.3	3.3	2.3	2.3
Chloride Surface		129	132	132	133	131	132
(ppm) 0.5m		130	136	137	132	132	131
Bottom		131	130	132	135	138	136
Total Surface		251	255	256	262	264	261
Hardness 0.5		264	264	266	267	272	271
(ppm) Bottom		268	262	264	275	274	272
Free CO ₂ Surface		25.2	25.3	10.3	Nil	19.8	24.9
(ppm) 0.5		17.2	17.5	7.9	Nil	14.4	17.3
Bottom		24.2	25.7	12.8	Nil	21.4	23.8
Bicarbo Surface		12	14	11	10	12	12
Alkalinity 0.5		12	14	11	10	12	12
(ppm) Bottom		12	14	11	10	12	12

Table 2 (c)
Diurnal variations in some Physico-chemical parameters of Adalatgunj
Pond at Patna on 25th April, 2003

Time Intervals(h)		4	8	12	16	20	24
Parameters							
Atm. Temperature °C		29.5	30.5	36.5	32.5	30	29
Water Surface		31.5	33.5	36	35	34.5	33
Temperature 0.5m		31	33.5	35.5	35	35	33.5
°C Bottom		31	32.5	35	35	35	33.5
pH Surface		8.4	8.6	8.85	9	8.77	8.6
0.5m		8.3	8.5	8.66	8.84	8.8	8.55
Bottom		8	8.21	8.46	8.47	8.7	8.2
DO Surface		5	8	8	8.8	5.6	5.2
(ppm) 0.5		3.9	6.08	6.24	6.4	4.16	3.8
Bottom		2.3	2.48	3.2	3.2	2.32	2.3
Chloride		130	131	132	124	131	132
(ppm) 0.5m		131	138	136	121	128	130
Bottom		131	128	130	138	138	132
Total Surface		258	250	250	260	268	262
Hardness 0.5		268	260	260	268	274	272
(ppm) Bottom		268	262	262	274	274	272
Free CO ₂ Surface		25	26.4	Nil	Nil	20.2	24.4
(ppm) 0.5		17.4	18.6	Nil	Nil	14.8	16.8
Bottom		24.8	26.4	Nil	Nil	22	24.4
Bicarbo Surface		14	16	10	10	12	12
Alkalinity 0.5		14	16	10	10	12	12
(ppm) Bottom		14	16	10	10	12	12

Table 3
Correlation coefficient matrix (r) of physico-chemical parameters of
Secretariate ponds. (* —Significant at 5%)

Parameters	Time	Tempe rature	pH	DO	Hard ness	Chlo ride	Bicar. alkalinity
Time	1						
Temperature	0.112	1					
pH	0.575	*0.930	1				
DO	0.486	*0.710	0.469	1			
Hardness	0.576	0.368	0.37	0.823	1		
Chloride	0.343	0.465	0.364	0.743	*0.943	1	
Bicarbonate alkalinity	0.317	0.712	0.34	*0.959	0.669	0.585	1

Table 4
Correlation coefficient matrix 'r' of physico-chemical parameters of
Adalatgunj ponds. (* —Significant at 5%)

Parameters	Time	Tempera ture	pH	DO	F.CO ₂	Hard ness	Chlo ride	Bicar. alkalinity
Time	1							
Temperature	0.318	1						
pH	0.476	*0.904	1					
DO	-0.171	0.481	0.619	1				
F.CO ₂	-0.092	*-0.827	*-0.866	*-0.703	1			
Hardness	0.653	-0.164	0.068	-0.582	0.207	1		
Chloride	0.013	-0.165	-0.758	-0.5	0.499	-0.182	1	
Bicarbonate	0.302	-0.665	-0.729	-0.06	0.657	-0.041	0.2	1
Total alkalinity	0.407	0.32	0.608	*0.906	*-0.773	0.718	0.473	-0.41

The diurnal periodicity of dissolved oxygen is an indirect reflection of biochemical pulse of the system. DO varied from 5 to 8.8 ppm at the surface, 3.9 to 6.4 ppm at the depth of 0.5 meter and 2.3 to 3.2 ppm at the pond bottom in Adalatgunj. Higher value of DO was observed at the Secretariat pond(8.2 to 16 ppm on the surface; 8 to 16 ppm at the depth of 0.5m; and, 8 to 9.6 ppm at the bottom). DO peaks in both the ponds were observed at 4.00 pm(16.00 hours). The values of DO started decreasing from 4pm (16.00 hours) and reached a minimum between 4.00am to 8.00am next day. Higher values of DO at surface and at the depth of 0.5 meter, in comparison to that of the pond bottom, suggest that diurnal variations of DO are mainly attributed to photosynthetic activities of the phytoplankton. The DO content begins to fall off with the decline of effective sunlight (16.00 hours). The continued activity of O₂ consuming factors, such as respiration of plants, bacterial decomposition and invertebrate respiration, results into decline in DO value progressively upto 4.00 hours. The maximum accumulation of DO at 16.00 hours is also due to increase in water temperature, which facilitates higher movement and mixing of water, thereby enhancing the dissolving capacity of the atmospheric O₂. DO in both the ponds showed a positive correlation with temperature. Correlation in the Secretariat pond ($r = +0.710$) is significant at 5% level [7]. At the Adalatgunj pond, clinograde distribution of oxygen is evident. DO was more at surface and it depleted fast with depth, suggesting water to be eutrophic (Fig.-1 a, b, & c).

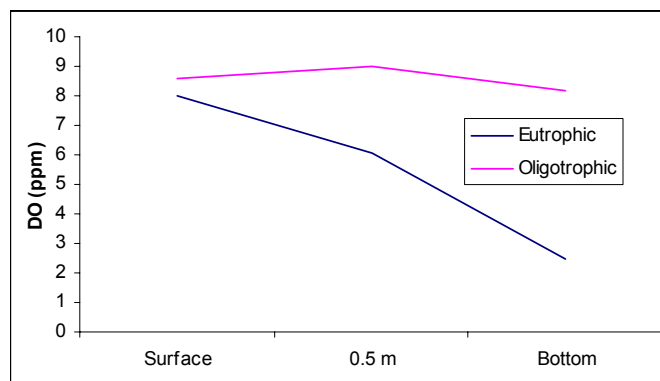


Fig. 1(a). Diurnal variations in DO of pond at 8.00

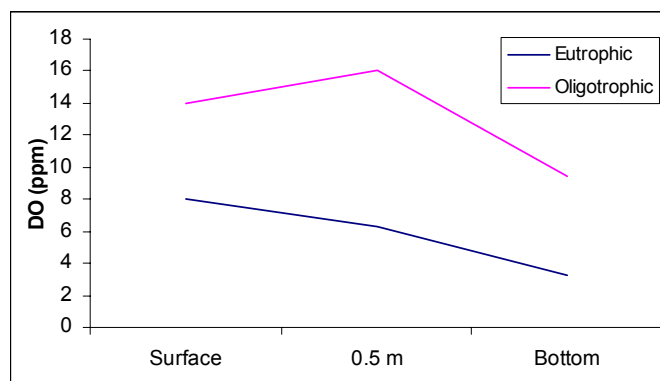


Fig. 1(b). Diurnal variations in DO of pond at 12.00

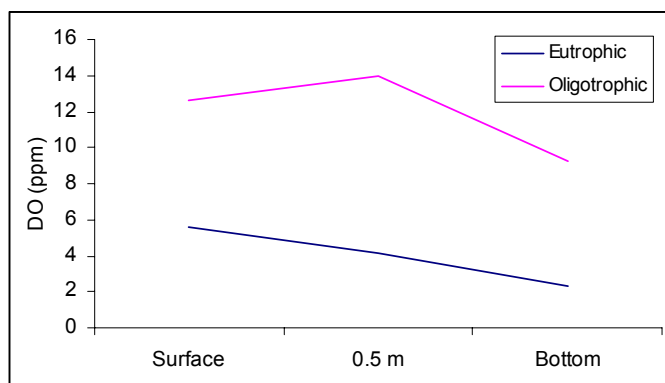


Fig. 1(c). Diurnal variations in DO of pond at 20.00

The free CO_2 ranged from 20.2 ppm at 20.00 hours to 26.4 ppm at 8.00 hours in the Adalatgunj pond. Higher value of free CO_2 might be due to higher rate of decomposition. It showed a negative correlation with DO and pH, which is similar to the findings of S.K. Chaudhary et al, [1] on eutrophic pond (TNB pond) of Bhagalpur. In the present case, the correlation ($r = -0.703$ for DO; -0.866 for pH) is significant at 5% level. Sharp diurnal variation, as well as variation with reference to depth, is suggestive of eutrophic pond (Fig. 2 a and b). At the Secretariat pond, no free CO_2 was observed. Higher pH (> 9.1) could be the reason, which favors HCO_3^- ions instead of free CO_2 .

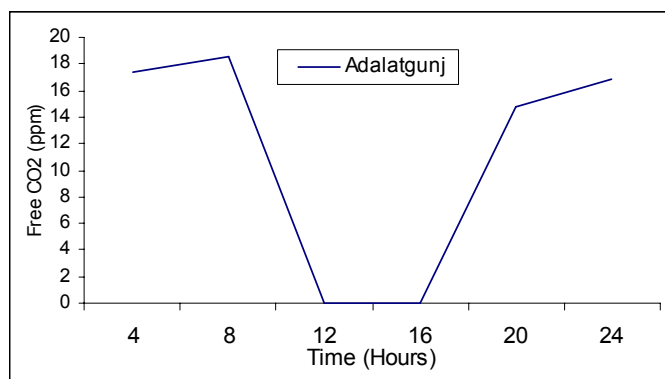


Fig. 2 (a). Diurnal variations of DO in Adalatgunj pond at 0.5 m

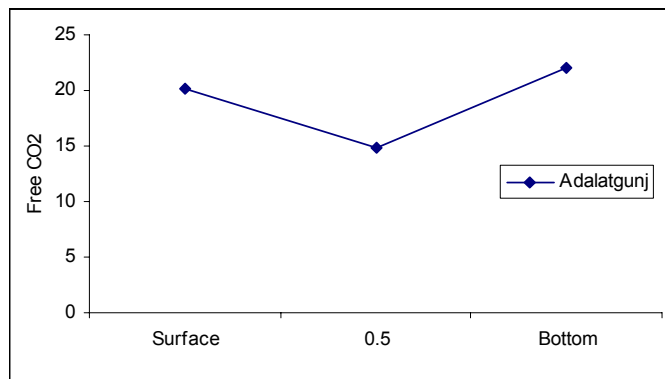


Fig. 2 (b). Diurnal Variation in free CO_2 at 0.5 m depth in Adalatgunj pond at 20.00 hours

Diurnal variations for total hardness and chloride were not significant. The value of total hardness was more (250 to 274 ppm) in the Adalatgunj pond than in the Secretariat pond (64 to 74 ppm). Chloride content was also higher at the Adalatgunj pond (120.5 to 138.2 ppm) than the Secretariat pond (30 to 37.59 ppm). The presence of chloride in higher concentration in aquatic ecosystem is an index of pollution of animal origin [8]. Chloride appears in an aquatic ecosystem mainly due to sewage contamination. Thus concentration of chloride was higher at the Adalatgunj pond on account of sewage discharge. This is an agreement with the findings of Munwar [9].

Bicarbonate alkalinity plays a vital role in CO_2 - H_2O system. Diurnal profile of bicarbonate alkalinity depends on pH and trophic status of the aquatic system. At the Secretariat pond, a well-marked diurnal variation was observed (Fig. 3). The bicarbonate alkalinity was maximum at 12.00 hours, suggesting the dominance of HCO_3^- ions by that time. When photosynthetic demand of CO_2 increases, the required CO_2 is furnished by dissolution of bicarbonate ions.

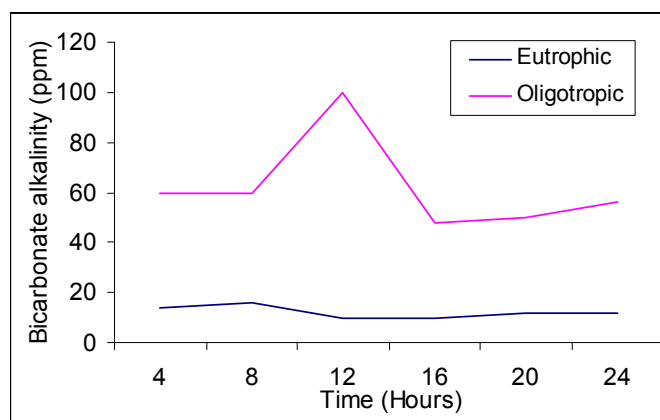
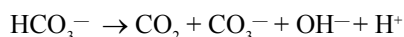
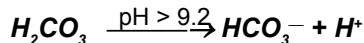


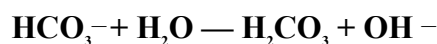
Fig. 3. Diurnal variation of bicarbonate alkalinity of two ponds at 0.5 m of depth.

As a result, the bicarbonate alkalinity started to decrease from 100 ppm at 12 hours to 50 ppm at 16 hours at the depth of 0.5 meters. It was also marked by decrease in pH due to the release of the H^+ ions in the process. Bicarbonate alkalinity again increased by converting the CO_2 to HCO_3^- (at pH > 9.2) when the photosynthetic activities ceased beyond 20 hours.



The total alkalinity, however, showed increasing trend throughout the day due to accumulation of carbonate and bicarbonate ions that is formed during photosynthetic demand of CO_2 . Carbonates and bicarbonates present in the medium, furnish OH^- ions

responsible for increase in alkalinity, as per the following reactions:



Carbonate produces double OH^- ions as compared to bicarbonate. This increases the TA and pH. This was quite evident in the Secretariat pond.

At Adalatgunj pond no significant change in alkalinity was observed. At the same time no variation with reference to depth in bicarbonate alkalinity was observed (Fig. 4). Very low and no significant diurnal variation in alkalinity at Adalatgunj pond is an indicative of eutrophic water.

The present study gives fair idea about the nature of water body and informations about its trophic status. Available data suggest that the Adalatgunj pond is eutrophic. Low alkalinity, clinograde distribution of DO and higher chloride supports our assumption. The Secretariat pond, on the other hand, owing to rich DO, low chloride and comparatively higher alkalinity, is oligotrophic. The diurnal variation in eutrophic pond is not sharp, particularly for bicarbonate alkalinity. On the other hand, it is very pronounced in case of oligotrophic ponds as observed in Secretariat pond. Similarly, relatively less diurnal variation in hardness and chloride at Adalatgunj pond suggest it to be eutrophic. Absence of free CO_2 indicates that the microbial status is low and, at the same time, sharp diurnal variation in free CO_2 is further indication of eutrophic water as observed in the Adalatgunj pond.

Acknowledgments

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References

- [1] S.K.Choadhary, M.Nayak, R.B.Singh and P.Banerjee, "Diurnal variations in some physico-chemical and biological parameters of two ponds at Bhagalpur (Bihar)," National Academy Science Letters, vol.14 (10) pp. 403-407, 1991.[5]
- [2] S.K.Singh and G.P.Singh, "Density and productivity of phytoplankton in the River Ganga at Patna, India," Tropical Ecology, vol. 37(1), pp.143-145, 1996.
- [3] N.R.Shastree, M.S.Islam, S.Pathak, and M.Afshan, "Studies on the physico-chemical dimensions of the lentic hydrosphere of Ravindra Sarovar (Gaya) in "Current trends of Limnology" (N.K.Shastree ed.), vol. I, Narendra Publishing House, New Delhi-India, pp.133-152, 1991.
- [4] L.S.S.O'Malley, Bihar and Orrisa District Gazetteer(Revised), Government Printing Press,Patna, pp.5-6,1924
- [5] "Standard Methods for the Examination of Water and Waste Waters," American Publication Health Association. APHA. NewYork,1985
- [6] B.Williams, "Biostatistics", Chapman and Hall, London, pp. 94-177, 1993
- [7] M.M.Prakash, "Correlation among the Physico-chemical characteristics of Pond water (Mehta pond, Jhabua)," Assesment of Water Pollution, S.R.Mishra (ed.), APH Publishing Corporation, New Delhi, India, pp. 441-449, 1996.
- [8] A.K.Singh, "Studies of pattern and evaluation of energy transfer in lentic and lotic ecosystem of Patna (Bihar)," Ph.D. thesis, Patna University, Patna, India, pp. 447, 1991.
- [9] M.Munwar, "Limnological studies on Fresh water ponds of Hyderabad, India," Hydrobiol35: vol.35 35, pp. 127-162, 1970.