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Comparative Limnological Studies of Barali Lake Hurda and Anasagar Lake Ajmer with Reference to Planktonic Population Dynamics

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ABSTRACT

Physico-chemical study are summarized. Air temperature varied between 28^{0}C in winter to 35^{0}C in summer 2015-16 and between 26^{0}C in winter to 38^{0}C in summer 2016-17. Water temperature was observed to be highest during summer 2016-17 (27^0 C) and lowest during winter 2015-16 (17^{0}C). The overall average value of air and water temperature was 36^{0}C and 27.3 ^{0}C respectively. A good synchronization between temperature and dissolved oxygen was seen. Temperature showed a significant inverse relationship with dissolved oxygen. Such an inverse relationship has also been observed in monsoon 2015-16 and 2016-17; pH fluctuated between 6.9 to 8.5. The minimum pH was recorded in monsoon 2015-16 and 2016-17 which was mainly attributed to rain water after a long dry period and maximum pH was recorded during summer 2015-16 and 2016-17. According to the study, Anasagar Lake was characterized by low levels of dissolved oxygen with average value of 7.1 mg/l. The highest oxygen value of 8.5 mg/l was observed in winter season of 2015-16 and 2016-17. The peak value during winter was also observed. Dissolved oxygen shows a significant negative relation with temperature, alkalinity, total hardness, electrical conductance, nitrate, phosphate, chloride, silicate and respiration. The observed high value of dissolved oxygen in winter due to the high-solubility at low temperature and less degradation of organic matter. During the study, the highest value of total alkalinity was in summer 2015-16 and 2016-17 (590 mg/l) and lowest value was observed in winter 2005-06 (410 mg/l). Total alkalinity shows a positive relationship with temperature, pH, total hardness, TDS, conductivity, chloride and nitrate. The average value of total hardness during the study was lowest value of 315 mg/l in 2015-16 and 2016-17 and highest value of 375 mg/l in 2006-07.

Keywords TDS, Alkalinity, Hardness, Solubility, Anasagar Lake.

INTRODUCTION

Study area for the proposed research work will be Anasagar Lake and Barali Lake. Anasagar Lake is situated in mid of Ajmer while Barali Lake is situated in village Hurda District Bhilwara. Both lakes serve people for different purposes like drinking, bathing, washing clothes and animals all the year so they play best role for research. Water the giver of life is most abundant and most versatile of chemicals of life.

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Table 1. Sites of collection of soil samples.

Site name	Source	Location
S_1	Fallow land	$26^0$55′46.97′′N $75^0$13′57.54′′ E
S_2	Fallow land	$26^0$59′16.55′′N $75^0$09′07.93′′ E
S_3	Open area	$26^0$58′ 07.58′′N $75^0$07′49.23′′E
S_6	Pond	$26^0$53′51.13′′ N $74^0$59′15.51′′E
S_7	Pond	$26^0$54′06.73′′N$75^0$07′30.60′′ E

Water is a surprisingly unique substance due to its thermal property i.e. with low freezing point, high boiling point, high specific heat and conductivity, makes it an essence of life. Water the most vital and precious natural resource is important for an ecosystem. Water is the only chemical compound which occurs in all the three states solid, liquid and vapor (Abhijna et al. 2013).

MATERIALS AND METHODS

Term limnology was coined by francois Alphonse Forel (1841-1912) who establishes the field with his studies of lake Geneva. Forel's original definition of limnology, expended to encompass the study of all inland waters. Task of limnology is to investigate and explain the system properties of natural waters (Abowei 2010). These furnish the basis of applied limnology. Besides pure or theoretical limnology, for which the research in not motivated by practical consideration. The more down to earth subject of applied limnology has the important task of providing answers to those problems of fresh water management created by our population and urbanization together with environmental protection which cannot be evaded by any responsible and public spirited limnologist.

Sewage treatment, population of natural waters, water quality conservation and restoration are the concern of applied limnology. The mineral content of water affects the organisms, since excess -PO_4, -P, -NO_3 even in an oligotrophic (clear water) lake cause zooplanktonic booms (Abowei and Sikoki 2009). No specific investigation has been conducted on Barali Lake and hence, no report is available on the physico-chemical characteristics of water, planktonic population and seasonal periodicity (Abraham 2010). The second lake of my investigation is Anasagar Lake Ajmer, here some of studies are done but as this lake is under tremendous pressure due to the development of residential accommodation and increased population, it is proposed to investigate limnological aspects of both of these. Due to multifold pressure of urbanization urban sewage waste discharge, cloth washing activities, agricultural practices and construction of housing colonies on the major part of lake margin the Anasagar Lake is greatly affected. Whereas by cloth, animal washing activities and agricultural practices the Barali Lake Hurda is affected (Adakole and Annune 2013).

Table 2. Anasagar Lake 2015-16.

Period/	Rainy			Winter			Spring			Summer		
Parameters	Jul 15	Aug 15	Sep 15	Oct 15	Nov 15	Dec 15	Jan 16	Feb 16	Mar 16	Apr 16	May 16	Jun 16
Air temp	33.0	30.0	32.5	28.5	27.5	24.5	22.5	28.5	30.5	33.0	35.5	34.0
Water temp	18.0	18.5	17.5	20.2	19.5	18.0	16.5	18.2	24.2	26.3	27.3	27.5
pH	6.9	6.8	6.9	7.25	7.3	7.6	7.3	7.5	7.3	8.2	8.3	8.5
Turbidity	80	89	82	78	75	79	74	76	72	85	86	84
Alkalinity	487.62	420.36	452.23	414.25	420.6	465.25	489.25	469.5	495.36	540.12	565.23	589.23
TDS	958	987	956	1023	1065	1042	1002	1120	1230	1345	1365	1350
DO	7.4	7.5	7.4	8.5	8.3	8.4	8.5	8.5	7.5	7.3	7.1	7.1
Total hardness	315.25	320.36	322.56	350.65	356.21	365.25	375.56	381.54	365.12	356.25	365.15	350.21
Chloride	142	149	156	169	154	136	154	163	170	181	183	189
Nitrates	3.26	3.36	3.56	3.98	3.66	4.25	4.32	4.63	3.12	3.03	3.26	3.96
Fluoride	2.04	2.11	2.14	2.77	2.83	2.78	2.35	2.48	2.45	2.99	2.87	2.99
BOD	15.5	15.8	14.8	17.6	16.25	17.0	15.26	17.65	17.95	15.83	17.24	14.23
COD	128	135	126	138	130	125	122	128	134	129	139	130

Table 3. Barali Lake 2015-16.

Period/ Parameters	Rainy			Winter			Spring			Summer		
	Jul 15	Aug 15	Sep 15	Oct 15	Nov 15	Dec 15	Jan 16	Feb 16	Mar 16	Apr 16	May 16	Jun 16
Air temp	30.0	31.0	32.9	26.5	28.5	23.5	21.5	21.75	31.5	33.25	36.5	36.0
Water temp	18.0	17.5	18.5	21.2	19.5	17.5	16.5	17.2	24.2	26.3	27.3	27.5
pH	6.9	6.7	6.25	7.3	7.5	7.3	7.25	7.3	7.6	8.2	8.3	8.5
Turbidity	80	79	82	88	75	89	84	86	82	95	97	84
Alkalinity	437.62	420.20	442.28	404.25	415.36	464.25	479.25	449.5	491.36	545.65	569.23	568.25
TDS	1158	1177	1056	1053	1165	1242	1102	1220	1270	1245	1355	1350
DO	7.4	7.5	6.9	7.5	7.3	7.4	7.5	7.5	6.8	6.9	6.7	6.7
Total hardness	325.25	370.36	362.56	350.65	376.21	378.25	365.56	381.90	365.12	378.25	365.15	350.21
Chloride	152	156	165	189	184	176	167	163	160	185	183	189
Nitrates	4.26	5.36	5.56	4.98	4.66	4.25	5.32	4.63	4.12	4.53	4.66	3.96
Fluoride	2.12	2.22	2.15	2.77	2.94	2.68	2.34	2.51	2.55	2.98	2.99	2.98
BOD	14.5	15.0	14.8	15.6	16.25	16.0	14.26	15.65	17.85	15.63	16.24	15.23
COD	120	125	136	138	140	125	132	121	134	126	129	130

RESULTS AND DISCUSSION

Results of physico-chemical study are summarized in Table 1 and 2. Air temperature varied between 28^{0}C in winter to 35^{0}C in summer 2015-16 and between 26^{0}C in winter to 38^{0}C in summer 2016-17. Water temperature was observed to be highest during summer 2016-17 (27^{0}C) and lowest during winter 2015-16 (17^{0}C). The overall average value of air and water temperature was 36^{0}C and 27.3^{0}C respectively. A good synchronization between temperature and dissolved oxygen was seen. Temperature showed a significant inverse relationship with dissolved oxygen. Such an inverse relationship has also been observed in monsoon 2015-16 and 2016-17 ; pH fluctuated between 6.9 to 8.5. The minimum pH was recorded in monsoon 2015-16 and 2016-17 which was mainly attributed to rain water after a long dry period and maximum pH was recorded during summer 2015-16 and 2016-17. According to the study, Anasagar Lake was characterized by low levels of dissolved oxygen with average value of 7.1 mg/l. The highest oxygen value of 8.5 mg/l was observed in winter season of 2015-16 and 2016-17 (Adakole et al. 2008). The peak value during winter was also observed. Dissolved oxygen shows a significant negative relation with temperature, alkalinity, total hardness, electrical conductance, nitrate, phosphate, chloride, silicate and respiration. The

Table 4. Anasagar Lake 2016-17.

Period / Parameters	Rainy			Winter			Spring			Summer		
	Jul 15	Aug 15	Sep 15	Oct 15	Nov 15	Dec 15	Jan 16	Feb 16	Mar 16	Apr 16	May 16	Jun 16
Air temp	32.0	31.0	33.5	27.5	28.5	23.5	21.5	28.5	30.25	32.0	36.5	35.0
Water temp	17.0	18.5	17.5	21.2	19.5	17.0	17.5	18.2	24.2	26.3	27.3	27.5
pH	6.9	6.8	6.9	7.25	7.3	7.6	7.3	7.5	7.3	8.2	8.3	8.5
Turbidity	80	89	82	78	75	79	74	76	72	85	86	84
Alkalinity	457.62	420.16	452.23	414.25	425.6	465.25	479.25	459.5	495.36	540.65	565.23	569.23
TDS	958	987	956	1023	1065	1042	1002	1120	1230	1345	1365	1350
DO	7.2	7.6	7.0	8.2	7.8	8.3	8.6	8.5	7.9	7.6	7.0	7.1
Total hardness	315.25	320.36	322.56	350.65	356.21	365.25	375.56	381.54	365.12	356.25	365.15	350.21
Chloride	142	149	156	169	154	136	154	163	170	181	183	188
Nitrates	3.26	3.36	3.56	3.98	3.66	4.25	4.32	4.63	3.12	3.03	3.26	3.96
Fluoride	2.02	2.12	2.14	2.77	2.93	2.78	2.34	2.41	2.45	2.99	2.89	2.98
BOD	15.5	15.8	14.8	17.6	16.25	17.0	15.26	17.65	17.95	15.83	17.24	14.23
COD	128	135	126	138	130	125	122	128	134	129	139	130

Table 5. Barali Lake 2016-17.

Period / Parameters	Rainy			Winter			Spring			Summer		
	Jul 15	Aug 15	Sep 15	Oct 15	Nov 15	Dec 15	Jan 16	Feb 16	Mar 16	Apr 16	May 16	Jun 16
Air temp	30.0	30.5	33.5	26.5	28.5	22.25	21.5	27.5	31.25	32.0	37.5	34.0
Water temp	17.5	17.5	18.5	20.2	20.5	17.0	16.5	17.2	25.2	26.3	28.53	28.25
pH	7.9	7.5	7.8	7.5	7.8	7.6	7.4	7.5	7.9	8.5	8.5	8.6
Turbidity	78	88	82	75	76	89	84	87	72	85	76	84
Alkalinity	457.62	420.16	452.23	414.25	425.6	465.25	479.25	459.5	495.36	540.65	565.23	569.23
TDS	978	987	996	1015	1025	1092	1102	1220	1280	1245	1255	1370
DO	7.4	7.4	6.8	7.5	7.3	7.4	7.5	7.5	6.8	6.9	6.7	6.7
Total hardness	325.35	330.26	342.56	380.85	366.21	385.25	365.56	371.54	358.12	359.25	367.75	370.81
Chloride	152	159	146	170	165	163	165	163	160	171	183	189
Nitrates	4.26	4.26	4.76	3.88	3.86	4.75	4.92	4.68	3.89	4.03	4.26	4.96
Fluoride	2.32	2.12	2.24	2.78	2.95	2.75	2.44	2.42	2.46	2.97	2.89	2.98
BOD	14.5	14.8	15.8	16.6	17.25	18.8	16.26	16.65	16.35	15.83	17.24	15.23
COD	132	135	130	135	128	127	128	127	139	139	139	138

Table 6. Zooplankton species.

Zooplankton species	Rainy			Winter			Spring			Summer		
	(ni)	(ni/N)	Log ni/N	(ni)	(ni/N)	Log ni/N	(ni)	(ni/N)	Log ni/N	(ni)	(ni/N)	Log ni/N
Rotifera												
Brachionus	82	0.171	-0.791	65	0.351	-0.650	89	0.210	-0.677	89	0.220	-0.667
B. rubens	66	0.160	-0.838	35	0.269	-0.773	48	0.137	-0.863	58	0.137	-0.863
B. calyciflorus	78	0.172	-0.754	30	0.141	-0.862	55	0.154	-0.813	65	0.144	-0.803
Asplanchna	60	0.078	-1.019	26	0.084	-1.089	45	0.106	-0.973	45	0.106	-0.973
Conochilus	43	0.66	-1.125	20	0.071	-1.127	30	0.071	-1.149	30	0.061	-1.145
Lophocaris	48	0.058	-1.026	32	0.12	-0.989	35	0.090	-1.047	38	0.090	-1.047
Colurella	16	0.093	-1.440	15	0.078	-1.412	15	0.040	-1.396	17	0.050	-1.496
Epiphanes	28	0.078	-1.365	9	0.044	-1.432	17	0.038	-1.422	16	0.048	-1.522
Lacane	30	0.096	-1.161	13	0.059	-1.313	29	0.069	-1.164	29	0.096	-1.164
K. quadrata	40	0.089	-1.052	12	0.025	-1.260	38	0.085	-1.070	36	0.085	-1.070
Total	491			257			401			423		
Cladocera												
Alonella	19	0.066	-1.184	9	0.051	-1.294	14	0.049	-1.310	19	0.066	-1.184
Alona	25	0.090	-1.047	14	0.079	-1.102	20	0.077	-1.114	26	0.090	-1.047
Daphnia	80	0.276	-0.559	35	0.226	-0.646	75	0.262	-0.581	80	0.276	-0.559
Brachiata	65	0.231	-0.636	43	0.243	-0.615	70	0.262	-0.571	67	0.231	-0.636
Monina	20	0.155	-0.809	35	0.215	-0.668	48	0.203	-0.693	38	0.215	-0.668
Chydorus	22	0.086	-1.064	18	0.107	-0.969	20	0.070	-1.155	19	0.107	-0.969
Ceriodaphnia	28	0.097	-1.015	14	0.079	-1.102	20	0.077	-1.114	14	0.079	-1.102
Total	259			168			267			263		
Copepode												
Cyclops	45	0.242	-0.616	12	0.127	-0.897	18	0.366	-0.509	10	0.128	-0.887
Mesocyclops	39	0.210	-0.678	12	0.211	-0.675	10	0.183	-0.754	14	0.221	-0.775
Diatomus	20	0.124	-0.908	14	0.197	-0.705	4	0.060	-1.164	12	0.198	-0.715
Phyllodiaptomus	15	0.081	-1.093	8	0.099	-1.006	5	0.088	-1.047	8	0.089	-1.006
Nauplius larva	25	0.156	-0.807	10	0.155	-0.825	4	0.148	-0.832	11	0.165	-0.820
Eucyclops	30	0.188	-0.725	15	0.211	-0.636	10	0.165	-0.656	14	0.211	-0.675
Total	174			71			51			69		
Protozoan												
Vorticella sps.	10	0.475	-0.315	17	0.441	-0.257	2	0.365	-0.416	18	0.441	-0.257
Paramecium aurelia	9	0.523	-0.289	20	0.449	-0.348	6	0.645	-0.208	17	0.559	-0.348
Total	19			37			8			35		

observed high value of dissolved oxygen in winter due to the high solubility at low temperature and less degradation of organic matter. During the study, the highest value of total alkalinity was in summer 2015-16 and 2016-17 (590 mg/l) and lowest value was observed in winter 2005-06 (410 mg/l). Total alkalinity shows a positive relationship with temperature, pH, total hardness, TDS, conductivity, chloride and nitrate.The average value of total hardness during the study was lowest value of 315 mg/l in 2015-16 and 2016-17and highest value of 375 mg/l in 2006-07. This increase in total hardness during summer period is due to higher photosynthetic activity, free carbon dioxide is utilized and bicarbonates are converted into carbonates and precipitated as calcium salts. Total dissolved solid (TDS) ranged between 950 mg/l to 1400 mg/l with lowest during winter 2015-16 and 2016-17 and highest during summer 2015-16 and 2016-17 respectively. Higher concentration of TDS also due to the discharge savage and organic matter by the interference of human. Chloride concentration varied between 140 mg/l to 190 mg/l in 2015-16 and 2016-17. Higher chloride concentration during the summer because high temperature and consequent evaporation. In rainy season, lower concentration of this factor due to dilution. According to the study, rich contents of nitrates were observed, with maximum of 4.5 mg/l during summer 2015-16 and 2016-17 and minimum of 2.1 mg/l during monsoon 2005-06. This can be attributed to high evaporation which increases the concentration during summers. Nitrate showed positive relation with temperature, pH, alkalinity, total hardness, TDS, chloride and fluoride and productivity and negative relation with dissolved oxygen. In the present study, the values of fluoride varied between 2.1 to 2.9 mg/l, with maximum value during summer 2015-16 and 2016-17 and minimum during monsoon 2015-16 and 2016-17 (Biswas (Mukherji) 2015). Fluoride showed positive correlation with pH, dissolved oxygen, hardness and nitrate (Tables 3–6).

Zooplankton abundance throughout the study period shown in Table 7. The highest diversity value in summer season while the lowest winter season which was dominated by Rotifera followed by Cladocera, Copepod and Protozoa. As per the result the Shannon Weaver diversity index value (1.61) stated that the Rotifera was recorded. Table 7 also show

Table 7. Biodiversity indexes of zooplankton in different seasons in the study area.

Zooplankton species	Rainy (ni/N) log ni/N	Winter (ni/N) log ni/N	Spring (ni/N) log ni/N	Summer (ni/N) log ni/N
Rotifera				
Brachionus	-0.216	0.0540	-0.317	-0.158
B. rubens	-0.190	-0.347	-0.158	-0.189
B. calyciflorus	-0.228	-0.163	-0.189	-0.108
Asplanchna	-0.076	-0.077	-0.108	-0.061
Conochilus	-0.58	-0.063	-0.062	-0.085
Lophocaris	-0.056	-0.121	-0.086	-0.028
Colurella	-0.064	-0.055	-0.030	-0.027
Epiphanes	-0.057	-0.030	-0.021	-0.26
Lacane	-0.059	-0.045	-0.054	-0.592
K. quadrata	-0.084	-0.019	-0.050	-0.079
Total	-1.61	-1.46	-1.075	-1.587
Cladocera				
Alonella	-0.055	-0.039	-0.03	-0.055
Alona	-0.085	-0.071	-0.067	-0.085
Daphnia	-0.493	-0.34	-0.451	-0.493
Brachiata	-0.363	-0.39	-0.458	-0.363
Monina	-0.191	-0.321	-0.292	-0.321
Chydorus	-0.080	-0.111	-0.060	-0.110
Ceriodaphnia	-0.095	-0.071	-0.007	-0.0716
Total	-1.362	-1.343	-1.365	-1.498
Copepode				
Cyclops	-0.0003	-0.143	-0.620	-0.144
Mesocyclops	-0.309	-0.312	-0.244	-0.249
Diatomus	-0.136	-0.279	-0.037	-0.276
Phyllodiaptomus	-0.074	-0.098	-0.084	-0.088
Nauplius larva	-0.193	-0.187	-0.177	-0.201
Eucyclops	-0.25	-0.33	0.251	-0.312
Total	-0.712	-1.019	-1.612	0.958
Protozoan				
Vorticella sps.	-1.50	-1.76	0.877	-1.71
Paramecium aurelia	-1.80	-1.29	3.10	-1.606
Total	-3.30	-3.05	-3.977	-3.316
H= ∑ (ni/N) log (ni/N)	6.982	-6.86	-8.21	-7.33

the dominance of Cladocera among zooplankton during summer and winter might be due to thermal and nutritional condition. Cladocera species also showed higher Shannon diversity index value (1.49) in summer. The present study concluded the dominance of rotifer and Cladocera, Copepoda indicating the eutrophication of lake suitable for fish culture. The values of Shannon Weaver index for zooplankton were mostly indicating that there was no impact of pollution in Anasagar Lake (Freitag 2014).

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