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Physico-chemical parameters of Itahari sub-metropolitan fish pond, Nepal

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ABSTRACT

Itahari Sub-metropolitan pond is located in the centre of the city. Influence of variations in physico-chemical parameters on aquatic flora and fauna especially in fishes brought strong stress on fishes and increases the incidence of diseases leading to high mortality. Due to lack of adequate knowledge about it, productivity of ponds is very low.

In the present study, maximum and minimum variations and correlation between different physico-chemical parameters - air temperature, water temperature, pH, turbidity, total dissolved solids, dissolved carbon dioxide, ammonia, dissolved oxygen, biological oxygen demand, chloride, total alkalinity, total hardness and phosphate were taken into consideration. The water quality of fish ponds were normal except high fluctuation of chloride 4.0 - 44.87 mg/l and ammonia 0.48-13.6 mg/l during manuaring period and casual addition of wastes like toilet cleaners, caustic potash etc.. Due to sudden fall in DO less than 4 mg/l during April and May, 2014 and increment of ammonia after addition of toilet wastes in Sept.19, 2015 ; mass mortality of fishes *Labeo rohita, Cirrhina mrigala, Hypothalamichthys molitrix, Aristichthys nobilis* occurred in the study site.

Keywords: Physicochemical, Itahari**,** fish, pond, environment, variations

INTRODUCTION

Nepal has four major perennial river systems: Koshi, Gandaki, Karnali and Mahakali. Around 6,000 rivers including tributaries and several lakes, swamps, ponds and streams are distributed throughout the country. The total water bodies occupy 2.8% of total area of the country. Natural water bodies consist of about 55% of total inland water resources. Due to the different altitudinal (Terai, Hills, Mountains within ranges between 200-4000 m) and climatological variation in water bodies, the various fish species (187 indigenous species) diversified (Shrestha, 2001), 232 species (Shrestha, 2008).

Though the potentiality of the extension of fish farming is very high, capture fisheries were much more (16700 MT/yr) than the production of cultured fish (10559 MT/yr) and total shares of fisheries in normal GDP is 0.81% (1999/2000). Later reported cultured fishery production increased to 26679 MT and captured fisheries to 20100 MT per year (DOFD, 2007). Total production of fish was 56,000 (36500 from aquaculture alone) Mt /year in the year 2012-2013 (Shrestha & Mishra, 2014).

The physico-chemical parameters of water bodies influence directly or indirectly the aquatic organisms in various ways. Functioning of the aquatic ecosystem is regulated by the interaction among the physico-chemical and biological components of the system. Hence, it is essential to have the knowledge of physico-chemical parameters for identifying suitability and fertility of an aquatic ecosystem. Reid (1961) stated that the successful development and maintenance of a population of organisms depends upon harmonious ecological balance between environmental conditions and tolerance of the organism to variations in one or more of these conditions. The physico-chemical parameters of a water body change due to seasonal change, diurnal changes and pollutants which influence in abundance of aquatic organisms. Among the physico-chemical parameters air temperature, water temperature, pH, dissolved oxygen (DO), free carbon dioxide ($CO_{2)}$, T alkalinity (TA), T hardness (TH), chloride (Cl^-) and BOD mainly determine the hydrological condition of water body. Extensive works have been carried out by different workers (Bhowmik, 1988; Dobriyal & Singh, 1989; Patralekh, 1994; Singh & Singh, 1995; Mishra & Sharma, 1998; Ashok *et al.,* 2007) on the physico-chemical and biological parameters of freshwater bodies in other countries.

In Nepal, Loffler (1969) reported the dominance of calcium among cations, low chloride and less than 1µg /l phosphorus from the high altitude lakes of Mount Everest region. Lohaman *et al.* (1988) studied pre and post monsoon limnological characteristics of lakes of Pokhara and Kathmandu valleys and obtained low alkalinity and conductivity in the lakes of Pokhara valley. Mc Eachern (1994) reported 8.4 pH, 0.03 mg/l phosphate and 8.5 mg/l dissolved oxygen in Narayani, a lowland (< 1000 m) river of Nepal. Aryal & Lacoul (1996) reported high pH, total hardness, BOD at polluted site, where transparency and DO were low in Punyamati river. Ormerod *et al.* (1996) reported the pH range between 7.3 to 8, chloride 0.4 mg/l to 1.4 mg/l, nitrate 0.06 mg/l to 0.28 mg/l, and phosphate 0.02 mg/l to 0.04 mg/l from the highland (> 2000 m) rivers of Nepal. Niraula *et al.* (2010) revealed pH, conductivity, turbidity, total phosphorus and total alkalinity were higher in summer whereas total dissolved solids, nitrate, total hardness- $CaCO_3$, dissolved oxygen, BOD, and chloride content were higher in winter, however, water depth, temperature, ammonia and carbon dioxide were higher in rainy season. Also, more seasonal fluctuations in turbidity (0.76-26.01 NTU), carbon dioxide (4.58-73.92 mg/l) and chloride content (2.0-7.0 mg/l) was recorded in Betana pond, eastern Nepal.

MATERIALS AND METHODS

Study area

Present study area includes Itahari sub- metropolitan artificial pond is located at latitude 26^0 39'47.41" N and longitude $87^0$16'37.97"E occupied 18 kattha (3280.5 square feet) area of the city at the sub-metropolitan premises. The study deals with the physicochemical parameters - air temperature, water temperature, pH, dissolved carbon dioxide, dissolved oxygen, biological oxygen demand, chloride, total alkalinity, total hardness, ammonia and phosphate of Itahari sub-metropolitan pond during the first and the second year (November 2013 to October 2015).

Sampling

The site Itahari sub-metropolitan pond was selected in its premises. Parameters taken were air temperature, water temperature, pH, dissolved carbon dioxide, dissolved oxygen, biological oxygen demand, chloride, total alkalinity, total hardness ammonia and phosphate following Trivedi and Goel (1984) and APHA (2005). During the study some physico-chemical parameters were studied on the spot e.g. DO, pH, temperature and CO_2. In addition, other parameters were analyzed in the laboratory by carrying water samples in closed bottles. Sampling was done at 8.00A.M. to 11.00 A.M. at the last week of each month. Whole year was divided into three seasons – summer (March-June), rainy (July-October) and winter season (November-February). Monthly data of different parameters were pooled into seasonal data. Standard deviation, correlation coefficient were calculated by using Microsoft excel statistical function of computer software. The correlation coefficient between different variables was calculated and their significance differences were tested using SPSS.

RESULTS AND DISCUSSION

Results of the air temperature and physico-chemical parameters of water of Itahari sub-metropolitan pond are shown in table 1 and table 2. Table 1 shows the results of air temperature and physico-chemical parameters of water of the first year (November 2013 to October 2014) and table 2 shows the second year (November 2014 to October 2015) of the study periods. The seasonal variations in air temperature, water temperature and physico-chemical parameters of the site in different seasons during first and second year study period are tabulated in table 4.

TABLE 1. Air and water temperature and physico-chemical parameters of water recorded at Itahari municipality pond during November 2013 to October 2014 (Mean±S.D., N=5).

Parameters	Months											
	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct
Air temperature (0°C)	23 ±0.325	19.5 ±0.236	23 ±0.214	26 ±0.245	29 ±0.134	33 ±0.145	30 ±0.221	29.5 ±0.095	25.5 ±0.437	28 ±0.342	30 ±0.332	27 ±0.165
Water temperature (0°C)	20 ±0.374	17 ±0.452	18 ±0.215	21 ±0.336	23 ±0.223	30 ±0.526	28 ±0.456	29 ±0.126	29 ±0.456	29 ±0.371	29.5 ±0.217	25 ±0.275
pH	8.8 ±0.24	8.1 ±0.212	8.7 ±0.325	7.4 ±0.216	6.8 ±0.332	6.6 ±0.315	7.3 ±0.168	7.2 ±0.256	6.6 ±0.122	7.4 ±0.345	8.3 ±0.470	8.7 ±0.335
CO_2 mg/l	1.909 ±0.536	56.1 ±0.573	65.47 ±0.657	87.29 ±0.634	60.01 ±0.731	78.2 ±0.315	76.38 ±0.553	179.59 ±0.332	136.4 ±0.675	16.02 ±0.132	18.48 ±0.408	36.96 ±0.560
DO mg/l	7.67 ±0.223	4.96 ±0.089	7.67 ±0.342	7.44 ±0.421	7.83 ±0.325	6.65 ±0.210	6.26 ±0.167	6.65 ±0.208	6.65 ±0.097	6.88 ±0.275	6.16 ±0.551	7.66 ±0.345
BOD mg/l	2.63 ±0.035	1.95 ±0.057	3.84 ±0.076	2.74 ±0.015	0.39 ±0.041	0.78 ±0.063	0.7 ±0.076	0.85 ±0.035	0.23 ±0.134	1.8 ±0.087	4.53 ±0.162	3.81 ±0.112
Chloride mg/l	16.99 ±0.216	13 ±0.116	32.09 ±0.217	31.38 ±0.237	31.24 ±0.216	44.87 ±0.235	42.6 ±0.257	32.66 ±0.218	44.02 ±0.275	14 ±0.120	14 ±0.139	15 ±0.431
T Alkalinity mg/l	80.36 ±0.563	67.68 ±0.32	108.16 ±0.336	105.04 ±0.345	124.8 ±0.442	115.4 ±0.642	135.2 ±0.453	135.2 ±0.351	114.4 ±0.667	95.94 ±0.655	69.3 ±0.671	79.8 ±0.539
Total Hard mg/l	77.52 ±0.661	91.8 ±0.546	82 ±0.711	80.2 ±0.534	90.66 ±0.477	80.6 ±0.576	76 ±0.635	92 ±0.895	94 ±0.932	86.4 ±0.655	84.24 ±0.563	69.36 ±0.736
Ammonia mg/l	1.72 ±0.059	6.8 ±0.271	15.43 ±0.573	9.63 ±0.344	10.77 ±0.473	5.99 ±0.076	6.11 ±0.094	9.31 ±0.197	1.74 ±0.068	3.06 ±0.086	9.69 ±0.437	6.46 ±0.081
Phosphate mg/l	0.08 ±0.003	0.07 ±0.015	0.16 ±0.011	0.09 ±0.001	0.1 ±0.001	0.37 ±0.031	0.64 ±0.053	0.62 ±0.002	0.76 ±0.003	0.04 ±0.002	0.22 ±0.011	0.4 ±0.032

TABLE 2. Air and water temperature and physico-chemical parameters of water at (Itahari sub-metropolitan pond recorded during November 2014 to October 2015 (Mean±S.D., N=5).

Parameters	Months											
	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct
Air temperature (0°C)	23 ±0,227	20.5 ±0,234	18.5 ±0.439	22 ±0.492	30 ±0.633	30 ±0.356	27 ±0.312	25.5 ±0.336	28 ±0.215	29.5 ±0.423	30 ±0.214	29 ±0.415
Water	24 ±0,219	19 ±0,231	17.5 ±0.315	20 ±0.355	27 ±0.218	29 ±0,332	29 ±0.273	29 ±0.344	30 ±0.265	30 ±0.556	31 ±0.342	28 ±0.213
pH	7.5 ±0.231	8.3 ±0.175	7.8 ±0.114	8.7 ±0.211	8.5 ±0.253	7.3 ±0.231	8.1 ±0.223	7.6 ±0.098	8.5 ±0.347	7.9 ±0.216	8.2 ±0.310	7.5 ±0.128
CO2 mg/l	9.9 ±0.452	6.69 ±0.225	23.76 ±0.544	16.02 ±0.365	2.4 ±0.247	4.49 ±0.132	2.24 ±0.105	4.58 ±0.545	6.07 ±0.634	8.8 ±0.551	4.58 ±0.322	3.78 ±0.163
DO mg/l	5.56 ±0.164	7.14 ±0.344	7.86 ±0.231	9.71 ±0.257	5.94 ±0.221	3.8 ±0.321	3.99 ±0.211	4.94 ±0.225	5.82 ±0.097	6.17 ±0.203	6.2 ±0.242	6.3 ±0.313
BOD mg/l	1.47 ±0.067	1.67 ±0.055	5.78 ±0.063	2.43 ±0.052	2.27 ±0.043	2.39 ±0.079	3.54 ±0.088	3.87 ±0.097	2.59 ±0.065	0.75 ±0.416	4.22 ±0.025	0.83 ±0.045
Chloride mg/l	9 ±0.302	4 ±0.224	18.99 ±0.442	17.99 ±0.345	17.99 ±0.341	21.99 ±0.433	23.99 ±0.552	25.99 ±0.606	13 ±0.350	14 ±0.403	5 ±0.203	15 ±0.476
T Alkalinity mg/l	141.64 ±0.655	128 ±0.438	100 ±0.677	151.2 ±0.757	82.5 ±0.486	110 ±0.539	176 ±0.875	108.1 ±0.459	101.2 ±0.443	99 ±0.376	112.2 ±0.445	112.2 ±0.558
T hardness mg/l	116.82 ±0.996	63.36 ±0.765	99.96 ±0.457	87.12 ±0.540	81.18 ±0.412	104.94 ±0.345	102.86 ±0.431	99 ±0.330	85.15 ±0.243	83.16 ±0.289	93.06 ±0.376	99 ±0.435
Ammonia mg/l	13.60 ±0.197	0.48 ±0.012	5.60 ±0.065	5.77 ±0.075	5.1 ±0.046	10.54 ±0.098	3.4 ±0.023	13.6 ±0.210	13.6 ±0.215	10.2 ±0.324	8.5 ±0.087	11.9 ±0.994
Phosphate mg/l	0.2 ±0.003	0.16 ±0.002	0.09 ±0.001	0.1 ±0.002	0.37 ±0.005	0.64 ±0.013	0.62 ±0.015	0.69 ±0.022	1.12 ±0.027	1.23 ±0.036	0.12 ±0.002	0.16 ±0.004

TABLE 3. Pearson's correlation coefficient (r) for air temperature and physico-chemical parameters of water at the study site (average of the corresponding month values) during November 2013 to October 2015; N=12; d. f. =11.

S2-I+II		Water temp. (ºC)	pH	Free CO_2 (mg/L)	DO(mg/L)	BOD (mg/L)	Chloride (mg/L)	Total alkal (mg/L)	Total hardn (mg/L)
Air temperature	P cor.	.917*	.571	-.759*	-.647**	-.272	.442	.616**	-.103
(0°C)	Sig. (2-t)	.001	.052	.004	.023	.393	.150	.046	.751
Water temperature	P cor.	1	-.539	-.741*	-.747*	-.251	.277	.330	.071
(0°C)	Sig. (2-t)		.071	.006	.005	.432	.383	.296	.826
pH	P cor.		1	-.513	.828*	.728*	-.541	.629**	-681**
	Sig. (2-t)			.088	.001	.007	.069	.029	.102
Free CO_2 (mg/L)	P cor.			1	.647**	-.654**	.648**	.688**	.475
	Sig. (2-t)				.023	.064	.023	.013	.119
DO (mg/L)	P cor.				1	.058	.091	.211	-.301
	Sig. (2-t)					.858	.778	.510	.341
BOD (mg/)	P cor.					1	.627**	.693**	-.643**
	Sig. (2-t)						.029	.012	.052
Chloride (mg/L)	P cor.						1	.834*	.135
	Sig. (2-t)							.001	.675
Total alk. (mg/L)	P cor.							1	.199
	Sig. (2-t)								.536
Total hardness (mg/L)	P cor.								1
	Sig. (2-t)								

* Significant at 1% level (P<0. 01), ** significant at 5% level (P<0. 05) and Values not marked denote non-significant correlation.

TABLE 4. Seasonal variations of air temperature and physico-chemical parameters of the study site during November 2013 to October 2015. (Mean±S.D., N=4).

Parameters	Year I			Year II		
	Winter	Summer	Rainy	Winter	Summer	Rainy
Air temperature (^{0} C)	23.87 ±2.954	30.37 ±1.796	27.625 ±1.887	21.00 ±1.957	28.12 ±2.250	29.12 ±0.853
Water temperature (^{0} C)	19.00 ±1.825	27.50 ±1.732	28.12 ±2.096	20.12 ±2.780	28.50 ±1	29.75 ±1.258
pH	8.25 ±0.645	6.97 ±0.330	7.77 ±0.944	8.07 ±0.548	7.87 ±0.507	8.04 ±0.405
CO_2 mg/l	56.98 ±28.442	101.38 ±60.272	51.96 ±57.060	14.09 ±7.517	3.45 ±1.255	5.80 ±2.209
DO mg/l	6.93 ±1.321	6.847 ±0.680	6.83 ±0.625	7.567 ±1.721	5.01 ±0.906	6.12 ±0.209
BOD mg/l	3.29 ±1.735	0.68 ±0.202	2.59 ±1.953	2.83 ±2.004	3.017 ±0.806	2.09 ±1.650
Chloride mg/l	23.36 ±4.805	37.84 ±6.891	21.75 ±14.850	12.49 ±7.228	22.49 ±3.415	11.75 ±4.573
Total alkalinity mg/l	90.31 ±19.550	127.65 ±9.525	89.86 ±19.690	130.21 ±22.276	119.15 ±39.920	106.15 ±7.043
Total hardness mg/l	82.88 ±6.225	84.81 ±7.773	83.5 ±10.314	91.81 ±22.533	96.995 ±10.826	90.09 ±7.317
Ammonia mg/l	8.39 ±5.718	8.04 ±2.379	5.23 ±3.570	6.362 ±5.413	8.16 ±4.735	11.05 ±2.194
Phosphate mg/l	0.010 ±0.040	0.432 ±0.253	0.355 ±0.307	0.13 ±0.051	0.58 ±0.143	0.65 ±0.599

PHYSICO-CHEMICAL PARAMETERS

Air temperature

The minimum air temperature was 19.5±0.236 °C ^{0}C in the month of December and maximum 33±0.145 °C in the month of April during the first year study period (table 1). The minimum air temperature was 18.5±0.439 °C in January and maximum 30±0.356°C was observed in April in the second year study period (table 2). The air temperature had positive and significant correlation with water temperature ($r = 0.917$, $P<0.01$), and TA ($r=0.616$, $p<0.05$) but inverse and significant correlation with pH ($r = - 0.653$, $P<0.05$), and free carbon dioxide ($r=-0.759$, $P<0.01$) and dissolved oxygen ($r =-0.647$, $P<0.05$) whereas other did not show significant correlation.

Water temperature

The lowest surface water temperature was recorded (17± 0.252°C) in December and maximum (30± 0.526°C) in April (table 1). Similarly, the minimum water temperature (17.5± 0.315°C) and maximum (31± 0.365°C) was recorded in September during the second year of the study period (table 2). The water temperature fond to be positive and significant correlation with air temperature (r =0.917, P<0.01) but inverse and significant correlation with CO_2 (r =-0.741, P<0.01) and dissolved oxygen (r = -0.747, P<0.01).

pH

The minimum pH recorded was 6.6± 0.315 in the month of April/July and maximum was 8.8± 0.24 in November (table 1). Likewise, the minimum pH was 7.3 ± 0.231 in April and maximum 8.7± 0.211 in February in the second year (table 2). pH had positive and significant correlation with DO (r = 0.828, P<0.01) and TA (r = 0.629, P<0.05) and BOD (r = 0.728, P<0.01) but inverse and significant correlation with TH (r= - 0.681, p<0.05) (table 3).

Dissolved oxygen

The maximum DO was 9.71± 0.257 mg/l in the end of February and the minimum 3.8 ± 0.321 mg/l in the month of April during the first year (table 1) and second year of the study period (table 2). The dissolved oxygen showed positive and significant correlation with free CO_2 (r =0.647, P<0.05) and pH (r = 0.828, P< 0.01) but inverse and significant correlation with temperature of air (r=-0.608, p <0.05) and temperature of water (r= -0.375, P < 0.01).

Free carbon dioxide

The maximum free CO_2 (179.59± 0.332 mg/l) was recorded in June and minimum (2.24 ± 0.247 mg/l) in March during the first year (table 1) and second year study period (table 2). Free carbon dioxide showed positive and significant correlation with chloride (r =0.648, P<0.05) but inverse and significant correlation with BOD (r=-0.654, P<0.05) and water temperature (r=-0.741, P <0.01).

Total alkalinity

The maximum total alkalinity recorded was 135.2 ±0.453 mg/l in May/June and the minimum was 67.68± 0.321 mg/l in December during the first year of the study period (table 1). Similarly, in second year study period, maximum TA was 176± 0.532 mg/l in May and minimum was 82.5± 0.465 mg/l in March (table 2). The positive and significant correlation with ambient temperature (r = 0.616, P<0.05), chloride (r = 0.834, P<0.01),BOD (r = 0.693, P<0.05) and free CO_2(r = 0.688, P<0.05) was found.

Total hardness

The maximum total hardness was 91.8 ± 0.546 mg/l in December and the minimum was recorded 76 ± 0.635 mg/l in May during the first (table 1) and the maximum was 116.82 ± 0.463 mg/l in November and minimum was recorded 63.36 ± 0.451 mg/l in December in the second year of the study period (table 2). The inverse and significant correlation with pH (r= -0.681, P<0.05) and BOD (r= -0.643, P<0.05) were found.

Chloride

The maximum chloride 44.87 ± 0. 235 mg/l in April and minimum 13 ± 0.116 mg/l in December were recorded during the first year (table 1) whereas the maximum 25.99 ± 0. 261 mg/l in June and the minimum 4± 0.247 mg/l in December of second year were recorded during the second year of the study period (table 2). The positive and significant correlation with CO_2 (r=0.648, P<0.05), TA (r= 0.834, P<0.01) and BOD (r= 0.627, P<0.05) were found. More amount of chloride obtained was may be due to mixing of toilet cleaners used in Itahari sub-metropolitan toilet.

Biological oxygen demand

The maximum BOD was 4.53 ±0.162 mg/l in September and the minimum was 0.23 ±0.134 mg/l in July during in first year (table 1) whereas the maximum BOD was 5.78 ±0.063 mg/l in January and the minimum was 0.75 ±0.416 mg/l in August in the second year (table 2). The positive and significant correlation with pH (r = 0. 728, P<0.01) but inverse and significant correlation with CO_2 (r = -0.654, P< 0.05), TH (r = -0.643, P<0.05) and TA (r= -0.693, P<0.05) were found.

Ammonia

The minimum ammonia (1.72±0.059 mg/L) in November and the maximum (15.43±0.573 mg/L) in January were recorded during the first year (table 1). Similarly, the minimum ammonia (0.48±0.012 mg/L) in December and the maximum (13.6±0.215 mg/L) in July during second year were recorded (table 2).

The death of fishes caused by diseases are of highest significance in fish culture, hence to achieve healthy fish stock. One should implement programs such as fish parasitological research, control of diseases and maintenance of health relationship between the fishes and their environment. The parasite community of fishes shows considerable variation with the environmental conditions in which they live. Various physico-chemical factors such as water temperature, alkalinity, ammonia, free CO_2, DO, pH and TH have strong influence on fish health and their resistance against the disease causing agents (Welch, 1941; Snieszko, 1974; Plumb *et al.,* 1988; Shrestha, 1994). Poor condition of physico-chemical properties of water is due to O_2 depletion, excess ammonia, excess CO_2 in water and temperature change. Delaware & Hossain *et al.* (2007) reported that monthly variations of the physico-chemical parameters in some 12 Beels and 210 ponds in Natore, changing in water quality parameters resulted in a stress response in the fishes, making them more susceptible to parasitic attacks and diseases, many of them being fatal.

The air temperature of study site was higher in summer in the first year but highest in the rainy season in the second year. The lowest temperature was recorded in winter in the second year (table 4). Gradual increase in air temperature was noticed during rainy seasons. Chakrawarty *et al.* (1959); Kant & Ananda (1978) and Rawat *et al.* (1995) also obtained strong positive significant correlation between air and water temperature.

In present study, the water temperature of study site was higher in rainy season in the first and second year (table 4). Generally water temperature is influenced by air temperature and intensity of solar radiations. Bose & Gorai (1993) reported negative correlation between water temperature and dissolved oxygen. Welch (1952) and Munawar (1970) had had observed that shallower the water body more quickly it reacts to the change in temperature.

The highest pH of study site was recorded in winter and lowest in the summer season in both years (table 4). Several workers have reported low pH during the low photosynthesis due to the formation of carbonic acid (Hannan & Yong, 1974; Cabecadas & Brogueiria, 1987; Bais *et al.,* 1995). However, Gautam (1990) reported highest pH in summer and lowest in rainy season. Rawat *et al.* (1995) reported positive correlation with total alkalinity.

The CO_2 of the present study site was higher in summer in the first year but higher in winter in the second year (table 4), it may be due to high temperature, high rate of decomposition of organic matter, low volume of water etc. Michel (1969) stated that the concentration of carbon dioxide is directly correlated with the amount and nature of biological activities in water. Gautam (1990), and Pandey & Lal (1995) also found minimum carbon dioxide in winter season.

The DO of study site was recorded higher in winter in both years (table 4). Generally, the maximum DO found in winter season may be due to low temperature (Moitra & Bhattacharya, 1965). Minimum DO was found in summer season due to high temperature and higher microbial demand for oxygen in decomposition of suspended organic matter (Bhowmic & Singh, 1985). But Mc Coll (1972) reported that the relationship between water temperature and is not so significant because production and consumption of oxygen takes place simultaneously.

The BOD of study site was higher in winter in the first year and in summer in the second year (table 4). The maximum value of BOD in summer may be due to high concentration of organic matter and minimum obtained in winter may be due to low temperature and retarded microbial activities for the decomposition of organic matters. Similar observations were made by Singh (1995). Barat & Jha (2002) showed inverse correlation of BOD with DO.

Total hardness of the study site was higher in summer in both the years (table 4). It is may be due to low volume and slow current of water. Similar results were obtained by Mishra *et al.* (1999). Minimum quantity in rainy season may be due to more dilution of water (Patralekha, 1994).

Total alkalinity was higher in summer in the first year and in winter in the second year (table 4). Singh (1990) and Mishra *et al.* (1998) also reported maximum pH in winter season. Barat & Jha (2002) also reported positive and significant correlation of total alkalinity with hardness.

Chloride content was found maximum in summer season in first year and the second year in present study (table 4). Chloride contents indicate the presence of organic wastes of animal origin (Thresh *et al.,* 1949). Swarup & Singh (1979) also reported an increase in chloride during summer and minimum amount of chloride in rainy seasons was due to dilution of water by rain water.

Ammonia in the study site was recorded higher in winter season in first year and in rainy season in second year (table 4). Ammonia content of pond water is directly affected by pH. With increase in pH values, the fraction of undissociated ammonia molecule increases the fraction of dissociated ammonium ions decrease. In the rainy and winter seasons, this competition is reduced and the nitrifying bacteria could take up the ammonia even at low concentration (Yoshifomi *et al.,* 2008).

Phosphate was recorded higher in summer season during first year and higher in rainy season in the second year in study site (table 4). It is noteworthy, phosphate increases the productivity of ponds.

On the basis of present study, the water quality of fish pond was normal except manuring period and casual addition of waste like toilet cleaners caustic potash etc. High fluctuation of chloride 4.0 - 44.87 mg/l and ammonia 0.48-13.6 mg/l was found during manuring period. Due to sudden fall in DO less than 4 mg/l; mass mortality of fishes *Labeo rohita, Cirrhina mrigala, Hypothalamichthys molitrix, Aristichthys nobilis* occurred. In September, 2015 mass mortality of same species of fishes as mentioned above occurred due to rise of ammonia after addition of human toilet wastes. Hence, drastic alterations in physico–chemical parameters adversely affect the aquatic flora and fauna (especially fish) in the study site and surrounding areas.

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