

## General properties of water of Baidya fish pond, Tankisinwari, Nepal

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### Abstract

In the present study, ranges and correlation among different physico-chemical parameters viz., air temperature, water temperature, pH, turbidity, total dissolved solids, conductivity, dissolved carbon dioxide, ammonia, nitrate, dissolved oxygen, biological oxygen demand, chloride, total alkalinity, total hardness and phosphate were taken into consideration. The water quality of Baidya fish pond was normal except high fluctuation of chloride  $1\pm 0.241$  to  $29.84\pm 0.260$  mg/l and ammonia  $1.55\pm 0.088$  to  $18.7\pm 0.061$  mg/l during manuring period and casual addition of wastes like toilet cleaners, caustic potash etc. Outbreak of epizootic ulcerative syndrome (EUS) was observed at the periphery of Baidya fish farm during winter months when polluted cold water from Koshi canal was added. The affected fishes developed several lesions around the body and fin rot. Due to sudden fall in dissolved oxygen, less than 4 mg/l during April and May, 2010 mass mortality of fishes *Labeo rohita*, *Cirrhina mrigala*, *Hypothalamichthys molitrix*, *Aristichthys nobilis* occurred. When chicken droppings were added in pond, ammonia was raised up to 18.7 mg/l which led to mass mortality of fish (*Pangasius*) during August.

**Key words:** Physico-chemical properties of water, Baidya fish pond, Itahari, Nepal

### Introduction

Nepal has about 6,000 rivers and their tributaries, several lakes, swamps, ponds and streams 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 and these water bodies support about 201 indigenous fish species (Shrestha, 2001; Shrestha, 2008). Though the potentiality of the extension of fish farming is very high, capture fisheries contribute much more (16700 MT/yr) than the production of cultured fish (10559 MT/yr) and total shares of fisheries to GDP is 0.81% (DOFD, 2007).

The physico-chemical parameters of water bodies influence directly or indirectly (the number, varieties, distribution, metabolic activities, growth etc.) of 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 of water bodies for aquaculture.

Reid (1961) has 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. These bring significant seasonal and diurnal change in abundance of aquatic organisms. Among the physico-chemical parameters air temperature, water temperature, transparency, pH, dissolved oxygen, free carbon dioxide, alkalinity, hardness, chloride and BOD mainly determine the hydrological condition of water body. Extensive works have been done by different workers on the physico-chemical and biological parameters of freshwater bodies in other countries (Bhowmik, 1988; Dobriyal & Singh, 1989; Patralekh, 1994; Singh & Singh, 1995; Mishra *et al.*, 1998; Hossain *et al.*, 2007) but very few works have been done in Nepal. Lohaman *et al.* (1988) studied pre and post monsoon limnological characteristics of lakes of Pokhara and Kathmandu valleys and reported low alkalinity and conductivity in those lakes.

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 and Lacoul (1996) reported high pH, total hardness and BOD at polluted site in Punyamati river. Ormerod *et al.* (1996) reported 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.

Shrestha *et al.* (2009) reported that the water quality parameters of Tamor river *viz.* air temperature (22-26.3°C), water temperature (16.0-19.0°C), dissolve oxygen (9.7-10 ppm), pH (7.3-7.5), alkalinity (17.1 mg/l), total hardness (28.5-34.2 mg/l), CO<sub>2</sub> (5 mg/l) and conductivity (37.7-56.7 µs/cm) were within the suitable range for cold water fishes. Niroula *et al.* (2010) have reported higher pH, conductivity, turbidity, total phosphorus and total alkalinity in summer whereas total dissolved solids, nitrate, total hardness- CaCO<sub>3</sub>, dissolve oxygen, BOD and chloride content were higher in winter, although, water depth, temperature, ammonia and carbon dioxide were found to be higher in rainy season in Betana pond, eastern Nepal.

Present study area (900 m<sup>2</sup>) includes a large commercial pond of Baidya fish farm located at latitude 26°31'12.00"N and longitude 87°16'19.86"E along the industrial corridor of Tankisinwari, Morang district. The present study deals with variation in physico-chemical parameters pond water *viz.*, air temperature, water temperature, pH, turbidity, total dissolved solids, dissolved carbon dioxide, ammonia, nitrate, dissolved oxygen, biological oxygen demand, chloride, total alkalinity, total hardness and phosphate during November, 2008 to October, 2010.

### Methodology

The physico-chemical parameters of Baidya fish pond were analysed as per the methods of Trivedi and Goel (1984) and APHA (2005). DO, pH, temperature and CO<sub>2</sub> were studied on the spot and other parameters were analyzed in the laboratory by carrying water samples in closed bottles. Sampling was done at 8.00-11.0 a.m. in the last week of each month. Monthly data of different parameters were pooled into seasonal data (summer from March to June, rainy from July to October and winter from November to February). Infected fishes from the study site were also collected. Standard deviation and correlation coefficient were calculated by using Microsoft excel statistical function of computer software. The correlation coefficient between different variables was calculated and their significance difference was tested using SPSS.

## Results and Discussion

### Air temperature

The minimum air temperature was  $20\pm 0.132^{\circ}\text{C}$  in December and maximum  $33\pm 0.325^{\circ}\text{C}$  in April during the first year study period (Tab. 1). Similar pattern of air temperature was observed in the second year study period also. The maximum air temperature was  $32.5\pm 0.497^{\circ}\text{C}$  in March and minimum  $19\pm 0.452^{\circ}\text{C}$  in January during the second year study period (Tab. 2). The air temperature had positive and significant correlation with water temperature ( $r = 0.935$ ,  $P < 0.01$ ), and biological oxygen demand ( $r = -0.579$ ,  $P < 0.05$ ) and ammonia ( $r = 0.671$ ,  $p < 0.05$ ) but inverse and significant correlation with pH ( $r = -0.614$ ,  $P < 0.05$ ), nitrate ( $r = -0.615$ ,  $p < 0.05$ ) and free carbon dioxide ( $r = -0.763$ ,  $P < 0.01$ ).

**Table 1.** Monthly variation in the physico-chemical parameters of water of Baidya fish farm (Nov., 2008 - Oct., 2009).

Parameters	Months											
	Nov	Dec	Jan	Feb	March	April	May	June	July	Aug	Sept	Octob
Air temp. $^{\circ}\text{C}$	25.07 $\pm 0.095$	20.01 $\pm 0.132$	22.17 $\pm 0.275$	25.07 $\pm 0.095$	29.95 $\pm 0.310$	33.02 $\pm 0.325$	31.2 $\pm 0.081$	29.05 $\pm 0.129$	26.07 $\pm 0.170$	29.5 $\pm 0.081$	30.5 $\pm 0.170$	28.17 $\pm 0.150$
Water temp. $^{\circ}\text{C}$	21.12 $\pm 0.095$	17.05 $\pm 0.550$	18.2 $\pm 0.216$	22.15 $\pm 0.173$	24.35 $\pm 0.506$	29 $\pm 0.216$	28.52 $\pm 0.170$	28.17 $\pm 0.150$	25.07 $\pm 0.170$	28.17 $\pm 0.150$	29.0 $\pm 0.320$	26.07 $\pm 0.170$
pH	7.62 $\pm 0.05$	8.17 $\pm 0.150$	8.12 $\pm 0.120$	8.3 $\pm 0.170$	8.2 $\pm 0.170$	6.22 $\pm 0.309$	6.5 $\pm 0.081$	7.32 $\pm 0.095$	6.37 $\pm 0.309$	6.72 $\pm 0.095$	7.25 $\pm 0.129$	7.82 $\pm 0.098$
Turbidity (NTU)	73.07 $\pm 0.095$	73.17 $\pm 0.150$	99.32 $\pm 0.05$	85.65 $\pm 0.238$	77.81 $\pm 0.022$	330.80 $\pm 0.171$	46.35 $\pm 0.051$	46.79 $\pm 0.012$	45.18 $\pm 0.033$	88.04 $\pm 0.133$	49.28 $\pm 0.014$	111.35 $\pm 0.506$
TDS mg/l	238.2 $\pm 0.081$	236.87 $\pm 0.478$	235.12 $\pm 0.853$	309.12 $\pm 0.478$	317.07 $\pm 0.095$	390.12 $\pm 0.853$	103.2 $\pm 0.081$	195.5 $\pm 0.411$	132.2 $\pm 0.081$	146.3 $\pm 0.571$	169.15 $\pm 0.265$	193.15 $\pm 0.265$
CO <sub>2</sub> mg/l	20.68 $\pm 0.090$	37.45 $\pm 0.057$	79.65 $\pm 0.114$	101.84 $\pm 0.028$	120.25 $\pm 0.645$	79.11 $\pm 0.095$	70.90 $\pm 0.294$	174.15 $\pm 0.326$	147.31 $\pm 0.358$	48.05 $\pm 0.129$	55.49 $\pm 0.082$	18.48 $\pm 0.287$
DO mg/l	4.80 $\pm 0.335$	5.88 $\pm 0.078$	6.27 $\pm 0.170$	7.28 $\pm 0.022$	7.16 $\pm 0.035$	7.83 $\pm 0.297$	7.04 $\pm 0.009$	7.47 $\pm 0.032$	7.04 $\pm 0.009$	5.52 $\pm 0.083$	6.25 $\pm 0.127$	6.52 $\pm 0.090$
BOD mg/l	1.94 $\pm 0.046$	1.02 $\pm 0.028$	2.32 $\pm 0.095$	0.35 $\pm 0.33$	0.67 $\pm 0.049$	1.17 $\pm 0.017$	1.18 $\pm 0.012$	0.62 $\pm 0.051$	0.79 $\pm 0.012$	2.98 $\pm 0.310$	3.54 $\pm 0.038$	3.06 $\pm 0.033$
Chloride mg/l	5.12 $\pm 0.095$	2.13 $\pm 0.216$	29.84 $\pm 0.260$	25.56 $\pm 0.079$	22.72 $\pm 0.137$	23.14 $\pm 0.026$	21.3 $\pm 0.045$	25.56 $\pm 0.017$	25.56 $\pm 0.017$	12.15 $\pm 0.129$	4.10 $\pm 0.083$	6.13 $\pm 0.124$
Total alkal. mg/l	137.25 $\pm 0.208$	97.76 $\pm 0.721$	133.12 $\pm 0.095$	156.0 $\pm 1.173$	187.2 $\pm 1.676$	198.2 $\pm 0.559$	208 $\pm 0.452$	166.25 $\pm 8.957$	158.18 $\pm 0.843$	110.75 $\pm 0.208$	101.22 $\pm 0.543$	128.52 $\pm 0.368$
Total hard. mg/l	118.37 $\pm 1.25$	122.4 $\pm 0.573$	105.2 $\pm 0.08$	107.6 $\pm 0.660$	144.6 $\pm 0.463$	123.6 $\pm 0.657$	118.3 $\pm 1.25$	90.2 $\pm 0.095$	90.8 $\pm 0.028$	82.19 $\pm 0.679$	101.52 $\pm 0.164$	106.08 $\pm 0.121$
Ammonia mg/l	3.42 $\pm 0.057$	1.7 $\pm 0.690$	10.77 $\pm 0.169$	7.42 $\pm 0.082$	11.05 $\pm 0.540$	6.69 $\pm 0.038$	6.69 $\pm 0.038$	10.48 $\pm 0.169$	2.23 $\pm 0.248$	6.16 $\pm 0.036$	6.46 $\pm 0.058$	9.69 $\pm 0.690$
Nitrate mg/l	<0.05 $\pm 0.0006$	<0.61 $\pm 0.052$	<0.001 $\pm 0.006$	<0.001 $\pm 0.0005$	<0.001 $\pm 0.0005$	0.001 $\pm 0.0005$	0.001 $\pm 0.0005$	0.001 $\pm 0.0005$	0.02 $\pm 0.008$	0.05 $\pm 0.0006$	0.001 $\pm 0.0005$	0.001 $\pm 0.0005$
Phosphate mg/l	0.28 $\pm 0.093$	0.22 $\pm 0.083$	0.117 $\pm 0.017$	0.45 $\pm 0.0005$	0.63 $\pm 0.235$	0.38 $\pm 0.175$	0.64 $\pm 0.114$	0.84 $\pm 0.045$	0.38 $\pm 0.175$	0.18 $\pm 0.009$	0.38 $\pm 0.175$	0.042 $\pm 0.026$

### Water temperature

The lowest surface water temperature was  $17.0\pm 0.550^{\circ}\text{C}$  in December and highest  $29\pm 0.320^{\circ}\text{C}$  in September during the first year (Tab. 1) and the minimum temperature was  $17.0\pm 0.452^{\circ}\text{C}$  in January and the highest  $31\pm 0.327^{\circ}\text{C}$  in September during second year

study period (Tab. 2). The water temperature had positive and significant correlation with air temperature ( $r = 0.935$ ,  $P < 0.01$ ) and phosphate ( $r = 0.610$ ,  $P < 0.01$ ), but inverse and significant correlation with  $\text{CO}_2$  ( $r = -0.755$ ,  $P < 0.01$ ), pH ( $r = -0.725$ ,  $P < 0.01$ ), dissolved oxygen ( $r = -0.710$ ,  $P < 0.01$ ) and total hardness ( $r = -0.909$ ,  $P < 0.01$ ).

**Table 2.** Monthly variation in the physico-chemical parameters of water of Baidya fish farm (Nov., 2009 - Oct., 2010).

Parameters	Months											
	Nov	Dec	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct
Air temp.	24.5 $\pm 0.415$	21.5 $\pm 0.416$	19.2 $\pm 0.452$	25.1 $\pm 0.81$	32.5 $\pm 0.497$	31.3 $\pm 0.359$	29.4 $\pm 0.359$	29.1 $\pm 0.374$	28.2 $\pm 0.432$	31.3 $\pm 0.359$	29.2 $\pm 0.432$	31.1 $\pm 0.371$
Water temp.	25.5 $\pm 0.535$	19.1 $\pm 0.273$	17.3 $\pm 0.526$	22.2 $\pm 0.216$	28.5 $\pm 0.415$	29.5 $\pm 0.082$	28.5 $\pm 0.415$	29.5 $\pm 0.082$	30.2 $\pm 0.216$	30.3 $\pm 0.051$	31.4 $\pm 0.327$	29.2 $\pm 0.216$
pH	8.3 $\pm 0.170$	8.9 $\pm 0.097$	8.2 $\pm 0.095$	8.2 $\pm 0.095$	7.8 $\pm 0.221$	8.3 $\pm 0.095$	9.2 $\pm 0.320$	8.8 $\pm 0.096$	8.5 $\pm 0.081$	8.9 $\pm 0.097$	9.1 $\pm 0.150$	8.8 $\pm 0.096$
Turbidity (NTU)	46.34 $\pm 0.506$	76.18 $\pm 0.033$	150.65 $\pm 0.238$	125.32 $\pm 0.05$	58.82 $\pm 0.022$	211.8 $\pm 0.172$	133.79 $\pm 0.312$	103.35 $\pm 0.251$	39.79 $\pm 0.012$	32.34 $\pm 0.506$	28.25 $\pm 0.056$	42.6 $\pm 0.238$
TDS mg/l	121.31 $\pm 0.566$	107.12 $\pm 0.255$	240.12 $\pm 0.478$	323.07 $\pm 0.195$	315.2 $\pm 0.081$	388.5 $\pm 0.411$	113.3 $\pm 0.571$	205.3 $\pm 0.358$	116.2 $\pm 0.263$	102.5 $\pm 0.411$	100.1 $\pm 0.853$	107.2 $\pm 0.081$
$\text{CO}_2$ mg/l	2.98 $\pm 0.235$	5.02 $\pm 0.134$	71.28 $\pm 0.326$	47.52 $\pm 0.082$	5.1 $\pm 0.095$	2.24 $\pm 0.0645$	2.24 $\pm 0.645$	2.29 $\pm 0.231$	4.05 $\pm 0.258$	8.8 $\pm 0.207$	4.58 $\pm 0.257$	2.24 $\pm 0.225$
DO mg/l	10.17 $\pm 0.221$	8.83 $\pm 0.521$	7.34 $\pm 0.231$	6.67 $\pm 0.452$	6.71 $\pm 145$	2.7 $\pm 0.248$	8.64 $\pm 0.215$	6.67 $\pm 0.046$	6.69 $\pm 0.118$	6.61 $\pm 0.340$	9.31 $\pm 0.561$	10.73 $\pm 0.258$
BOD mg/l	9.28 $\pm 0.063$	5.39 $\pm 0.165$	7.34 $\pm 0.355$	6.67 $\pm 0.065$	1.37 $\pm 0.034$	1.75 $\pm 0.062$	1.75 $\pm 0.055$	3.81 $\pm 0.311$	5.51 $\pm 0.067$	0.27 $\pm 0.032$	7.77 $\pm 0.048$	3.83 $\pm 0.117$
Chloride mg/l	2 $\pm 0.124$	2 $\pm 0.091$	9 $\pm 0.075$	6 $\pm 0.134$	5 $\pm 0.077$	1 $\pm 0.260$	1 $\pm 0.241$	10 $\pm 0.261$	5 $\pm 0.087$	4 $\pm 0.135$	2 $\pm 0.155$	7 $\pm 0.240$
Tot. alkal. mg/l	109.89 $\pm 0.891$	104 $\pm 0.865$	150 $\pm 1.02$	243.6 $\pm 0.521$	162.5 $\pm 0.756$	154 $\pm 0.884$	154 $\pm 1.062$	121.9 $\pm 0.645$	92 $\pm 0.766$	101.2 $\pm 0.443$	99 $\pm 0.355$	83.6 $\pm 0.325$
Tot. hardn. mg/l	91.02 $\pm 1.035$	49.5 $\pm 0.463$	130.56 $\pm 0.647$	130.68 $\pm 0.751$	132.66 $\pm 0.463$	126.72 $\pm 0.458$	126.72 $\pm 0.095$	81.18 $\pm 0.844$	75.24 $\pm 0.363$	77.22 $\pm 0.537$	79.2 $\pm 0.237$	73.26 $\pm 0.572$
Ammonia mg/l	10.2 $\pm 0.079$	1.55 $\pm 0.088$	8.4 $\pm 0.355$	5.77 $\pm 0.644$	11.9 $\pm 0.092$	15.3 $\pm 0.076$	15.3 $\pm 0.236$	8.5 $\pm 0.078$	8.5 $\pm 0.097$	18.7 $\pm 0.061$	6.8 $\pm 0.086$	13.6 $\pm 0.340$
Nitrate mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Phosphate mg/l	0.17 $\pm 0.004$	0.02 $\pm 0.083$	0.45 $\pm 0.017$	0.63 $\pm 0.0005$	0.46 $\pm 0.235$	0.38 $\pm 0.175$	0.38 $\pm 0.114$	0.84 $\pm 0.045$	0.64 $\pm 0.175$	1.15 $\pm 0.009$	0.39 $\pm 0.175$	0.21 $\pm 0.026$

### pH

The pH of water was minimum i.e.,  $6.3 \pm 0.309$  in April/July and  $7.8 \pm 0.221$  in March and maximum i.e.,  $8.3 \pm 0.12$  in February and  $9.2 \pm 0.32$  in May (Tabs. 1, 2). pH had positive and significant correlation with DO ( $r = 0.594$ ,  $P < 0.05$ ) and total alkalinity ( $r = 0.993$ ,  $P < 0.01$ ), free  $\text{CO}_2$  ( $r = 0.594$ ,  $P < 0.05$ ) and BOD ( $r = 0.857$ ,  $P < 0.01$ ) but inverse and significant correlation with nitrate ( $r = -0.675$ ,  $p < 0.05$ ).

### Dissolved oxygen

The dissolved oxygen was maximum ( $7.83 \pm 0.297$  mg/l) at the end of April and minimum ( $4.82 \pm 0.335$  mg/l) in November during the first year (Tab. 1). In the second year, the maximum DO ( $10.73 \pm 0.258$  mg/l) occurred in November and minimum ( $2.7 \pm 0.248$  mg/l)

in June (Tab. 2). The DO showed positive and significant correlation with total alkalinity ( $r=0.715$ ,  $P<0.05$ ), Phosphate ( $r = 0.577$ ,  $P<0.05$ ) and total hardness ( $r = 0.915$ ,  $P<0.05$ ) but inverse and significant correlation with free  $\text{CO}_2$  ( $r = -0.839$ ,  $P<0.01$ ), BOD ( $r = -0.398$ ,  $P<0.05$ ), temperature of air ( $r = -0.608$ ,  $p<0.05$ ), temperature of water ( $r = -0.710$ ,  $P<0.01$ ).

#### *Free carbon dioxide*

The free carbon dioxide decreased from June to October then increased during the first year and the second year study periods. The maximum free  $\text{CO}_2$  was  $174.15 \pm 0.326$  mg/l in June and minimum  $18.48 \pm 0.287$  mg/l in April during the first year (Tab. 1). In the second year, maximum  $\text{CO}_2$  ( $71.28 \pm 0.326$  mg/l) was recorded in January. Free carbon dioxide showed positive and significant correlation with BOD ( $r = 0.839$ ,  $P<0.01$ ) and turbidity ( $r = 0.760$ ,  $P<0.01$ ) but inverse and significant correlation with chloride ( $r = -0.596$ ,  $P<0.05$ ) and total alkalinity ( $r = -0.971$ ,  $P<0.05$ ).

#### *Total alkalinity*

The maximum total alkalinity was  $208 \pm 0.45$  mg/l in April and minimum  $97.76 \pm 0.721$  mg/l in December during the first year study period (Tab. 1). It had positive and significant correlation with turbidity ( $r = 0.598$ ,  $P<0.05$ ), total hardness ( $r = 0.915$ ,  $P<0.05$ ) and chloride ( $r = 0.578$ ,  $P<0.05$ ) but inverse and significant correlation with biological oxygen demand ( $r = -0.705$ ,  $P<0.05$ ).

#### *Total hardness*

The maximum total hardness was  $144.02 \pm 0.463$  mg/l in March and minimum  $82.08 \pm 0.679$  mg/l in August during the first year (Tab. 1). It had positive and significant correlation with TDS ( $r = 0.635$ ,  $P<0.05$ ), turbidity ( $r = 0.650$ ,  $P<0.05$ ) and total alkalinity ( $r = 0.915$ ,  $P<0.05$ ) and inverse and significant correlation with air temperature ( $r = -0.671$ ,  $P<0.05$ ), water temperature ( $r = -0.909$ ,  $P<0.01$ ) and phosphate ( $r = -0.608$ ,  $P<0.05$ ).

#### *Chloride*

The maximum chloride was  $29.82 \pm 0.260$  mg/l in January and minimum  $2 \pm 0.216$  mg/l in December during the first (Tab. 1) and maximum  $10 \pm 0.261$  mg/l in June and minimum  $1 \pm 0.260$  mg/l in April/May of second year study period (Tab. 2). It had positive and significant correlation with carbon dioxide ( $r = 0.647$ ,  $P<0.05$ ) and total alkalinity ( $r = 0.578$ ,  $P<0.05$ ) and inverse and significant correlation with BOD ( $r = -0.640$ ,  $P<0.05$ ).

#### *Biological oxygen demand*

The biological oxygen demand decreased from July to January and increased from February to May. The maximum biological oxygen demand was  $3.52 \pm 0.062$  mg/l in September and minimum  $0.32 \pm 0.042$  mg/l in February during the first (Tab. 1) and maximum  $9.28 \pm 0.063$  mg/l in November and minimum  $0.27 \pm 0.032$  mg/l in August in the second year study period (Tab. 2). It had positive and significant correlation with turbidity ( $r = 0.663$ ,  $P<0.05$ ), pH ( $r = 0.988$ ,  $P<0.01$ ) but inverse and significant correlation with  $\text{CO}_2$  ( $r = -0.654$ ,  $P<0.05$ ), phosphate ( $r = -0.630$ ,  $P<0.05$ ), dissolved oxygen ( $r = -0.579$ ,  $P<0.05$ ) and total alkalinity ( $r = -0.621$ ,  $P<0.05$ ).

Various physicochemical factors such as water temperature, alkalinity, ammonia, free  $\text{CO}_2$ , DO, pH and total hardness have strong influence on fish health and their resistance against the disease causing agents (Shrestha, 1994). Poor condition of physicochemical properties of

water is O<sub>2</sub> depletion, excess ammonia, excess CO<sub>2</sub> in water and temperature change. Hossain *et al.* (2007) have reported that changes in water quality parameters result in stress in the fishes, making them more susceptible to parasitic attacks and diseases.

The air temperature of the study site was higher in summer than in rainy season in the first and second year study period and the lowest temperature was recorded in winter in the second year. The water temperature of Baidya fish farm was higher in summer in first year and in rainy seasons in the second year (Tab. 3). Generally water temperature is influenced by air temperature and intensity of solar radiations. Rawat *et al.* (1995) have obtained strong positive significant correlation between air and water temperature. Bose and Gorai (1993) reported negative correlation between water temperature and dissolved oxygen.

**Table 3.** Seasonal variation in the physico-chemical parameters of water of Baidya fish farm (Nov., 2008-Oct., 2010)

Parameters	Year I			Year II		
	Winter	Summer	Rainy	Winter	Summer	Rainy
Air temperature °C	23.00 ±2.449	30.75 ±1.707	28.50 ±1.957	22.35 ±2.688	30.37 ±1.701	29.75 ±1.5
Water temperature °C	19.50 ±2.380	27.37 ±2.286	27.00 ±1.825	20.75 ±3.50	29.00 ±0.577	30.00 ±0.816
pH	8.07 ±0.330	7.07 ±0.865	7.0 ±0.648	8.4 ±0.336	8.52 ±0.607	8.82 ±0.02
TDS mg/l	254.75 ±36.188	251.25 ±127.432	160 ±26.770	197.75 ±102.63	255.25 ±121.041	106.25 ±7.135
CO <sub>2</sub> mg/l	59.89 ±37.387	111.15 ±47.427	67.32 ±55.666	31.45 ±33.722	2.97 ±1.420	4.91 ±2.775
DO mg/l	6.04 ±1.012	7.36 ±0.537	6.32 ±0.635	8.25 ±1.564	6.18 ±2.495	8.33 ±2.030
BOD mg/l	1.40 ±0.900	0.91 ±0.306	2.58 ±1.217	6.87 ±1.686	1.655 ±0.19	4.34 ±3.160
Chloride mg/l	15.59 ±14.127	23.18 ±1.771	11.89 ±9.726	4.75 ±3.403	4.25 ±4.272	4.5 ±2.081
Total alkalinity mg/l	131.02 ±24.309	189.95 ±18.090	124.42 ±25.117	151.87 ±64.476	148.1 ±17.920	93.95 ±17.937
Total hardness mg/l	113.39 ±8.298	119.05 ±22.498	95.12 ±10.797	100.44 ±38.752	128.5 ±3	76.23 ±2.556
Ammonia mg/l	5.82 ±4.074	8.80 ±2.465	6.07 ±3.140	6.48 ±3.756	12.75 ±3.255	11.9 ±5.375
Nitrate mg/l	0.16 ±0.297	0.001 ±0.000	0.018 ±0.023	0.001 ±0	0.001 ±0	0.001 ±0
Phosphate mg/l	0.26 ±0.145	0.62 ±0.188	0.24 ±0.170	0.31 ±0.274	0.515 ±0.219	0.59 ±0.408

The highest pH was recorded in winter in the first year but the lowest in rainy season. It was due to lowering of water temperature and lack of liming on time. In second year, pH was higher in rainy and lower in winter season. Several workers have reported low pH during the low photosynthesis due to the formation of carbonic acid (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<sub>2</sub> was higher in summer in first year and in rainy in the second year which may be due to high temperature, high rate of decomposition of organic matter, low volume of water etc. Michael (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 and Lal (1995) also found minimum carbon dioxide in winter season.

DO was higher in summer in the first year and in rainy in the second year. Generally, the maximum DO found in winter season may be due to low temperature. Minimum DO was found in summer due to high temperature and higher microbial demand for oxygen in decomposition of organic matter (Bhowmic & Singh, 1985). But McColl (1972) reported that the relationship between water temperature and DO is not so significant because production and consumption of oxygen takes place simultaneously.

BOD of the present study site was higher in rainy season during first year and lowest in winter in the second year. The maximum value of BOD in summer may be due to high concentration of organic matter and minimum BOD in winter may be due to low temperature and retarded microbial activities for the decomposition of organic matters. Similar observations were made by Singh and Singh (1995).

Total hardness was higher in summer. It was due to low volume and slow current of water. Similar results were obtained by Mishra *et al.* (1998). Minimum quantity in rainy season may be due to more dilution of water (Patralekha, 1994).

Total alkalinity of the site was higher in summer in the first year but higher in winter in the second year (Tab. 3). Singh (1990) and Mishra *et al.* (1998) also reported maximum pH in winter.

Ammonia was recorded higher in summer in first and second year. Ammonia content of pond water is directly affected by pH. With increase in pH values, the fraction of undissociated ammonia increases and the fraction of dissociated ammonium ions decrease. However, nitrifying bacteria could take up the ammonia even at low concentration (Yoshifomi *et al.*, 2008).

Phosphate was recorded higher in summer during first year and in rainy season in the second year. Phosphate increases the productivity of ponds.

Chloride content was recorded maximum in summer in the first year and in winter in the second year. Chloride content indicates the presence of organic wastes of animal origin (Thresh *et al.*, 1949). Swarup and Singh (1979) also reported an increase in chloride during summer and decrease in rainy seasons mainly due to dilution of water by rain water. On the basis of present study, the water quality of fish pond was normal except manuring period and casual addition of wastes like toilet cleaners, caustic potash etc.

Outbreak of epizootic ulcerative syndrome (EUS) were observed at periphery of Baidya fish farm due to sudden fall in temperature (more than 5<sup>0</sup>C) during winter when polluted cold water from Koshi canal was added. The affected fishes developed several lesions around the body and fins. Due to sudden fall in DO less than 4mg/l during April and May; mass

mortality of fishes *Labeo rohita*, *Cirrhina mrigala*, *Hypothalamichthys molitrix*, *Aristichthys nobilis* occurred whereas when chicken droppings was added in pond ammonia concentration raised up to 18.7 mg/l which led to mass mortality of fish (*Pangasius*) during August.

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