Study on physico-chemical features of water in Tarahara Fish Farm, Sunsari, Nepal

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Abstract

Tarahara Fish Farm includes 37 large ponds as a fish super zone. Physico-chemical parameters *viz.*, air and water temperature, pH, DO, BOD, CO_2, Cl^-, TA and TH of these ponds were studied for two years (Nov. 2008 to Oct. 2010). The air temperature had positive and significant correlation with water temperature (r=0.893, P<0.01) but inverse and significant correlation with DO (r = - 0.669 P<0.05) and TH (r = - 0.673, P<0.05). Both air and water temperature showed a decreasing trend during the winter months of November to January and again September to October in both years. Similarly, positive and significant correlation showed by pH with DO (r =0.660, P<0.05) and BOD (r =0.846, P<0.05); by free CO_2 with DO (r=0.854, P<0.01), chloride (r=0.648, P<0.05) and TA (r=0.616, P<0.05); by DO with TA (r =0.715, P<0.01) and chloride (r =0.625, P<0.05) and by TH with TA (r= 0.592, P<0.05) but inverse and significant correlation showed by pH with water temperature (r =-0.671, P<0.05); by free CO_2 with BOD (r=-0.627, P<0.05) and by DO with BOD (r = -0.810, P <0.01). The water quality parameters were within suitable range for the fish growth and breeding with small fluctuations in different months during the first and second years. Physico-chemical parameters significantly (P<0.01; 0.05) differed between different months. However, no mass mortality of fish was recorded from this site. So, the area selected as fish super zone is fruitful to meet the expected production level of fishes and fish seeds in peripheral areas.

***Key words*:** Fish seed, Fish super zone, Water parameters

Introduction

Tarahara Fish Farm, Sunsari is a government farm (now included in fish super zone) established in 1971 to promote the fish farming and producing fish seeds to supply private sectors along with live stocks, poultry farming and horticulture occupies about 111 ha area. Later on it was developed as regional research center under the NARC in 1994. It contains around 37 ponds covering water surface areas about 10 ha out of total fish farm areas (18 ha). Expected annual average production of food fish was about 2 ton/year but about 4 ton/year has produced in 2016-17. Besides this fish seed of *Labeo rohita, Cirrhinus mrigala, Catla catla, Cyprinus carpio, Pangas* sp. and *Puntius* sp. hatchlings: 50 lakhs/yr; fries 20 lakhs/yr and fingerlings: 2 lakhs/yr were produced according to fish scientists in Tarahara (Tara = Terai + Hara = Hariyali).

The physico-chemical parameters mainly air and water temperature, transparency, pH, DO, BOD, free CO_2, chloride, TA and TH of water bodies influence the aquatic organisms in

various ways directly or indirectly which determine the hydrological condition of water body and any alteration of it influences the outbreak of diseases and production level of fishes. In fish farming, fish disease is one of the major constraints for the adequate production. Fish disease is a global problem affecting fresh water and marine fish, wild, cultured, sport fish and even ornamental fish with large scale mortalities (Trust, 1986). The present production level is still much below the potentiality of existing water resources. Nepal government has given priority to aquaculture development by establishing the fish super zones for high production to fulfill the protein demand of the country. The use of artificial feed, fertilizer in the semi-intensive and intensive culture to increase production may adversely alter the physico-chemical properties of water and other environmental conditions that generate the diseases outbreak.

However, McEachern (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) studied water quality and diversity of diatoms in Punyamati river. Sharma (1996) reported quite suitable physico-chemical characteristics of the Koshi River. Shrestha *et al.* (2009) reported that the water quality parameters of Tamor River. Niroula *et al.* (2010) revealed more seasonal fluctuations in turbidity, carbon dioxide and chloride content were observed in Betana pond, Eastern Nepal. Thapa Chhetry and Pal (2011) studied the physico-chemical parameters of Koshi river. Bhatt and Khanal (2011) reported that the increase in pH of water appeared to be associated with increasing use of alkaline detergents in residential areas. Thapa and Pal (2012) found maximum and minimum variation and correlation between different physico-chemical parameters in Baidya Fish Farm and Itahari fish ponds. Thapa and Pal (2014) mentioned the physico-chemical parameters of Singhia and Budhi Rivers. Extensive work in physico-chemical characters of water has not been done yet in Tarahara, so the study will provide information about the quality of pond waters whether fit or not for successful fish/seed productions.

Materials and Methods

Tarahara Fish Farm is located at latitude 26°42'05.77"N and Longitude 87°16'38.50"E in Sunsari district (Fig. 1).

Figure 1. Tarahara Fish Farm, Sunsari.

Water collection was done in between 8.00-11.00 A.M. in air tights bottles. Temperature was estimated on the site by glass thermometer. The pH of water was estimated on the site by Hanna's pocket pH meter. All other physico-chemical analysis of water like dissolved oxygen (DO), biological oxygen demand (BOD), free carbon dioxide (free CO_2) in site ,chloride ions (Cl⁻), total alkalinity (TA) and total hardness (TH) were determined for two years (Nov. 2008 to Oct. 2010) following standard methods (Trivedy & Goel, 1986; APHA, AWWA & WEF, 2012).

Standard deviation, correlation coefficient were calculated by using Microsoft excel statistical function of computer software. The significance of correlation coefficient was tested by applying t-test by using SPSS-V20 computer software.

Results and Discussion

Results of the air temperature and physico-chemical parameters of water of Tarahara Fish Farm are shown in Table 1 and 2. Table 1 shows the result of air temperature and physico-chemical parameters of water of the first year (Nov. 2008 to Oct. 2009) study period. Table 2 shows the results of air temperature and physico-chemical parameters of water of the second year (Nov. 2009 to Oct. 2010) study period. Table 3 shows the correlation coefficient (r) of air temperature and different physico-chemical parameters of water. The figs. 2, 3 and 4 show histograms of the monthly variations of different physico-chemical parameters of water at in the first year (Nov. 2008 to Oct. 2009) and the second year (Nov. 2009 to Oct. 2010) study periods.

Air temperature

The minimum air temperature was 19.75 ± 0.645°C in the month of December and maximum was 31.62 ± 0.478°C in April during the first year study period (Table 1). The minimum air temperature was 17.52 ± 0.445°C in the December and maximum was 30.5 ± 0.386°C in September during the second year study period (Table 2).

The temperature showed a declining trend during the winter months of November to January in both the first and second year. Decreasing trend was also observed during the months of September to October in both years (Tables 1, 2). The air temperature had positive and significant correlation with water temperature (r=0.893, P<0.01) but inverse and significant correlation with DO (r = - 0.669 P<0.05) and TH (r = - 0.673, P<0.05) (Table 3). The highest air temperature was recorded in the month of April in first year and in September in the second year. It was mainly due to geographical positions and weather conditions. Chakraborty *et al*. (1959) and Rawat *et al*. (1995) also obtained strong positive significant correlation between air and water temperatures.

Water temperature

The lowest surface water temperature was 15.3±0.489°C in the month of December and highest 29.12±0.275°C in the month of April during the first year study period (Table 1). The maximum water temperature was 30.25±0.347°C in the month of September and the minimum 17.31 ± 0.459°C in the month of December during the second year study period. The temperature showed a decreasing trend during the winter months of November to January in both the years. Decreasing trend was also observed during the months of September to October in both years (Tables 1, 2; Fig. 2). The water temperature had

positive and significant correlation with air temperature (r = 0.893, P<0.01) but inverse and significant correlation with DO (r = -0.704, P<0.05) and TH (r= -0.909, P<0.01) (Table 3).

Highest value was recorded in summer might be due to high air temperature and greater light penetration. A little lower water temperature was recorded at rainy season in comparison to that during summer. It might be due to high turbidity, high volume of water and greater velocity of water in rainy season. Bose and Gorai (1993) reported negative significant correlation between water temperature and dissolved oxygen.

pH

The minimum pH was 6.67±0.125 in the month of April and maximum 8.62±0.095 in January, during the first year study period (Table 1). The minimum pH was 7.08±0.058 in October and maximum 10.02±0.276 was in February during the second year study period (Table 2). pH had positive and significant correlation with DO (r =0.660, P<0.05), BOD (r =0.846, P<0.05) but inverse and significant correlation with temperature of air (r = -0.523, P<0.10) and temperature of water (r =-0.671, P<0.05) (Table 3). Hutchinson *et al*. (1992) have shown that the higher pH is associated with the phytoplankton maxima. The minimum pH recorded in summer may be due to low photosynthesis. Several workers have reported low pH during the low photosynthesis due to the formation of carbonic acid (Bais *et al*., 1995). But, Gautam (1990) reported highest pH in summer and lowest in rainy season. The pH showed positive and significant correlation with dissolved oxygen at the site. Rawat *et al*. (1995) reported positive correlation with TA (r = 0.523, P< 0.05) and inverse correlation with water temperature.

Free carbon dioxide

The maximum free CO_2 was 135.6 ± 1.356 mg/L in the month of June and minimum was 16.75 ± 0.952 mg/L in the month of September during the first year (Table 1). During the second year, the maximum free CO_2 was 114.58 ± 1.356 mg/L in the month of June and minimum was 12.24 ± 0.584 mg/L in May (Table 1). Free CO_2 showed positive and significant correlation with DO (r=0.854, P<0.01), chloride (r=0.648, P<0.05) and TA (r=0.616, P<0.05) but had an inverse and significant with BOD (r=-0.627, P<0.05) (Table 3). In this study the minimum free CO_2 was found in winter season. Pahwa and Mehrotra (1966) observed inverse correlation of free CO_2 with DO. Gautam (1990) and Pandey and Lal (1995) also found minimum free carbon dioxide in winter season.

Dissolved oxygen

The maximum dissolved oxygen was 8.92 ± 0.221 mg/L in the month of January and the minimum was 4.86±0.079 mg/L in the month of August during the first year study period (Table 1). In the second year, the maximum dissolved oxygen was 10.16 ± 0.215 mg/L in February and minimum 2.94±0.305 mg/L was recorded in September (Table 2). The DO showed positive and significant correlation with TA (r =0.715, P<0.01), CO_2 (r =0.854, P<0.01), chloride (r =0.625, P<0.05) and pH (r = 0.660, P<0.05) but inverse and significant correlation with air temperature (r = - 0.669, P<0.05), water temperature (r = - 0.704, P<0.05) and BOD (r = -0.810, P <0.01) (Table 3). The maximum dissolved oxygen found in winter season may be due to low temperature. Similar observations were found by Moitra and Bhattacharya (1965). The minimum dissolved oxygen was found in summer due to high temperature, and higher microbial demand for oxygen in decomposition of

suspended organic matter (Bhowmick & Singh, 1985; Palharya & Malviya, 1988). Elmore and West (1961) stated that an increase in temperature of water resulted in the decrease of dissolved oxygen content of water. Bose and Gorai (1993) also reported inverse and significant correlation of dissolved oxygen with water temperature. Jindal and Kumar (1993) reported inverse correlation of dissolved oxygen with water temperature.

Biological oxygen demand

The maximum biological oxygen demand was 5.31±0.082 mg/L in January and minimum was 0.47±0.145 mg/L in May during the first year study period (Table 1). During the second year, the maximum biological oxygen demand was 7.14±0.263 mg/L in December and minimum was 0.45±0.075 mg/L in November (Table 2). It had positive and significant correlation with pH (r =0.846, P<0.01) but inverse and significant correlation with dissolved oxygen (r = -0.810, P<0.01) (Table 3). Similar observations were also made by Singh (1995). Barat and Jha (2002) also reported inverse correlation of BOD with dissolved oxygen. BOD showed positive and significant correlation with air temperature, water temperature and free CO_2 were inverse and significant correlation with pH and DO.

Chloride

The maximum chloride was 12.98 ± 0.416 mg/L in January and minimum was 5.2 ± 0.288 mg/L in October during the first year study period (Table 1). During the second year, the maximum chloride was 9.02 ± 0.525 mg/L in the month of June and minimum was 1.06 ± 0.035 mg/L in April (Table 2). It had a positive and significant correlation with DO (r = 0.625, P<0.05) and free CO_2 (r= 0.648, P<0.05) (Table 3). In this site maximum chloride was recorded in winter season which might be due to more contamination by organic matters. Swarup and Singh (1979) also reported an increase in chloride during summer. Minimum quantity of chloride in rainy season might be due to dilution by rain water.

Total alkalinity

The maximum total alkalinity was 202.50±5.802 mg/L in the month of January and minimum was 103.40 ± 0.469 mg/L in the month of September during the first year study period (Table 1; Fig. 3). During the second year, the maximum total alkalinity was 215.03 ± 1.089 mg/L in the month of March and minimum was 72.74±1.092 mg/L in the month of December (Table 2, Fig. 3). It had positive and significant correlation with DO (r = 0.715, P<0.01), CO_2 (r = 0.616, P<0.05) and TH (r = 0.592, P<0.05) (Table 3). Total alkalinity showed decreasing trend from June to September. The values in the month of June (125.62±0.805 mg/L) was significantly decreased (P<0.01) as compared to May (167.12±0.689 mg/L) in the first year study (Table 1; Fig. 3). In the second year, decreasing trend was seen from June to October. The value of June (124.22±0.995 mg/L) was significantly decreased (P< 0.01) as compared to May (136.40±1.642 mg/L) (Table 2; Fig. 3). It remained low for five months from June to October in both years. Water bodies having total alkalinity from 40 to 90 mg/L is considered as medium productive and above 90 mg/L as highly productive (Jhingran, 1991). It showed that the study area is suitable for aquatic flora and fauna production. Total alkalinity showed positive and significant correlation with total hardness and chloride at the site. Barat and Jha (2002) also reported positive and significant correlation of total alkalinity with hardness. Chakraborty *et al.* (1959), Singh (1990) and Mishra *et al.* (1998) also reported maximum total alkalinity during winter.

Total hardness

The maximum total hardness was 164.4±1.478 mg/L in January and minimum was 83.6±0.585 mg/L in the month of July during the first year study period (Table 1; Fig. 4). During the second year, the maximum total hardness was recorded 163.26±1.023 mg/L in February and minimum 35.64±1.578 mg/L in the month of January (Table 2; Fig. 4). It had positive and significant correlation with TA (r= 0.592, P<0.05) but inverse and significant correlation with air temperature (r= -0.673, P<0.05) and water temperature (r= -0.909, P<0.01) (Table 3). The hardness showed a decreasing trend from the months of April to August and increased slightly during the months of September and October but the values were less than that of during the month of April. The values in April (101.2±0.776 mg/L) showed significant decrease (p< 0.01) as compared to March (146.14±0.985 mg/L) in the first year (Table 1; Fig. 4). It also showed decreasing trend from March 2010. The values in March (156.420±0.675 mg/L) was significantly lower (P<0.01) as compared to February (163.26±1.023 mg/L) in the second year (Table 2; Fig. 4). It remained low for seven months from April to October in the first year and for eight months from March to October in the second year. Minimum quantity in rainy season may be due to more dilution of water (Patralekh, 1994).The maximum total hardness in winter season might be due to low volume of water and slow current of water. Mishra *et al.* (1999) obtained similar results.

Table 1. Water parameters of Tarahara Farm, from Nov. 2008 to October 2009. (Mean ± S.D., N=5).

Parameters	Months											
	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct
Air Temp. (ºC)	21.25 ±0.645	19.75 ±0.645	20.87 ±1.108	24.75 ±0.645	29.25 ±0.645	31.62 ±0.478	29.12 ±0.629	29.25 ±0.288	25.75 ±0.645	29.37 ±0.478	29.25 ±0.288	27.45 ±0.420
Water Temp. (ºC)	18.75 ±0.228	15.3 ±0.489	18.75 ±0.288	21.5 ±0.408	23.57 ±0.434	29.12 ±0.275	27.07 ±0.25	27.45 ±0.42	27.07 ±0.25	27.12 ±0.275	27.25 ±0.645	25.27 ±0.499
pH	7.9 ±0.089	8.05 ±0.129	8.62 ±0.095	8.12 0.095±	7.325 ±0.095	6.67 ±0.125	8.12 ±0.629	8.2 ±0.081	7.05 ±0.057	7.12 ±0.275	8.2 ±0.216	7.62 ±0.478
Free CO_2 (mg/L)	21.63 ±1.203	55.02 ±1.275	91.05 ±1.078	126.35 ±0.86	135.12 ±0.85	101.96 ±0.416	93.15 ±0.580	135.6 ±1.356	113.35 ±0.85	49.13 ±1.3	16.75 ±0.952	38.16 ±0.623
DO (mg/L)	5.71 ±0.335	5.84 ±0.079	8.92 ±0.221	8.61 ±0.115	7.86 ±0.354	8.1 ±0.127	7.04 ±0.225	7.83 ±0.009	8.90 ±0.553	4.86 ±0.079	5.45 ±0.245	5.75 ±0.365
BOD (mg/L)	2.91 ±0.145	2.30 ±0.067	5.31 ±0.082	3.67 ±0.238	0.65 ±0.253	1.74 ±0.057	0.47 ±0.145	0.54 ±0.235	2.35 ±0.082	2.78 ±0.365	3.5 ±0.325	3.35 ±0.346
Chloride (mg/L)	8.2 ±0.332	5.3 ±0.082	12.98 ±0.416	9.88 ±0.334	11.32 ±0.221	12.06 ±0.132	8.46 ±0.129	12.2 ±0.629	8.41 ±0.145	9.96 ±0.546	6.21 ±0.223	5.2 ±0.288
Total Alkali (mg/L)	147.96 ±1.860	128.72 ±1.112	202.5 ±5.802	194.95 ±1.962	176.82 ±1.189	157.7 ±0.877	167.12 ±0.689	125.62 ±0.805 *	135.85 ±0.585	118.07 ±0.449	103.49 ±0.46	133.02 ±0.694
Total Hardness (mg/L)	138.72 ±2.125	157.08 ±1.325	164.4 ±1.478	148.66 ±1.036	146.14 ±0.985	101.2 ±0.776 *	96.32 ±1.745	91.2 ±1.558	83.6 ±0.998	92.88 ±0.756	108.25 ±0.955	118.23 ±0.779

* Significant differences at 1% level, ** Significant differences at 5% level.

Table 2. Water parameters of Tarahara Fish Farm, Sunsari studied from Nov. 2009 to October 2010. (Mean ± S.D., N=5).

Parameters	Months											
	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct
Air Temp. (ºC)	19.12 ±0.345	17.52 ±0.445	18.37 ±.608	21.35 ±0.545	28.25 ±0.745	28.02 ±0.478	24.13 ±0.229	25.15 ±0.278	29.5 ±0.635	29.17 ±0.378	30.5 ±0.386	27.85 ±0.620
W Temp. (ºC)	21.26 ±0.325	17.31 ±0.459	17.45 ±0.246	19.20 ±0.218	25.26 ±0.335	27.12 ±0.275	26.57 ±0.251	28.05 ±0.42	28.65 ±0.254	30.12 ±0.235	30.25 ±0.347	25.87 ±0.578
pH	7.33 ±0.185	8.68 ±0.426	7.82 ±0.565	10.02 ±0.276	7.72 ±0.076	7.76 ±0.325	7.51 ±0.427	7.62 ±0.281	8.05 ±0.068	7.81 ±0.078	7.64 ±0.216	7.08 ±0.058
Free CO_2 (mg/L)	19.52 ±1.325	15.12 ±1.205	47.52 ±1.078	16.03 ±0.965	15.12 ±0.853	14.56 ±0.817	12.24 ±0.584	114.5 ±1.356	18.35 ±0.915	16.14 ±1.325	16.75 ±0.652	15.68 ±0.323
DO (mg/L)	4.48 ±0.215	8.48 ±0.067	8.81 ±0.229	10.16 ±0.215	4.64 ±0.308	7.71 ±0.125	3.04 ±0.232	3.31 ±0.058	4.81 ±0.373	4.65 ±0.079	2.94 ±0.305	4.22 ±0.265
BOD (mg/L)	0.45 ±0.075	7.14 ±0.263	3.38 ±0.172	7.01 ±0.241	2.68 ±0.158	5.02 ±0.089	2.04 ±0.165	1.75 ±0.245	2.85 ±0.064	0.82 ±0.325	1.03 ±0.227	0.51 ±0.243
Chloride (mg/L)	2.70 ±0.092	2.58 ±0.184	4.21 ±0.317	4.02 ±0.314	3.12 ±0.322	1.06 ±0.035	4.14 ±0.132	9.02 ±0.525	5.11 ±0.097	4.01 ±0.374	6.10 ±0.152	5.03 ±0.238
Total Alkalin (mg/L)	144.08 ±1.663	72.74 ±1.092	180.25 ±4.532	117.55 ±1.876	215.03 ±1.089	195.57 ±1.877	136.40 ±1.642	124.22 ±0.99*	119.77 ±0.887	101.23 ±0.849	118.75 ±0.559	117.86 ±0.893
Total Hardn (mg/L)	138.72 ±2.125	116.82 ±1.721	35.64 ±1.578	163.26 ±1.023	156.42 ±0.67*	152.32 ±1.445	97.02 ±1.342	102.95 ±0.906	93.06 ±1.097	83.16 ±0.356	93.01 ±0.978	110.85 ±0.719

* Significant differences at 1% level, ** Significant differences at 5% level.

Table 3. Pearson's Correlation Coefficient (r) for water parameters of Tarahara Fish Farm (average of the corresponding month values) from Nov. 2008 to Oct. 2010. (N=12, d.f. =11)

		Water Temp (ºC)	pH	Free CO_2 (mg/L)	DO (mg/L)	BOD (mg/L)	Chloride (mg/L)	Total alkali (mg/L)	Total hard (mg/L)
Air Temp (ºC)	P corr.	.893*	-.523	.241	-.669**	-.373	.308	-.199	-.673**
	Sig(2-t)	.000	.081	.450	.048	.232	.331	.535	.017
Water Temp. (ºC)	P corr.	1	-.571**	.148	-.704**	-.299	.148	-.429	-.909*
	Sig.(2-t)		.051	.647	.011	.346	.647	.165	.000
pH	P corr.		1	-.219	.660**	.846*	-.053	.315	.515
	Sig.(2-t)			.495	.019	.001	.870	.318	.086
Free CO_2 (mg/L)	P corr.			1	.854*	-.627**	.648**	.616**	-.049
	Sig.(2-t)				.000	.051	.023	.039	.880

DO	P corr.		.810[*]	.625[**]	.715[*]	.155
(mg/L)	Sig.(2-t)		.001	.030	.009	.631
BOD	P corr.		1	-.044	.028	.316
(mg/L)	Sig.(2-t)			.892	.930	.317
Chloride	P corr.			-.624[**]	.555	.026
(mg/L)	Sig.(2-t)			.046	.061	.935
Total alkal (mg/L)	P corr.				1	.592[**]
	Sig.(2-t)					.043
Total hard (mg/L)	P corr.					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.
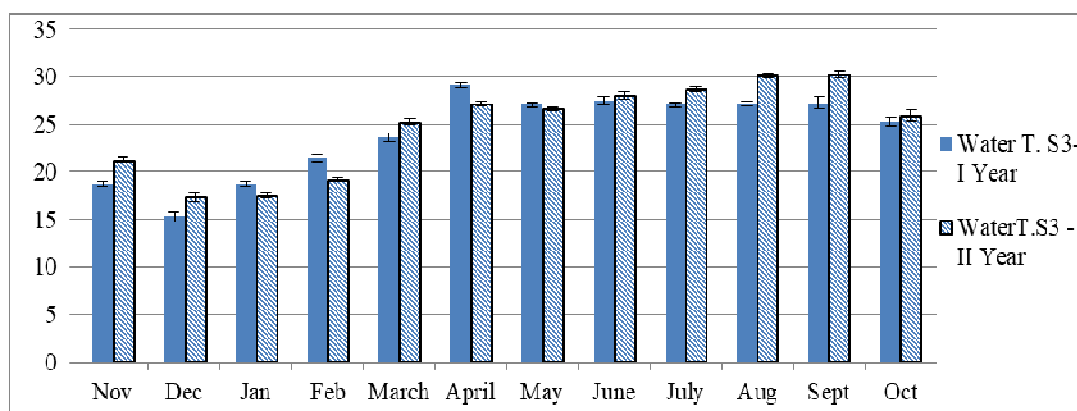

Figure 2. Monthly variations in water temperature at Tarahara Fish Farm during the first and second year study periods (Nov. 2008- Oct. 2010).
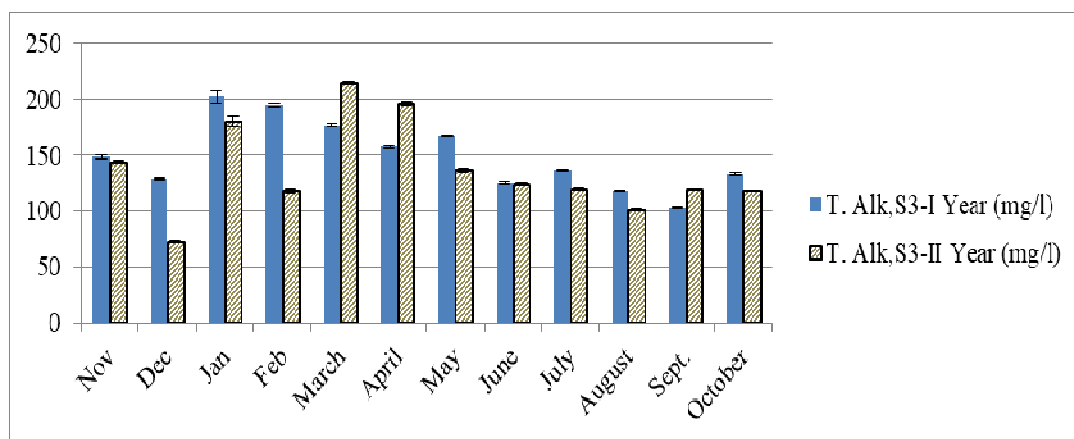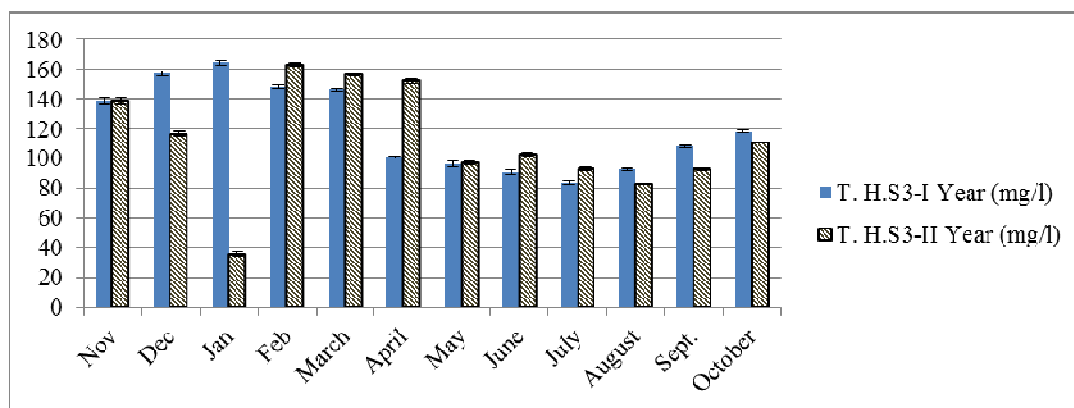

Figure 3. Monthly variations in TA at Tarahara Fish Farm during the first and second year study periods (Nov. 2008- Oct. 2010).

Figure 4. Monthly variations in T.H. at Tarahara Fish Farm during the first and second year study periods (Nov.2008- Oct. 2010).

Conclusion

Physico-chemical parameters significantly (P<0.01; 0.05) differed in different months. Although the water quality parameters were within suitable range for the fish growth and breeding, the periodic monitoring is required to avoid any alterations of its natural environment for the maximum production of fish. Tarahara fish farm has greater importance being its location in fish super zone. It has to be developed one of the leading technical manpower producers for fish farming team of eastern Nepal.

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