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STUDIES ON MONTHLY VARIATIONS IN BIOLOGICAL AND PHYSICO-CHEMICAL PARAMETERS OF BRACKISH WATER FISH POND, MUZAFFAR GARH, PAKISTAN

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Abstract: Diversity of plankton life were used a s a measure of water quality of a brackish water aquaculture pond. Phytoplanktons were abundant as compared to zooplanktons. During the study period total of 48 genera were observed in which 38 genera were of Phytoplanktons. Those genera, present in different divisions, were Cyanophyta (10) Xanthophyta (3) Bacillariophyta (7) Chlorophyta (13) Chrysophyta (3) and Cryptophyta (2). The genera of Zooplanktons were 10 including 8 genera of Protozoa, 1 of Cladoceran and 1 of Rotifer. Total number of organisms was 575 out of which 472 were Phytoplanktons and 103 were of Zooplanktons. Diversity index of phytoplankton ranged from 2.6 to 3.55 and diversity index of zooplanktons ranged between 0.48 to 1.67. Various physico-chemical parameters were studied in brackish water pond at Muzaffargarh, near Multan (Pakistan). The air temperature ranged from 23.75 (0.274) to 45.667 (0.058) ^{o}C and the water temperature ranged 15 (0.894) to 39.917 (0.564) ^{o}C. Light penetration varied from 12 (0.894) to 27.0 (0.894) cm. pH and dissolved oxygen fluctuated between 7.30 (0.559) to 8.19 (0.689) and 7.65 (1.084) to 8.75 (0.935) mg l^{-1} respectively. Salinity and electric conductivity ranged 2.965 (0.18) to 4.007 (2.89) g l^{-1} and 12.89 (0.018) to 17.42 (0.289) ms cm^{-1} respectively. Total solids and total dissolved solids varied from 11.33 (1.05) to 15.00 (1.414) mg l^{-1} and 9.99 (0.009) to 15.99 (0.009) mg l^{-1}. Total volatile solids and total dissolved volatile solids fluctuated between 1.15 (0.1049) to 2.00 (0.707) mg l^{-1} and 1.33 (0.0089) to 2.33 (0.637) mg l^{-1} respectively.

Keywords: Biological parameter, brackish water pond, monthly variations, physico-chemical parameters.

INTRODUCTION

Biodiversity means the variability among the living organisms from all source including terrestrial, marine and other aquatic ecosystem and ecological complex of which they are part [Ali 1999]. Plankton community is a heterogeneous group of tiny plants (phytoplankton) and animals (zooplanktons) adapted to suspension in the sea and fresh water [Battish 1992].

Phytoplankton is a predominant type of a plant found in most aquaculture pond. The quality and quantity of phytoplankton is a good indicator of water quality. The high relative abundance of chlorophyta is a indicator of productive water [Boyd 1981]. Zooplanktons form an intermediate step in grazing food chain in aquatic bio-loop and an ecosystem [Rao 1993]. The component of phytoplankton communities and relative abundance of component species undergo continuous changes and on varying scale

[Srivastava *et al.* 1987]. The driving forces and mechanism of seasonal changes are acknowledged to be related to variation in physical, chemical and biotic environment and to the many possibilities brought about by their mutual interaction which together effect differential specific growth and less rate among the algae [Reynold 1984].

The climatic characteristic influences the water quality and quantity affects the biodiversity [Boyd and Tucker 1998]. Benthic algal growth and biomass development is regulated by several physicochemical and biotic parameters. Thus algal growth is regulated by basic growth parameters such as light [Steinman 1992] and inorganic nutrients [Hart and Robinson 1990].

In recent years aquaculture is being projected as possible solution to food problems faced by masses. It gives higher productivity per unit as compared to agriculture and animal husbandry. Water quality studies are important and have been taken up because these play a key role in aquaculture [Sinha and Srivastava 1991]. Object of aquaculture is to produce the maximum fish (or other marketable species) in a given volume of water in a shortest time. The lowest possible cost will not be attained because of poor water quality [Barnabe 1994]. The maximum production is obtained when physico-chemical factors are at optimum level [Sinha and Srivastava 1991]. Therefore water quality is a paramount factor in a ecosystem productivity. The present study is designed to monitor the monthly variations in water quality parameters of a brackish water fish pond to investigate the limiting factors, which adversely affect the fish production. Further purpose was to explore the possibility of using the very large area, which is saline and the subsoil water is brackish, for the purpose of fish farming.

MATERIALS AND METHODS

The present study was carried out on brackish water pond situated at 18Km away from Muzaffar Garh at Shah Garh. The area of this pond was 2 acres and its depth was 5 feet. The study was carries out for a growth period of seven months from May 2002 to December 2002 except October. The water samples for biological studies were taken from the subsurface in plastic bottles on monthly basis. The water sample for planktons study were preserved by using 4% formaline solution [Battish 1992] and examined under a microscope using 10X ocular and 10X and 40X objectives. The identification of phytoplankton and zooplanktons up to generic level were done with the help of following literature [Ward and Whipple 1959, APHA 1989, Tonapi 1980, Battish 1992, Fritsch 1979].

Relative abundance and frequency of occurrence were calculated. Diversity index of planktons during each month was calculated by using the following formula:

$$\text{Diversity Index} = H = \frac{S-1}{\ln N}$$

where

S = No. of genera of phyto and zooplanktons.
N = Total No. of phyto and zooplanktons
ln = Natural logarithm

At the time of sampling the air and water temperature was determined by ordinary alcoholic thermometer. The light penetration was determined with the help of Sacchi's disc. pH of samples was determined with the help of pH meter (Model CD-720). Boiling point measured by using Mercury thermometer. Sunrise and sunset time was recorded to calculate the photoperiod and humidity from newspaper (NAWA-I-WAQT). Conductivity of sample was determined with help of conductivity meter (Model CM.30ET, Tokyo, Japan). Free CO_2, turbidity, solids, total hardness, salinity, alkalinity and total oxygen contents were determined by methods given by Boyd [1981]. Salinity was measured by methods of Richards [1968]. Whereas viscosity, density, surface tension and specific gravity was determined by the methods given by Nabi *et al*. [1998].

RESULTS

The monthly distribution of phytoplanktons and zooplanktons is given in Table 1. The distribution data of Phytoplanktons and Zooplanktons are given in Tables 1-4. During the study period total 48 genera were observed in which 38 genera were of Phytoplanktons. Those genera, present in different divisions, were Cyanophyta (10 genera) Xanthophyta (3 genera) Bacillariophyta (7genera) Chlorophyta (13 genera) Chrysophyta (3 genera) and Cryptophyta (2genera). The genera of Zooplanktons were 10 including 8 genera of Protozoa, 1 of Cladoceran and 1 of Rotifer. Total number of organisms 575 out of which 472 were Phytoplanktons and 103 were of Zooplanktons.

Table 1: Monthly distribution of planktons

Months	May	June	July	Aug.	Sep.	Nov.	Dec.
No. of Phytoplankton	66	95	50	69	58	65	69
No. of Zooplanktons	13	20	21	15	12	14	8
Total No. of Planktons	79	115	71	84	70	79	77
R.A. of Phytoplankton	83.58%	82.6%	70.4%	82.14%	82.9%	82.3%	89.6%
R.A. of Zooplankton	16.57%	17.4%	29.6%	17.9%	17.4%	17.1%	10.4%

FREQUENCY OF OCCURRENCE

Among the phytoplanktons, the members of Cyanophyta, Xanthophyta and Chlorophyta were present through out the study period. The members of Bacillariophyta were present in all months except in July. The members of Chrysophyta were present in May, June, and August and in November while Cryptophyta were present only in two months i.e. in June and July.

Among Zooplanktons, Protozoan was present in all months. Cladoceran was present in al months except in December. Rotifers were present only in three months i.e. July, August and in September.

RELATIVE ABUNDANCE

Phytoplanktons were most abundant as compared to zooplanktons during the whole study time. Cyanophyta was relatively abundant as compared to all other divisions.

Table 2: Relative abundance of phyla

Months	May	June	July	Aug.	Sep.	Nov.	Dec.
Cyanophyta	36.59	23.3	12.89	21.37	27.1	30.34	24.65
Xanthophyta	10.9	13	16.86	14.2	15.71	13.92	22.06
Bacillariophyta	16.4	16.5	14	11.8	18.57	11.36	19.46
Chlorophyta	15.13	23.3	19.68	23.73	21.3	24.03	23.36
Chrysophyta	5.1	0.86	-	10.60	-	2.53	-
Cryptophyta	-	5.2	1.4	-	-	-	-
Protozoa	11.37	13.7	19.64	8.26	7.0	10.12	10.38
Cladoceran	5.1	3.4	8.45	7.1	8.57	7.59	-
Rotifers	-	-	1.41	2.3	1.4	-	-

In May, Cyanophyta was relatively more abundant followed by Bacillariophyta, Chlorophyta, Protozoa and Xanthophyta. Chrysophyta and Cladoceran was of the same range of abundance. In June, Cyanophyta and Chlorophyta were relatively more abundant followed by Bacillariophyta, Protozoa, Xanthophyta, Cryptophyta, Cladoceran and Chrysophyta. In July, Chlorophyta was relatively most abundant followed by Protozoa, Cyanophyta, Xanthophyta, Bacillariophyta, Cladoceran, Cryptophyta and Rotifer. In August, Chlorophyta was relatively most abundant followed by Cyanophyta, Xanthophyta, Bacillariophyta, Chrysophyta, Protozoa, Cladoceran and Rotifer. In September, Cyanophyta was most abundant followed by Chlorophyta, Bacillariophyta, Xanthophyta, Cladoceran, Protozoa and Rotifer. In November, Cyanophyta was most abundant followed by Chlorophyta, Xanthophyta, Bacillariophyta, Protozoa and Cladoceran. In December, Cyanophyta was most abundant followed by Chlorophyta, Xanthophyta, Bacillariophyta and Protozoa (Table 2).

DIVERSITY INDEX

Diversity index of phytoplanktons ranged from 5.98 to 8.15. It was maximum in August and minimum in December. Diversity index of zooplanktons ranged from 1.11 to 3.85. It was maximum in June and minimum in December (Tables 3 and 4)

Table 3: Diversity index of phytoplanktons

Month	No. of genera (S)	Total No. of individuals (N)	ln N	Diversity Index H
May	13	66	4.19	2.86
June	15	95	4.55	3.08
July	12	50	3.91	2.81
Aug.	16	69	4.23	3.55
Sep.	15	58	4.06	3.45
Nov.	14	65	4.17	3.12
Dec.	12	69	4.23	2.60

Table 4: Diversity index of zooplanktons

Month	No. of genera (S)	Total No. of individuals (N)	ln N	Diversity Index H
May	5	13	2.56	1.56
June	6	20	2.99	1.67
July	6	21	3.04	1.64
August	4	15	2.71	1.11
September	4	12	2.48	1.21
November	3	14	2.64	0.76
December	2	8	2.08	0.48

The comparison of different physico-chemical parameters between months was done by using ANOVA technique following Zar [1996]. Statistical package MINITAB was used for data analysis.

There was highly significant ($P<0.001$) difference in water and air temperature between months. The maximum water temperature 39.971˚C (0.564) was observed in May and minimum 15˚C (0.894) in December. The maximum air temperature 45.667˚C (0.577) was observed in May and minimum value 23. 75˚C (0.274) was observed in December. The maximum humidity 84% was observed in June and minimum 9% was observed in December. The value of clouds ranged between 0% to 70%. The maximum value (70%) was observed in June and minimum (0%) in May, August and December. There was no rain in all months from May to December. There was highly significant ($P<0.001$) difference in light penetration. The minimum 12cm (0.894) light penetration was observed in November and maximum 27cm (0.894) was in July. There was highly significant ($P<0.001$) difference in boiling point between months. The maximum value 103˚C (0.894) was observed in November and minimum 97˚C (0.894) was observed in July. There was highly significant ($P<0.001$) difference in the density between months. The maximum value 1.0544 mg ml^{-1} (0.00009) was observed in four months i.e. June, July, November and December. The minimum value 1.0508 mg ml^{-1} (0.00009) was observed in May. There was highly significant ($P<0.001$) difference in specific gravity. The maximum value 1.06051 (0.00334) was observed in July and minimum 1.0539 (0.00009) was observed in May. There was a highly significant ($P<0.001$) difference in turbidity between months. The maximum value 4.00mg l^{-1} (0.6633) was observed in November and minimum 1.00mg l^{-1} (0.1414) in July. There was also a highly significant ($P<0.001$) difference in viscosity between the months for the sample

analyzed. The maximum values 1.013 NS m^{-2} (0.0006) was observed in September and minimum values 0.945 NS m^{-2} (0.0245) in June. There was a highly significant (P<0.001) difference in surface tension. The maximum value 63.13dynes cm^{-1} (0.329) was observed in September and minimum 56.57 dynes cm^{-1} (0.208) in July (Tables 5 and 6).

Table 5: Effect of monthly variations in Physical parameters of brackish water fishpond in Muzaffargarh District, Punjab, Pakistan. Standard Deviations are given in Paranthesis.

Parameters	May	June	July	August	Septe-mber	Nove-mber	Dece-mber
Air Temperature (^oC)	45.667 (0.0577)	38.917 (0.665)	36.833 (0.753)	39.583 (0.492)	32.167 (0.7530)	30.750 (0.418)	23.750 (0.274)
Water Temperature (^oC)	39.917 (0.564)	35.0 (0.894)	26.5 (0.089)	32.00 (0.894)	30.383 (0.833)	25.00 (0.894)	15.0 (0.894)
Light Penetration (cm)	-	20.0 (0.81)	27.0 (0.89)	26.0 (0.84)	16.8 (0.082)	12.0 (0.94)	-
B.P. (^oC)	99.0 (0.824)	99.0 (0.792)	97.0 (0.854)	101.0 (0.894)	95.0 (0.888)	103.0 (0.843)	99.0 (0.894)
Photoperiod (hours)	14.32	14.8	13.48	13.0	12.16	11.01	10.23
Density (gm m^{-1})	1.0508 (0.00009	1.0544 (0.0088)	1.0536 (0.00077)	1.0524 (0.00009)	1.0534 (0.00091)	1.0544 (0.00009)	1.054 (0.001)
Specific Gravity	1.0539 (0.00009)	1.0575 (0.0088)	1.060 (0.000334)	1.0555 (0.00000)	1.0565 (0.00066)	1.05745 (0.00012)	1.0571 (0.001)
Turbidity (mg l^{-1})	2.90 (0.0894)	3.05 (2.0285)	1.00 (0.1414)	1.35 (0.2881)	1.45 (0.5010)	4.00 (0.6633)	1.05 (0.1045)
Viscosity (NS m^{-2})	0.9832 (0.0000)	0.945 (0.0245)	0.9904 (0.0256)	0.9892 (0.0252)	1.0132 (0.0006)	0.9723 (0.0151)	1.0092 (0.02)
Surface Tension (dynes cm^{-1})	62.20 (0.018)	59.025 (0.455)	56.57 (0.208)	59.63 (1.283)	63.13 (0.329)	59.255 (6.994)	62.125 (0.26)

There was non-significant effect of months on the pH of the fish pond under study (P>0.05). The maximum value 8.19(0.6895) was found in November and minimum 7.30 (0.5593) in July. There was a highly significant (P<0.001) difference in conductivity between months for the sample analyzed. The maximum value 17.42ms cm^{-1} (0.289) was observed in December and minimum12.89ms cm^{-1} (0.018) in May. There was a non-significant difference (P>0.05) in dissolved oxygen contents between months. The maximum value 8.75mg l^{-1} (0.9354) was observed in September and minimum 7.65mg l^{-1} (1.0840) in August. There was a highly significant (P<0.001) difference in salinity between months. The maximum value 4.007g l^{-1} (2.89) was observed in December and minimum 2.965g l^{-1} (0.018) in May. There was highly significant (P<0.001) difference in hardness between months. The maximum value 185mg l^{-1} (5.55) was observed in December and minimum 137mg l^{-1} (0.89) was in May. There was highly significant (P<0.001) difference in total solids between months. The maximum value 15.00mg l^{-1} (1.414) was observed in November and minimum 11.33mg l^{-1} (1.050) in July. There was also a highly significant (P<0.001) difference in total volatile solids between months. The maximum value 2.0mg l^{-1} (0.7071) was observed in June and minimum 1.15mg l^{-1} (0.1049) in December. There was highly significant (P<0.001) difference in total dissolved solids between months.

Table 6: ANOVA table showing the comparison between physical parameters.

Sr. No.	Parameters	DF	SS	MS	F	p
1	Air temperature (^oC)	6.35	1488.9	248.156	721.91	<0.001***
2	Water temperature (^oC)	6.35	2305.475	384.246	637.48	<0.001***
3	L.P (cm)	4.25	952.032	238.008	370.96	<0.001***
4	B.P (^oC)	6.35	240.000	40.000	50.00	<0.001***
5	Density (gm m^{-1})	6.35	0.0000604	0.0000101	23.25	<0.001***
6	Specific Gravity	6.35	0.0001343	0.0000224	12.64	<0.001***
7	Turbidity (mg l^{-1})	6.35	68.563	11.427	16.23	<0.001***
8	Viscosity (NS m^{-2})	6.35	0.019103	0.003184	8.08	<0.001***
9	Surface Tension (dynes cm^{-1})	6.35	192.15	32.03	4.04	<0.001***

Table 7: Monthly variations in chemical parameters of brackish water fish farm (Bismillah fish farm) at Muzaffargarh. Standard Deviations are in Parenthesis.

Parameters	May	June	July	August	September	November	December
pH	7.95 (0.636)	7.95 (0.63)	7.30 (0.559)	7.59 (0.636)	7.9 (0.634)	8.19 (0.6895)	8.00 (0.0645)
Conductivity (ms cm^{-1})	12.89 (0.018)	13.22 (0.163)	14.15 (0.11)	14.80 (0.390)	16.33 (0.37)	17.38 (0.643)	17.42 (0.289)
Salinity (g l^{-1})	2.965 (0.18)	3.041 (1.63)	3.255 (1.10)	3.404 (3.90)	3.756 (3.70)	3.997 (6.43)	4.007 (2.89)
Oxygen contents (mg l^{-1})	7.93 (0.633)	8.20 (0.9210)	7.75 (1.214)	7.65 (1.084)	8.75 (0.935)	8.50 (0.894)	8.65 (0.821)
Free CO_2 (mg per liter)	7.82 (0.633)	6.91 (1.255)	16.51 (4.657)	19.81 (2.256)	18.94 (1.593)	19.12 (2.705)	19.26 (0.839)
Alkalinity (mg per liter)	12.00 (0.894)	13.00 (1.304)	18.00 (2.302)	18.00 (2.302)	16.00 (0.707)	20.00 (0.707)	16.00 (0.707)
Acidity (mg per liter)	27.50 (1.049)	19.00 (1.414)	29.00 (3.406)	28.00 (2.366)	27.00 (3.3620	19.00 (1.304)	26.50 (1.265)
CO_3^{-2} (mg per liter)	12.00 (0.707)	9.00 (1.414)	-	15.83 (0.816)	13.00 (1.673)	18.00 (2.302)	12.00 (1.265)
HCO_3^- (mg per liter)	-	3.17 (1.472)	-	2.00 (1.214)	3.00 (1.265)	2.00 (1.214)	4.00 (0.447)
Hardness (m. eq per liter)	137.0 (0.89)	180.0 (1.79)	150.0 (10141)	160.0 (11.10)	162.8 (38.54)	163.3 (7.47)	185.0 (5.55)
Total solids (mg l^{-1})	11.65 (0.633)	12.30 (0.460)	11.33 (01.05)	12.65 (1.143)	11.60 (0.544)	15.00 (1.414)	11.55 (0.589)
Total dissolved solids (mg l^{-1})	9.99 (0.009)	12.33 (0.367)	12.66 (0.009)	11.66 (1.829)	12.66 (0.734)	14.99 (0.362)	15.99 (0.009)
Total volatile solids (mg l^{-1})	1.30 (0.141)	2.00 (0.707)	1.65 (0.75)	1.95 (0.95)	1.65 (0.513)	1.65 (0.50)	1.15 (0.105)
Total dissolved volatile solids (mg l^{-1})	1.33 (0.008)	1.33 (0.009)	1.99 (0.73)	1.99 (0.73)	1.99 (0.009)	2.33 (0.64)	1.99 (0.009)

The maximum value15.99mg l^{-1} (0.009) was observed in December while minimum value 9.99 mg l^{-1} (0.009) in May. There was also highly significant (P<0.001) difference in total dissolved volatile solids. The maximum value 2.33 mg l^{-1} (0.6371) was observed in November and minimum 1.33 mg l^{-1} (0.0089) in May and June. There was highly significant (P<0.001) difference in water temperature between months. The maximum temperature 39.917^{o}C (0.564) was observed in May and minimum15^{o}C (0.894) in December. There was highly significant (P<0.001) difference in air temperature. The maximum temperature 45.667^{o}C (0.577) was observed in May and minimum value 23.75^{o}C (0.274) was observed in December. For photoperiod the maximum value 14.80 hours was observed in June and minimum 10.23 hours in

December. There was highly significant (P<0.001) difference in light penetration. The minimum12cm (0.894) light penetration was observed in November and maximum 27cm (0.894) was in July (Tables 7 and 8).

Table 8: ANOVA table showing the comparison between chemical parameters.

Sr. No.	Parameters	DF	SS	Ms	F	p
1	pH	6.35	3.176	0.529	1.54	$0.194^{n.s.}$
2	Conductivity (ms/cm)	6.35	128.602	21.434	181.98	<0.001***
3	Salinity (g l^{-1})	6.35	12860.2	2143.4	181.98	<0.001***
4	D.O.C. (mg l^{-1}r)	6.35	6.389	1.065	1.19	$0.5^{n.s.}$
5	FreeCO_2 (mg l^{-1})	6.35	1244.47	207.41	36.93	<0.001***
6	Alkalinity (mg l^{-1})	6.35	293.14	48.86	22.95	<0.001***
7	Acidity (mg l^{-1})	6.35	656.14	109.36	22.25	<0.001***
8	Hardness (m.eq l^{-1})	6.35	9756	1626	6.69	<0.001***
9	T.S. (mg l^{-1})	6.35	58.97	9.828	12.14	<0.001***
10	T.V.S. (mg l^{-1})	6.35	146.206	24.368	41.09	<0.001***
11	T.D.S. (mg l^{-1})	6.35	146.206	24.368	41.09	<0.001***
12	T.D.V.S. (mg l^{-1})	6.35	5.086	0.848	4.96	<0.001***
13	Carbonates (mg l^{-1})	5.30	30281	60.56	28.24	<0.001***
14	Bicarbonates (mg l^{-1})	5.30	57.47	11.49	5.01	<0.001***

n.s.	=	P>0.05	=	non significant
*	=	P<0.05	=	marginally significant
**	=	P<0.01	=	significant
***	=	P<0.001	=	highly significant

DISCUSSION

In the present study phytoplankton were most abundant as compared to zooplanktons. Among the phytoplanktons, the members of Cyanophyta, Xanthophyta and Chlorophyta were present through out the study period. The members of Bacillariophyta were present in all months except in July. The members of Chrysophyta were present in May, June, and August and in November while Cryptophyta were present only in two months i.e. in June and July.

Among Zooplanktons, Protozoan was present in all months. Cladoceran was present in al months except in December. Rotifers were present only in three months i.e. July, August and in September.

Among algae cyanophyta were the most abundant through out the study period. The increase in Cyanophyta may be due to the high concentration of organic matter, low level of CO_2 and high pH [Boyd 1981]. Cyanophyta was inversely related with Chlorophyta [Shepherd and Bromage 1992]. Chrysophyta was maximum in august and absent in July, September and December. Chrysophyta showed negative relation with Chlorophyta.

Primary production was related to nutrients concentration, light and temperature [Rath 1993]. Light penetration determines the extent of euphotic zone and is determined by the turbidity of water [Slingsby and Cook 1986]. Turbidity has quantitative and qualitative effect on light penetration and thus on phytoplankton production [Barnabe 1990]. Oxygen plays very important role in determine the potential biological quality of water. pH of water is important because many biological activities can occur only within narrow range [Shepherd and Bromage

1992]. Diversity index was inversely affected by total dissolved solids [Salam and Rizvi 1999]. The similar results were also obtained in the present study.

Temperature is one of the most important factor among the external factors which influences the fish production [Huet 1986]. In present study, air and water temperature showed a decreasing trend. Maximum temperature was observed in May and minimum in December. Ashraf [1987], Ali *et al.* [1994], Salam and Perveen [1996], Salam *and* Mahmood [1998], and Salam *et. al.* [2000] reported similar results. Photo period increased in May and June and then declined. In winter photoperiod was shorter than summer. This is accordance with the results reported by Salam *et. al.* [2000].

One of the most obvious and familiar properties of water is its transparency. Light penetration shows an increase to July and then a decrease till November. It was inversely affected by turbidity in this study. Turbidity was minimum in July and maximum in November. Similar conclusion was reported by. Ashraf [1987], Ali *et. Al.* [1994], Salam and Perveen [1997] and Salam *et al.* [2000] also observed the same results while Salam and Bhatti [1999] observed opposite results to the present study.

The favorable range of pH is 6.5-9.0 at any daybreak, are most suitable for fish penetration [Boyd and Tucker 1998]. In present study pH ranged 7.30 (0.5593) to 8.19 (0.6895), which indicates that water is suitable for fish production. pH showed seasonal fluctuations between the favorable range throughout the study period which may be due to increase or decrease in CO2. The similar results were reported by Salam *et al*. [2000]. Conductivity was maximum in December and minimum in May. There was a fluctuating trend in electric conductivity. The fluctuations in electric conductivity are due to fluctuation in total dissolved solids and salinity [Boyd 1981].

Salinity refers to total concentration of all ions in water. In present study salinity was maximum in December and minimum in May. There was a fluctuation in other months. The fluctuation in salinity is probably due to fluctuation in total solids [Boyd and Tucker 1998]. Salam *et. al.* [2000] also observed the fluctuation trend in salinity. Dissolved oxygen showed maximum value in winter season. It may be due to temperature variation. Dissolved oxygen showed inverse relationship with water temperature [Boyd 1981]. Similar type of result was observed in the present study. The maximum dissolved oxygen was observed in September when the temperature was minimum. Same results were also observed by Ali *et al.* [1994] and Salam *et. al.* [2000]. The inverse relationship of dissolved oxygen with temperature is well documented in literature [Barnabe 1994, Salam and Perveen 1996].

Total solids were maximum in November and minimum in July. Total solids also showed a positive correlation with turbidity. Same results were

observed by Salam and Perveen [1996] and Salam *et. al.* [1998]. Total dissolved solids were maximum in December and minimum in May. Dissolved solids indicate the total amount of inorganic chemicals in solution A maximum value of 400mg l^{-1} of TDS is permissible for diverse fish population [Nadeem 1994]. But in present study, TDS in Brackish water may indicate enough diversity of fish. Same results were also observed by Salam and Mahmood [1998] and Salam *et. al.* [2000]. Total dissolved volatile solids and total volatile solids showed seasonal fluctuation throughout the study period. TVS has maximum value in June and minimum in December while TDVS has maximum in November and minimum in May and June.

The present study concluded that most of the pysico-chemical and biological parameters in the pond under study showed a monthly pattern. Therefore the fish farmers can utilize this trend to optimize the growth performance of the cultured fish by taking these variations into account. Although Bismillah Fish farm is present in an area where most of the land is not used for agriculture because of high level of salts in soil and brackish subsoil water, yet this farm had most of the water quality parameters quite suitable for fish culture. Therefore this vast area having a very large untapped resources that can be utilized for fish farming with careful monitoring of water quality parameters throughout the year and making little adjustments on expert's advice.

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