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Study of the Seasonal Variations in the Physico Chemical and Biological Aspects of Indus River Pakistan

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Abstract: The present study was carried out to investigate the seasonal variations in physico chemical and biological parameters of River Indus for a period of eleven months from November 1993 to September 1994. For this purpose five different locations, Kaloorkot, Darya Khan, Ghazi Ghat Taunsa Barrage and Chachran Sharif were selected for sampling. Water samples were collected on monthly basis and were analyzed for estimation of water temperature, temperature above surface of water, temperature above surface of bank, pH and total dissolved solids. Only Darya Khan was selected for studying planktonic life. The minimum value of temperature of water 0°C in winter months while the maximum temperature of water was 36.67°C in the month of July. The minimum pH 6.9 was recorded in the month of June, while in winter months pH goes on increasing, reaching up to 8.9 showing that in winter months pH of water increases and in summer months pH of water decreases. The minimum value of total dissolved solids was 0.3 mg l^{-1} in April and 12.49 in August showing an increase in total dissolved solids in winter months. During the whole study 43 different genera of phytoplankton and 17 different genera of zooplankton were observed at Darya Khan. The parameters were analyzed to investigate probable pollution at different points in River Indus to suggest ways and means to improve the feeding and conservation of Indus Dolphin ecology.

Key words: Physico-chemical parameters, seasonal variations, river Indus, water quality

INTRODUCTION

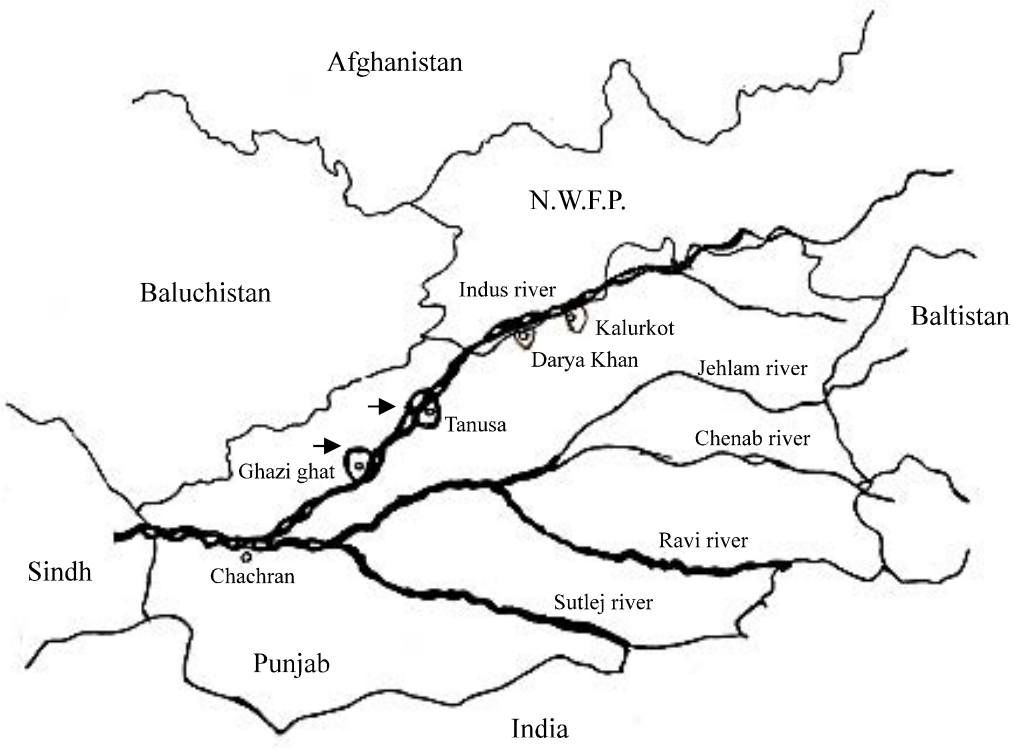
The ecosystem consists of three major components i.e., water, air and soil. The aquatic ecosystem has generally been divided into two types i.e., marine ecosystem and fresh water ecosystem (Mishra and Saksena, 1992).The science dealing with the study of fresh or saline waters contained within continental boundaries is called Limnology. Limnological studies include the physico chemical and biological parameters of fresh waters. These parameters are used to analyze the quality of water (Goldman and Horne, 1983; Boyd and Tucker, 1988). The water quality ultimately determines the survival and growth of cultured animals and plants (Dehadrai, 1992). Aquatic organisms need a healthy environment to live and have adequate nutrients for their growth. The productivity depends on the physico-chemical characteristics of the pond water. The maximum production is obtained when the physical parameters are at the optimum level (Huet, 1986). If the water that is a habitat of animals and plants is unfit then these organisms would not grow and reproduce. So objective of aquaculture is to produce the maximum production for marketable species in a given volume of water in the shortest time and at the lowest possible cost, will not be attained because of poor water quality and such habitat becomes prime target for pathogens and parasites (Barnabe, 1994). The quantity and quality of phytoplankton is a good indicator of water quality. The high relative abundance of chlorophyta is indicative of productive water. Blue green algae blooms results in a number of problems including off-flavor in fish, toxic substances, shallow chemical and thermal stratification, taste and odor in drinking water. Phytoplankton die off and gives unsightly appearance (Boyd, 1981;Salam and Perveen, 1996). Diatoms (Bacillariophytes have been used by ecologists to indicate pollution in water body and other variations of ecological conditions e.g. certain genera avoid acid water and very low concentration of Ca and Mg for example *Nitzschia, Gyrosigma* and *Epithemia* (Ward and Whipple, 1959; Mason, 1988). Numerical analysis of plankton and environmental data identifies the most important regulating environmental variables and probable cause for the observed diatoms distribution pattern. Species of diatoms *Stephanodisus* are useful indicators of Eutrophication. An increase in the preparation of acidophilous diatoms can be taken as indicator of acidification i.e. *Cyctotella* spp. (diatom) (Boney, 1983). Dense surface blooms of blue green algae (Aphanizomenon) are regarded as indicator of potential productivity in fishpond (Leonard, 1971). Limnology plays an important role in decision-making process for pollution

control and aquaculture enhancement. Researches on the limnolgical aspects are of paramount significance in developing fresh water quality. Therefore water quality is a paramount factor in ecosystem productivity. Present study is among series of research conducted by Chowdhry *et al.* (1997), Ali *et al.* (2000) and Salam *et al.* (2001), to monitor seasonal variations in physico chemical and biological aspects of river Indus to investigate limiting factors, which could adversely affect the plants and animals as well as life of a very rare and valuable species of mammal, the blind Indus Dolphin *Platanista minor*, found in Indus river, a natural home of this important species.

MATERIALS AND METHODS

The present study was carried out for a period of eleven months (November 1993 to September 1994) at five different locations of River Indus. Kaloor Kot, Darya Khan, Ghazi Ghat, Taunsa Barrage and Chachran Sharif were selected for sampling because of their road connections along with the availability of water through out the year and the depth and flow of water was maximum (Fig. 1). The samples were collected from the mid stream at the depth of 1–2ft in polyethylene liter screw cap containers, which were cleaned sequentially with detergent wash tap water rinse, soak in 1% HNO_3 and several distilled water rinses.

The containers were then dried at 100°C for one hour, cooled to room temperature, capped and labeled. 5% formaline by volume was added in each container to preserve fauna and flora in water. At the time of sampling, water temperature, temperature above surface of water, temperature above surface of bank was recorded using a mercury thermometer. The weather at the time of collection of sample was also recorded. The water temp was recorded at 6 inches depth. Temperature above surface of water was recorded 12 inches above water surface and the temperature of air of bank was recorded 20 feet away from river, 12 inches above surface of bank. The pH of water was determined at the time of sampling by using pH meter. For total dissolved solids samples of



Location map of Indus river

Fig.1: Location map of study site at Indus River

water without adding formaline were taken. The samples were then transported to the laboratory and were placed at room temperature and were examined under a compound microscope (OSK 9715–HB-I). The identification of zooplanktons and phytoplanktons was made up to generic level.

RESULTS

At Kaloor Koot the over all range of water temperature was 0–32.78°C. The temperature above surface of water fluctuated between 0–32.9°C while temperature above surface of bank of Kaloor Kot ranged between 2.22–33.89°C. The minimum and maximum values of temperature were observed during months of October and May respectively. At Darya Khan the over all range of water temperature was 0–32.22°C. The air temperature above surface of water fluctuated between 2.22–32.78°C while air temperature of bank ranged between 1.66–32.22°C.The minimum and maximum values of temperatures were observed during months of October and May respectively. At Ghazi Ghat over all range of water temperature was 0–34.44°C. The temperature above surface of water fluctuated between 0–37.22°C, while temperature of bank ranged between 1.66–35.55°C. The minimum and maximum values of temperatures were observed during months of October and August respectively. At Taunsa Barrage the over all range of water temperature was 0 -32°C. The temperature above surface of water fluctuated between O-32.78°C while temperature of bank ranged between 2.77 -33.89°C. The minimum and maximum values of different types of temperatures were observed during the months of October and May respectively. At Chachran Sharif the over all range of water temperature was 0 -36.67°C. The temperature above surface of water fluctuated between 2.22 -35.56°C while the temperature of bank ranged between 4.44 -36. 67°C. The minimum and maximum values of different types of temperatures were observed during the months of October and July respectively. It was found that the respective temperature show increasing trend reaching maximum in may or June and then decline afterward in response to seasonal fluctuations. At Kaloor Kot minimum pH recorded was 7.04 in the month of June and maximum 8.5 in the month of October. At Darya Khan minimum pH recorded was 7.03 in the month of June and maximum 8.6 in January. At Ghazi Ghat, minimum pH recorded was 6.93 in the month of June and maximum 8.4 in October. At Taunsa Baradge minimum pH recorded was 6.8 in the month of June and maximum 8.6 in February. At Chachran Sharif minimum pH recorded was 6.9 in the month of June and maximum 8.9 in January. The total dissolved solids of five different points are given in tables. The total solids ranged 0.22 l^{-1}–12.49 l^{-1} of the sample. The minimum and maximum values were observed in October and August respectively, at the same spot Taunsa Baradge (Table 1-5).

Among the blue green algae, Agmenellum was common from January to June. Gomphospheria, Lymgbya, Myriotrichia, Spirogyra, Tribonema, Cyclotella, Tabelleria, Synedra were common in October. Agmenellum and Navicula were common in January. Myriotrichia, Ankistrodesmus, Chlorella, Tribonema, Cyclotella, Ectocarpus were common in February. Spyridia, Spirogyra, Chloregonium were abundant in March. Anacystis, Surirella, Tatraedron, Spirogyra and Synedra were common in April. Gomphospheria, Tribonema and Tabellaria were common in May. Apicocystis, Chlorella, Cocconies, Ectocarpus were common in June. Anabaena, Ankistrodesmus were common in July. Cocconies was very abundant in August while Microthamnion was common in September. Spirogyra, Tribonema, Apicocystis, Navicula, Synedra, were observed frequently through out the year, while Anabaena, Euglenoids, Surirella, Actrothix, Rhizogonium, Pediastrum, Oedogonium, Ulothrix were rarely observed (Table 6).

The Zooplanktonic population was represented mainly by the protozoans, however appendages of crustaceans were also observed. Paramecium was dominant through out the study period. Amoeba Lacquereusia, Colopoada, Aspidisca, were more frequent. Difflugia, Paranema, Gonium, Coleps, Vorticella, Calathrulina were rarely observed (Table 7).

DISCUSSION

Fresh water environment, unlike the marine ones, are subjected to variations in the ecological parameters like temperature of water, temperature of water above surface, temperature of bank, pH of water, total dissolved solids in water and planktonic life etc. These factors are responsible for the distribution of organisms in different fresh water habitats according to their adaptations, which allow them to survive in that specific habitat. The physical and chemical characteristics of water differ along with its biological characteristics (Jeffries and Mills, 1992). The physical and chemical characteristics of water showed seasonal fluctuations interacting with one another and have a combined effect on animals and plants (Odum,1971; Jeffries and Mills, 1992; Salam and Rizvi, 1999). Temperature fluctuations, both diurnal and seasonal are more evident in fresh water habitats. Temperature is one of the most important among the external factors which influence fish production (Huet,

Table 1: Seasonal variation in physico chemical parameters of Kaloor Kot

Date	pH	Temp. of water	Temp. of Bank	Temp. above Surface	T. dissolved Solids	Weather
13.11.1993	8.5	0.0°C	2.22°C	0.0°C	0.18 mg l^{-1}	Sunny
28.01.1994	8.5	3.33°C	7.77°C	4.44°C	0.28 mg l^{-1}	Sunny
28.02.1994	8.1	3.88°C	12.77°C	11.11°C	5.02 mg l^{-1}	Sunny
29.03.1994	8.4	14.44°C	19.44°C	18.33°C	0.38 mg l^{-1}	Cloudy
30.04.1994	8.1	27.78°C	29.44°C	28.88°C	0.30 mg l^{-1}	Sunny
18.05.1994	8.1	31.67°C	33.89°C	32.78°C	0.16 mg l^{-1}	Sunny
29.06.1994	7.04	15.78°C	32.38°C	32.27°C	3.48 mg l^{-1}	Sunny
21.07.1994	7.23	24.44°C	25.56°C	25.00°C	1.53 mg l^{-1}	Sunny
27.08.1994	7.24	28.89°C	30.00°C	29.44°C	2.06 mg l^{-1}	Sunny
24.09.1994	7.64	30.00°C	31.11°C	30.56°C	0.47 mg l^{-1}	Sunny

Table 2: Seasonal variation in physico chemical parameters of Drya Khan

Date	pH	Temp. of water	Temp. of Bank	Temp. above Surface	T. dissolved Solids	Weather
14.11.1993	8.4	0.0°C	3.33°C	2.22°C	10.3 mg l^{-1}	Cloudy
28.01.1994	8.6	1.11°C	1.66°C	2.22°C	0.28 mg l^{-1}	Sunny
27.02.1994	7.8	5.0°C	17.22°C	14.44°C	4.72 mg l^{-1}	Sunny
30.03.1994	7.9	14.44°C	19.44°C	18.33°C	0.74 mg l^{-1}	Rainy
29.04.1994	8.1	29.44°C	31.11°C	30.55°C	0.29 mg l^{-1}	Sunny
17.05.1994	8.0	32.22°C	32.78°C	32.78°C	0.57 mg l^{-1}	Sunny
28.06.1994	7.03	21.11°C	32.22°C	32.22°C	3.80 mg l^{-1}	Sunny
20.07.1994	7.34	24.44°C	24.44°C	28.89°C	1.68 mg l^{-1}	Sunny
26.08.1994	7.20	25.00°C	28.89°C	25.56°C	1.68 mg l^{-1}	Sunny
23.09.1994	7.87	31.67°C	32.22°C	32.78°C	0.42 mg l^{-1}	Sunny

Table 3: Seasonal variation in physico chemical parameters of Ghazi Ghat

Date	pH	Temp. of water	Temp. of Bank	Temp. above Surface	T. dissolved Solids	Weather
07.11.1993	8.4	0.0°C	1.66°C	0.0°C	0.23 mg l^{-1}	Cloudy
25.01.1994	8.4	2.77°C	4.44°C	8.88°C	0.38 mg l^{-1}	Sunny
20.02.1994	8.5	3.33°C	7.22°C	6.67°C	5.33 mg l^{-1}	Sunny
22.03.1994	7.6	15.56°C	22.77°C	18.89°C	0.41 mg l^{-1}	Sunny
27.04.1994	8.3	28.89°C	32.78°C	31.11°C	0.32 mg l^{-1}	Sunny
15.05.1994	8.0	31.89°C	35.55°C	34.44°C	0.37 mg l^{-1}	Sunny
27.06.1994	6.93	21.22°C	26.72°C	26.83°C	0.30 mg l^{-1}	Sunny
18.07.1994	7.52	32.78°C	35.55°C	33.33°C	1.93 mg l^{-1}	Sunny
24.08.1994	7.23	34.44°C	34.44°C	37.22°C	1.31 mg l^{-1}	Sunny
21.09.1994	8.02	32.78°C	35.55°C	34.44°C	0.88 mg l^{-1}	Sunny

Table 4: Seasonal variation in physico chemical parameters of Taunsa Baradge

Date	pH	Temp. of water	Temp. of Bank	Temp. above Surface	T. dissolved Solids	Weather
06.11.1993	8.4	0.0°C	2.77°C	0.0°C	0.22 mg l^{-1}	Sunny
27.01.1994	8.4	4.44°C	7.77°C	8.88°C	1.01 mg l^{-1}	Sunny
15.02.1994	8.6	2.22°C	16.66°C	16.11°C	0.19 mg l^{-1}	Sunny
21.03.1994	7.8	14.44°C	22.22°C	18.89°C	3.10 mg l^{-1}	Sunny
38.04.1994	7.9	26.11°C	33.89°C	32.78°C	0.32 mg l^{-1}	Sunny
16.05.1994	7.9	32.77°C	33.88°C	33.33°C	0.45 mg l^{-1}	Sunny
27.06.1994	6.8	21.16°C	12.27°C	26.71°C	0.80 mg l^{-1}	Sunny
19.07.1994	8.2	27.22°C	28.84°C	28.89°C	2.76 mg l^{-1}	Sunny
28.08.1994	7.0	20.00°C	31.11°C	21.11°C	12.4 mg l^{-1}	Sunny
22.09.1994	7.5	27.78°C	30.00°C	28.33°C	5.03 mg l^{-1}	Sunny

Table 5: Seasonal variation in physico chemical parameters of Chachran Sharif

Date	pH	Temp. of water	Temp. of Bank	Temp. above Surface	T. dissolved Solids	Weather
10.11.1993	8.8	0.0°C	4.44°C	2.22°C	0.25 mg l^{-1}	Sunny
27.01.1994	8.9	3.88°C	6.67°C	2.77°C	0.84 mg l^{-1}	Sunny
18.02.1994	8.6	6.11°C	16.66°C	16.11°C	0.39 mg l^{-1}	Sunny
25.03.1994	7.8	15.55°C	22.22°C	18.89°C	0.54 mg l^{-1}	Sunny
25.04.1994	8.1	26.66°C	29.44°C	28.89°C	0.47 mg l^{-1}	Sunny
14.05.1994	8.0	31.66°C	33.33°C	32.22°C	1.33 mg l^{-1}	Sunny
26.06.1994	6.9	21.22°C	26.89°C	32.27°C	0.56 mg l^{-1}	Sunny
17.07.1994	7.5	36.67°C	36.67°C	35.56°C	2.15 mg l^{-1}	Sunny
23.08.1994	7.0	34.44°C	34.44°C	33.33°C	11.6 mg l^{-1}	Sunny
20.09.1994	7.6	33.34 C	33.33°C	32.18°C	1.94 mg l^{-1}	Sunny

Table 6: The seasonal distribution of 43 different genera of algae observed at Darya Khan

Phytoplanktons	Nov.	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	% age
Chroococcus	-	+	-	-	-	-	-	-	-	+	20
Anacystis	-	-	-	+	++	-	+	-	+	++	50
Gomphospheria	++	-	-	-	-	++	-	++	-	-	30
Agmenellum	-	+++	-	+	+	+	+	-	-	-	50
Apiocystis	+	-	+	+	+	-	++	+	-	-	60
Anabaena	-	-	-	-	-	-	-	++	-	-	10
Hydriodictyon	-	-	-	-	-	+	+	-	-	-	20
Lymgbya	+++	-	-	-	+	+	-	-	-	-	30
Nostoc	-	+	+	-	+	+	-	-	-	-	40
Euglena	-	-	-	-	-	-	-	+	-	-	10
Chlorogonium	-	-	-	-	++++	-	+	+++	-	-	30
Spyridia	+	-	-	++	-	-	-	-	-	-	20
Myriotrichia	++	-	++	++	++	-	-	+++	+	-	60
Surirella	-	-	-	-	++	-	-	-	-	-	10
Actrothix	-	-	-	-	-	+	-	-	-	-	10
Gyrosigma	-	-	+	+	-	+	-	-	-	-	30
Hildenbrandia	-	-	-	-	-	-	-	+	+	+	30
Rhizogonium	-	-	-	-	-	-	-	-	+	-	10
Ankistrodesmus	-	+	++	-	-	+	-	++	+	+	60
Tetraedron	+	-	+	-	++	-	+	-	+	-	50
Pediastrum	-	-	-	-	-	-	+	-	-	-	10
Chlorella	+	-	+++	-	-	-	-	+	-	-	30
Spirogyra	++	-	+	+++++	+++++	+++	+++	+++	-	-	70
Tribonema	++	+	++	+	+	+++	++	+	+	-	90
Oedogonium	+	-	-	-	-	-	-	-	-	-	10
Mougeotia	-	-	-	+	-	-	-	-	-	-	10
Staurustrum	-	-	-	-	-	+	+	+	-	+	40
Dichotomosiphon	-	-	-	+	+	-	-	-	-	-	20
Cocconies	-	-	-	-	-	+	++	+++	+++	+	50
Microthamnion	-	-	-	+	-	-	-	-	-	++	20
Ulothrix	-	+	-	-	-	-	-	-	-	-	10
Cyclotella	++	-	++	-	++	+	-	-	-	-	40
Stephanodescus	-	+	-	+	+	-	-	+	-	-	40
Tabellaria	++	-	-	-	++	-	-	+	+	+	50
Fragellaria	-	-	-	-	-	-	-	+	+	+	30
Synedra	++	-	+	+	+	++	-	+	-	-	60
Navicula	+	++	-	+	+	-	+	++	-	+	70
Astrionella	-	-	-	-	-	+	-	-	-	+	20
Cryptomonas	-	-	-	-	-	-	+	+	-	-	20
Batryococus	-	-	-	-	+	-	-	+	+	+	40
Chodatella	-	-	-	-	-	-	+	+	-	+	30
Ectocarpus	-	-	+++	-	-	+	++	-	-	-	30
Nemalion	-	-	-	-	+	-	-	-	+	-	20

Table 7: The seasonal distribution of 16 different genera of zooplanktons recorded at Darya Khan

Zooplanktons	Nov.	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	% age
Amoeba	-	-	+	+	+	+	+	-	-	-	50
Lacquereusia	+	-	-	+	+	-	-	+	+	-	50
Difflugia	-	+	-	-	-	-	-	-	-	-	10
Coleps	-	+	-	-	-	+	-	-	-	-	20
Colopoada	+	+	+	-	-	+	-	-	-	-	40
Paramecium	-	-	+	+	+	+	-	-	+	+	60
Actinophrys	-	-	-	-	-	-	+	++	+	-	30
Chlamydomonas	+	-	-	+	-	-	-	-	-	-	20
Chilomonas	-	+	+	-	-	+++	-	-	-	-	30
Paranema	-	-	-	-	-	-	++	-	-	-	10
Vorticella	_	_	-	+	+	-	-	-	-	++	30
Gonium	-	-	-	+	-	-	+++	-	-	-	20
Euplotes	-	+++	+	-	-	+	-	-	-	+	40
Aspidisca	-	+	+++	+	+	-	++	-	-	-	50
Keratella	+	-	-	-	-	-	-	+	+	-	30
Clathrulina	-	-	-	-	-	-	-	+++	-	++	20
Appendages of crustaceans	++	+	++	+	-	+	-	-	-		50

1986). Flowing waters, however lack wide fluctuations in temperature. It is evident from the present results that air temperature showed a seasonal variation. The maximum temperature of water observed was 36.67 °C in July at Chachran Sharif and minimum about 0 °C in October and January. The temperature of bank and temperature above surface of water showed a seasonal trend similar to that of water temperature. It is clear from the results that there is a direct relationship between air temperature and water temperature. A direct relationship between atmospheric and water temperature was also recorded by Mahboob *et al.* (1988) while working on Ajmal Fish Farm Faisalabad. There was a maximum difference between air and water temperature in the months of May and June. This was due to decrease in humidity, which greatly increased the loss of water by evaporation. The pH of water is important because many biological activities can occur only within a narrow range. Thus, any variation beyond acceptable range could be fatal to a particular organism. In river it was found that seasonal and diurnal in pH of water is related with temperature.In June and July pH of water was minimum while in December pH goes on increasing. The concentration of total dissolved solids during the period of study varied between 0.22 mg l^{-1}–12.49 mg $l^{-1}$of the sample. The minimum and maximum values were observed in October and August respectively; at the same spot i.e Tounsa Barrage. The biota of the river under study varied both qualitatively as well as quantitatively through out the study period. These fluctuations could be interpreted as a result of changes in physico chemical parameters of the river. The distribution pattern of zooplanktons and phytoplankton at Darya Khan indicates their relationship with components of food chain as described by Davis (1955) and Lindeman (1992). Both quantitatively and qualitatively phytoplankton generally dominated over the zooplankton throughout the year at the surface due to photosynthetic activity of these plankton. This pattern of distribution also shows the diurnal vertical migration of planktonic organisms as described by Williamson *et al*., 1996 that phytoplankton are always found at the surface during day hours to perform the process of photosynthesis while zooplankton found below the surface (Lampet *et al*., 1986). The present data also show domination of phytoplankton over zooplankton, which may be resulted due to the same reason as the water samples were always obtained in day hours. In addition to this reduction in the abundance of phytoplankton was noticed in winter season either due to sudden reduction in temperature (Nazneen *et al.,* 2000). The seasonal distribution of 43 different genera of algae observed at Darya Khan is summarized (Table 6). Among the blue green algae, Agmenellum was common from January to June. Gomphospheria, Lymgbya, Myriotrichia, Spirogyra, Tribonema, Cyclotella, Tabelleria, Synedra were common in October. Agmenellum and Navicula were common in January. Myriotrichia, Ankistrodesmus, Chlorella, Tribonema, Cyclotella, Ectocarpus were common in February. Spyridia, Spirogyra, Chloregonium were abundant in March. Anacystis, Surirella, Tatraedron, Spirogyra and Synedra were common in April. Gomphospheria, Tribonema and Tabellaria were common in May. Apicocystis, Chlorella, Cocconies, Ectocarpus were common in June. Anabaena, Ankistrodesmus were common in July. Cocconies was very abundant in August while Microthamnion was common in September. Spirogyra, Tribonema, Apicocystis, Navicula, Synedra, were observed frequently through out the year, while Anabaena, Euglenoids, Surirella, Actrothix, Rhizogonium, Pediastrum, Oedogonium, Ulothrix were rarely observed. Seasonal distribution of phytoplankton in the present study is also similar to Kinjhar and Haleji lakes (Nazneen, 1980 ; Nazneen and Bari, 1984). As the maximum number of phytoplankton were observed in these lakes during the summer months, generally coinciding with the maximum temperature ranges. While the minimum concentrations were recorded in the winter season due to the interaction of light and temperature as described by Nazneen (1980). The seasonal distribution of 16 different genera of zooplanktons recorded at Darya Khan is summarized (Table 7) The Zooplanktonic population was represented mainly by the protozoans, however appendages of crustaceans were also observed. Paramecium was dominant through out the study period. Amoeba, Lacquereusia, Colopoada, Aspidisca, were more frequent. Difflugia, Paranema, Gonium, Coleps, Vorticella, Calathrulina were rarely observed.

The present study showed both temporal and seasonal variations in water quality of river Indus. The different parameters used in the study showed that quality of water is within safe limits and good to support micro and macro flora and fauna.

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