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Biodiversity in Relation to Physicochemical Properties of Keenjhar Lake, Thatta District, Sindh, Pakistan

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Abstract

Keenjhar Lake is an artificial and tropical lake. It is located almost 120 km from Karachi; Keenjhar Lake is essential for diverse aspects such as, supply of drinking water, irrigation and wild life intention. Adverse effects of physicochemical parameters on aquatic ecosystem may occur at all levels of biological communities can be wide-ranging or limited, temporary or permanent. Mainly serious effects involve loss in productivity, changes in growth, loss of primary productivity, altered diversity or community structure, changes in aquatic ecosystem process (such as nutrient cycling) and losses of valuable species. These ecological losses in turn may be economically, aesthetically, or socially important. Hence, the present research work was planned to resolve the physicochemical properties and biota of Keenjhar Lake. Biota and physicochemical properties of Keenjhar Lake were determined beginning from January until December 2005. A total of 142 species of phytoplankton, 37 species of zooplankton, 39 species of aquatic plants, 51 species of fishes, and 8 species of prawns were recorded. The physicochemical properties such as temperature, alkalinity, dissolved oxygen, salinity, conductivity, total dissolved solids, chlorides, turbidity, pH, and hardness were determined on monthly basis. The physicochemical properties of Keenjhar Lake were suitable for growth of aquatic biota.

Key words: Biodiversity, Physicochemical properties, Keenjhar Lake, Thatta.

Introduction

Keenjhar Lake was created by providing a link between two natural lakes, "Keenjhar" and "Sunheri" "Green" and "Golden". Keenjhar and Sunheri were two smaller depressions, which were joined in 1958 by dynamiting the separating hills to make one lake; the "Kalri Lake". Again in 1972 was renamed as "Keenjhar Lake" an artificial and tropical lake (Michael, 1967). It is situated nearly 120 km from Karachi, between 24°47' N. Lat. and 68°02' E. Long (Blatter *et al*., 1929). This Lake is 27.35 km long (Figure 1). It receives water from river Indus by canal "Kalri Baghar Feeder", originating from Ghulam Muhammad Barrage. The minimum depth of Lake is 4 meters and maximum depth of Lake is 8 meters and average depth of Lake is 7 meters (Baquai *et al*., 1974a). Modest numbers of research activity have been conducted on the biodiversity of Keenjhar Lake, (Sufi, 1957; Ahmed, 1962; Siddiqui *et al*., 1973; Baquai *et al*., 1974a).

Estimation of water quality and biodiversity is among frequently conducted research activities in Sindh (Siddiqui *et al*., 1973; Baquai *et al*., 1974a; Baquai *et al*., 1974b; Sahato and Arbani, 1997; Sahato *et al*., 1997; Leghari *et al*., 1997; Salam *et al*., 1997; Leghari *et al*., 2000; Mahmood *et al*., 2000; Leghari *et al*., 2005). However, less attempts have been noticed on Keenjhar Lake.

Keenjhar Lake is important for different aspects such as, source of drinking water, irrigation and wild life purpose and a source of cheap diet rich in protein.

Therefore present study has conducted for exploration of biodiversity and physico-chemical parameters of Keenjhar Lake district, Thatta, Sindh, Pakistan.

Materials and Methods

Water, plankton, aquatic plants, prawn and fish samples were collected monthly between January-December 2005 from three stations of Keenjhar Lake (Figure 1): (1) Sunheri, (2) Helaya and (3) Khumbo.

Water Samples for the Determination of Physicochemical Properties

Fort he determination of physicochemical properties of the lake water, 1 liter of surface water was collected from each of the three stations in a colored, sterilized bottle. Sampling was usually done in the morning. Standard methods of for analysis were used (APHA 1980). Temperature was measured with a mercury thermometer and pH with an Orion model 420 pH meter. Transparency was determined with the secchi disc depth measurements. Dissolved oxygen samples were collected in colored bottles and analyzed by a modified Winkler method (Welch, 1948), Conductivity and total dissolved solids were determined with a WTW LF 320 conductivity meter, and salinity was estimated by Mohr's method (Treadwell and Hall, 1919). Standard titration

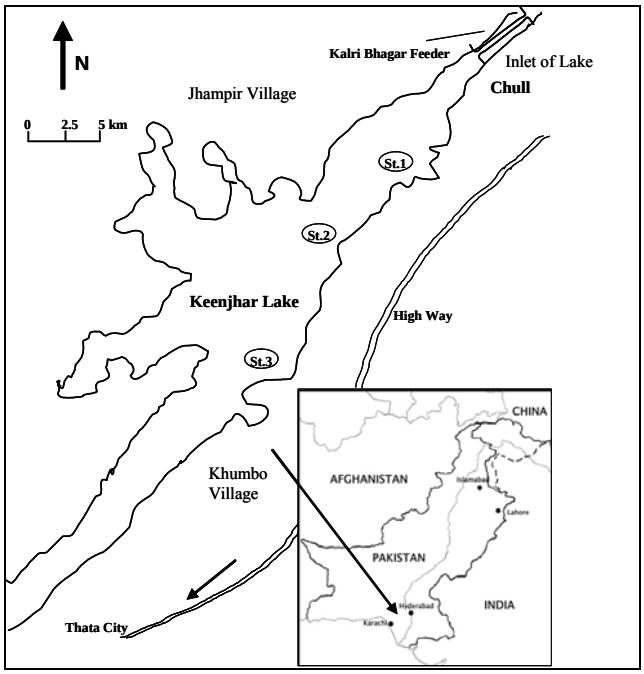

Figure 1. The position of three selected stations at Keenjhar Lake.
(St. 1) Sunheri, (St. 2) Helaya, and (St. 3) Khumbo.

methods (Framan, 1981; APHA, 1980) were used to determine alkanity (with sulphuric acid), hardness (with EDTA), and chloride (with silver nitrate).

Sampling of Plankton: Plankton were collected with a No. 25 μ plankton net towed with a motor boat traveling at a slow speed up to depth of 0.5 meter. The samples were stored in wide-mouth plastic bottles and fixed in 4% formalin. A known volume of water was strained through plankton net to assess the quality of the plankton. A qualitative study of the plankton was made with a light microscope, and species identifications were made by reference to Desikachary (1959), Prescott (1962), Leghari and Arbani (1984), Davis (1955), and Ward and Whiple (1959).

Sampling of Aquatic Plants: Aquatic plants were normally collected by handpicking at each station. A plant grapnel was used to sample submerged rooted plants. The macrophytes were identified by reference to Ahmed and Younus (1979), Subramanyam (1962), Khan and Halim (1987) and Cook (1996).

Sampling of Prawns: Prawns were sampled at the landing center from the catch of fishermen. They had been caught by gillnetting (2-2.5 cm mesh size). Specimens were preserved in 8 % formalin, packed in polythene bags, and brought to the laboratory of the Fresh Water Biology and Fisheries University of Sindh Jamshoro. They were identified by reference with Kuriom and Sebastian (1993).

Fish Sampling: Fish samples were collected from the catch of fishermen from all three stations. They had been caught by gillnetting (2.0-2.5 cm mesh size). Samples were preserved in 10 % formalin. Formalin (5 cm^3) was injected into the belly of each fish with a disposable syringe (BD), and samples were packed in sterilized polythene bags and brought to the laboratory. The samples were identified by reference to Day (1878), Mirza (1990), Mirza and Shafique (1996), and Jayaram (1999).

Results

Water

Temperature: Recorded temperatures during the study period, January-December 2005, ranged from 22 to 31°C at Station 1, from 21 to 30°C at Station 2, and from 21 to 32°C at Station 3. From selected three stations, the maximum temperature was reached in July and the minimum in January.

Transparency: Station 1, located at the inlet by the canal Kalri Bhaggar feeder, was more turbid throughout the year compared with the rest of the stations. The transparency at Station 1 ranged between 36 cm in January and 67 cm in September. At Station 2, it ranged between 38 cm in February and 78 cm in August and at Station 3, between 51 cm in January and 85 cm in August.

Dissolved Oxygen: The concentration of dissolve oxygen ranges between 7.1-8.9 mg L^{-1} in the

month of July and December respectively at Station 1. Maximum 9.1 mg L^{-1} was observed in December and minimum 7.1 mg L^{-1} was recorded during July and March at Station 2. At Station 3 maximum content of dissolve oxygen was 9.5 mg L^{-1} in December and minimum 7.3 mg L^{-1} was in month of June, however maximum dissolved oxygen was 9.5 mg L^{-1} at Station 3 and minimum 7.1 mg L^{-1} at Station 1 and 2 during present study.

Conductivity: Maximum conductivity was observed 320 µS cm^{-1} and 142 µS cm^{-1} in months of January and July respectively at Station 1. Conductivity ranges between 180-298 µS cm^{-1} in months of September and April respectively at Station 2. At Station 3 maximum observed conductivity was 300 µS cm^{-1} in month of January and minimum 180 µS cm^{-1} in month of September, overall maximum conductivity was 320 µS cm^{-1} and minimum 142 µS cm^{-1} at Station 1.

Salinity: Salinity was variable throughout present study period. A minimum salinity of 0.05‰ was observed in February, and a maximum salinity of 0.3 ‰ were observed in April and September at Station 1. A minimum salinity of 0.1‰ was observed in January, April, October and December, and a maximum salinity of 0.3‰ was observed in March and June at Station 2. At Station 3 the minimum salinity was 0.1‰ in January and February, and maximum was 0.3‰ in May and October.

Total Dissolved Solids: At Station 1 the minimum value of total dissolved solids was 190 mg L^{-1} in January and maximum was 390 mg L^{-1} in July. A minimum of 210 mg L^{-1} was recorded in January and a maximum of 350 mg L^{-1} in July at Station 2. A maximum of 350 mg L^{-1} in August and a minimum of 210 mg L^{-1} in December were recorded at Station 3.

pH: The minimum value of pH was 7.8 in July, and maximum was 8.8 in January at Station 1. At Station 2 the minimum value was 7.7 in September and maximum was 8.8 in January. At Station 3 the minimum value was 7.4 in October, and maximum value was 8.6 in January. The pH was affected by temperature, salinity and alkalinity.

Alkalinity: Alkalinity varied between 175 mg L^{-1} in July and 252 mg L^{-1} in December at Station 1. At Station 2 the range was from 192 mg L^{-1} in July to 287 mg L^{-1} in February. At Station 3 the range was from 165 mg L^{-1} in July to 258 mg L^{-1} in February.

Chloride: The minimum value for chloride was 118.78 mg L^{-1} in December and maximum 210.7 mg L^{-1} in June at Station 1. The minimum at Station 2 was 105.8 mg L^{-1} in January and maximum 220.6 mg L^{-1} in May. At Station 3 the minimum was 80.83 mg L^{-1} in October and maximum 162.5 mg L^{-1} in June.

Hardness: The minimum hardness was 120 mg L^{-1} in January and maximum 330 mg L^{-1} in August at Station 1. At Station 2 minimum was 140 mg L^{-1} in January and maximum 370 mg L^{-1} in September. At Station 3 a minimum of 130 mg L^{-1} was recorded in January and a maximum of 355 mg L^{-1} in September. Analytical procedures and minimum and maximum ranges with (Mean±SD) are shown in Table 1.

Phytoplankton

A total of 142 species representing 68 genera and 7 classes were recorded. In Table 2, there are 21 species of *Bacillariophyceae*, 57 species of *Cyanophyceae*, 55 species of *Chlorophyceae*, 1 species of *Chrysophyceae*, 2 species of *Dinophyceae*, 5 species of *Euglenophyceae*, and 1 species of *Xanthophyceae*

Zooplankton

A total of 37 species of Zooplankton comprising 15 species of Cladocera, 3 species Copepoda, 4 species Ostracoda and 15 species of Rotifera were determined during present studies (Table 3).

Aquatic Plants

A total of 39 species of aquatic plants were

Table 1. Minimum and maximum range and Mean ± SD from selected stations, of physicochemical parameters of Keenjhar Lake and their analytical procedure during 2005

Variables	Abbreviations	Units	Analytical methods	Mean ±SD	Min-Max
Temperature	Temp	°C	Mercury thermometer	27.14±2.87	22-31
pH	pH	pH unit	pH meter	8.23±0.36	7.6-8.7
Alkalinity	Alkaline	mg L^{-1}	Titration (H_2SO_4)	216.22±26.6	177.3-256.6
Dissolved Oxygen	DO	mg L^{-1}	Winkler method	8.01±0.67	7.3-8.7
Salinity	Saline	‰ (ppt)	Mohr method	0.17±0.047	0.01-0.2
Conductivity	EC	µS cm^{-1}	Conductivity meter	236.61±42.62	172.3-302.3
Total Dissolved Solids	TDS	mg L^{-1}	WTW LF 320 TDS meter	273.75±50.65	218.3-358.3
Chloride	Cl^-	mg L^{-1}	Titration (Silver nitrate)	144.23±26.08	114.7-187.2
Transparency	Trans	cm	Secchi disc	58.94±10.21	42.3-73.3
Hardness	T-Hard	mg L^{-1}	Titration (EDTA)	226.8±66.76	130-338.3

Table 2. List of Phytoplankton identified from Keenjhar Lake during present studies

	St: 1	St: 2	St: 3
Bacillariophyceae.			
Achnanthes hungarica Grun.	**	**	-
Amphora ovalis Kuetz.	*	**	*
Amphora veneta Kuetz.	**	***	**
Cocconeis pediculus Ehr.	**	***	*
Cocconeis placentula var. lineate Ehr.	*	*	*
Cyclotella operculata (Ag) Kuetz.	**	**	*
Cyclotella stelligera Cl. Et Grun.	**	**	-
Cyclotella striatata Grun.	**	*	*
Cymbella cistula (Hempr).	**	**	***
Cymbella tumida (Breb) Van Hanerck.	*	**	**
Eunatia pectinatis Rab.	*	**	**
Gomphonema helveticum Braun.	*	**	*
Gomphonema parvulum Grun.	*	*	*
Gyrosigma attenuatum (Kuetz) Rabh.	*	*	**
Melosira granulata (Ehr) Ralfs.	**	*	*
Navicula dicephala (Ehr) Smith.	**	**	-
Nitzschia acuminsts Grun.	*	**	*
Nitzschia amphibia Grun.	*	*	*
Nitzschia gracilis Hantzsch.	**	**	*
Nitzschia hungarica Grun.	**	*	*
Synedra affinia Kuetz.	*	*	-
Cyanophyceae			
Anabaena oscillarioides Bory ex Born.	*	-	**
Anabaena wisconsinese Prescott.	**	**	*
Anabaenopsis reciborski Wolosz.	**	**	*
Aphanocapsa elachista Wand G.S.G West var. conferta.	*	-	*
Aphanocapsa grevillei (Hass) Rabenh.	**	*	*
Aphanocapsa littoralis Hansgirg.	**	***	**
Aphanocapsa richterana Heir.	**	**	*
Aphanocapsa rivularis (Carm) Rabenh.	**	**	**
Aphanothece castagnei Berb.	**	**	*
Aphanothece jenneri stizbenb ex Gomont.	**	**	-
Aphanothece salina Elenk.	*	-	**
Calothrix marchica Lemm.	*	**	*
Calothrix viguieri (Fremy).	**	*	**
Chroococcus dispersus Lemm.	*	*	**
Chroococcus giganteus (West).	**	*	**
Chroococcus limneticus Lemm.	**	**	-
Chroococcus minor (Kuetz).	**	*	-
Chroococcus minutus (Kuetz) Naeg.	*	**	**
Coelosphaerium kuetzingianum Naeg.	***	**	**
Coelosphaerium naegelianum Ungar.	**	*	*
Gloeocapsa aeruginosa (Carm) Kuetz.	**	*	**
Gloeocapsa lithophila (Erceg).	*	**	**
Gloeocapsa magma (Berg) Kuetz.	**	**	*
Gloeocapsa minuta (Kuetz) Hollerb.	**	**	-
Gloeocapsa punctata (Naeg).	**	*	**
Gloeothece rupestris (Lyngb) Bornet.	*	*	-
Gloeotrichia reciborski Wolosz.	**	*	*
Gomphosphaeria aponina (Kuetz) var. delicatula Elenk.	**	**	**
Gomphosphaeria aponina (Wolle) var. cordiformis Elen.	**	**	*
Lyngbya confervoides Gomont.	**	*	*
Lyngbya contorta Lemm.	**	**	-

	St: 1	St: 2	St: 3
Cyanophyceae			
Lyngbya sordida (Zonard) Gomont.	*	-	-
Merismopedia angularis B. P. Nor.	***	**	**
Merismopedia convoluta (Berb) kuetz.	***	**	**
Merismopedia gplauca (Ehrenb) Naeg.	**	*	*
Merismopedia minima Beck.	**	**	**
Merismopedia punctata Meyen.	**	**	*
Microcystis aeruginosa Kuetz.	*	*	**
Microcystis aeruginosa var. elongata Rao, CB.	**	-	**
Microcystis flosaquae (Wittr) Kirchner.	*	*	-
Microcystis holsatica Lemm.	**	*	*
Microcystis orissica West.	**	**	*
Microcystis pseudo filamentosa (Crow).	***	**	**
Microcystis pulverea (Wood) Forti.	**	-	**
Nostoc calcicola Brebission ex et Flah.	*	*	*
Oscillatoria chlorina Kuetz (Fremy).	**	**	-
Oscillatoria formosa Bory ex Gomont	**	**	***
Oscillatoria limosa Ag ex Gomont.	**	**	**
Oscillatoria okeni Ag ex Gomont.	***	**	*
Oscillatoria sancta (Kuetz) Gomont.	**	**	*
Phormidium ambiguum Gomont.	**	*	*
Phormidium anomala Rao C. B.	*	*	*
Phormidium corium (Ag) Gomont.	**	*	-
Rivularia aquatica Wilde.			
Spirulina laxa Smith.	*	*	*
Spirulina laxissima West.	**	*	**
Spirulina subtilissima Kuetz ex Gomont.	**	**	*
Chlorophyceae			
Ankistrodesmus falcatus Corda.	**	*	-
Ankistrodesmus falcatus var. Stipitatus (Chod) Lemm.	**	*	*
Ankistrodesmus convolutus (Corda).	**	**	*
Coelastrum leikbleinii Kuetz.	**	*	*
Coelastrum microporum Naegeli.	**	*	-
Coelastrum parvulum var. Maius W. West.	**	*	*
Characium obtusum A. Braun.	*	*	*
Characium ornithocephalum A. Braun.	*	*	*
Chlorella pyrenoides.	**	*	*
Chlorella vulgaris Beyerinck.	*	*	-
Cladophora glomerata. (L) Kuetz.	***	**	**
Cosmarium depressum Naegeli.	*	**	*
Cosmarium granatum Berb.	**	*	-
Cosmarium javanicum Nordst.	**	**	**
Cosmarium margaritatum var. *Margaritatum* Lund.	**	*	*
Cosmarium portianum Arch.	*	*	**
Cosmarium regnelli Wille.	**	*	*
Cosmarium venustum Wille.	*	*	*
Euastrum spinulosum Delp.	**	**	*
Euastrum substellatum Nordst.	*	*	*
Gloeotaenium loitelsbergerianum Hansgirg.	**	-	*
Microspora tumidula Hazen.	*	*	*
Kirchneriella lunaris var. Lunaris (Krichnaris).	*	**	*
Kirchneriella microscopica var. Microscopica Nagard.	**	**	**
Oedogonium striatum Tiffany.	**	*	*

Table 2. (Continued)

	St: 1	St: 2	St: 3		St: 1	St: 2	St: 3
Chlorophyceae							
Oocystis elliptica W. West.	**	**	*	*Spirogyra gratiana* Transean.	*	-	*
Oocystis naegelii A. Brown.	*	-	*	*Staurastrum iotanum* Wolle.	**	*	*
Oocystis pusilla Hansgirg.	**	*	*	*Tetraedron hastatum* Reinsch Hansgirg.	**	**	*
Oocystis solitaria Wttrock.	*	-	**	*Tetraedron muticum* (A. Braun) Hansgirg.	*	*	-
Palmella mucosa Kuetz.	**	**	*	*Tetraedron regulare* Kuetz.	*	*	-
Pediastrum boryanum Turp var. boryanum.	**	**	*	*Tetraedron trigonum.*	**	-	*
Pediastrum duplex var clathratum. (A. Braun).	*	*	*	*Tetraedron trigonum* var. Gracile Reinsch.	*	*	**
Pediastrum duplex Meyen.	**	**	*	*Tetraedron quadratum* Reinsch.	**	*	**
Pediastrum duplex var. Rug	*	*	-	*Ulothrix subconstricta* G. S. West.	*	*	-
Pediastrum duplex var. Reticulatum lagerheim.	*	*	-				
Pediastrum simplex (Meyen) Lemm.	**	-	*	***Dinophyceae***			
Pediastrum tetras (Ehre) Ralf.	*	*	**	*Ceratium hirundinella* (O. F. Muell) Dujardin.	**	*	**
Scenedesmus abundans Chodat.	**	*	**	*Ceratium teridenella*.	*	*	-
Scenedesmus acuminatus (Lag) Chodat.	*	*	-	***Euglenophyceae***			
Scenedesmus bijuga var. bijuga (Turp) Lagerheim.	**	**	**	*Euglena acus* Ehr.	***	***	**
Scenedesmus dimorphus (Turp) Kuetz.	**	*	*	*Euglena sociabilis* Dang.	**	**	*
Scenedesmus obliqus (Turp) Kuetz.	*	-	**	*Phacus curvicauda* Swir	**	-	*
Scenedesmus quadricauda (Turp) Breb.	**	**	*	*Phacus ranula* Pochm.	*	*	*
Scenedesmus quadricauda var. Parvus Smith.	**	**	*	*Phacus tortus* (Lemm) skr.	**	*	*
Selenastrum gracile var. Gracile Reinsch.	**	**	*	***Xanthophyceae***			
Selenastrum westii Smith.	*	*	*	*Botryococcus braunii* Kuetz.	*	**	-

- = Absent; * = Rare; ** = Common; *** = Dominant.
St: 1= Station 1; St: 2 = Station 2; St: 3 = Station 3.

Table 3. List of Zooplankton identified from Keenjhar Lake during present studies

	St: 1	St: 2	St: 3		St: 1	St: 2	St: 3
Cladocera				***Ostracoda***			
Alona rectangula Sars.	**	*	-	*Cyclocypris* sp.	**	**	-
Bosminopsis deitersi Richard.	***	***	**	*Cypris* sp.	**	**	**
Bosmina longirostris O. F. Muller.	*	**	**	*Cypria mediana*.	*	*	**
Ceriodaphnia reticulata Jurine.	**	**	*	*Eucypris* sp.	**	*	*
Ceriodaphnia cornuta Sars.	**	**	**	***Rotifera***			
Chydorus eurynotus.	*	*	**	*Brachionus buda pestinensis* Daday.	**	**	-
Chydorus eurynotus brehmi Biswas.	**	*	*	*Brachionus falcatus* Zacharias.	*	*	-
Chydorus ovalis Kuetz.	*	*	*	*Brachionus rubens* Ehrenberg	*	*	*
Chydorus parvuus Daday	**	**	*	*Brachionus quadridentatus* Hermann.	*	-	**
Daphnia sp.	**	***	**	*Euchlanis* sp.	*	*	-
Daphnia lumholtzi Sars.	***	***	**	*Keratella cochlearis* Gosse.	**	**	*
Macrocthrix rosea Jurine.	*	*	**	*Keratella cochlearis* var. tecta Gosse.	**	***	**
Moina sp.	*	*	-	*Keratella tropica* Apstein.	**	**	*
Sida sp.	**	**	*	*Keratella volga* Ehrenberg.	**	**	**
Simocephalus vetulus King.	**	**	*	*Lecane* sp.	*	*	*
Copepoda				*Macrochaetus* sp.	*	-	-
Calonoid copepods.	**	**	*	*Monostyla* sp.	**	*	-
Cyclopoid copepods.	**	**	**	*Mytilina* sp.	*	-	**
Limnoncaea genuine Kokubo.	**	**	*	*Platyias quadricoruns* Ehrenberg.	**	**	**
				Tetramatrix opotiensis.	**	-	*

- = Absent; * = Rare; ** = Common; *** = Dominant.
St: 1= Station 1; St: 2 = Station 2; St: 3 = Station 3.

identified comprising 6 free floating species , 7 attached floating species , 12 submerged aquatic species, and 14 emergent aquatic species during present studies (Table 4).

Prawns

A total of 8 species of prawns were identified comprising 3 species of Palaemonidae and 5 species of Penaeidae during present studies (Table 5).

Fish

In present observation, 30 out of 51 species were the most popular food as well as game fish and posses high economic value. Identified fish including 2 exotic, 2 species comprising each *Clupeidae* and *Notopteridae* family; 19 species belonging to *Cyprinidae* family; 6 species of *Bagridae* family; 2 species comprising each *Siluridae* and *Schilbeidae* family; 1 species comprising *Claridae*; *Heteropneusitidae* and *Belonidae*; 3 species belonging to *Mastacembelidae* family; 2 species comprising each *Chandidae* and *Nandidae* family; 1 species belonging to each *Cichlidae* and *Gobidae* family; 2 species belonging to *Belontidae* family; and 4 species belonging to Channidae family, are given in Table 6.

Discussion

Keenjhar Lake is a significant natural resource. It is a potential source of drinking and irrigation water, and its diverse flora and fauna support important fisheries.

Maximum water temperature recorded during the present study was 32°C in July, a value similar to

Table 4. List of Aquatic plants identified from Keenjhar Lake during present studies

	St: 1	St: 2	St: 3
Azolla pinnata R. Brown *	+	++	+
Ceratophyllum demersum Linnaeus. ***	-	+	+
Cyperus difformis Linnaeus. ****	+	+	++
Cyperus longus Linnaeus ****	+	++	+
Cyperus rotundus Linnaeus ****	+	-	+
Equisetum debile Roxb ****	+	++	+
Echinochloa oryzoides Arduino Fritsch. **	+	+	-
Fimbristylis aestivalis (Linn.) Vahl ****	+	-	+
Hydrilla verticillata Linnaeus Royle ***	++	+	+
Ipomoea aquatica Forsskal **	+	+	+
Lemna gibba Linnaeus *	+	-	+
Lemna minor Linnaeus *	+	+	++
Marsilea minuta Linnaeus **	++	+	++
Marsilia minuta Linnaeus ****	+	+	-
Myriophyllum spicatum Linnaeus. ***	+	++	+
Nymphoides hydrophylla Loureiro Kutz. **	+	+	-
Najas indica Willdenow Chanisso. ***	+	-	+
Najas minor Ailioni. ***	+	+	+
Nelumbo nucitera Gaertner. **	+	+	++
Nymphaea louts Linnaeus. **	++	++	++
Pharagmites vallatoria P. Commnuis. ****	+	+	++
Phyla nodiflora Linnaeus Greene. ****	+	+	+
Pistia stratiotes Linnaeus *	++	+	-
Polygonum barbatum Linnaeus. ***	-	+	+
Potamogetons crispus Linnaeus. ***	++	++	+
Potamogetons indicus Roxburgh. ***	+	+	-
Potamogetons nodosus Poiret. ***	++	+	++
Potamogetons natans Linnaeus. ***	+	++	+
Potamogetons pectinatus Linnaeus. ***	+	+	+
Salvinia molesta Micheal *	+	+	++
Schoeno grossus (L. F. Palalla) ****	+	-	+
Schoenoplectus juncoides (Rox) Palle ****	+	+	+
Scirpus articulatus (L.) Palla ****	+	+	-
Scirpus litoralis Vahl. ****	+	-	+
Typha domingenis Persoon. ****	+	+	++
Typha elephantina Roxburgh. ****	+	+	+
Utricularia australis R. Brown **	+	++	+
Vallisneria spiralis Linnaeus ***	++	+	+
Zannichellia palustris Linnaeus. *	-	+	+

* Free floating, ** Attached floating, *** Sub-merged aquatic, **** Emergent aquatic.
– Absent, + Present, ++ Dominant.
St: 1= Station number 1, St: 2= Station number 2 and St: 3= Station number 3.

Table 5. List of Prawns identified from Keenjhar Lake during present studies

	St: 1	St: 2	St: 3
Palaemonidae			
Macobrachium lamarei. (M. Edward).	**	**	*
Macobrachium malcomsonii. (M. Edward).	*	*	**
Macobrachium rosenbergii. (de. Man).	***	**	**
Metapenaeus brevicornis (M. Edward).	*	*	*
*Parapenaeopsis stylifera (*M. Edward).	-	*	*
Penaeus indicus. (M. Edward).	**	*	-
Penaeus japonicus (Bate).	*	*	**
Penaeus merguiensis. (de. Man).	*	*	*

- = Absent; * = Rare; ** = Common; *** = Dominant.
St: 1= Station 1; St: 2 = Station 2; St: 3 = Station 3.

Table 6. List of Fishes identified from Keenjhar Lake during present studies
Systematic Account of Fishes: -

SUPER CLASS	GNATHOSTOMATA.		
CLASS	ACTINOPTERYGII.	FAMILY	SCHILBEILIDAE.
SUB CLASS	NEOPTERYGII.	SUB FAMILY	SCHILBEINAE.
INFRA CLASS	TELEOSTEI.	32. *Clupisoma garua* (Hamilton).	
SUPER ORDER	CLUPEOMORPHA.	33. *Eutropiichthys vacha* (Hamilton).	
ORDER	CLUPEIFORMES.	FAMILY	CLARIIDAE.
FAMILY	CLUPEIDAE.	34. *Clarias batrachus* (Linnacus).	
1. *Gudusia chapra* (Hamilton).		FAMILY	HETEROPNEUSTIDAE.
2. *Gudusia variegata* (Day).		35. *Heteropneustes fossilis* (Bloch).	
SUPER ORDER	OSTEOGLOSSOMORPHA.	SUPER ORDER	ACANTHOPTERYGII.
ORDER	OSTEOGLOSSIFORMES.	ORDER	BELONIFORMES.
FAMILY	NOTOPTERIDAE.	SUB ORDER	BELONOIDEI.
3. *Chitala chitala* (Hamilton).		FAMILY	BELONIDAE.
4. *Notopterus notopterus* (Pallas).		36. *Xenentodon cancila* (Hamilton).	
SUPER ORDER	OSTARIOPHYSI.	ORDER	SYNBRANCHIFORMES.
ORDER	CYPRINIFORMES.	SUB ORDER	MASTACEMBELOIDEI.
FAMILY	CYPRINIDAE.	FAMILY	MASTACEMBELIDAE.
SUB FAMILY	BARBINAE.	SUB FAMILY	MASTACEMBELINAE.
5. *Catla catla* (Hamilton).		37. *Macrognathus oral* (Bloch).	
6. *Cirrhinus mrigala* (Hamilton).		38. *Mastacembellus armatus* (Lecepede).	
7. *Cirrhinus reba* (Hamilton).		39. *Mastacembellus pancalus* (Hamilton).	
8. *Labeo bata* (Hamilton-Buchanan).		ORDER	PERCIFORMES
9. *Labeo calbasu* (Hamilton).		SUB ORDER	PERCOIDEI
10. *Labeo fimbriatus* (Bloch).		FAMILY	CHANDIDAE
11. *Labeo gonius* (Hamilton).		40. *Ambassis nama* (Hamilton).	
12. *Labeo rohita* (Hamilton).		41. *Ambassis ranga* (Hamilton).	
13. *Labeo sindensis* (Day).		FAMILY	NANDIDAE
14. *Osteobrama cotio* (Day).		SUB FAMILY	BADINAE
15. *Puntius ticto* (Hamilton).		42. *Badis badis* (Hamilton).	
16. *Puntius stigma* (Hamilton).		SUB FAMILY.	NANDINAE
17. *Systomas sarana* (Hamilton).		43. *Nandus nandus* (Hamilton).	
SUB FAMILY	CYPRININAE.	SUB ORDER.	LABROIDEI
* 18. *Cyprinus carpio* (Linnaeus).		FAMILY	CICHLIDAE.
SUB FAMILY.	RASBORINAE	* 44. *Oreochromis mossambicus* (Peters).	
19. *Chela laubuca* (Hamilton).		SUB ORDER.	GOBIOIDEI
20. *Devario devario* (Hamilton).		FMAILY	GOBIIDAE
21. *Esomus danricus* (Hamilton).		SUB FAMILY	GOBIINAE
22. *Rasbora daniconius* (Hamilton).		*Glossogobius giuris* (Hamilton).	
23.*Salmophasia bacaila* (Hamilton).		FAMILY	BELONTIDAE
ORDER	SILURIFORMES.	SUB FAMILY	TRICHOGASTERINAE.
FAMILY	BAGRIDAE.	46. *Colisa faciata* (Schneider).	
SUB FAMILY	RITINAE.	47. *Colisa lalius* (Hamilton).	
24. *Rita rita* (Hamilton).		ORDER	CHANNIFORMES.
SUB FAMILY	BAGRINAE.	SUB ORDER	CHANNOIDEI.
25. *Mystus bleekeri* (Day).		FAMILY	CHANNIDAE.
26. *Mystus cavasius* (Hamilton).		48. *Channa gachua* (Hamilton).	
27. *Mystus gulio* (Hamilton).		49. *Channa marulius* (Hamilton).	
28. *Mystus vittatus* (Bloch).		50. *Channa punctata* (Bloch).	
29. *Sperata seenghala* (Sykes).		51. *Channa striata* (Bloch).	
FAMILY	SILURIDAE.		
30. *Ompok pabda* (Hamilton).			
31. *Wallago attu* (Schneider).			

***** Exotic fishes identified from Keenjhar Lake.

those reported by Siddiqui *et al.* (1973) and Baquai *et al*. (1974) for Keenjhar Lake district Thatta, by Sahato *et al*. (1997) for Phoosna Lake district Badin, by Leghari *et al*. (1997) for Bakar Lake district Sanghar. Minimum temperature was 21°C in January, consistent with the result of Leghari *et al*. (2000) for Makhi Lake district Sanghar.

Maximum transparency was 85 cm in August and minimum 36 cm in January during the present study The results were consistent with those of Baquai *et al*. (1974a) for Keenjhar Lake, district Thatta. It was observed during the present study that inlet of the lake was always laden with silt and clay, making the water very turbid and thus reducing light penetration. Silt gives the advantage that it checks light penetration in certain areas of the lake, including the inlet, thus limiting the growth of larger aquatic plants. Due to limited light penetration, the process of photosynthesis is checked by slit. Keenjhar Lake was observed to be more turbid during spring, summer and autumn compared with Bakar, Makhi, Haleji, Phoosna, Sonharo, Mehro, Pateji, and Cholri Lakes of Sindh province, owing to bathing and boating activities.

Dissolved oxygen reached a maximum of 9.5 mg L^{-1} in December and a minimum of 7.1 mg L^{-1} in July. These results are identical to those reported by Leghari *et al*. (1997) for Bakar Lake district Sanhar, by Leghari *et al*. (2000) for Sonharo, Mehro, Pateji, and Colri Lakes district Badin, and by Leghari *et al*. (2005) for Makhi Lake district, Sanghar.

Maximum and minimum conductivity were 320 µS cm^{-1} in January and 142 µS cm^{-1} in July. Fluctuation of conductivity was observed to be higher during winter at certain stations. In summer, the situation was reversed.

Keenjhar Lake was observed to be fresh water during the present study because of continuous flow of water (from Sunheri inlet, with its water source through the Kalri Bhaggar feeder from River Indus, to Khumbo outlet of lake). The maximum salinity was 0.3‰ from March until June, from September until October, while the minimum salinity was 0.05 ‰ in February. These results are identical to those reported by Sahato *et al*. (1997) for Phoosna Lake district, Badin.

Maximum dissolved solids were 390 mg L^{-1} in July, and minimum of 190 mg L^{-1} occurred in January. These concentrations were suitable for the growth of aquatic fauna and flora. Minimum values were higher than those reported by Jahangir *et al*. (2000) from Keenjhar and Haleji Lake district, Thatta, while maximum values were similar.

Maximum pH was 8.8 in January and minimum 7.4 in September; the pH fluctuations in Keenjhar Lake are attributable to discharge of fuel from boats and domestic sewage. The range of pH was identical to that reported by Jahangir *et al*. (2000) for Keenjhar and Haleji Lake district Thatta, and by Leghari *et al*. (2005) for Makhi Lake district, Sanghar.

Alkalinity in Keenjhar Lake was found to be within the tolerance limits regarding aquatic biota during present study. Maximum alkalinity was 287 mg L^{-1} in February, and minimum was 165 mg L^{-1} in July. The alkalinity was observed to increase steadily from summer to winter. Higher values were above the range reported by Sahato and Arbani (1997) for ponds of Chilya district Thatta.

Maximum chloride concentration was 220 mg L^{-1} in May, and minimum was 80.8 mg L^{-1} in October. Maximum concentrations were lower and the minimum concentrations higher than those reported by Jahangir *et al*. (2000) for Keenjhar and Haleji Lake. However, all values during present study were lower than those reported by Leghari *et al.* (2000) for Sonharo, Mehro, Pateji, and Cholri Lakes district Badin.

Maximum hardness was 370 mg L^{-1} in September, and minimum was 120 mg L^{-1} in January. These values are higher than those observed by Jahangir *et al*. (2000) at Keenjhar and Haleji Lake district Thatta. Peak values of hardness were found in summer 370 mg L^{-1} in September, 355 mg L^{-1} in August, 335 mg L^{-1} in July and 300 mg L^{-1} in June. High values in summer might be due to bathing activities. In winter the values were lower.

Physicochemical properties of Keenjhar Lake were within tolerance limits for growth of aquatic fauna and flora and stocking of fish.

142 species of phytoplankton recorded during present study are fewer than reported by Leghari *et al.* (1997 and 1999) from Bakar Lake and Chotiari Reservoir district, Sanghar and Jahangir *et al.* (2000) from Haleji and Keenjhar Lake, but they are more than reported by Sahato and Lashari (2003) from the River Indus at Kotri Barrage. *Spirogyra*, *Oedegonium*, *Zygnema*, *Ulothrix*, *Mougeotia*, *Cladophora*, and diatoms were recorded previously Siddiqui *et al.* (1973) from Keenjhar Lake. During the present study a great diversity of phytoplankton and algae resulted from the supply of nutrients like phosphate and nitrate in source water from the River Indus through Kalri Bhaggar feeder. Nutrients are a basic requirement for aquatic productivity and play a key role in aquatic ecosystems.

Thirty-seven species of zooplankton were identified during the present study, more than reported by Leghari *et al.* (1999) from Chotiari Reservoir district Sanghar or by Lashari *et al.* (2001) from Keenjhar Lake district Thatta. Zooplankton is essential food items of fish. *Cladocera*, *Daphnia* spp., *Simocephalus* spp., *Chydorus* spp., *Bosmina coregoni*, *Moina* spp., *Daphnia lumholtzi* spp., *Macrothrix rosea*, *Alona* spp., and *Alonella* spp., previously reported by Siddiqui *et al.* (1973). There is now an increased number of zooplankton species in Keenjhar Lake.

Thirty-nine species of aquatic plants were identified from Keenjhar Lake during the present study, more than those observed by Leghari *et al.* (1999) in Chotiari Reservoir district, Sanghar, by Leghari *et al.* (2000) in lakes of district Badin, and by

Jahangir *et al.* (2000) in Keenjhar and Haleji Lake district, Thatta. *Hydrilla verticellata*, *Najas indica*, *Myriophyllum spicatum*, *Potamageton* spp. (3 species), *Vallisneria spiralis*, *Ceratophyllum demersum*, *Eichornia speceosa*, *Chara* spp., *Typha angustata*, *Scirpus* spp., and *Cyperus difformis* have been previously reported from Keenjhar Lake Siddiqui *et al.* (1973).

Prawns of families *Palaemonidae* and *Atyidae* have been previously reported by Keenjhar Lake Siddiqui *et al.* (1973). Eight species of family *Penaeidae* were reported by Leghari *et al.* (2000) from the Lakes of Badin. During present study similar numbers but dissimilar species of prawns were identified, more than those of earlier studies conducted from Keenjhar Lake.

Sufi (1957) recorded 33 fish species representing 24 genera and 14 families. Ahmed (1962) recorded 39 fish species, and Siddiqui *et al*. (1973) 46 fish species from similar water body. Fifty-one fish species were identified during present study, more than those reported in previous studies. A further increase in fish diversity over next few years may be possible.

Among identified fish species from Keenjhar Lake, 13.74%, 40.05% and 39.21% were omnivorous, carnivores and planktivores fish respectively. Keenjhar Lake is eutrophic lake, rich in plant nutrients and thus high productivity, which produce high number of phytoplankton and relatively high numbers of zooplanktons. This provides high nutritional diet to fish, which bears good growth rates. The productivity of Keenjhar Lake is affected by physicochemical parameters among prominent parameters are pH, temperature and dissolve oxygen.

Conclusion

The physicochemical properties of Keenjhar Lake were within tolerance limits; no excessive value was recorded during study period. Therefore, the water of Keenjhar Lake is suitable for irrigation, for drinking if purified and for the growth of aquatic fauna and flora. No parasitic or fungal infection was found on prawns or aquatic plants or even on fish of Keenjhar Lake during present study.

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