

EFFECTS OF ENVIRONMENTAL POLLUTION ON AQUATIC VERTEBRATES AND INVENTORIES OF HALEJI AND KEENJHAR LAKES: RAMSAR SITES

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ABSTRACT

In the present study, the effects of environmental pollution on aquatic vertebrates of two Ramsar Sites viz. Haleji and Keenjhar Lakes were noted and inventories of the vertebrate fauna were prepared during 2006-2009. In the water samples taken from Haleji Lake, the pesticides of organophosphate (OP) and organochlorine (OC) groups were estimated above the Maximum Acceptable Concentrations (MAC). These concentrations were much higher in muscles and fat contents than other tissues of birds. All water samples from Keenjhar Lake found contained pesticides below the MAC level. The analysis revealed that KB Feeder Canal is the major source of pollution to Keenjhar Lake. The depletion of Dissolved Oxygen indicated organic pollution harmful for aquatic biodiversity. A total of 22 species of mammals, 228 species of birds, 32 species of reptiles, 2 species of amphibia, 37 species of fishes and 33 species of plants were recorded from Haleji Lake, while, 25 species of mammals, 121 species of birds, 29 species of reptiles, 2 species of amphibia, 54 species of fishes and 258 floral species were recorded from the Keenjhar Lake. The biodiversity of Haleji Lake is on decline due to many environmental and anthropological factors. In Keenjhar Lake, the number of water birds visiting the lake during migratory season has fallen considerably mainly due to hunting, disturbance and habitat degradation. There are also problems of increasing pollution and resulting eutrophication.

Keywords: Wetlands of Sindh, Ramsar Sites, aquatic vertebrates, inventories.

INTRODUCTION

Natural wetlands of Pakistan are disappearing due to increased urbanization, expansion of agriculture, irrigation systems and drainage systems.

The biodiversity of Sindh is unique due to presence of various ecosystems and diverse range of landscapes including deserts, wetlands, riverine and mangrove forests, agriculture, and coastal areas. Sindh is located on the Central Asian Flyway which provides many ideal habitats for several migratory species of birds.

Thatta District is very important due to its wetlands, wildlife protected areas and cultural heritage sites. The two study sites i.e. Haleji and Keenjhar Lakes are located in this district (Fig. 1).

Haleji Lake

It is located at 067° 46'E and 24° 47'N with 60m elevation from sea level. The lake is spread in an area 6.58km² (1,704ha) with level of water about 1-1.5m and maximum depth about 5-6m. The area is silty, muddy and sandy. The Lake is situated at a distance of 21km from Thatta and 88km from Karachi. It is a perennial freshwater lake with associated marshes and adjacent brackish seepage lagoons, set in stony desert of limestone and sandstone bedrocks. This Lake was a saline lagoon and in late 1930s

it was converted into reservoir to provide an additional supply to Karachi. It is a homeland to a number of important fauna especially birds. The area is also important for Marsh Harrier, Pallas's Fishing Eagle, Monitor Lizards and Fishes.

Haleji Lake with its surrounding lagoons provides an important wintering and staging site for a number of waterbirds, including Coots and Ducks, and it is also a breeding site for many birds like Egrets and Herons, Cotton Teal (upto 55), Spotbill Duck (upto 60), Purple Moorhen (upto 1,470) and Pheasant-tailed Jacana (upto 850). Marshes of the area host as roosting sites to some thousand Night Herons.

The Sindh Wildlife Department maintains a Captive Breeding Centre at the lake in which Hog Deer (*Axis porcinus*), Marsh Crocodile (*Crocodylus palustris*), Smooth-coated Otter (*Lutrogale perspicillata*), Mallard (*Anas platyrhynchos*) and Pea Fowl (*Pavo cristatus*) are kept.

Keenjhar Lake

Keenjhar Lake is located at 68° 03'E and 24° 56'N. It is one of the largest lakes of Pakistan with an area 13,468ha and supplies water to the villages around the lake, and to Karachi city, Keti Bunder and Thatta. It is a perennial freshwater lake fed by River Indus. The lake is located at

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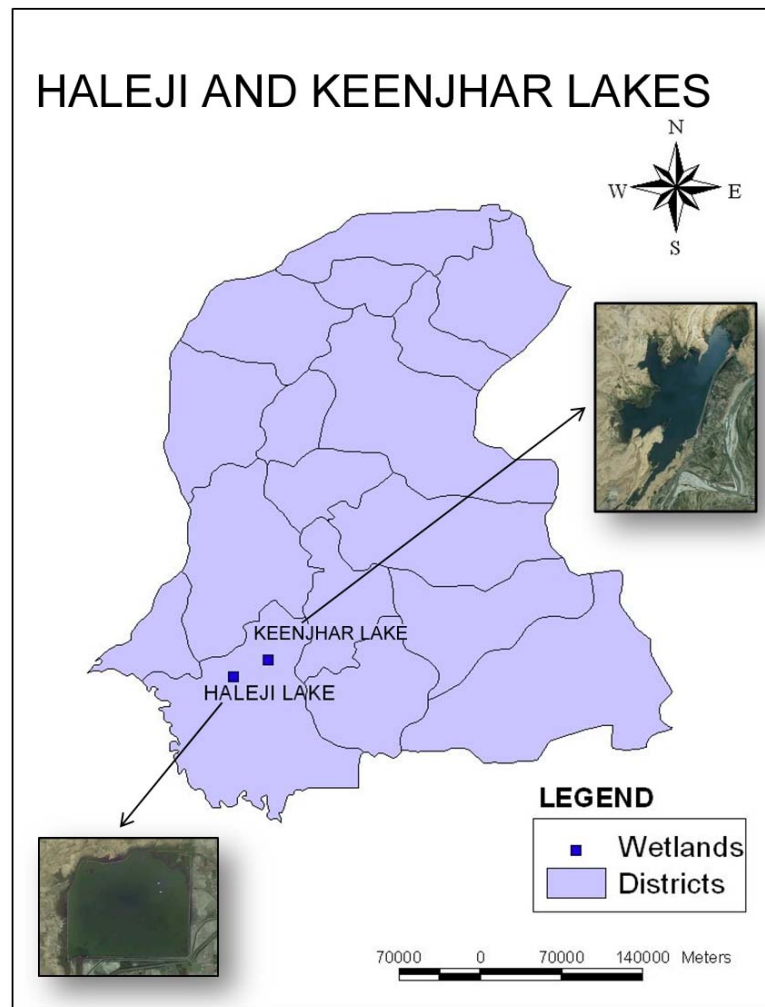


Fig. 1. Map of Sindh province, showing location of Haleji and Keenjhar Lakes.

about 19km North and North-East of Thatta town at a distance of 113km from Karachi city. The lake is associated with adjacent brackish seepage lagoons and marshes which are in a stony desert. It was made in 1930s by the joining of Keenjhar and Kalri Lakes, because of the construction of Chiliya Bangla dam and bunds of 12 km along the east side of the lake. Many small seasonal streams also feed the lake. KB Feeder canal is the main source of water supply to the lake and enters the lake from northwestern corner of lake area. The lake has only one outlet through Jam branch canal towards northern and western parts.

The Lake provides a number of natural resources in which fishing is considerably important because most of the 50 villages nearby are either partially or fully dependent on the lake. Thus, around 35-40,000 people are dependent on the lake.

The area has a great importance as roosting, wintering and breeding site for a number of resident and migratory

birds. Night Heron (*Nycticorax nycticorax*), Cotton Teal (*Nettapus coromandelianus*), Pheasant-tailed Jacana (*Hydrophasianus chirurgus*) and Purple Moorhen (*Porphyrio porphyrio*) are some of the important breeding birds of this lake although Cotton Teal has disappeared in the recent years. It is also an important area for the game birds such as Grey Partridge (*Francolinus pondicerianus*) and Chestnut-bellied Sandgrouse (*Pterocles exustus*). Fishing Cat (*Prionailurus viverrinus*), Smooth-coated Otter (*Lutrogale perspicillata*), Cotton Teal (*Nettapus coromandelianus*), Pallas's Fishing Eagle (*Haliaeetus leucorhynchus*), Indian Monitor Lizard (*Varanus bengalensis*) and Spiny-tailed Lizard (*Saara hardwickii*) are the key species of the area.

A small patch of Mangrove trees of *Avicinia marina* also exists near the lake area and used by locals as fodder for the camels. Hilaya Forest is also located near the eastern bank of the lake which is under severe logging pressure by the nearby communities.

The published work relating to the biodiversity of these two wetlands and/ or its biological and environmental studies includes the following: Ali and Ripley (1987), Ahmad and Khan (1974), Ashraf and Jaffar (1990), Ashraf *et al.* (1991, 1992), Baqai and Rehana (1973), Baqai and Siddiqui (1973), Baqai *et al.* (1974a,b), Condor (1977), Durrane and Khan (2008), Ghalib *et al.* (1981), Ghalib and Bhaagat (2004), Ghalib *et al.* (2004, 2006), Ghalib and Nawaz (2008), Ghalib *et al.* (2009), Grimmett *et al.* (1998, 2008), Ghani (1975), IFAP (2007, 2009), IUCN (2004), Jaffar *et al.* (1988), Jafri *et al.* (1999), Javed and Rehman (2004), Jalbani (2009), Jehangir *et al.* (2000), Karim (1985), Kazmi *et al.* (2006), Khan (2004, 2005), Khan and Ghalib (2006), Khan and Haleem (1986), Khan *et al.* (2010, 2012), Khanum and Ahmad (1990-1991), Korai *et al.* (2008a,b), Lashari *et al.* (2001, 2009), Mahar *et al.* (2010), Mirza (2001, 2007), Nazneen (1994, 1980), Nazneen and Begum (1992), Qureshi (1965), Rais *et al.* (2009), Rais and Abbas (2010), Rahman and Javed (2004), Roberts *et al.* (1986), Roberts (1991, 1992, 1997, 2005a,b), Sahato *et al.* (2004), Saqib *et al.* (1990-91a,b, 2003), Saqib *et al.* (2005), Scott (1989), Scott and Poole (1989), Sheikh and Molur (2005), Siddiqui *et al.* (1973, 1990), Siddiqui and Saqib (1993) and Siddiqui (1998).

There are several factors that can adversely affect and change biodiversity within aquatic ecosystems. Aquatic biodiversity may decrease due to pollution, fragmentation, habitat destruction, or the introduction of an invasive species. In many countries, anthropogenic activities have lead to aquatic organisms being at a higher risk for extinction compared to terrestrial mammals, water birds and amphibians (Ali *et al.*, 2011). The objective of the present study was to investigate the effects of environmental pollution on aquatic vertebrates and preparation of the inventories of the two Ramsar Sites, Haleji and Keenjhar Lakes.

MATERIALS AND METHODS

Study Areas

After baseline study, some important areas were selected for the study as shown in tables 1 and 2.

Methodology of Physico-chemical Samples Collection and Analysis

During the study from 2006- 2009, conductivity meter was used for the estimation of conductivity, Total Dissolved Solids, Turbidity, Salinity, and pH was recorded by pH meter, Alkalinity, Carbon dioxide and Phosphates were examined by the process of Acid Base Titration (Titrimetric methods), Total Hardness, Calcium, Magnesium and Chloride were analyzed by using EDTA (Complexometric Titration), Basic Oxygen Demand was examined by Incubation Method-Redox Titration, while Sulphate was analyzed by Gravimetric method, Nitrate

was analyzed by Brucine Colorimetric Method and Cadmium, Chromium, Lead and Nickel were analyzed by atomic absorption Spectro-photometric Method.

Table 1. Main wildlife habitats in Haleji Lake area.

S. No.	Name of study area	Co-ordinates
1.	Main Lake	24 47. 243 N 067 45. 421 E
2.	Near Information Centre	24 47 12.2 N 67 47 24.0 E
3.	Near Rest Houses	24 49.161 N 67 46 .171 E 24 47. 446 N 67 44 .940 E
4.	Seepage Lagoon/Villages	24 49 19.3 N 67 45 36.7 E
5.	Near Regulator	24 49 19.3 N 67 47 58.0 E

Table 2. Main wildlife habitats in Keenjhar Lake area.

S. No.	Name of study area	Co-ordinates
1.	Reservoir area	24 54 .40 N 68 04 .21 E
2.	Daulatpur	24 55 .36 N 68 01 .55 E
3.	Moldi	24 58 .06 N 68 01. 38
4.	Sonehri	25 01 .067 N 68 07 .877 E
5.	Jhimpir	25 02 .163 N 68 05 .740 E
6.	Garhi Mai or Fossil Valley	24 54 .486 N 68 01 .348 E
7.	Chilia	24 50 190 N 68 00 081 E
8.	Adam Bhambhro Village	24 51 .102 N 67 59. 761 E
9.	Chull Area	25 03 55.6 N 68 07 45.6 E
10.	Garho Pir /Garho Shah	24 55. 942 N 68 02. 640 E
11.	Main Lake Area	24 54 990 N 68 04 387 E 24 58 .378 N 68 05 .566 E 24 58 7465 N 68 05 .578 E 24 54 .657 N 68 06 .501 E 25 06 .628 N 68 07 .636 E
12.	Chakro	24 01 69.6 N 68 02 06.0 E
13.	Jhol Lake	24 50 988 N

		67 5885.6 E
14.	Amir Peer (Drainage inlet into the lake)	25 00 24.6 N 68 05 24.5 E
15.	K.B. Feeder Canal	25 02 21.7 N 68 07 55.2 E

Methodology for Faunal Surveys

Survey of Mammals

For large and medium size mammals, several direct and indirect methods were used such as roadside counts, counts of tracks, footprints, burrows, pellet counts, point surveys and line transects. One effective way to survey small mammals is active searching, particularly during the daytime. This method is equally applicable to both nocturnal and diurnal species, particularly in potential and suitable microhabitats along the canal banks, open plains, bushy areas and agriculture fields. Active searching is very effective for inventory of *Gerbillus*, *Meriones*, *Hystrix*, and *Hemiechinus spp.*

For small mammals, active searching, traps and trapping procedure were used. Specifically, Sherman traps were used to collect the live specimens of rodents.

Survey of Birds

Each major habitat type in the study area was first identified and surveys were made to record the species of birds found in each discrete habitat such as lakes, canals, ponds, marshes, forest, agriculture fields, vicinity of human habitation and fallow lands. The number of birds observed in each habitat type was also recorded with particular emphasis on the key species and to relate the data to other components of the study area such as vegetation, water and soil etc.

Line transects method was used as the most common field method. It is based on recording birds continually along a predefined route within a predefined survey unit. This method is suitable for extensive, open and uniform habitats and for large and conspicuous species.

Survey of Reptiles and Amphibians

Various methods were employed for observation of reptiles and amphibians.

A: Direct Counting:

In direct counting method, one-hour plot searching, use of pitfall traps, spot lighting or night observations, turning of stones, rock and rotten trees and study of basking behavior were used for searching and observing reptiles and amphibians.

B: Indirect Counting

Indirect counting method was also used for counting and observing reptiles and amphibians including presence of

signs like faecal pellets, tracks, den or tunnels (egg laying excavation), evidences from the impression of finger or foot prints, or tail assisted in determining the existence, range and rough population of reptilian fauna.

Fish Collection Methodology

The methods used for obtaining the representative sample of fish species are the gill netting and cast netting.

Gill Netting

Three nets each measuring 15m length with mesh size 2.5x2.5cm and 1.5x1.5cm were used for gill netting. The gill nets were used in the morning.

Cast Netting

Cast nets with known circumference were casted in a stretch of 200m. Five cast nets were used on a line at different stations along the bank of the reservoir. Fish species were collected and identified and released after identification.

RESULTS

In the present study, the environmental impacts of factors such as pollution have been assessed. In addition, inventories of mammals, birds, reptiles, amphibians, fish and plants of the two lakes have been prepared.

Haleji Lake

Physico-chemical Parameters

Several physico-chemical parameters were analyzed to determine water quality of both lakes. Temperature, Conductivity, Total Dissolved Solids, pH, Turbidity, Alkalinity, Total Hardness, Salinity, Basic Oxygen Demand, Carbon dioxide, Magnesium, Sulphates, Chloride, Calcium, Nitrate, Phosphates, Cadmium, Chromium, Lead and Nickel were selected for the analysis of water quality, and parameters were analyzed seasonally.

Aquatic biodiversity is sensitive to changes in water temperature. Temperature is an important water quality parameter and is relatively easy to measure, during the studies, water temperature in pre-monsoon observed from 27 to 33°C, while in post monsoon it varied from 24 - 30°C. The air temperature in pre-monsoon recorded from 26 - 36°C, while in post monsoon it varied from 27 - 31°C. Conductivity varied from 390 - 1820mg/l, TDS varied from 190 - 1520mg/l. The pH of water can provide information about several chemical and biological processes and provides indirect correlations to a number of different impairments, here pH ranged from 6.2 - 8.2, turbidity ranged from 2.0 - 8.0NTU, alkalinity ranged from 39 - 132mg/l, total hardness recorded from 81-153mg/l, salinity from 0.5 - 2.02mg/l, Basic Oxygen Demand from 4.2mg/l - 6.78mg/l, Carbon dioxide from 1 - 2mg/l, Calcium from 43 - 82mg/l, the range of

Magnesium was recorded from 39 - 72mg/l, Chloride ranged from 39.6 - 122mg/l, range of Nitrates was 0.13 - 1.09mg/L, range of Phosphates from 0.012 - 0.63mg/l, range of Cadmium varied from 0.00 - 0.021mg/l, Chromium from 0.00 to 0.07mg/l, Lead from 0.00 to 0.01mg/l, and Nickel recorded from 0.2 - 0.6mg/l (Table 3).

Bioecological Studies

Based on field surveys during the study, 22 mammalian species, 228 species of birds, 32 reptilian species, 2 species of amphibians and 37 species of fishes were recorded (Tables 4-8).

Status of Various Species

Mammals

Table 3. Water Quality Analysis of Heleji Lake during 2006-2009.

Parameters	Haleji Lake							
	Average Pre-monsoon				Average Post-monsoon			
	2006	2007	2008	2009	2006	2007	2008	2009
Colour	A	A	A	A	A	A	A	A
Odour	O	O	O	O	O	O	O	O
Water Temperature (°C)	31.33	27.67	29.00	31.67	15.67	16.67	16.33	15.00
Air Temperature (°C)	33.67	28.67	32.00	34.33	18.67	19.67	19.67	18.33
Conductivity (µS/cm)	960.00	846.67	913.33	910.00	960.00	960.00	1066.67	1006.67
TDS (mg/l)	456.33	408.33	438.33	422.00	896.67	820.00	885.00	713.33
pH	7.33	7.42	7.44	7.57	7.51	7.41	7.48	7.74
Turbidity (NTU)	2.92	2.53	2.58	2.33	7.71	7.34	6.94	7.15
Alkalinity	123.33	118.00	120.33	114.00	40.00	40.67	40.33	42.33
Total Hardness (mg/l)	146.33	142.33	147.00	142.67	114.67	98.00	128.67	101.33
Salinity (mg/l)	1.82	1.77	1.46	1.79	0.66	0.64	0.65	0.57
BOD (mg/l)	5.38	5.24	4.70	5.38	6.05	6.16	6.11	6.01
Carbon dioxide (mg/l)	1.33	1.67	1.67	1.33	1.33	2.00	1.67	1.00
Calcium (mg/l)	76.67	70.67	75.00	79.67	48.00	44.33	43.67	43.67
Magnesium (mg/l)	55.33	50.33	57.67	57.33	70.67	64.33	42.00	62.67
Sulphates (mg/l)	20.00	20.00	18.33	18.67	119.00	132.67	62.67	116.33
Chloride (mg/l)	41.97	44.43	46.00	47.87	114.67	120.00	123.67	103.67
Nitrates (mg/l)	0.66	0.72	0.65	0.79	0.50	0.51	36.07	0.52
Phosphates (mg/l)	0.05	0.05	0.05	0.05	0.02	0.01	0.55	0.02
Cadmium (mg/l)	0.00	0.00	0.00	0.02	0.01	0.01	0.55	0.02
Chromium (mg/l)	0.02	0.04	0.01	0.02	0.05	0.05	0.02	0.02
Lead (mg/l)	0.01	0.01	0.00	0.00	0.00	0.01	0.05	0.01
Nickel (mg/l)	0.23	0.01	0.10	0.28	0.03	0.09	0.01	0.33

Table 4. List of Mammals of Haleji and Keenjhar Lakes.

S. No.	Order/Family	Scientific name	Common name	Haleji	Keenjhar
	Order	Insectivora			
	Family	Ericinaceidae			
1.		<i>Paraechinus micropus</i>	Indian Hedgehog	+	--
2.		<i>Hemiechinus collaris</i>	Long-eared Desert Hedgehog	+	+
	Family	Soricidae			
3.		<i>Suncus murinus</i>	House Shrew	+	--
	Order	Rodentia			
	Family	Hystricidae			
4.		<i>Hystrix cristatus</i>	Indian Crested Porcupine	+	+
	Family	Sciuridae			
5.		<i>Funambulus pennanti</i>	Palm Squirrel	+	+

Continued...

The common species of mammals found in the area were Palm Squirrel (*Funambulus pennanti*), House Mouse

Table 4 continued...

S. No.	Order/Family	Scientific name	Common name	Haleji	Keenjhar
Family	Muridae				
6.		<i>Rattus rattus</i>	Roof Rat	+	+
7.		<i>Mus musculus</i>	House Mouse	+	+
8.		<i>Mus booduga</i>	Little Indian Field Mouse	+	--
9.		<i>Mus saxicola</i>	Grey Spiny Mouse		+
10.		<i>Nesokia indica</i>	Short-tailed Mole Rat	+	+
11.		<i>Meriones hurrianae</i>	Indian Desert Jird	+	+
12.		<i>Tatera indica</i>	Indian Gerbil	+	+
13.		<i>Gerbillus nanus</i>	Balochistan Gerbil	+	+
14.		<i>Bandicota bengalensis</i>	Indian Mole Rat	--	+
Order	Chiroptera				
Family	Megadermatidae				
15.		<i>Hipposideros fulvus</i>	Leaf-nosed Bat	--	+
Family	Vespertilionidae				
16.		<i>Pipistrellus kuhlii</i>	Kuhl's Bat	+	+
Family	Pteropidae				
17.		<i>Rhinopoma microphyllum</i>	Large Mouse-tailed Bat	--	+
Order	Carnivora				
Family	Canidae				
18.		<i>Canis aureus</i>	Asiatic Jackal	+	+
19.		<i>Vulpes bengalensis</i>	Bengal Fox	+	+
20.		<i>Vulpes vulpes</i>	Desert Fox	--	+
Family	Mustellidae				
21.		<i>Lutrogale perspicillata</i>	Smooth-coated Otter		+
Family	Herpestidae				
22.		<i>Herpestes edwardsi</i>	Grey Mongoose	+	+
23.		<i>Herpestes javanicus</i>	Small Indian Mongoose	+	+
24.					
Family	Felidae				
25.		<i>Felis chaus</i>	Jungle Cat	+	+
26.		<i>Felis sylvestris</i>	Indian Desert Cat	+	--
27.		<i>Prionailurus viverrina</i>	Fishing Cat	+	+
Family	Viverridae				
28.		<i>Viverricula indica</i>	Small Indian Civet	+	--
Order	Artiodactyla				
Family	Suidae				
29.		<i>Sus scrofa</i>	Indian Wild Boar	--	+
Order	Pholidata				
Family	Manidae				
30.		<i>Manis crassicaudata</i>	Indian Pangolin	--	+
Order	Lagomorpha				
Family	Leporidae				
31.		<i>Lepus nigricollis</i>	Desert Hare	+	+

Table 5. List of Birds of Haleji and Keenjhar Lakes.

S. No.	Order/Family	Scientific name	Common name	Haleji	Keenjhar
Order	Podicipediformes				
Family	Podicipedidae				
1.		<i>Tachybaptus ruficollis</i>	Little Grebe	+	+
2.		<i>Podiceps cristatus</i>	Great Crested Grebe	+	--

Continued...

Table 5 continued...

S. No.	Order/Family	Scientific name	Common name	Haleji	Keenjhar
Order	Pelecaniformes				
Family	Phalacrocoracidae				
3.		<i>Phalacrocorax carbo</i>	Great Cormorant	+	--
4.		<i>Phalacrocorax fuscicollis</i>	Indian Shag	+	--
5.		<i>Phalacrocorax niger</i>	Little Cormorant	+	+
6.		<i>Anhinga melanogaster</i>	Snake Bird	+	--
Family	Pelecanidae				
7.		<i>Pelecanus onocrotalus</i>	White Pelican	+	--
8.		<i>Pelecanus crispus</i>	Delmatian Pelican	+	--
Order	Ciconiiformes				
Family	Ardeidae				
9.		<i>Ixobrychus sinensis</i>	Yellow Bittern	+	--
10.		<i>Ixobrychus cinnamomeus</i>	Chestnut Bittern	+	--
11.		<i>Dupetor flavicollis</i>	Black Bittern	+	--
12.		<i>Nycticorax nycticorax</i>	Night Heron	+	+
13.		<i>Ardeola grayii</i>	Pond Heron	+	+
14.		<i>Bubulcus ibis</i>	Cattle Egret	+	+
15.		<i>Egretta gularis</i>	Western Reef Heron	+	--
16.		<i>Egretta garzetta</i>	Little Egret	+	+
17.		<i>Egretta intermedia</i>	Intermediate Egret	+	+
18.		<i>Ardea alba</i>	Great White Egret	+	+
19.		<i>Ardea cinerea</i>	Grey Heron	+	--
20.		<i>Ardea purpurea</i>	Purple Heron	+	+
Family	Ciconiidae				
21.		<i>Anastomus oscitans</i>	Openbill Stork	+	--
22.		<i>Ciconia ciconia</i>	White Stork	+	--
Family	Threskiornithidae				
23.		<i>Plegadis falcinellus</i>	Glossy Ibis	+	--
24.		<i>Threskiornis melanocephalus</i>	White Ibis	+	--
25.		<i>Platalea leucorodia</i>	Spoonbill	+	--
Family	Phoenicopteridae				
26.		<i>Phoenicopterus roseus</i>	Greater Flamingo	+	--
Order	Accipitriformes				
Family	Accipitridae				
27.		<i>Elanus caeruleus</i>	Black-winged Kite	+	+
28.		<i>Milvus migrans</i>	Black Kite	+	+
29.		<i>Haliastur indus</i>	Brahminy Kite	+	+
30.		<i>Haliaeetus albicilla</i>	White-tailed Sea Eagle	+	
31.		<i>Haliaeetus leucoryphus</i>	Pallas's Fishing Eagle	+	+
32.		<i>Gyps bengalensis</i>	White-backed Vulture	+	+
33.		<i>Gyps fulvus</i>	Griffon Vulture	--	+
34.		<i>Aegypius monachus</i>	Cinereous Vulture	--	
35.		<i>Circus gallicus</i>	Short-toed Eagle	+	+
36.		<i>Circus aeruginosus</i>	Marsh Harrier	+	+
37.		<i>Circus macrourus</i>	Pallid Harrier	+	--
38.		<i>Accipiter badius</i>	Shikra	+	--
39.		<i>Butastur teesa</i>	White-eyed Buzzard	+	--
40.		<i>Buteo buteo</i>	Desert Buzzard	+	--
41.		<i>Buteo rufinus</i>	Long-legged Buzzard	+	--

Continued...

Table 5 continued...

S. No.	Order/Family	Scientific name	Common name	Haleji	Keenjhar
42.		<i>Aquila clanga</i>	Greater Spotted Eagle	+	+
43.		<i>Aquila nipalensis</i>	Steppe Eagle	+	--
44.		<i>Aquila rapax</i>	Tawny Eagle	+	--
45.		<i>Aquila heliaca</i>	Imperial Eagle	+	--
46.		<i>Hieraaetus pennatus</i>	Booted Eagle	+	--
47.		<i>Hieraaetus fasciatus</i>	Bonelli's Eagle	+	--
Family	Pandionidae				
48.		<i>Pandion haliaetus</i>	Osprey	+	+
Order	Falconiformes				
Family	Falconidae				
49.		<i>Falco tinnunculus</i>	Kestrel	+	+
50.		<i>Falco chiquera</i>	Red-headed Merlin	+	+
Order	Anseriformes				
Family	Anatidae				
51.		<i>Dendrocygna javanica</i>	Lesser Whistling Teal	+	--
52.		<i>Dendrocygna bicolor</i>	Greater Whistling Teal	+	--
53.		<i>Cygnus columbianus</i>	Bewick's Swan	+	--
54.		<i>Anser erythropus</i>	Lesser White-fronted Goose	+	--
55.		<i>Tadorna ferruginea</i>	Ruddy Shelduck	+	--
56.		<i>Tadorna tadorna</i>	Common Shelduck	+	--
57.		<i>Anas acuta</i>	Pintail	+	+
58.		<i>Anas penelope</i>	Wigeon	+	--
59.		<i>Anas crecca</i>	Common Teal	+	+
60.		<i>Anas strepera</i>	Gadwall	+	+
61.		<i>Anas platyrhynchos</i>	Mallard	+	--
62.		<i>Anas querquedula</i>	Garganey	+	--
63.		<i>Anas poecilorhyncha</i>	Spotbill Duck	+	+
64.		<i>Anas clypeata</i>	Shoveller	+	+
65.		<i>Aythya ferina</i>	Common Pochard	+	+
66.		<i>Aythya nyroca</i>	White-eyed Pochard	+	--
67.		<i>Aythya fuligula</i>	Tufted Duck	+	+
68.		<i>Aythya marila</i>	Scaup	+	--
69.		<i>Netta rufina</i>	Red-crested Pochard	+	--
70.		<i>Nattapus coromandelianus</i>	Pygmy Cotton Teal	+	+
71.		<i>Marmaronetta angustirostris</i>	Marbled Teal	+	--
Order	Galliformes				
Family	Phasianidae				
72.		<i>Francolinus francolinus</i>	Black Partridge	+	--
73.		<i>Francolinus pondicerianus</i>	Grey Partridge	+	+
74.		<i>Coturnix coturnix</i>	Common Quail	+	--
Order	Gruiformes				
Family	Rallidae				
75.		<i>Porzana porzana</i>	Spotted Crake	+	--
76.		<i>Amaurornis phoenicurus</i>	White-breasted Waterhen	+	+
77.		<i>Gallinula chloropus</i>	Indian Moorhen	+	+
78.		<i>Porphyrio porphyrio</i>	Purple Moorhen	+	--
79.		<i>Gallix rex cinerea</i>	Watercock	+	--
80.		<i>Rallus aquaticus</i>	Water Rail	+	--
81.		<i>Fulica atra</i>	Coot	+	+
82.		<i>Porzana porzana</i>	Spotted Crake	+	--

Continued...

Table 5 continued...

S. No.	Order/Family	Scientific name	Common name	Haleji	Keenjhar
Family	Gruidae				
83.		<i>Grus grus</i>	Common Crane	+	--
84.		<i>Grus virgo</i>	Demoiselle Crane	+	--
Order	Charadriiformes				
Family	Jacanidae				
85.		<i>Hydrophasianus chirurgus</i>	Pheasant-tailed Jacana	+	+
86.		<i>Metopidius indicus</i>	Bronze-winged Jacana	+	--
Family	Recurvirostridae				
87.		<i>Himantopus himantopus</i>	Black-winged Stilt	+	+
88.		<i>Recurvirostra avosetta</i>	Avocet	+	--
Family	Burhinidae				
89.		<i>Glareola pratincola</i>	Collared Pratincole	+	--
90.		<i>Glareola lactea</i>	Small Indian Pratincole	+	--
Family	Charadriidae				
91.		<i>Charadrius leucurus</i>	White-tailed Lapwing	+	+
92.		<i>Vanellus vanellus</i>	Green Plover	+	--
93.		<i>Vanellus indicus</i>	Red-wattled Lapwing	+	+
94.		<i>Vanellus malabaricus</i>	Yellow-wattled Lapwing	+	--
95.		<i>Pluvialis squatarola</i>	Black-bellied Plover	+	--
96.		<i>Pluvialis dominica</i>	Eastern Golden Plover	+	--
97.		<i>Charadrius dubius</i>	Little Ringed Plover	+	+
98.		<i>Charadrius alexandrinus</i>	Kentish Plover	+	+
Family	Scolopacidae				
99.		<i>Calidris minuta</i>	Little Stint	+	+
100.		<i>Calidris temminckii</i>	Temminck's Stint	+	+
101.		<i>Calidris alpina</i>	Dunlin	+	--
102.		<i>Philomachus pugnax</i>	Ruff	+	--
103.		<i>Gallinago gallinago</i>	Common Snipe	+	+
104.		<i>Limosa limosa</i>	Black-tailed Godwit	+	--
105.		<i>Numenius arquata</i>	Curlew	+	--
106.		<i>Numenius phaeopus</i>	Whimbrel	+	--
107.		<i>Tringa erythropus</i>	Spotted Redshank	+	--
108.		<i>Tringa totanus</i>	Redshank	+	--
109.		<i>Tringa stagnatilis</i>	Marsh Sandpiper	+	+
110.		<i>Tringa nebularia</i>	Greenshank	+	+
111.		<i>Tringa ochropus</i>	Green Sandpiper	+	+
112.		<i>Tringa glareola</i>	Wood Sandpiper	+	+
113.		<i>Tringa hypoleucos</i>	Common Sandpiper	+	+
Family	Laridae				
114.		<i>Larus argentatus</i>	Herring Gull	+	+
115.		<i>Larus heuglini</i>	Heuglin's Gull	+	--
116.		<i>Larus ichthyaetus</i>	Great Black-headed Gull	+	+
117.		<i>Larus brunnicephalus</i>	Brown-headed Gull	+	--
118.		<i>Larus ridibundus</i>	Black-headed Gull	+	+
119.		<i>Larus genei</i>	Slender-billed Gull	+	--
120.		<i>Larus canus</i>	Common Gull	+	--
Family	Sternidae				
121.		<i>Chlidonias hybridus</i>	Whiskered Tern	+	+
122.		<i>Chlidonias leucoptera</i>	White-winged Black Tern	+	--
123.		<i>Gelochelidon nilotica</i>	Gull-billed Tern	+	+

Continued...

Table 5 continued...

S. No.	Order/Family	Scientific name	Common name	Haleji	Keenjhar
124.		<i>Hydropogne caspia</i>	Caspian Tern	+	--
125.		<i>Sterna aurentia</i>	River Tern	+	+
126.		<i>Sterna albifrons</i>	Little Tern	+	+
127.		<i>Sterna acuticauda</i>	Black-bellied Tern	--	+
128.		<i>Sterna bergii</i>	Large Crested Tern	+	--
Family	Rhynchopidae				
129.		<i>Rhychops albicollis</i>	Indian Skimmer	+	--
Order	Columbiformes				
Family	Pteroclididae				
130.		<i>Pterocles exustus</i>	Chestnut-bellied Sandgrouse	+	+
Family	Columbidae				
131.		<i>Columba livia</i>	Blue Rock Pigeon	+	+
132.		<i>Columba eversmanni</i>	Eastern Rock Pigeon	+	--
133.		<i>Treron phoenicoptera</i>	Yellow-legged Green Pigeon	+	--
134.		<i>Streptopelia decaocto</i>	Collared Turtle Dove	+	+
135.		<i>Streptopelia tranquebarica</i>	Red Turtle Dove	+	--
136.		<i>Streptopelia senegalensis</i>	Little Brown Dove	+	+
Order	Psittaciformes				
Family	Psittacidae				
137.		<i>Psittacula krameri</i>	Rose-Ringed Parakeet	+	+
Order	Cuculiformes				
Family	Cuculidae				
138.		<i>Clamator jacobinus</i>	Pied-crested Cuckoo	+	--
139.		<i>Eudynamus scolopacea</i>	Koel	+	+
140.		<i>Centropus sinensis</i>	Greater Coucal or Crow Pheasant	+	+
Order	Strigiformes				
Family	Strigidae				
141.		<i>Otus bakkamoena</i>	Collared Scops Owl	+	--
142.		<i>Bubo bubo</i>	Eagle Owl	+	--
143.		<i>Athene brama</i>	Spotted Owlet	+	--
Order	Caprimulgiformes				
Family	Caprimulgidae				
144.		<i>Caprimulgus asiaticus</i>	Indian Little Nightjar	+	--
145.		<i>Caprimulgus europaeus</i>	European Nightjar	+	--
146.		<i>Caprimulgus mahrattensis</i>	Syke's Nightjar	--	+
Order	Apodiformes				
Family	Apodidae				
147.		<i>Apus affinis</i>	House Swift	+	+
Order	Coraciiformes				
Family	Alcedinidae				
148.		<i>Ceryle rudis</i>	Lesser Pied Kingfisher	+	+
149.		<i>Alcedo atthis</i>	Common Kingfisher	+	+
150.		<i>Halcyon smyrnensis</i>	White-breasted Kingfisher	+	+
Family	Meropidae				
151.		<i>Merops persicus</i>	Blue-cheeked Bee-eater	+	--
152.		<i>Merops orientalis</i>	Green Bee-eater	+	+
Family	Coraciidae				
153.		<i>Coracias garrulus</i>	European Roller	+	--

Continued...

Table 5 continued...

S. No.	Order/Family	Scientific name	Common name	Haleji	Keenjhar
154.		<i>Coracias bengalensis</i>	Indian Roller	+	+
Family	Upupidae				
155.		<i>Upupa epops</i>	Hoopoe	+	+
Order	Piciformes				
Family	Picidae				
156.		<i>Jynx torquilla</i>	Wryneck	+	--
157.		<i>Dinopium bengalensis</i>	Lesser Golden-backed Woodpecker	+	+
158.		<i>Dendrocopos mahrattensis</i>	Yellow-fronted Pied Woodpecker	+	--
Order	Passeriformes				
Family	Alaudidae				
159.		<i>Mirafa erythroptera</i>	Indian/Red-Winged Bush Lark	+	--
160.		<i>Eremopterix grisea</i>	Ashy-crowned Finch Lark	+	+
161.		<i>Eremopterix nigriceps</i>	Black-crowned Finch Lark	--	+
162.		<i>Ammomanes deserti</i>	Desert Finch Lark	+	+
163.		<i>Calandrella cinerea</i>	Yarkan Short-toed Lark	+	--
164.		<i>Galerida cristata</i>	Crested Lark	+	+
165.		<i>Alauda gulgula</i>	Oriental Sky Lark	--	+
Family	Hirundinidae				
166.		<i>Riparia paludicola</i>	Plain Martin	+	+
167.		<i>Hirundo rustica</i>	Barn Swallow	+	+
168.		<i>Hirundo smithii</i>	Wire-tailed Swallow	+	+
169.		<i>Hirundo daurica</i>	Red-rumped Swallow	+	--
Family	Motacillidae				
170.		<i>Anthus rufulus</i>	Paddyfield Pipit	+	+
171.		<i>Anthus campestris</i>	Tawny Pipit	+	+
172.		<i>Anthus trivialis</i>	Tree Pipit	+	--
173.		<i>Motacilla flava</i>	Yellow Wagtail	+	+
174.		<i>Motacilla citreola</i>	Yellow-headed Wagtail	+	--
175.		<i>Motacilla alba</i>	Pied Wagtail	+	+
176.		<i>Motacilla maderaspatensis</i>	White-browed Pied Wagtail	--	+
Family	Campephagidae				
177.		<i>Tephrodornis pondicerrianus</i>	Common Woodshrike	+	--
178.		<i>Pericrocotus cinnamomeus</i>	Wandering Minivet	+	--
Family	Pycnonotidae				
179.		<i>Pycnonotus leucogenys</i>	White-cheeked Bulbul	+	+
180.		<i>Pycnonotus cafer</i>	Red-vented Bulbul	+	+
Family	Turdidae				
181.		<i>Cercotrichas galactotes</i>	Rufous Chat/Rufous-tailed Scrub Robin	+	--
182.		<i>Luscinia svecica</i>	Bluethroat	+	+=
183.		<i>Phoenicurus ochruros</i>	Black Redstart	+	+
184.		<i>Saxicola caprata</i>	Pied Bush Chat	+	--

Continued...

Table 5 continued...

S. No.	Order/Family	Scientific name	Common name	Haleji	Keenjhar
185.		<i>Oenanthe alboniger</i>	Hume's Wheatear	--	+
186.		<i>Oenanthe deserti</i>	Desert Wheatear	+	+
187.		<i>Oenanthe picata</i>	Pied Chat	+	+
188.		<i>Saxicoloides fulicata</i>	Indian Robin	+	+
Family	Sylviidae				
189.		<i>Sylvia nana</i>	Desert Warbler	+	--
190.		<i>Sylvia hortensis</i>	Orphean Warbler	+	--
191.		<i>Sylvia curruca</i>	Lesser Whitethroat	+	+
192.		<i>Sylvia communis</i>	Common Whitethroat	+	--
193.		<i>Cettia cetti</i>	Cetti's Warbler	+	+
194.		<i>Prinia buchanani</i>	Rufous-fronted Long-tailed Warbler	+	--
195.		<i>Prinia gracilis</i>	Streaked Wren Warbler	+	--
196.		<i>Prinia inornata</i>	Plain Prinia	--	+
197.		<i>Prinia flaviventris</i>	Yellow Bellied Long-tailed Warbler	+	+
198.		<i>Prinia burnesii</i>	Long-tailed Grass Warbler	+	--
199.		<i>Orthotomus sutorius</i>	Tailor Bird	+	+
200.		<i>Acrocephalus stentoreus</i>	Clamorous Great Reed Warbler	+	+
201.		<i>Acrocephalus dumetorum</i>	Blyth's Reed Warbler	+	--
202.		<i>Acrocephalus agricola</i>	Paddy-field Warbler	+	+
203.		<i>Hippolais caligata</i>	Syke's Tree Warbler	+	--
204.		<i>Phylloscopus nitidus</i>	Bright Green Leaf Warbler	+	--
205.		<i>Phylloscopus neglectus</i>	Plain Leaf Warbler	+	+
206.		<i>Phylloscopus collybita</i>	Brown Leaf Warbler	+	--
Family	Rhipiduridae				
207.		<i>Rhipidura rhipidura</i>	White-browed Fantail Flycatcher	--	+
Family	Muscicapidae				
208.		<i>Muscicapa striata</i>	Spotted Flycatcher	+	--
209.		<i>Ficedula parva</i>	Red-throated Flycatcher	+	--
210.		<i>Hypothymus azurea</i>	Black-naped Flycatcher	+	--
Family	Timaliidae				
211.		<i>Turdoides caudatus</i>	Common Babbler	+	+
212.		<i>Turdoides earlei</i>	Striated Babbler	+	+
213.		<i>Turdoides striatus</i>	Jungle Babbler	+	+
Family	Nectariniidae				
214.		<i>Nectarinia asiatica</i>	Purple Sunbird	+	+
Family	Dicruridae				
215.		<i>Dicrurus macrocercus</i>	Black Drongo/King Crow	+	+
Family	Laniidae				
216.		<i>Lanius merodionalis</i>	Southern Grey Shrike	+	+
217.		<i>Lanius isabellinus</i>	Isabelline Shrike	+	+
218.		<i>Lanius schach</i>	Rufous-backed Shrike	+	
219.		<i>Lanius vittatus</i>	Bay-backed Shrike	+	+
Family	Corvidae				
220.		<i>Dendrocitta vagabunda</i>	Tree Pie	+	+

Continued...

Table 5 continued...

S. No.	Order/Family	Scientific name	Common name	Haleji	Keenjhar
221.		<i>Corvus corax</i>	Common Raven	+	--
222.		<i>Corvus splendens</i>	House Crow	+	+
Family	Sturnidae				
223.		<i>Sturnus vulgaris</i>	Common Starling	+	+
224.		<i>Sturnus roseus</i>	Rosy Pastor	+	--
225.		<i>Acridotheres tristis</i>	Indian Myna	+	+
226.		<i>Acridotheres ginginianus</i>	Bank Myna	+	+
Family	Passeridae				
227.		<i>Passer domesticus</i>	House Sparrow	+	+
228.		<i>Passer hispaniolensis</i>	Spanish Sparrow	+	--
229.		<i>Passer pyrrhonotus</i>	Sindh Jungle Sparrow	+	--
230.		<i>Petronia xanthocollis</i>	Yellow-throated Sparrow	+	+
Family	Ploceidae				
231.		<i>Ploceus philippinus</i>	Baya/Weaver Bird	+	--
232.		<i>Ploceus manyar</i>	Streaked Weaver	+	+
Family	Estrilidae				
233.		<i>Lonchura malabarica</i>	White-throated Munia/Indian Silver Bill	+	+
Family	Fringillidae				
234.		<i>Fringilla montifringilla</i>	Brambling	+	--
235.		<i>Bucanetes githagineus</i>	Trumpeter Finch	+	--
Family	Emberizidae				
236.		<i>Emberiza buchanani</i>	Grey-necked Bunting	+	--
237.		<i>Emberiza melanocephala</i>	Black-headed Bunting	+	--
238.		<i>Emberiza striolata</i>	Striolated Bunting/House Bunting	+	+

Table 6. List of Reptiles of Haleji and Keenjhar Lakes.

S. No.	Order/Family	Scientific name	Common name	Haleji	Keenjhar
Order	Chelonia				
Family	Trionychidae				
1.		<i>Lissemys punctata</i>	Indian Flap-shell Turtle	+	+
Family	Emydidae				
2.		<i>Geoclemys hamiltonii</i>	Spotted Pond Turtle	+	--
Order	Squamata				
Family	Elapidae				
3.		<i>Bungarus caeruleus</i>	Indian Krait	+	+
4.		<i>Naja naja</i>	Indian Cobra	+	+
		<i>Naja oxiana</i>	Oxus Cobra/Brown Cobra	--	+
Family	Colubridae				
5.		<i>Coluber fasciolatus</i>	Banded Racer	--	+
6.		<i>Lycodon striatus</i>	Spotted Wolf Snake	+	+
7.		<i>Lytorhynchus paradoxus</i>	Sindh Awl-headed Snake	+	--
8.		<i>Platyceps ventromaculatus</i>	Glossy-bellied Racer	+	+
9.		<i>Platyceps rhodorachis</i>	Streaked Kukri Snake	--	+
10.		<i>Oligodon taeniolatus</i>	Cliff Racer	--	+
11.		<i>Psammophis condanarus</i>	Indian Sand Snake	+	+

Continued...

Table 6 continued...

S. No.	Order/Family	Scientific name	Common name	Haleji	Keenjhar
12.		<i>Psammophis leithii</i>	Pakistan Ribbon Snake	+	--
13.		<i>Psammophis schokari</i>	Afro-Asian Sand Snake	+	--
14.		<i>Ptyas mucosus</i>	Dhaman	+	+
15.		<i>Spalerosophis diadema</i>	Royal Snake	+	--
16.		<i>Xenochrophis piscator</i>	Checkered-keel Back	+	--
Family	Boidae				
17.		<i>Exyx johnii</i>	Common Sand Boa	+	--
18.		<i>Eryx conicus</i>	Russel's Sand Boa	+	+
Family	Viperidae				
19.		<i>Echis carinatus</i>	Saw-scaled Viper	+	+
20.		<i>Daboia russelii</i>	Russel's Viper	+	+
Family	Lacertidae				
21.		<i>Acanthodactylus cantoris</i>	Indian Fringe-toed Lizard	+	+
22.		<i>Ophisops jerdonii</i>	Punjab Snake-eyed Lacerta	--	+
Family	Scincidae				
23.		<i>Ophiomorus tridactylus</i>	Three-toed Sand Swimmer	+	--
Family	Varanidae				
24.		<i>Varanus griseus</i>	Desert Monitor Lizard	+	--
25.		<i>Varanus bengalensis</i>	Indian Monitor lizard	+	+
Family	Uromastycidae				
26.		<i>Saara hardwickii</i>	Indian Spiny-tailed Lizard	+	+
Family	Agamidae				
27.		<i>Trapelus megalonyx</i>	Afghan Ground Agama	+	+
28.		<i>Trapelus agilis</i>	Brilliant Agama	+	+
29.		<i>Calotes versicolor</i>	Indian Garden Lizard	+	+
Family	Eublepharidae				
30.		<i>Eublepharis macularius</i>	Fat-tailed Gecko	--	+
Family	Gekkonidae				
31.		<i>Cyrtopodian kachhensis</i>	Warty Rock Gecko	+	+
32.		<i>Cyrtopodian scaber</i>	Keeled Rock Gecko	+	+
33.		<i>Crossobamon orientalis</i>	Sindh Sand Gecko	+	--
34.		<i>Hemidactylus flaviviridis</i>	Yellow-bellied House Gecko	+	+
35.		<i>Hemidactylus brookii</i>	Spotted Indian House Gecko	+	+
36.		<i>Hemidactylus leschenaultia</i>	Bark Gecko	+	+
Order	Crocodylia				
Family	Crocodylidae				
37.		<i>Crocodylus palustris</i>	Marsh Crocodile	+	--

Table 7. List of Amphibians of Haleji and Keenjhar Lakes.

S. No.	Order/Family	Scientific name	Common name	Haleji	Keenjhar
Order	Anura				
Family	Ranidae				
1.		<i>Euphlyctis cyanophlyctis</i>	Skittering Frog	+	+
Family	Bufonidae				
2.		<i>Duttaphrynus stomaticus</i>	Indus or Marbled Toad	+	+

Continued...

Table 8. List of Fishes of Haleji and Keenjhar Lakes.

S. No.	Order/Family	Scientific name	Haleji	Keenjhar
Order	Clupieformes			
Family	Clupiedae			
1.		<i>Gadusia chapra</i>	+	+
2.	Osteoglossiformes	<i>Notopterus chitala</i>	+	+
3.	Notopteridae	<i>Notopterus notopterus</i>	+	+
Order				
Family				
4.		<i>Chela cachius</i>	+	+
5.		<i>Salmostoma bacaila</i>	--	+
6.		<i>Securicula gora</i>	--	+
7.		<i>Amblypharyngodon mola</i>	--	+
8.		<i>Aspidoparia morar</i>	--	+
9.		<i>Barilius vagra</i>	--	+
10.		<i>Esomus danricus</i>	--	+
11.		<i>Rasbora daniconius</i>	+	+
12.		<i>Barbodes sarana</i>	+	+
13.		<i>Catla catla</i>	+	+
14.		<i>Cirrhinus mrigala</i>	+	+
15.		<i>Cirrhinus reba</i>	--	+
16.		<i>Labeo calbasu</i>	+	+
17.		<i>Labeo dero</i>	--	+
18.		<i>Labeo dyocheilus</i>	--	+
19.		<i>Labeo gonius</i>	+	+
20.		<i>Labeo rohita</i>	+	+
21.		<i>Osteobrama cotio</i>	--	+
22.		<i>Puntius chola</i>	--	+
23.		<i>Puntius fimbriatus</i>	+	
24.		<i>Puntius sophore</i>	+	+
25.		<i>Puntius ticto</i>	+	+
26.		<i>Cyprinus carpio</i>	--	+
27.		<i>Ctenpharyngodon idella</i>	--	+
28.		<i>Aristichthys nobilis</i>	--	+
29.		<i>Hypophthalmichthys molitrix</i>	--	+
Order	Siluriformes			
Family	Bugridae			
30.		<i>Aorichthys aor</i>	+	--
31.		<i>Mystus bleekeri</i>	--	+
32.		<i>Mystus cavasius</i>	+	+
33.		<i>Mystus gulio</i>	+	--
34.		<i>Mystus vittatus</i>	+	+
35.		<i>Rita rita</i>	+	+
Family	Sisoridae			
36.		<i>Bagarius bagarius</i>	--	+
37.		<i>Gagata cenia</i>	--	+
38.		<i>Nangra nangra</i>	--	+
Family	Siluridae			
39.		<i>Ompok bimaculatus</i>	+	+
40.		<i>Wallago attu</i>	+	+

Continued...

Table 8 continued...

S. No.	Order/Family	Scientific name	Haleji	Keenjhar
Family	Heteropneustidae			
41.		<i>Heteropneustes fossilis</i>	+	+
Family	Schilbeidae			
42.		<i>Ailia coila</i>	--	+
43.		<i>Clpisoma garua</i>	--	+
44.		<i>Clpisoma naziri</i>	--	+
45.		<i>Eutropiichthys vacha</i>	+	+
Order	Beloniformes			
Family	Belonidae			
46.		<i>Xenentodon cancila</i>	+	+
Order	Channiformes			
Family	Channidae			
47.		<i>Channa marulia</i>	+	+
48.		<i>Channa punctata</i>	+	+
49.		<i>Channa striata</i>	+	--
Order	Perciformes			
Family	Chandidae			
50.		<i>Chanda nama</i>	+	+
51.		<i>Parambassis baculis</i>	--	+
52.		<i>Parambassis ranga</i>	+	+
Family	Badidae			
53.		<i>Badius badis</i>	+	--
Family	Mugilidae			
54.		<i>Sicamugil cascasia</i>	+	+
Family	Gobidae			
55.		<i>Glossogobium giuris</i>	+	--
Family	Belontiidae			
56.		<i>Colisa fasciata</i>	+	+
57.		<i>Colisa lalia</i>	--	+
Family	Cichlidae			
58.		<i>Oreochromis mossambicus</i>	+	+
Order	Synbranchiformes			
Family	Mastacembelidae			
59.		<i>Mastacembelus armatus</i>	+	+

Legend: + present -- absent

(*Mus musculus*), Indian Gerbil (*Tatera indica*). Indian Hare (*Lepus nigricollis*), Smooth-coated Otter (*Lutrogale perspicillata*) and Wild Boar (*Sus scrofa*) previously reported from the area were not found during our study.

A total of six species recorded as they key species of mammals in Haleji Lake (Table 9).

The threatened species of mammals of the area include Fishing Cat (E) and Smooth-coated Indian Otter (V).

Table 9. Key Species of Mammals of Haleji Lake.

S. No.	Common name	Scientific name
1.	Indian Fox	<i>Vulpes bengalensis</i>
2.	Fishing Cat	<i>Prionailurus viverrinus</i>
3.	Desert Hare	<i>Lepus nigricollis</i>
4.	Small Indian Civet	<i>Viverricula indica</i>
5.	Jungle Cat	<i>Felis chaus</i>
6.	Smooth-coated Otter	<i>Lutrogale perspicillata</i>

Birds

The common birds of the area are Black-headed Gull (*Larus ridibundus*), Little Cormorant (*Phalacrocorax niger*), Purple Moorhen (*Porphyrio porphyrio*), Indian Moorhen (*Gallinula chloropus*), Long-legged Buzzard (*Buteo rufinus*), Coot (*Fulica atra*), Little Grebe/Dabchick (*Tachybaptus ruficollis*), Tufted Duck (*Aythya ferina*), Pied Wagtail (*Motacilla alba*), Yellow Wagtail (*Motacilla flava*), Black Drongo (*Dicrurus macrocercus*), Pied Bush Chat (*Saxicola caprata*), Sand Martin (*Riparia paludicola*) and Wire-tailed Swallow (*Hirundo smithi*).

A total of 13 species of birds have been recorded to be the key species of the area (Table 10).

Table 10. Key Species of Birds of Haleji Lake.

S. No.	Common name	Scientific name
1.	Purple Moorhen	<i>Porphyrio porphyrio</i>
2.	Dalmatian Pelican	<i>Pelecanus crispus</i>
3.	White Pelican	<i>Pelecanus onocrotalus</i>
4.	Pheasant-tailed Jacana	<i>Hydrophasianus chirurgus</i>
5.	Cotton Teal	<i>Nettapus coromandelianus</i>
6.	Pallas's Fishing Eagle	<i>Haliaeetus leucorhynchus</i>
7.	Marsh Harrier	<i>Circus aeruginosus</i>
8.	Common Coot	<i>Fulica atra</i>
9.	Grey Partridge	<i>Francolinus pondicerianus</i>
10.	Night Heron	<i>Nycticorax nycticorax</i>
11.	Marbled Teal	<i>Marmaronetta angustirostris</i>
12.	Greater Flamingo	<i>Phoenicopterus roseus</i>
13.	Moorhen	<i>Gallinula chloropus</i>

The threatened birds of the area are White-backed Vulture, *Gyps bengalensis* (CE), Imperial Eagle, *Aquila heliaca* (V), Lesser White-fronted Goose, *Anser erythropus* (V), Pallas's Fishing Eagle, *Haliaeetus leucorhynchus* (V), Marbled Teal, *Marmaronetta angustirostris* (V), Dalmatian Pelican, *Pelecanus crispus* (V) and Egyptian Vulture, *Neophron percnopterus* (E) and Darter *Anhinga melanogaster* (NT).

Reptiles

Among reptiles, Indian Garden Lizard (*Calotes versicolor*), Indian Fringe-toed Lizard (*Acanthodactylus cantoris*), Glossy Bellied Racer (*Platycephalus ventromaculatus*) and Yellow-bellied House Gecko (*Hemidactylus flaviviridis*) are common.

The key species of the area include; Indian Monitor (*Varanus bengalensis*), Desert Monitor (*Varanus griseus*),

and Spiny-tailed Lizard (*Saara hardwickii*), while Marsh Crocodile (*Crocodylus palustris*) is a threatened species of the area.

Amphibians

Skittering Frog (*Euphlyctis cyanophlyctis*) and Indus Toad (*Duttaphrynus stomaticus*) are commonly found.

Fishes

A total of 49 species of fishes have been recorded from the lake. Out of these, 10 species have very high commercial value such as Mori (*Cirrhinus mrigala*), Thaila (*Gibelion catla*), Rohu (*Labeo rohita*), Common Carp (*Cyprinus carpio*), Singhari (*Sperata sarwari*), Fauji Khagga (*Bagarius bagarius*), Malli (*Wallago attu*), Thalli (*Clupisoma garua*), Thalli (*Clupisoma naziri*) and Soul (*Channa marulias*) (Rafiq, 2009). At the present time, the numbers of these food fishes have drastically declined in the lake and now only Tilapia (*Oreochromis mossambicus*) is found in abundance.

Flora

A total of 33 species were recorded. *Hydrilla verticillata*, *Phragmites karka* and *Typha angustata* were found common aquatic floral species in the Haleji Lake.

Keenjhar Lake

Physico-chemical Parameters

During the study period the water temperature of Keenjhar Lake in pre-monsoon varied from 28 - 33°C, while in post monsoon it varied from 16 - 20°C. The air temperature in pre-monsoon varied from 31- 36°C while in post monsoon it varied from 18- 24°C. Conductivity of the Keenjhar Lake varied from 453 - 742µS/cm, TDS varied from 243 to 492mg/L, pH value ranged from 6.81 to 8.31, turbidity ranged from 1.37 - 12.6NTU, alkalinity range from 28 - 107mg/l, Total Hardness varied from 58 to 144mg/l, Salinity varied from 0.21 to 1.9mg/l, Value of Basic Oxygen Demand varied from 1.12 - 9.9mg/l, Carbon dioxide ranges from 1 to 2mg/l. Range of Calcium varied from 28 to 87mg/l, range of Magnesium varied from 38 - 106mg/l, range of Sulphates varied from 18 to 156mg/l, Chloride ranged from 35.2 to 98mg/l, range of Nitrate in Keenjhar Lake was 0.04 - 0.37mg/l, range of Phosphate determined during the study varied from 0.006 to 0.28mg/l, range of Cadmium varied from 0.00mg/l to 1.32mg/l, the range of Chromium in Keenjhar Lake varied from 0.00mg/l to 1.01mg/l, value of Lead varied from 0.00 - 0.013mg/l and Nickel varied from 0.01 - 0.80mg/l (Table 11).

Biological Studies

A total of 25 species of mammals, 121 species of birds, 29 species of reptiles, 2 species of amphibians, 54 species of fishes and 258 species of plants were recorded.

Table 11. Water Quality Analysis of Keenjhar Lake during 2006-2009.

Parameters	Keenjhar Lake							
	Average Pre-monsoon				Average Post-monsoon			
	2006	2007	2008	2009	2006	2007	2008	2009
Colour	A	A	A	A	A	A	A	A
Odour	O	O	O	O	O	O	O	O
Water Temperature (°C)	30.40	29.60	29.60	31.40	16.60	19.60	17.00	18.40
Air Temperature (°C)	33.40	33.00	32.60	34.40	19.20	22.40	19.80	21.00
Conductivity (µS/cm)	516.80	508.20	509.80	518.40	579.40	615.80	571.40	584.20
TDS (mg/l)	256.20	260.20	253.40	263.00	387.00	389.00	373.60	392.80
pH	7.76	7.77	7.74	7.82	7.94	7.93	7.95	8.00
Turbidity (NTU)	2.59	2.45	2.35	2.68	7.11	6.92	6.63	21.72
Alkalinity	98.22	96.66	93.94	97.80	33.60	33.40	32.20	35.60
Total Hardness (mg/l)	132.20	130.40	127.00	133.60	98.00	97.20	94.20	101.80
Salinity (mg/l)	0.62	0.59	0.61	1.58	0.33	0.26	0.56	1.14
BOD (mg/l)	8.32	8.06	7.80	8.53	1.74	1.74	1.52	1.98
Carbon dioxide (mg/l)	1.60	1.40	1.20	1.40	1.40	1.40	1.60	1.60
Calcium (mg/l)	77.60	74.60	69.80	78.80	34.20	34.80	31.60	38.20
Magnesium (mg/l)	57.60	58.20	54.40	62.20	72.80	76.60	70.80	81.20
Sulphates (mg/l)	18.80	18.80	18.20	19.00	137.20	138.40	132.80	143.60
Chloride (mg/l)	52.38	51.46	49.22	53.44	80.20	82.00	78.20	85.80
Nitrates (mg/l)	0.26	0.22	0.21	0.21	0.15	0.07	0.08	0.10
Phosphates (mg/l)	0.02	0.02	0.02	0.02	0.06	0.03	0.07	0.02
Cadmium (mg/l)	0.00	0.22	0.20	0.05	0.49	0.78	0.15	0.27
Chromium (mg/l)	0.01	0.19	0.04	0.03	0.43	0.51	0.19	0.20
Lead (mg/l)	0.00	0.05	0.01	0.05	0.00	0.00	0.04	0.01
Nickel (mg/l)	0.16	0.55	0.35	0.32	0.45	0.51	0.31	0.29

Status of Various Species

Mammals

The common species of the mammals found in the area include Palm Squirrel (*Funambulus pennanti*), Indian Gerbil (*Tatera indica*), Indian Desert Jird (*Meriones hurrianae*), House Mouse (*Mus musculus*), House Rat (*Rattus rattus*), Asiatic Jackal (*Canis aureus*) and Indian Porcupine (*Hystrix indica*).

The key species of the area include Fishing Cat (*Prionailurus viverrina*), Smooth-coated Otter (*Lutrogale perspicillata*), Bengal Fox (*Vulpes bengalensis*), and Indian Pangolin (*Manis crassicaudata*).

The threatened species are the Fishing Cat, *Prionailurus viverrina* (E) and the Smooth-coated Otter, *Lutrogale perspicillata* (V).

Birds

A total of 121 species were recorded comprising of waterbirds, birds of prey, passerines and game birds. The common birds of the area are Shoveller (*Anas clypeata*), Tufted Duck (*Aythya fuligula*), Grey Partridge (*Francolinus pondicerianus*), Striated Babbler (*Turdoides earlei*), Great Grey Shrike (*Lanius excubator*), Ashy-crowned Finch Lark (*Eremopterix griseus*), Indian Robin

(*Saxicoloides fulicata*), White-cheeked Bulbul (*Pycnonotus leucogenys*), Red-vented Bulbul (*Pycnonotus cafer*), Tailor Bird (*Orthotomus sutorius*), Bluethroat (*Luscinia svecica*), Lesser white-throat (*Sylvia curruca*), Bay-backed Shrike (*Lanius vittatus*), Pied Bush Chat (*Saxicola caprata*) and Crested Lark (*Galerida cristata*), while 12 species have been recorded to be the key species of birds (Table 12).

Table 12. Key Species of Birds of Keenjhar Lake.

S. No.	Common name	Scientific name
1.	Cotton Teal	<i>Nettapus coromandelianus</i>
2.	Night Heron	<i>Nycticorax nycticorax</i>
3.	Purple Moorhen	<i>Porphyrio porphyrio</i>
4.	Pheasant-tailed Jacana	<i>Hydrophasianus chirurgus</i>
5.	Marsh Harrier	<i>Circus aeruginosus</i>
6.	Greater Flamingo	<i>Phoenicopterus rosues</i>
7.	White Pelican	<i>Pelecanus roseus</i>
8.	Dalmatian Pelican	<i>Pelecanus crispus</i>
9.	Grey Partridge	<i>Francolinus pondicerianus</i>
10.	Pallas's Fishing Eagle	<i>Haliaeetus leucorhyphus</i>
11.	Black-bellied Tern	<i>Sterna acuticauda</i>
12.	Ferruginous Duck	<i>Aythya nyroca</i>

The threatened and other rare birds recorded are: Ferruginous Duck (NT), Black-bellied Tern (NT), Dalmatian Pelican (V), White Ibis (*Threskiornis melanocephalus*), White Stork (*Ciconia ciconia*) and Cotton Teal (*Nettapus cormandelianus*).

Reptiles

A total of 29 species of reptiles were recorded. The key species include Indian Monitor (*Varanus bengalensis*), Spiny-tailed lizard (*Saara hardwickii*), Indian Flap Shell turtle (*Lissemys punctata*), and Fat-tailed Gecko (*Eublepharis macularius*).

Amphibians

Only 2 species were recorded viz. Skittering Frog (*Euphlyctis cyanophlyctis*) and Marbled Toad (*Duttaphrynus stomaticus*).

Fishes

A total of 54 fish species were recorded. *Catla catla*, *Gadusia chapra*, *Heteropneustis fossilis*, *Labeo rohita*, *Tenulosa ilisha*, *Notopterus notopterus*, *Wallago attu* and *Xenentodon cancila* are the important fishes of Keenjhar Lake.

Flora

Typha angustata was found as common where as *Tamarix spp.* was found abundant. *Eichhornia crassipes* and *Salvinia molesta* are the common invasive species.

Threatened Species of both lakes

Based on our data 17 species including mammals, birds and reptiles have been recorded as Threatened species from Haleji and Keenjhar Lake areas (Table 13).

Table 13. Threatened Species recorded from Haleji and Keenjhar Lake areas.

S. No.	Threatened Species
Mammals	
1.	Smooth-coated Otter (V) (Fig. 2)
2.	Fishing Cat (E) (Fig. 3)
Birds	
1.	Darter (NT) (Fig. 4)
2.	Ferruginous Duck (NT) (Fig. 5)
3.	Blackbellied Tern (NT) (Fig. 6)
4.	Lesser Whitefronted Goose (V) (Fig. 7)
5.	Marbled Teal (V) (Fig. 8)
6.	Whitebacked Vulture (CE) (Fig. 9)
7.	Imperial Eagle (V) (Fig. 10)
8.	Pallas's Fishing Eagle (V) (Fig. 11)
9.	Dalmatian Pelican (V) (Fig. 12)
10.	Egyptian Vulture (E) (Fig. 13)
Reptiles	
1.	Marsh Crocodile (V)
2.	Indian Softshell Turtle (V)
3.	Crowned River Turtle (V)
4.	Peacock Shell Turtle (V)
5.	Narrow-headed Softshell (E)

DISCUSSION

There are several factors that can adversely affect and change biodiversity within aquatic ecosystems. Aquatic biodiversity may decrease due to pollution, fragmentation, habitat destruction, or the introduction of an invasive species. In many countries, anthropogenic activities have lead to aquatic organisms being at a higher risk for extinction compared to terrestrial mammal water birds and amphibians (Ali *et al.*, 2011). Many biochemical and physiological changes in aquatic organisms are caused by pesticides which influence the activities of several enzymes (Khan and Law, 2005).

In the water samples of Haleji Lake, the pesticides of OP and OC groups were estimated above the maximum acceptable concentrations. Earlier, Siddiqui (1998) has also recorded much higher concentration of Dimethoate (OP) and DDT and Dieldrin (Cyclodiene) (OC) and Cypermethrin from Haleji Lake. The concentration was much higher in muscles and fat contents than other tissues of the birds. While water samples of Keenjhar Lake showed pesticides below the maximum acceptable concentration.

The analysis revealed that the KB Feeder Canal is the major source of pollution to these lakes. Turbidity, BOD and COD along with other toxic pollutants such as Cd and Pb were found to be closer to upper limits. These pollutants as well as Ni are already present in the water of the Indus due to discharge of municipal and industrial effluents in it mainly from Kotri Industrial Area. The depletion of dissolved oxygen is the indicator of organic pollution harmful for fishes and other aquatic biodiversity.

Lead and phenol levels have been found to increase after monsoon. This may be due to release of lead and phenol containing substances through the rain flow. The rain water, however, causes dilution, aeration and more biological activity as the BOD and COD load is reduced and solubility level of air in water is increased.

Environmental Problems in Haleji Lake

Haleji Lake used to supply water to Karachi before 2006. Water used to be supplied to Haleji Lake from Keenjhar Lake and then it was supplied to Karachi. After the construction of a direct supply line to Karachi from Keenjhar, the water of the lake has become stagnant which has resulted in the deterioration of water quality.

The ongoing RBOD scheme construction work has caused much degradation in the area. The RBOD is hardly 50-100 feet away from the lake and its water level is 20-30 feet below the level of the wetland area. The lake may be affected by the seepage of its water to the drain.



Fig. 2. Smooth-coated Otter.



Fig. 3. Fishing Cat (Courtesy by true wildlife.blogspot.com).



Fig. 4. Darter.



Fig. 5. Ferruginous Duck.



Fig. 6. Blackbellied Tern.



Fig. 7. Lesser Whitefronted Goose.

Most of the marginal area of the lake is overgrown with aquatic vegetation such as Typha, Phragmites and Lotus along with Mesquite elsewhere. So the open water area is shrinking which is the habitat for many waterbirds.

A Few years ago, the Apple Snail (*Pomacea canaliculata*) was introduced into the Haleji Lake. The Snail has since infested the lake and is now the most common species

found within. Its negative impacts on the ecology of the lake need to be investigated. Intensive fish angling has been going on in and around the lake area. It has been causing disturbance to the wildlife dependant on the lake.

Environmental Problems in Keenjhar Lake

Keenjhar Lake had been receiving water from the main Indus River through Kalri-Baghar Feeder (KB Feeder)

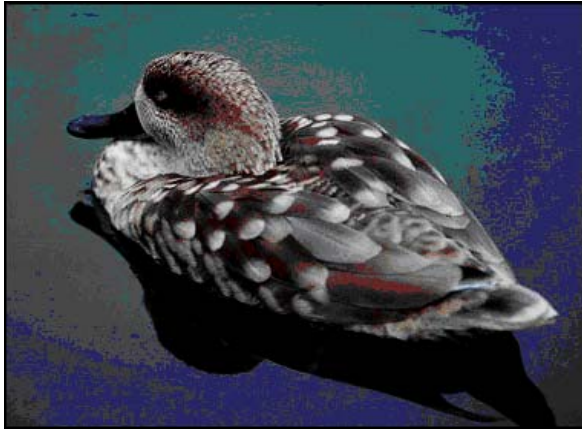


Fig. 8. Marbled Teal (Courtesy by sundancevillas.co.uk).



Fig. 9. Whitebacked Vulture (Courtesy by thefalconrycentre.co.uk).



Fig. 10. Imperial Eagle.



Fig. 11. Pallas's Fishing Eagle (Courtesy by indianaturewatch.net).



Fig. 12. Dalmatian Pelican.



Fig. 13. Egyptian Vulture.

canal. Currently the lake's freshwater ecosystem is under threat due to increased industrial and domestic effluent discharge through the Kalri-Baghar Feeder (KB Feeder) canal which carries contaminants from Kotri urban and Industrial area. There are a number of industries in Kotri which dump their effluents into the KB Feeder and these chemicals combined with the sewage discharged by the town end up in Keenjhar Lake (WWFP, 2010).

In the Keenjhar Lake, main factor affecting water quality is industrial discharge from Kotri and Nooriabad industries, while eutrophication is also a major problem in the lake. The lake water is being enriched with nutrients causing excessive plant growth. Runoff from agriculture fields containing chemical fertilizers triggers pollution. More than 15,000 people visit this lake every week in the season and the garbage produced is also a source of

Table 14. Annual waterbird Census at Haleji and Keenjhar Lake.

Year	2000	2001	2002	2003	2004	2010	2011
Haleji Lake	69,194	44,931	40,062	15,367	2,570	3,000	2,370
Keenjhar Lake	30,270	38,958	30,470	15,886	3770	7,174	2,252

pollution. Tourists also pollute water by washing their vehicles in the lake.

Tilapia species has been introduced into the lake which is a frequent breeder and a carnivorous fish. It has become widespread in the lake and has somewhat suppressed the native species such as Rohu, Thaila and Murakhi which breed in confined waters.

Moreover, the plant species such as *Eichhornia crassipes* (Water Hyacinth), *Salvania molesta* (Water Fern) *Pistia stratiotus* (Water Lettuce) have occupied most of the open area.

Mats of Water Hyacinth, Water Lettuce and Water Fern impede access to use of waterways for recreational and commercial purposes. These also reduce habitats of waterbirds, moreover, fishes are also facing threats because of these mats which is a negative sign for economy.

Introduction of non-native species of plants and animals may damage the food web, which can in turn destabilize the whole ecosystem resulting in the disappearance of some species or a population buildup of an undesired species.

Due to many environmental and anthropological factors, annual waterbird census from 2000 showed decline in bird population in both lakes (Table 14). Our data shows that Haleji Lake has a rich vertebrate biodiversity as compared to Keenjhar Lake (Table 15), but due to environmental and other anthropogenic factors, this wetland is threatened.

Table 15. Biodiversity recorded from Haleji and Keenjhar Lake.

S. No.	Animal Groups	Haleji Lake (number of species)	Keenjhar Lake (number of species)
1.	Mammals	27	25
2.	Birds	225	111
3.	Reptiles	32	29
4.	Amphibians	02	02
5.	Fishes	42	55

CONCLUSION

The results of the present study defined an alarming situation due to pollution in the two wetlands. Detailed studies are required for pollution control. The environmental effects of unlined RBOD system passing through these two lakes area need to be monitored. The overall population of migratory waterbirds has been decreasing over the two wetlands due to large scale disturbance, hunting and trapping in Keenjhar area, while due to hunting and habitat degradation and poor water quality in Haleji Lake. Ecotourism may be developed at Keenjhar Lake by managing the wetland through Public Private Partnership Programme. Wetland conservation may be promoted through policy development, training, capacity building and awareness programs. The data is sufficient enough to chalkout and implement a monitoring program to provide protection to the threatened species and their habitats. Being the first study of its kind, it will serve as a baseline data for the future workers on the biodiversity and environment of the area.

ACKNOWLEDGEMENTS

Thanks are due to WWF-Pakistan Karachi office for extending help and facilities for wildlife surveys at Haleji and Keenjhar Lakes. The authors are also grateful to Mr. Hussain Bux Bhaagat, Conservator Wildlife, Sindh Wildlife Department and Syed Fazal Shah, Incharge, Haleji Wildlife Sanctuary for providing information regarding the wildlife of the area during the visit to the lake. Thanks to Miss. Sumaiya Ahmed, Department of Geography, University of Karachi for preparation of map.

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Received: Oct 6, 2011; Revised: Nov 22, 2011;

Accepted: Dec 5, 2011