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A REVIEW: VERTEBRATE BIODIVERSITY, ENVIRONMENTAL HAZARDS AND ECOLOGICAL CONDITION OF KEENJHAR LAKE, PAKISTAN

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ABSTRACT

Globally there are 2247 Ramsar sites with total area of 214,958,432 ha, including 19 sites of Pakistan. Keenjhar Lake is considered as one of largest freshwater lakes of Sindh, and it is the major source of water supply through different feeder canals to largest city of Karachi. There are 54 species of fishes, 121 species of birds, 25 species of mammals, two species of amphibian and 29 species of reptiles were reported. Aquatic ecosystem of the lake is under threat due to increased industrial and domestic effluent discharge via Kalri-Baghar Feeder Canal which carries contaminants from Kotri urban and Industrial area. KB Feeder Canal is the main source of pollution to Keenjhar Lake. Presently, industrial discharge from Kotri and Nooriabad industries are source for affecting water quality and health of this wetland, we also noted that eutrophication is also problem in the lake. Water samples collected from Keenjhar Lake found contained pesticides below the Maximum Acceptable Concentrations level.

Keywords: Keenjhar lake, vertebrate biodiversity, environment, threats.

INTRODUCTION

Wetland plays a vital role in ecological balance of an ecosystem. Significance of wetlands and their role in ecosystem management is well known but so many hazards are present which directly or indirectly affect the health of wetlands. Hazards are may be natural or artificial which are influenced by human activities. Sindh is the third largest province of Pakistan having a lot of diversity in ecosystems including mountains, deserts, grasslands, woodlands and variety of wetlands. Presently, Pakistan has 19 designated Ramsar Sites with the total area of 1,343,627 hectares, Convention entered into force in Pakistan on November 23, 1976 [(Table 1) (Ramsar Convention, 2017)].

Keenjhar Lake is located in Thatta District of Sindh (Fig. 1). It covers approximately 14,000 ha of area and having latitude and longitude of 68° 03'E and 24° 56'N. It is considered as one of largest fresh water lakes of Sindh and it is the major source of water supply through different feeder canals to Karachi city, Thatta city and Ketibunder. The main water supply to Keenjhar Lake comes from River Indus. The location of Keenjhar Lake is about 19km North and North East to Thatta District, while it is situated 113km away from Karachi city.

Many seepage lagoons and marshes are surrounding the Keekjhar Lake which is connected with semi deserted areas bearing limestone rock beds. This man made fresh water lake was formed in 1930 when two small lakes named Keenjhar and Kalri Lake were merged together after development of a dam at Bangla (Khan and Abbas, 2011).

The fish fauna of lake is diversified and contains a variety of fresh water fishes including Dahi (*Labeo calbasu*), Daya (*Oreochromis mossambicus*), Gandhan (*Chitala chitala*), Ganer (*Cirrhinus rebo*), Goj (*Mastacembelus armatus*), Jerki (*Wallago attu*), Kago (*Rita rita*), Kandar (*Chanda nama*), Luhr (*Heteropneustes fossillis*), Morakhi (*Cirrhinus mrigala*), Popri (*Puntius chola*), Palla (*Tenualosa ilisha*), Rohu (*Labeo rohita*), Sole (*Channa marulia*) and Thaila (*Gibelion catla*).

Birds mostly visit to Keenjhar Lake for many purposes like breeding and nesting grounds, roosting areas and for foraging purposes (Khan *et al*., 2012). The important breeding birds of the lake are Night Heron (*Nycticorax nycticorax*), Cotton Teal (*Nettapus coromondelianus*), Pheasant-tailed Jacana (*Hydrophasianus chirurgus*), Purple Moorhen (*Porphyrio porphyris*) and some passerine birds.

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Table 1. List Designated Ramsar Sites of Pakistan upto Jan 2017.

S. No.	Name	Province	Area hectares	Co-ordinates
1	Hub (Hab) Dam	Balochistan, Sindh	27,000	25°15'N 067°07'E
2	Astola (Haft Talar) Island	Balochistan	5,000	25°07'N 063°52'E
3	Jiwani Coastal Wetland	Balochistan	4,600	25°05'N 061°48'E
4	Miani Hor	Balochistan	55,000	25°24'N 066°06'E
5	Ormara Turtle Beaches	Balochistan	2,400	25°13'N 064°28'E
6	Chashma Barrage	Punjab	34,099	32º25'N 071º22'E
7	Taunsa Barrage	Punjab	6,576	30º42'N 070º50'E
8	Uchhali Complex (including Khabbaki, Uchhali and Jahlar Lakes)	Punjab	1,243	32º37'N 072º00'E
9	Tanda Dam	Khyber Pakhtunkhwa	405	33º35'N 071º22'E
10	Thanedar Wala	Khyber Pakhtunkhwa	4,047	32º37'N 071º05'E
11	Deh Akro-II Desert Wetland Complex	Sindh	20,500	26°50'N 068°20'E
12	Drigh Lake	Sindh	164	27º34'N 068º06'E
13	Haleji Lake	Sindh	1,704	24º47'N 067º46'E
14	Indus Delta	Sindh	472,800	24°06'N 067°42'E
15	Indus Dolphin Reserve	Sindh	125,000	28°01'N 069°15'E
16	Jubho Lagoon	Sindh	706	13,468 ha
17	Nurri Lagoon	Sindh	2,540	24°30'N 068°47'E
18	Runn of Kutch	Sindh	566,375	24°23'N 070°05'E
19	Kinjhar (Kalri) Lake	Sindh	13,468	24º56'N 068º03'E

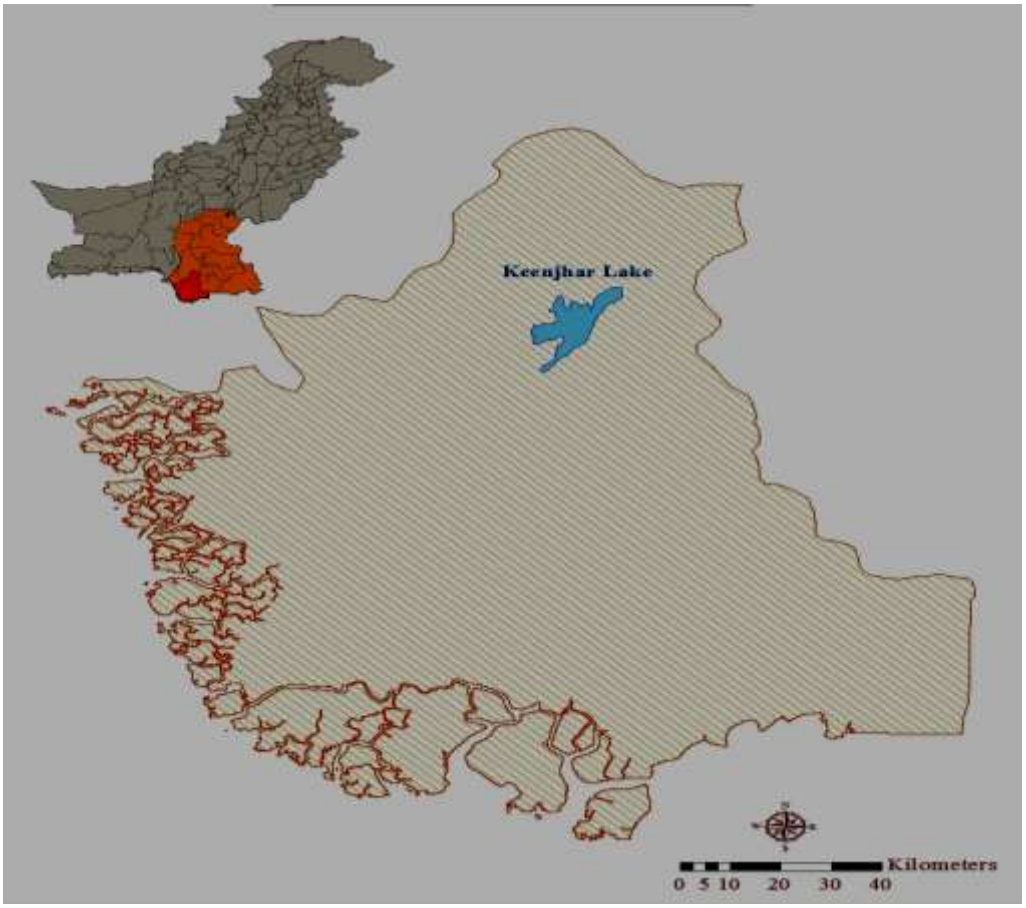

Fig. 1. Map of Pakistan with location of Keenjhar Lake.

Keenjhar Lake is playing a important role in providing the natural resources of livelihood to the local community consist of over 50 villages of Thatta district, and whole community are dependent on this lake for their survival (Khan and Abbas, 2011; Khan *et al*., 2012).

Keenjhar Lake also provides good habitat for various mammalian and reptilian species. Key species of mammals found in vicinity of Keenjhar Lakes includes Smooth-coated Otter (*Lutrogale perspicillatus*) and Fishing Cat (*Prionailurus viverrinus*). While important birds includes Cotton Teal (*Nettapus coromandelianus*) and Pallas's Fishing Eagle (*Haliacetus leucoryphus*). Reptiles includes Spiny-tailed Lizard (*Sara hardwickii*) and Indian Monitor Lizard (*Varanus bengalensis*).

Keenjhar Lake is contains a huge variety of water weeds and a complex network of aquatic vegetation in its depth. It also supports migratory birds annually as it offers an attractive habitat for aquatic migratory birds as their wintering area, staging and breeding grounds. The important species of birds includes European Wigeon (*Anas penelope*), Black Coot (*Fulica atra*) and Common Pochard (*Aythya ferina*) (Khan and Abbas, 2011; Khan *et al*., 2012).

Some work has been done by Ashraf *et al*., 1992; Baqai and Rehana, 1973; Baqai and Siddiqui, 1973; Baqai, 1974a,b; Conder, 1977; Durranee and Khan, 2008; Ghalib *et al*., 1981; Ghalib and Bhaagat, 2004; Ghalib *et al*., 2004, 2009; IFAP, 2009; IUCN, 2004; Jafri *et al*., 1999; Jehangir *et al*., 2000; Kazmi *et al*., 2006; Khan, 2005; Khan and Law, 2005; Khan and Ghalib, 2006; Khanum and Ahmed, 1991; Korai *et al*., 2008a,b; Korai *et al*., 2001; Korai *et al*., 2009; Khan and Abbas, 2011; Khan *et al*., 2012; Khan *et al*., 2015; Mahar *et al*., 2010; Nazneen, 1974, 1980; Nazneen and Begum, 1992; Roberts *et al*., 1986; Saqib *et al*., 2005; Scott, 1989; Scott and Poole, 1989 and Siddiqui *et al*., 1973. The aim of this paper is review the status of important vertebrate biodiversity, effects of environmental hazards and ecological condition of the lake.

DISCUSSION

The climate of Sindh is semiarid and the climatic studies of lake has revealed that lake being a individual ecosystem contains dry monsoonal fluctuating temperature with extreme hot weather during summers and moderately low temperatures in winter seasons. The average monsoonal rainfall measures about 175mm. The mean temperature during summers has been recorded as 47^0C, while in winters it is about 15^0C. Some adjacent small seasonal streams also supply water to the Keenjhar Lake from West and Northern sites. The lake is having one main canal which is called as Karli Bagri feeder Canal which is connected with the lake from North West site. Through South East site the only outlet of lake is Jam branch canal. Its length is about 24km, while its width is about 6km. Presently, depth of the lake is about 8m with the network of reef beds and aquatic weeds.

In the pre Monsoon period the minimum temperature of water of Keenjhar Lake was 28^0C, while the maximum temperature was about 33^0C and it was 16 to 20^0C during the post Monsoon. The air temperature was also monitored; during pre Monsoon it was recorded from 31 to 36^0C and it was from 18 to 24^0C in post Monsoon.

The conductivity was recorded as 453 to 742 mg/L, while, 243 to 492 mg/L was the value of total dissolved solids present in the lake, 6.81 to 8.31 was the value of pH recorded. 1.37 NTU to 12.6 NTU was the estimated turbidity level. Total alkalinity calculated from the values of 28 to 107 mg/L. 58 up to 144 mg/L was the value of total hardness present in lake. 0.21 to 1.9 mg/L was the recorded value of salinity. The BOD value ranged from 1.12 to 9.9 mg/L. The value of Carbon dioxide estimated from 1 up to 2 mg/L, while 28 to 87 mg/L was the value of calcium present in Lake. It was observed that 38 to 106 mg/L was the quantity of magnesium in Lake and the quantity of sulfate ranged from 18 to 156mg/L. The estimated range of chlorides was from 35.2 to 98 mg/L. While 0.006 to 0.28 mg/L was the quantity of phosphates in the Lake. The estimated amount of Cadmium was 0.00 to 1.32 mg/L, and the value of Chromium was from 0.00 to 1.01 mg/L. The quantity of Lead was from 0.00 to 0.01 mg/L, and the estimated amount of nickel recorded was 0.01 to 0.80 mg/L.

Vertebrate Biodiversity

Earlier studies regarding vertebrate biodiversity, Khan and Abbas (2011) and Khan *et al*. (2012) reported that there were twenty five species of mammals, and presently no change in the reported species (Table 2). The key species were Asiatic Jackal (*Canis aureus*), Bengal fox (*Vulpes bengalensis*), Desert Fox (*Vulpes vulpes*), Smooth-coated Otter (*Smooth-coated Otter*), Jungle Cat (*Felis chaus*), Fishing Cat (*Prionailurus viversina*), Grey Mongoose (*Herpestes edwardsi*), Small mongoose (*Herpestes javanicus*), Pangolin (*Manis crassicaudata*), Long-eared Hedgehog (*Hemiechinus collaris*) and Porcupine (*Hystrix indica*). There were 121 species of birds were identified from the Keenjhar Lake area (Table 3). The common birds present near lake were waterbirds, birds of prey, passerines and Grey Partridge (*Francolinus pondicerianus*).

While, Ferruginous Duck (*Aythya nyroca*), Dalmatian Pelican (*Pelecanus crispus*), Black-bellied Tern (*Sterna acuticauda*), Black-headed Ibis (*Threskiornis melanocephalus*), White Stork (*Ciconia ciconia*) and Cotton Teal (*Nettapus cormandelianus*) were noted as

Threatened or Near Threatened species (Figs. 2 - 6) and still these species observed as Threatened.

Fig. 2. Ferruginous Duck (*Aythya nyroca*) (Photo source: hotspotbirding.com).

Fig. 3. Dalmatian Pelican (*Pelecanus crispus*).

Fig. 4. Black-bellied Tern (*Sterna acuticauda*).

Fig. 5. Black-headed Ibis (*Threskiornis melanocephalus*)

Fig. 6. White Stork (*Ciconia ciconia*).

In a recent studies, Khan and Abbas (2011) and Khan *et al*. (2012) reported 29 species of reptiles and we observed that presently no change see Table 4, and still key species were Brilliant Agama (*Trapelus agilis*), Fat-tailed Gecko (*Eublepharis macularius*), Spiny-tailed Lizard (*Sara hardwickii*), Indian Monitor Lizard (*Varanus bengalensis*), Common Krait (*Bungarus caeruleus*), Indian Cobra (*Naja naja*), Oxus Cobra (*Naja oxiana*), Russel's Viper (*Daboia russelii*) and saw-scaled Viper (*Echis carinatus*). Two species of amphibian were observed from the study area which includes Skittering Frog (*Euphlyctis cyanophlyctis*) and Marbled Toad (*Bufo stomaticus*). We observed that in the recent years habitat degradation, habitat modification, disturbance by humans illegal hunting are important threats to the *Varanus* spp. and *S. hardwickii* in the areas surveyed.

Earlier studies was documented 54 fish species in the Keenjhar Lake, we reviewed that currently no change was reported regarding number of species, see Table 5.

Table 2. Mammals of Keenjhar Lake (Khan and Abbas, 2011; Khan *et al*., 2012)

S. No.	Scientific Name	Common Name	Status
1	*Canis aureas*	Asiatic Jackal	C
2	*Vulpes bengalensis*	Bengal Fox	S
3	*Vulpes vulpes*	Desert Fox	R
4	*Lutragale perspicillata*	Smooth-coated Otter	R
5	*Felis chaus*	Jungle Cat	S
6	*Prionailurus viverina*	Fishing Cat	S
7	*Herpestes edwardsi*	Grey Mongoose	LC
8	*Herpestes javanicus*	Small Indian Mongoose	LC
9	*Sus scrofa*	Indian Wild boar	LC
10	*Manis crassicaudata*	Indian Pangolin	R
11	*Hemiechinus collaris*	Long-eared Hedgehog	LC
12	*Hipposideros fulvus*	Leaf-nosed bat	LC
13	*Pipistrellus kuhlii*	Kuhls' bat	C
14	*Rhinopoma microphyllum*	Large mouse-tailed bat	LC
15	*Lepus nigricollis*	Desert Hare / Indian Hare	LC
16	*Funambulus pennant*	Palm squirrel	C
17	*Hystrix cristatus*	Indian crested porcupine	C
18	*Gerbillus nanus*	Balochistan Gerbil	C
19	*Bandicota bengalensis*	Indian Mole Rat	LC
20	*Meriones hurrianae*	Indian Desert Jird / Desert Gerbil	C
21	*Mus musculus*	House mouse	C
22	*Mus saxicola*	Grey spiny Mouse	LC
23	*Nesokia indica*	Short-tailed rat	LC
24	*Rattus rattus*	Common Rat	C
25	*Tatera indica*	Indian Gerbil	C

Table 3. Birds of Keenjhar Lake (Khan and Abbas, 2011; Khan *et al*., 2012).

S. No.	Scientific Name	Common Name	Status
1	*Tachybaptus ruficollis*	Little Grebe	C
2	*Phalacrocorax niger*	Little Cormorant	C
3	*Nycticorax nycticorax*	Night Heron	LC
4	*Ardeola grayii*	Indian Pond Heron	C
5	*Bubulcus ibis*	Cattle Egret	C
6	*Egretta garzeta*	Little Egret	C
7	*Egretta intermedia*	Intermediate Egret	C
8	*Egretta alba*	Great White Egret	C
9	*Ardea purpurea*	Purple Heron	LC
10	*Anas strepera*	Gadwall	C
11	*Anas crecca*	Common Teal	C
12	*Anas acuta*	Pintail	C
13	*Anas clypeata*	Shoveller	C
14	*Aythya ferina*	Common Pochard	C
15	*Aythya fuligula*	Tufted Duck	C
16	*Nettapus coromandelianus*	Cotton Teal	WV
17	*Elanus caeruleus*	Black-shouldered Kite	LC
18	*Milvus migrans*	Black Kite	C
19	*Haliastor indus*	Brahminy Kite	LC
20	*Haliaeetus leucoryphus*	Pallas's Fishing Eagle	S
21	*Gyps fulvus*	Eurasian Griffon Vulture	C
22	*Neophron perenopterus*	Egyptian Vulture	Ra
23	*Circus aeruginosus*	Marsh Harrier	C

24	*Aquila clanga*	Greater Spotted Eagle	LC
25	*Aquila nipalensis*	Steppe Eagle	C
26	*Circaetus gallicus*	Short-toed Eagle	Ra
27	*Pandion haliaetus*	Osprey	LC
28	*Falco tinnunculus*	Common Kestrel	LC
29	*Falco columbarius*	Merlin	Ra
30	*Francolinus pondicerianus*	Grey Partridge	C
31	*Amaurornis phoenicurus*	White-breasted Waterhen	LC
32	*Gallinula chloropus*	Common Moorhen	C
33	*Fulica atra*	Common Coot	C
34	*Hydrophasianus chirurgus*	Pheasant-tailed Jacana	LC
35	*Himantopus himantopus*	Black-winged Stilt	C
36	*Charadrius dubius*	Little-ringed Plover	LC
37	*Hoplopterus (vanellus) indicus*	Red-wattled Lapwing	C
38	*Chettusia (vanellus) leucurus*	White-tailed Lapwing	LC
39	*Calidris minutus*	Little Stint	C
40	*Gallinago (capella) gallinago*	Common Snipe	LC
41	*Tringa stagnatilis*	Marsh Sandpiper	LC
42	*Tringa totsnus*	Redshank	C
43	*Tringa nebularia*	Green Shank	LC
44	*Tringa ochropus*	Green Sandpiper	C
45	*Tringa glareola*	Wood Sandpiper	LC
46	*Actitis hypoleucos*	Common Sandpiper	LC
47	*Calidris temminckii*	Temminck’s Stint	C
48	*Calidris minuta*	Little Stint	C
49	*Larus ichthyaetus*	Great Black-headed Gull	C
50	*Larus ridibundus*	Black-headed Gull	C
51	*Larus argentatus*	Herring Gull	C
52	*Gelochelidon nilotica*	Gull-billed Tern	C
53	*Sterna aurantia*	River Tern	C
54	*Sterna albifrons*	Little Tern	C
55	*Chlidonias hybrid*	Whiskered Tern	C
56	*Sterna acuticauda*	Black-bellied Tern	S
57	*Columba livia*	Blue Rock Pigeon	C
58	*Pterocles exustus*	Chestnut-bellied Sandgrouse	LC
59	*Streptopelia decaocto*	Collared Dove	C
60	*Streptopelia senegalensis*	Little Brown Dove	C
61	*Psittacula krameri*	Rose-ringed Parakeet	LC
62	*Centropus sinensis*	Crow Pheasant	LC
63	*Endynamys scolopacea*	Common Koel	C
64	*Caprimulgus mahrattensis*	Syke’s Nightjar	LC
65	*Apus affinis*	House Swift	C
66	*Halcyon smyrnensis*	White-throated Kingfisher	C
67	*Alcedo atthis*	Common Kingfisher	LC
68	*Ceryle rudis*	Pied Kingfisher	C
69	*Merops orientalis*	Little Green Bee-eater	LC
70	*Coracias benghalensis*	Indian Roller	LC
71	*Upupa epops*	Hoopoe	LC
72	*Dinopium benghalensis*	Golden-backed Woodpecker	LC
73	*Eremopterix grisea*	Ashy-crowned Finch Lark	LC
74	*Eremopterix nigriceps*	Black-crowned Finch Lark	LC
75	*Ammomanes deserti*	Desert Finch Lark	LC
76	*Galerida cristata*	Crested Lark	C
77	*Alanda gulgula*	Oriental Sky Lark	C

78	*Riparia paludicola*	Plain Sand Martin	C
79	*Hirundo rustica*	Common Swallow	C
80	*Hirundu smithi*	Wire-tailed Swallow	C
81	*Lanius isabellinus*	Isabelline Shrike	LC
82	*Lanius vittatus*	Bay-backed Shrike	LC
83	*Lanius meridionalis*	Southern Grey Shrike	LC
84	*Dicrurus macrocercus*	Black Drongo	C
85	*Acridotheres tristis*	Common Myna	C
86	*Acridotheres ginginianus*	Bank Myna	C
87	*Stumus vulgaris*	Common Starling	C
88	*Dendrocitta vagabunda*	Indian Tree-pie	LC
89	*Corvus splendens*	Indian House crow	C
90	*Pycnonotus leucogenys*	White-cheeked Bulbul	A
91	*Pycnonotus cafer*	Red-vented Bulbul	LC
92	*Turdoides caudatus*	Common Babbler	C
93	*Turtoides earlei*	Striated Babbler	LC
94	*Turtoides striatus*	Jungle Babbler	LC
95	*Acrocephalus Agricola*	Paddy-field Warbler	S
96	*Acrocephalu neglectus*	Clamorous Reed Warbler	LC
97	*Cettia cetti*	Cettis Warbler	S
98	*Phylloscopus collybita*	Eurasian Chiffchaff	C
99	*Phylloscopus neglectus*	Plain Leaf Warbler	C
100	*Prinia inornata*	Plain Prinia	S
101	*Sylvia curruca*	Lesser Whitethroat	LC
102	*Rhipidura rhipidura*	White-browed Fantail Flycatcher	LC
103	*Prinia flaviventris*	Yellow-bellied Prinia	S
104	*Orthotomus suturius*	Common Tailor Bird	LC
105	*Luscinia svecica*	Blue-throat	LC
106	*Saxicola caprata*	Pied Bushchat	LC
107	*Oenanthe deserti*	Desert Wheatear	LC
108	*Oenanthe picata*	Eastern Pied Wheatear	LC
109	*Oenanthe alboniger*	Hume's Wheatear	LC
110	*Saxicoloides fulicat*	Indian Robin	C
111	*Anthus compestris*	Tawny Pipit	LC
112	*Anthus rufulus*	Paddy-field Pipit	C
113	*Motacilla flava*	Yellow Wagtail	C
114	*Motacilla alba*	White Wagtail	C
115	*Motacilla maderaspatensis*	White-bowed Pied Wagtail	LC
116	*Nectarina asiatica*	Purple Sunbird	LC
117	*Passer domesticus*	Indian House Sparrow	C
118	*Petronia xanthocollis*	Yellow-throated Sparrow	C
119	*Ploceus manyar*	Streaked Weaver	C
120	*Lonchura malabarica*	White-throated Munia	LC
121	*Emberiza stiolata*	House Bunting	LC

Table 4. Reptiles of Keenjhar Lake (Khan and Abbas, 2011; Khan *et al*., 2012).

S. No.	**Scientific Name**	**Common Name**
1.	*Calotes versicolor*	Indian Garden Lizard
2.	*Trapelus agilis*	Brilliant Agama
3.	*Trapelus megalonyx*	Afghan Ground Agama
4.	*Eublepharis macularius*	Fat-tailed Gecko
5.	*Cyrtopodion kachhensis*	Warty Rock Gecko

6.	*Cyrtopodian scaber*	Keeled Rock Gecko
7.	*Hemidactylus brookii*	Spotted Indian House Gecko
8.	*Hemidactylus flaviviridis*	Yellow-bellied House Gecko
9.	*Hemidactylus leschenaultii*	Bark Gecko
10.	*Acanthodactylus cantoris*	Indian Fringed-toed Sand Lizard
11.	*Ophisops jerdonii*	Punjab Snake-eyed Lacerta
12.	*Sara hardwickii*	Indian Spiny-tailed Lizard
13.	*Varanus bengalensis*	Indian Monitor Lizard
14.	*Eryx conicus*	Russel's Sand Boa
15.	*Coluber fasciolatus*	Banded Racer
16.	*Lycodon striatus*	Spotted Wolf Snake
17.	*Oligodon taeniolatus*	Streaked Kukri Snake
18.	*Platyceps rhodorachis*	Cliff Racer
19.	*Platyceps ventromaculatus*	Glossy-bellied Racer
20.	*Psammophis condanarus*	Pakistan Ribbon Snake
21.	*Psammophis leithii*	Indian Sand Sake
22.	*Ptyas mucosus*	Dhaman/Rope Snake
23.	*Spalerosophis diadema*	Royal Snake
24.	*Bungarus caeruleus*	Common Krait
25.	*Naja naja*	Indian Cobra
26.	*Naja oxiana*	Oxus Cobra/Brown Cobra
27.	*Daboia russelii*	Russel's Viper/ Chain Viper
28.	*Echis carinatus*	Saw-scaled Viper
29.	*Lissemys punctata*	Indian Flap-shelled Turtle

Table 5. Fishes of Keenjhar Lake (Khan and Abbas, 2011; Khan *et al*., 2012).

S. No.	**Species**
1	*Gadusia chapra*
2	*Notopterus chitala*
3	*N. notopterus*
4	*Chela cachius*
5	*Salmostoma bacaila*
6	*Securicula gora*
7	*Amblypharyngodon mola*
8	*Aspidoparia morar*
9	*Barilius vagra*
10	*Esomus danricus*
11	*Rasbora daniconius*
12	*Barbodes sarana*
13	*Catla catla*
14	*Cirrhinus mrigala*
15	*Cirrhinus reba*
16	*Labeo calbasu*
17	*Labeo dero*
18	*Labeo dyocheilus*
19	*Labeo gonius*
20	*Labeo rohita*
21	*Osteobrama cotio*
22	*Puntius chola*
23	*Puntius sophore*
24	*Puntius ticto*
25	*Cyprinus carpio*
26	*Ctenpharyngodon idella*
27	*Aristchthys nobilis*
28	*Hypophthalmichthys molitrix*
29	*Mystus bleekeri*
30	*Mystus cavasius*
31	*Mystus vittatus*
32	*Rita rita*
33	*Bagarius bagarius*
34	*Gagata cenia*
35	*Nangra nangra*
36	*Ompok bimaculatus*
37	*Wallago attu*
38	*Heteropneutes fossilis*
39	*Ailia coila*
40	*Clpisoma garua*
41	*Clpisoma naziri*
42	*Eutropiichthys vacha*
43	*Xenentodon cancila*
44	*Channa marulia*
45	*Channa punctata*
46	*Chanda nama*
47	*Parambassis baculis*
48	*Parambassis ranga*
49	*Sicamugil cascasia*
50	*Glossogobium giuris*
51	*Colisa fasciata*
52	*Colisa lalia*
53	*Oreochromis mossambicus*
54	*Mastacembelus armatus*

Pollution is considered as a major hazard for the water of Keenjhar Lake. It directly affects the quality of water and made it harmful for human consumption because of the addition of hazardous wastes from the industrial effluents of Kotri industrial area as well as Nooriabad industries (Fig. 7). The lake also serves a waste dumping area for at least 12 villages with a population of about over 1,500 people (Ilyas, 2015). Second major threat to ecology of Keenjhar Lake is Eutrophication (Fig. 8). This lake is also a hotspot of ecotourism. The main cause of its pollution is the arrival of above 15,000 visitors weekly which pose a serious risk to biodiversity of lake by polluting its water (see Figs. 9-12). Some people also used to wash their vehicles in the lake which resulted in the contamination of water with oil and fuels. Two types of system are followed in the lake for fishing practices, first one is Auction system and another one is License system but none of these are properly followed by fishermen and local people. There are so many disagreements based on these two systems in between Fisheries department and local fishermen. There are so many drawbacks developed in fisheries system of lake as there is no recruitment of new fish seeds in that lake and the continuous fishing practices has decreased the fisheries stock in this Lake. There is a major canal emerging from lake which supplies water to Karachi which is also an important source for exclusion of fish from the lake (Khan *et al*., 2012).

Fig. 7. Polluted water enter to Keenjhar Lake.

Fig. 8. A view of eutrophication in Keenjhar Lake.

There are five departments of Government which participates in the management of Keenjhar Lake. They includes Sindh Irrigation Department, Sindh Fisheries Department, Sindh Tourism Department, Sindh Wildlife Department and the Sindh Local Government Department. The problem is that these all departments are not working on collaboration with each other and that's the reason of mismanagement in the matters of lake`s development.

One example of this mismanagement is the introduction of *Tilapia* species on the lake which is a carnivorous fish. It is a predator species and has dominated over the native herbivorous species present in the lake such as Rohu, Thaila and Murakhi. Whereas, the introduced plant species have also invaded the whole open area in the lake. These introduces plants are *Eichhornia crassipes* (Water Hyacinth) and *Salvania molesta* (Water Fern).
These invasive aquatic weeds included Hyacinth (*Eichhornia crasspes*) and Water lettuce (*Pista stratiotes)* not only disturbs ecology of other aquatic vegetation but also obstruct water channels which are used for different purposes including commercial, recreational and household utilization. This eutrophication leads to habitat destruction and degradation, shortening of fishing sites and modification in infrastructure of fisheries system of the lake. These weeds also act as breeding grounds for mosquitoes and resulted in disastrous hazards for neighboring human populations. Exotic species not only disturb the ecology of the area but having severe effects on food chains and food web of that ecosystem. Interference of invasive species may results in disappearance of many native species from any ecosystem.

Fig. 9. Keenjhar Lake, a popular picnic point.

Fig. 10. Public disturbance at Keenjhar Lake.

Fig. 11. Oil pollution at Keenjhar Lake.

Fig. 12. Fishing activity in the Keenjhar Lake.

CONCLUSION

Based on this review, it is concluded that a more scientific detailed studies of Keenjhar Lake should be taken via academia and Sindh Wildlife Department with respect to habitat modifications due to environmental hazards present in the lake. The major threats should be point out and highlighted. All sources of pollution should be blocked including the industrial waste and agricultural waste. All projects including RBOD which is passing through Keenjhar and Haleji should be systematically monitored through Government of Sindh. The movements of migratory birds should be noted and there should be a check and balance on their population estimation. It should be ensured that there will be no illegal hunting of migratory species. The rare or vulnerable species should have special protection. There should be annual water bird census which will enable us to conserve them more effectively.

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