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Avifauna Studies in Co-Relation with Alteration in Climatic Patterns and Hydrology of Uchalli Lake, Punjab, Pakistan

Muhammad Arshad,[1*] Naunain Mehmood,[1] Hira Muqadas,[1] Jamshed Chaudhry,[2] Irfan Mustafa,[1] Mobushir Riaz Khan,[3,4] Inayat Ullah Malik[5] and Haroon Ahmed[6]

[1]*Department of Biological Sciences, University of Sargodha, Sargodha, Pakistan*

[2]*WWF, Lahore, Pakistan*

[3]*Institute of Space Technology, Near Rawat Toll Plaza, Islamabad Express Way, Islamabad, Pakistan*

[4]*Department of Geo-informatics, Faculty of Agricultural Engineering, PMAS-Arid Agriculture University, Rawalpindi, Pakistan*

[5]*Department of Zoology, Wildlife & Fisheries, GC University, Faislabad, Pakistan*

[6]*Department of Biosciences, COMSATS Institute of Information Technology (CIIT), Park Road, Chak Shazad, Islamabad, Pakistan*

Abstract.-Mid-winter population count of bird species and hydrological analysis of surface water were carried out for Uchalli lake (ramsar site) in year 2010 and 2011. Eleven species visited the lake in 2010 and their total number was 1,139. Moreover, the number of species observed in 2011 was 34 with population of 18,606 birds in total. The species observed both in 2010 and 2011 were Greater Flamingo, Black-winged Stilt, Gadwall, Mallard, Northern Pintail, Common Coot, Kentish Plover, Indian Courser, Great Bittern and Little Bittern which constituted about 29% of the total number of species present at the lake. The relative abundance was calculated for each species. Common Coot was the most abundant species in both years. The total area of lake was estimated to be 850 ha in 2010 and 943 ha in 2011. The Shannon-Weiner diversity index was also calculated. In year 2010, the diversity index was 1.47 while for year 2011 it was 1.88. In surface water analysis, Cu^{+2}, Cd^{+2}, Co^{+2}, Fe^{+2}, Mn^{+2}, Pb^{+2}, Zn^{+2}, Mg^{+2}, total hardness, Cl^{-} and SO^{-4} were found to be above the permissible limits. Parameters like EC, pH, temperature, transparency were also calculated. All parameters had varied values in different months of the year. However, less variation was seen in concentration of sulphates, nitrates, total phosphorous and chlorides.

Key words: Uchalli lake, mid-winter population count, hydrological analysis, Avifauna, Ramsar site.

INTRODUCTION

Wetlands are an important geographical feature upon which the existence of natural resources like ground water, fisheries and wildlife depend. Wetlands also play key roles like control of flood and storm by absorption and storage of water, provision of breeding, nesting and feeding grounds and shelter for many forms of wildlife, reservoir recharging ground water supplies, erosion control by serving as a sedimentation area and source of nutrients (Hairston and Fussmann, 2002; Ali, 2005; Galbraith *et al.*, 2005).

Climate change affects almost every aspect of the environment, including wetlands and waterfowl. Altering precipitation levels, sea level rise, warming, variation in length and timing of seasons are the most predicted changes in climatic patterns. Practically, there is no remedy for impacts of climatic change, but taking specific measures can reduce the level of this impact. For instance, increased protection of wetlands and reduction in water pollution may make plants and animals more tolerant to small temperature changes and also help in achieving wetland protection and restoration goals. Loss of wetlands encourages global warming as wetlands play a vital role in carbon cycle. Changes in flight patterns of geese and ducks have been observed in some parts of North America due to unusual weather events. The rapid climatic change is enhanced by continued anthropogenic induction of carbon dioxide in atmosphere during the past hundred years (Browne and Dell, 2007). The largest component (14%) of global terrestrial biosphere carbon pool is contained in wetlands, including peatlands, as these have a substantial potential for long-term carbon storage (Wylynko, 1999). Minor changes in clime significantly affect the hydrology of wetlands. Not only the

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precipitation level, but the onset of precipitation events like increase in amount of precipitation per event and drier periods in between affects the wetlands to a considerable level (Browne and Dell, 2007).

The annual life cycles of migratory avian species vary with the changes in climate which affect migration timing, breeding period, egg-laying and demography (Alerstam and Hedenström, 1998; Crick and Sparks, 1999; Przybylo *et al.*, 2000; Jonzen *et al.,* 2002; Tryjanowski *et al.*, 2002; Hüppop and Hüppop, 2003; Jenni and Kery, 2003; Sparks and Mason, 2004; Newton, 2008). Various environmental factors (the presence and number of parasites, predators, eutrophication, and human activity) that affect the habitat of a bird species are also affected by changing climate (Mustin *et al.,* 2007). Fresh water habitats and the species associated with them are more threatened in comparison to terrestrial habitats (McAllister *et al.*, 1997; Ricciardi and Rasmussen, 1999).

Migratory birds serve as bio-indicators for the productivity and ecological conditions of the wetlands. Migratory patterns, distribution status and population dynamics of these birds give a vivid picture about the condition of a wetland (Kushlan, 1993).

The present study was undertaken to assess the concentration levels of various heavy metals and other physico-chemical parameters in surface water of Uchalli lake. Avifauna census was carried out to take into account the number of species and their population at the wetland. The study was carried out most importantly to determine the condition of the lake and to check the impact of anthropogenic activities and the climate change on aquatic biota and the migratory species visiting this water body. This would help in outlining the major factors responsible for species decline at this internationally important wetland and updating the knowledge for the species status and hydrology of this Ramsar site.

MATERIALS AND METHODS

Study area

The study was carried out at Uchalli lake (32°33'N, 72°04'E), situated some 13 kilometers north-east of Nowshera village and is at a distance of 42 kilometers from District Khushab, Punjab province (Fig. 1). The total area of lake is 943 ha. It is a brackish to saline lake; the depth varies from 4-6 m. The basic source of water in lake is rain water thus the area of lake fluctuates in accordance with rainfall. Several small springs arising from the surrounding hills also feed the lake. Water is hyper saline with pH of about 10. Salinity and water level vary in accordance with the local rains. Large scale agriculture takes place around the lake. The catchment area is used for agricultural practices and these lands are cultivated with the tube well water. The lake water serves many purposes for the local people like washing of clothes, utensils, bathing of livestock. Grazing lands adjoining the lake are used by buffaloes, horses and donkeys. The lake was declared as a wildlife sanctuary in 1985 and was also declared (as a part of Uchalli Wetlands Complex) Ramsar site on 22-3-1996 (Ali, 2005; Arshad, 2011).

Birds

Early morning and late evening visits were made to the lake and its catchment area for avi-fauna census. Point count method was applied to estimate the density of birds (Bibby and Burgess, 1992; Sutherland, 1996). Birds were identified using binoculars (12x50) and spotting scope (15x60) following Ali and Ripley (1987), Woodcock (1980), Roberts (1991, 1992) and Grimmett *et al.* (2008). To ease up the identification of birds care was taken that the sun was always at the back. Three random observation points were chosen. The relative abundance of each species was calculated besides determining the most abundant species during the counts.

$$\text{Relative abundance: } \frac{\text{Total number of individuals of one species}}{\text{Total number of individuals of all species}} \times 100$$

Criterion employed by Bull (1964) and McCaskle (1970) was used to calculate the abundance of each species. Dominant and sub-dominant index was applied to species having higher relative abundance (Ali, 2005). Census index was used to calculate the density of birds belonging to each species. For this purpose the total area of

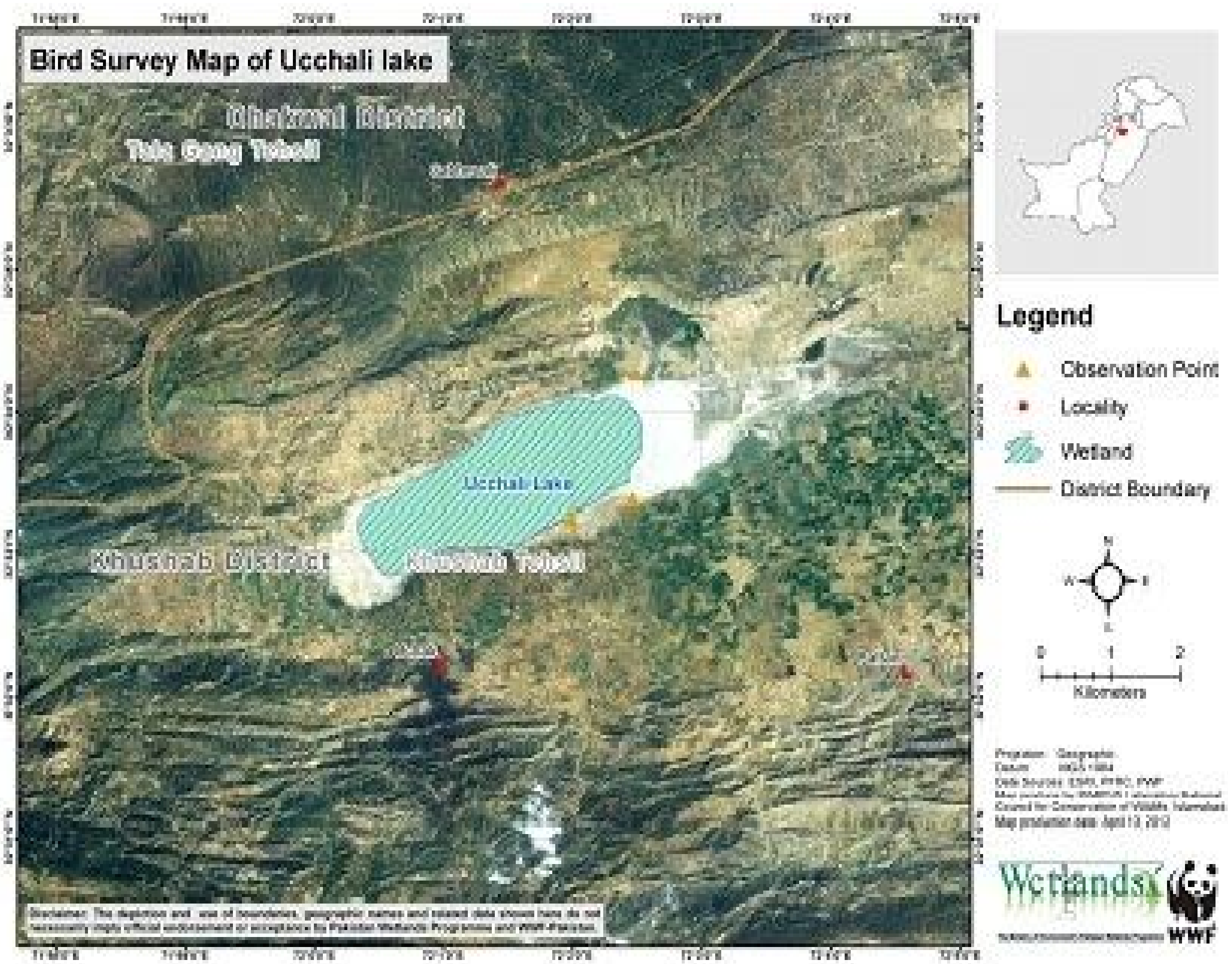

Fig. 1. Study area (Uchalli lake)

lake was determined by GIS technique. The surface area of water was calculated from a map plotted against the coordinates recorded with a Garmin GPS (Ali and Akhtar, 2005).

$$\text{Census Index:} \quad \frac{\text{Total number of individuals of one species}}{\text{Total area of the lake in km}^2}$$

Feeding habits of different species were determined on the basis of their food preferences as observed by Roberts (1991, 1992). The diversity of each species was calculated using Shannon-Weiner Diversity Index (1963). The equation for the index is given below:

$$\text{Diversity index} = H' = -\Sigma\,(P_i \ln P_i)$$

Where H is the amount of diversity in a particular habitat or ecosystem, P_i represents relative abundance of species to the total population and ln P_i is the natural logarithm of it.

A well known richness index was employed known as Margalef Index (1958) which is calculated as:

$$R = S - 1/\ln(n)$$

Where R is the richness of species, S is the number of species and n is the number of individuals representing the sample.

Evenness index used in current study is the one used by Pielou (1966). It is calculated as:

$$e = H / \ln S$$

Where H is Shannon-Wiener diversity index and S is the total number of species in the sample. Diversity, richness and evenness were calculated using SPDIVERSE software which is designed by Ludwig and Reynolds (1988).

Physicochemical parameters

Water samples were taken from three sampling points within the lake and the samples were collected from the same location each time. On spot readings were taken for pH, temperature and electrical conductivity (EC). The samples were collected regularly for a year *i.e.* August 2010- July 2011. The surface water samples were taken in 1 liter polythene bottles. The bottles were soaked in nitric acid (5%) for 24 hours after washing. Bottles were again rinsed with deionized water before sampling (Laxen and Harrison, 1981). Titration and turbidimetric procedures were followed to determine chloride and sulphate concentration (inacidified portion) respectively while nitrate and phosphate concentrations were calculated using spectrophotometric methods. 5 ml nitric acid was immediately added to the samples to avoid adsorption of heavy metals onto the walls of sampling bottles (Ademoroti, 1996). Samples were safely transferred to laboratory.

For heavy metal analysis, samples underwent the process of digestion. 200ml of the sampled water was taken in beaker and 5ml di-acid mixture (HNO_3: $HCLO_4$ :: 9:4) was added to it. The beaker was then placed on hot plate after which the concentrate was filtered by Whatman No: 42 filter paper. Double distilled water was added to filtrate to make the volume of 50ml (Kar *et al.*, 2008). Digested samples were then placed in pre-washed polythene bottle. Throughout the processing period analytical grade (AG) reagents were used. Various standards of heavy metals were prepared from certified standard stock solution (ppm) by using double distilled water. These standards were used to obtain calibration curve on Atomic Absorption Spectrophotometer.

Water sample were analyzed for heavy metals (Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb, Zn) in Shimadzu (AA-6300) Atomic Absorption Spectrophotometer (AAS). Obtained readings were multiplied with dilution factor. Values were recorded in mg/L.

Statistical analysis

One way ANOVA (Steel and Torrie, 1980) had been applied to statistically summarize the results.

RESULTS

In the present study the population count of birds at Uchalli lake was carried out for two consecutive years *i.e.* 2010 and 2011. Bird species varied both in numbers and diversity. A total of eleven species visited the Uchalli lake in 2010 with their total numbers calculated upto 1,139 whereas, an observable difference was seen in year 2011 as the number of species rose to 34 and their total numbers reaching upto 18,606. Species observed both in 2010 and 2011 were Greater Flamingo, Black-winged Stilt, Mallard, Gadwall, Northern Pintail, Common Coot, Kentish Plover, Indian Courser, Great Bittern and Little Bittern while Gray Wagtail was not recorded in 2011. The relative abundance was calculated for each species. Common Coot was the most abundant species in both years. Its relative abundance was 52.43 and 44.14 in 2010 and 2011 respectively, the highest among other species. The sub-dominant species at the lake in 2010 was Northern Pintail (28.13%) while for 2011 it was Common Pochard (18.98%). Common Pochard and Northern Shoveler were not recorded at the lake in 2010 but they had fairly large populations in 2011. Gadwall and Mallard had generally lower populations in 2010 as compared to 2011 but they had higher relative abundance in 2010. The least abundant birds were Kentish Plover, Common Moorhen, Purple Swamphen, Common Redshank, Common Greenshank, Intermediate Egret, Purple Heron, Grey Heron, Indian River Tern, Common Tern and Marsh Harrier among other species whose abundance values were even less than one (Tables I, II).

The area covered by lake was calculated by using GIS techniques. The total area of lake was calculated to be 850 ha and 943 ha in 2010 and 2011, respectively. This was done to calculate the density of each species visiting the lake as less density of birds was seen in year 2010 as compared to 2011. Dense populations of common coot were observed; the census index values turned out to be

Table I.- **Census index of avifauna observed at Uchalli lake for year 2010.**

Species (Common name)		Scientific name	Total population[a]	Relative abundance	Census index (Density/km^2)
1.	Common coot	*Fulica atra*	602±7.61	52.43	70.82
2.	Northern pintail	*Anas acuta*	323±4.03	28.13	38.00
3.	Gadwall	*Anas strepera*	61±5.26	5.31	7.17
4.	Mallard	*Anas platyrhynchos*	41±5.75	3.57	4.82
5.	Gray wagtail	*Motacilla cinerea*	35±4.47	3.04	4.11
6.	Black-winged stilt	*Himantopus himantopus*	34±5.60	2.96	4.00
7.	Greater flamingo	*Phoenicopterus ruber*	31±2.92	2.70	3.64
8.	Kentish plover	*Charadrius alexandrinus*	9±3.07	0.78	1.05
9.	Great bittern	*Botaurus stellaris*	1±2.55	0.08	0.11
10.	Indian courser	*Cursorius coromandelicus*	1±2.54	0.08	0.11
11.	Little bittern	*Ixobrychus minutus*	1±1.88	0.08	0.11

[a] mean population of birds

Table II.- **Census index of avifauna observed at Uchalli lake for year 2011**

Species (Common name)		Scientific name	Total population[a]	Relative abundance	Census index (Density/km^2)
1.	Common coot	*Fulica atra*	8219±7.69	44.14	871.58
2.	Common pochard	*Aythya ferina*	3534±4.14	18.98	374.76
3.	Common teal	*Anas crecca*	1605±11.5	8.62	170.20
4.	Northern shoveler	*Anas clypeata*	1215±2.00	6.52	128.84
5.	Black-winged stilt	*Himantopus himantopus*	1193±5.37	6.40	126.51
6.	Northern pintail	*Anas acuta*	960±9.47	5.15	101.80
7.	Little grebe	*Tachybaptus ruficollis*	359±1.30	1.92	38.07
8.	Tufted Duck	*Aythya fuligula*	248±3.85	1.33	26.29
9.	Black headed gull	*Larus ridibundus*	239±4.40	1.28	25.34
10.	Mallard	*Anas platyrhynchos*	234±6.32	1.25	24.81
11.	Gadwall	*Anas strepera*	204±5.34	1.09	21.63
12.	Cattle egret	*Bubulcus ibis*	158±1.85	0.84	16.75
13.	Little stint	*Calidris minuta*	117±6.34	0.62	12.40
14.	Little cormorant	*Phalacrocorax niger*	39±7.25	0.20	4.13
15.	Common snipe	*Gallinago gallinago*	38±4.53	0.20	4.03
16.	Red-wattled lapwing	*Vanellus indicus*	30±6.11	0.16	3.18
17.	Indian pond heron	*Ardeola grayii*	29	0.15	3.07
18.	Common sandpiper	*Actitis hypoleucos*	25±3.46	0.13	2.65
19.	Common moorhen	*Gallinula choloropus*	21±2.82	0.11	2.22
20.	Northern lapwing	*Vanellus vanellus*	20±3.92	0.10	2.12
21.	Common redshank	*Tringa totanus*	20±4.40	0.10	2.12
22.	Common tern	*Sterna hirundo*	14±1.06	0.07	1.48
23.	Common greenshank	*Tringa nebularia*	13±1.77	0.07	1.37
24.	Intermediate egret	*Mesophoyx intermedia*	12±1.85	0.06	1.27
25.	Indian River tern	*Sterna aurantia*	12±2.77	0.06	1.27
26.	Purple heron	*Ardea purpurea*	11±0.92	0.05	1.16
27.	Marsh harrier	*Circus aeeruginosus*	10±0.00	0.05	1.06
28.	Purple swamp hen	*Porphyrio porphyrio*	9±2.82	0.04	0.95
29.	Grey heron	*Ardea cinerea*	7±2.07	0.03	0.74
30.	Greater flamingo	*Phoenicopterus ruber*	4±2.13	0.02	0.42
31.	Kentish plover	*Charadrius alexandrinus*	4±2.72	0.02	0.42
32.	Great bittern	*Botaurus stellaris*	1±3.70	0.01	0.21
33.	Indian courser	*Cursorius coromandelicus*	1±1.23	0.005	0.10
34.	Little bittern	*Ixobrychus minutus*	1±2.47	0.005	0.10

[a] mean population of birds

70.82/km^2 and 871.58/km^2 for 2010 and 2011, respectively. Shannon-Weiner diversity index was used to calculate the species diversity for Uchalli lake in year 2010 and 2011. Diversity of avifauna was higher for 2011 (1.88) as compared to 2010 (1.47). Species richness was also high in 2011. However, evenness was more in 2010 as compared to 2011 (Table III).

Among 35 species that were recorded from lake, 21 species were wintering (60%), 6 passage migrants (17.14%), 2 summer breeders (5.71%) and 6 year-round residents (17.14%). Furthermore, species status of avifauna at Uchalli lake was noted. Bird populations differed at the lake for both years.

Table III.- Summary of different analysis at Uchalli lake for year 2010 and 2011

Analysis	2010	2011
Area surveyed (ha)	850	943
Total population	1139	18,606
Number of species	11	34
Census index	134.00/km^2	1973.17/km^2
Shannon-Weiner Diversity Index	1.47	1.88
Mergalef index (M)	1.41	3.35
Evenness index (E)	0.60	0.53
Dominant species	Common Coot (52.43)	Common Coot (44.14)
Sub-dominant species	Northern Pintail (28.13)	Common Pochard (18.98)

Species status of birds was determined according to their population numbers. In 2010 out of total 11 species five species were very common followed by very rare (3), abundant (2) and fairly common (1). Whereas in 2011, eleven species were fairly common followed by very abundant (5), abundant (5), common (4), uncommon (3) and very rare (Fig. 2). Feeding habits of birds were also determined. Carnivorous birds (insects, crustaceans, fish, frog and mollusks) were higher (68%) than omnivorous (29%; seeds, submerged vegetation, shoots, leaves, insects, small beetles, insect larvae, worms, and micro-crustacea) and herbivorous birds (3%; vegetation in water and shoots of the plants; Fig. 3). Different trend of species status was observed in both years. With the rise in number of species and their population an upward trend was noted in 2011. Rainfall records were also taken. In year 2009, the amount of rainfall was 225mm while in year 2010 it was 668mm.

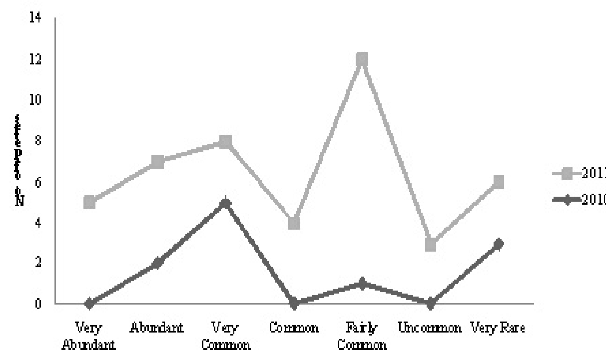

Fig. 2. comparison of species status at Uchalli lake for year 2010 and 2011.

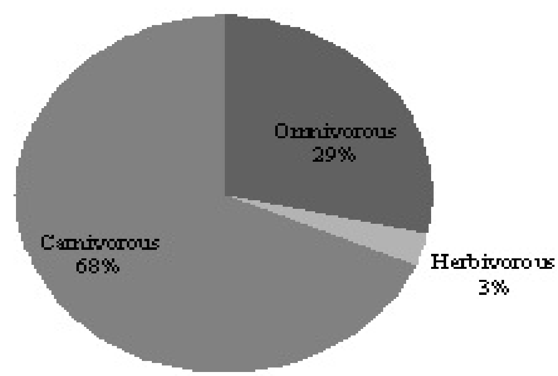

Fig. 3. Feeding habits of birds at Uchalli lake.

The EC values ranged between 39830.33-39831 μScm^{-1} while the pH varied from 9.10 to 9.12. The temperature varied from 20.08-20.29 ºC (Table IV). Not much variation was observed at different sampling stations in the same month. The transparency of lake varied temporally. Overall, the transparency values ranged between 63.66 and 64.58 cm. Other physico-chemical parameters including nitrates, sulphates, calcium, magnesium, total hardness, carbonates, bicarbonates, chloride and total phosphorous were also studied (Table IV). All these parameters had varied values in different months of the year. However, less variation was seen in concentration of sulphates, nitrates, total phosphorous, total hardness, carbonates and bicarbonates. Slight variation was seen in calcium,

Table IV.- Analytical values of different surface quality parameters in Uchalli lake

Parameter	Sampling Locations			USEPA/WHO Standards
	Site 1	Site 2	Site 3	
Temperature (°C)	20.08±6.02	20.12±5.93	20.29±6.61	-
Transparency (Cm)	64.58±16.16	63.91±16.82	63.66±16.85	-
pH	9.12±0.18*	9.10±0.17*	9.11±0.17*	6.5-9[a]
Electrical conductivity (μScm^{-1})	39830.33±39.72	39831±39.271	39831±39.43	-
Total nardness (mg/L)	712.66±16.52*	710.41±15.47*	712.75±14.68*	500[b]
Nitrates (mg/L)	0.076±0.007	0.076±0.007	0.076±0.007	-
Total phosphorous (mg/L)	0.683±0.067	0.680±0.066	0.682±0.066	400[b]
Sulphates (mg/L)	7208.16±3.24*	7207.75±3.64*	7207.83±2.88*	250[b]
Cadmium (mg/L)	0.072±0.0419*	0.073±0.0424*	0.075±0.0399*	0.002[a]
Cobalt (mg/L)	0.053±0.0337*	0.0537±0.033*	0.047±0.0331*	0.04[b]
Chromium (mg/L)	0.015±0.007	0.014±0.006	0.016±0.006	0.016[a]
Copper (mg/L)	0.167±0.0577*	0.166±0.0544*	0.159±0.0559*	0.013[a]
Iron (mg/L)	6.681±2.188*	6.682±2.1878*	6.683±2.1876*	1.000[a]
Manganese (mg/L)	0.499±0.3526*	0.5005±0.3522*	0.501±0.3503*	0.4[b]
Nickel (mg/L)	0.148±0.054	0.152±0.0549	0.151±0.0551	0.470[a]
Lead (mg/L)	0.208±0.060*	0.210±0.0598*	0.210±0.0594*	0.065[a]
Zinc (mg/L)	0.596±0.303*	0.598±0.3019*	0.597±0.305*	0.12[a]
Chloride (mg/L)	3584.58±10.94*	3584.08±10.38*	3583.91±9.80*	860[a]
Calcium (mg/L)	94.83±7.73	94±5.87	94.5±6.25	200[b]
Magnesium (mg/L)	617.83±9.24*	617.75±9.05*	618.25±8.88*	100[b]
Carbonates (mg/L)	341.25±2.05	342.25±2.13	342.66±2.30	-
Bicarbonates (mg/L)	775.25±3.07	774.58±3.02	775.91±2.27	-

[a] USEPA (2002)
[b] WHO (1985, 2006)
*values higher than USEPA/WHO standards

magnesium and chlorides. The heavy metal concentrations in the surface water samples from Uchalli lake followed the decreasing trend: Fe> Zn> Mn> Pb> Cu> Ni> Cd> Co> Cr for three sites (Table IV). Minimum values for Cd, Cr, Cu, Fe, Ni and Zn were recorded during June and July. However, maximum level for Co was found in July. Furthermore, minimum concentration of Pb, Co and Mn was recorded during August, December and January.

According to the distribution of heavy metals to the sampling sites, the difference in the measurements between sampling sites for all heavy metals was found to be non-significant ($p > 0.05$).

DISCUSSION

A total of 331 species of birds were reported by Roberts (1991, 1992) from Salt Range Wetlands Complex (Kallar Kahar, Nammal, Uchalli, Khabeki and Jahlar lakes) and its catchment area out of which 164 were passerines and 167 were non passerines. Grimmett *et al.* (2001) had recorded 346 species from the same area. Surveys done by Ali and Chaudhary (2006) indicated the presence of 121 species among which the House Crow, Common Coot, Common Pochard, Mallard, Gadwall, Northern Pintail, Northern Shoveler and Black-winged Stilt had very high populations in the Salt Range Wetlands Complex.

Uchalli lake had been a major wintering ground of majority of waterfowl which spend winters here and fly back to their breeding grounds. Majority of birds that visit these wetlands come from Europe and Siberia (Ali, 2005). The migratory birds start their journey from frozen grounds of Europe and northern Asia on the arrival of winter season when food resources become scarce due to snow cover. These birds breed in summer when the photoperiods are longer and food is abundant. They take up major migratory routes termed as flyways to reach their wintering grounds. Bird migration is a complex phenomenon and involves many physiological processes. Bird migration starts mostly at dusk when winds are favorable. This also protects them from likely predation risks which are least at night (Ali, 2005).

Uchalli lake had suffered major morphometric and climatic changes in past (Ali, 2005) thus the migratory avifauna that visited this complex had declined considerably with the changes in characteristics of this wetland (Ali, 2005; Ali and Chaudhary, 2006; Azam *et al.*, 2008) as noted in the current study. Distribution of waterfowl is determined by the structure and form of wetland. Current study suggested that migratory birds were attracted to a large extent with higher water level in lake. This could be seen as the bird populations differed in co-relation with a change in area of the lakes. In 2010 when water level was less, bird population count was just 1,139 while this number rose to 18,606 due to higher water level. The amount of precipitation determined the morphometery of lake each year. As the avifauna census was conducted in first two months of year 2010 and 2011 so the rainfall records of year 2009 and 2010 were taken into account. The amount of precipitation in year 2009 was not ample to fill up the lake. However, in year 2010, heavy monsoon rains helped in bringing the wetland back to life. So a positive correlation among the bird population and amount of precipitation was indicated by these findings.

Thus the Uchalli lake supported high number of birds due to availability of sufficient resources to waterbirds. Each bird species had its own ecological needs and specialized on a particular food type. Birds inhabiting a particular ecosystem reflect its resources like vegetation types and food production. The bird numbers declined gradually due to shrinkage of lake upto 70% and population count was measured even below 1,000 (Ali, 2005). Urbanization could also be responsible for decreasing species richness and abundance (Yu and Guo, 2013).

Being an important wintering area for birds Uchalli lake supported a large number of species of waterfowl amongst which the most significant were the Greater Flamingo, ducks, Common Coot and waders. The population of the birds was strictly dependent on water level and the extent of salinity differed each year. In a census during winter of 1985/86, over 100,000 waterfowl were reported, large numbers of *Fulica atra* constituted that population. About 50,000 *Fulica atra* were observed in November 1986 (Ali, 2005; Chaudhary, 2002). Uchalli lake which was once considered as a paradise of waterfowl suffered heavy degradation as only 11 species were observed in 2010 with numbers upto 1,139 in the present study. Monsoon rains in 2010 resulted in an increase in the lake area and the following year supported quite high populations of birds recorded at Uchalli lake *i.e.* 18,606. The *Fulica atra* population count in 2011 was about 8,000. Gray wagtail was the only species that wasn’t seen in 2011 and it did not visit any other lake of the Uchalli Wetlands Complex too.

The most rich, diverse, wonderful and magnificent winter visitors to Pakistan and Indian sub-continent are the ducks and waders that make up the 85% of water bird populations (Alfred *et al.*, 2001). Likewise in our study, ducks visited the wetland in significant numbers constituting fairly large populations. Birds share a unique relationship with wetlands. Various physical and biological factors contribute in shaping this exclusive dependence of birds on wetlands. These attributes include the availability, quality, temperature and depth of water; food availability and shelter; vegetation, its types and distribution; geographical location of water body; and predation risks (Ali, 2005). Any variation in these characteristics may cause distinct differences in the use of wetlands by birds. Different species inhabiting a particular aquatic ecosystem have different micro habitats and nest at different times of the year. These relationships are indeed complex and need to be understood from conservation point of view of important avian species.

Ducks are affected more by wetland features like water chemistry, total area of wetland basins because their populations are more aquatic and less terrestrial (Cross, 1988). Different species of water birds prefer different levels of water for their food. Each species has its own desirable range of water depths. Diving birds prefer deep water level and some birds need depths more than 1m (Halse *et al.*, 1993). These observations hold well in present study as lower number of birds was seen during 2010 when there was less water in the lake. Seemingly, the birds migrated locally to the other wetlands because of resource shortage. Trends in water bird population could be the indicator of ecological change (Ali, 2005). About seven duck species were observed in the present study. Majority of the ducks were omnivorous which fed on variety of food like seeds, molluscs, insects, water weeds, annelid worms, amphibian tadpoles, crustaceans etc. Some feeders forage for food in the wetland soils, some find food in the water column, and some feed on the vertebrates and invertebrates that live on submerged and emergent plants. Vegetarian birds eat the fruits, tubers, and leaves of wetland plants. Ducks were seen in greater number at Uchalli lake due to its abundant resources and high carrying capacity.

In our study, most frequent populations observed in both years were of Common Coot (*Fulica atra*), Common Pochard (*Aythya ferina*), Common Teal (*Anas crecca*), Black-winged Stilt (*Himantopus himantopus*), Northern Shoveler (*Anas clypeata*) and Northern Pintail (*Anas acuta*) which constituted nearly 90% of the abundance of the species inhabiting Uchalli lake. Our results were almost similar to that of Ali (2005) where Greater Flamingo (*Phoenicopterus ruber*) was also the part of most abundant species but in current study the Flamingo population seemed to have declined at the lake as only 35 birds were observed in the two year study period. This lake had been regarded as a regular wintering area for Greater Flamingoes (Roberts, 1991). Uchalli lake in particular was famous for Flamingoes; every wintering season 100-150 birds stopped over for 3-4 weeks and refueled themselves for the long journey (Ahmed, 2000). Roberts (1991) reported that the Flamingo populations that visit Salt Range breed in Afghanistan while Ali (2005) mentioned that Flamingo populations breed at Uchalli Wetlands complex as the birds were seen to be nesting at eastern edge of Uchalli lake. Ali (2005) termed Uchalli Wetlands Complex as the resident area of Greater Flamingos. No such evidence was seen in current study.

Species which need immediate conservation are Great Bittern, little Bittern, Indian Courser, Gray Wagtail, Greater Flamingo and Water Rail as these visited the lake in very low numbers. These species are needed to be conserved so that biodiversity of the wetland be maintained which it is famous for.

The analysis of surface water was done to determine pollutant levels and the effect of contamination on aquatic flora and fauna. In metal analysis it was observed that most of the heavy metals were above the permissible limits set by USEPA (2002). Cadmium, copper, chromium, iron, manganese, lead and zinc had concentrations higher than the acceptable values (WHO 1985, 2006).

The most highly concentrated metal found in Uchalli lake was Iron (6.683 mg/L; Table IV), far higher than standard value (1 mg/L; USEPA 2002). High value was most probably due to the surrounding hills which possess a high amount of iron. The surface run off from hills and agricultural wastes bring Fe to the lake water (Ikem *et al.*, 2003). Iron is an essential metal and is required for certain redox reactions as a part of enzymes and it is an important component of hemoglobin molecule which binds oxygen during respiration (Beard and Dawson, 1997; Pinero *et al.*, 2000, Wood and Ronnenberg, 2006). Iron appears in higher concentration in lakes because it is an essential component of clay minerals which are abundantly found in lakes (Carrol, 1958).

Another heavy metal found naturally is Zinc. In the current study, its concentration (0.596 mg/L; Table IV) was also found to be above the normal levels. It is widely used in corrosion- resistant alloys, brass, steel and iron products. Zinc carbamates are now-a-days used as pesticides (Elinder *et al.*, 1986).

Manganese (0.5005 mg/L) was also reported to be higher in concentration, in current study, than the limits set by USEPA (2002). Mn is not a toxic metal but the possible source may be domestic waste water, raw sewage and agricultural waste water. Such sources of contamination were also reported by Keen *et al.* (2000).

One of the oldest metals known to man is lead and is discharged in the lake water through paints, solders, pipes, building material, gasoline etc. (Dixit and Tiwari, 2008). High concentration of lead (0.2107 mg/L; Table IV) was found in surface water of Uchalli lake. The possible source of Pb in studied lake could be domestic sewage, urbanization and geology of catchments.Higher values in studied lake could be due to atmospheric fallout of Pb^{+2}, an important source of lead in the freshwaters (Franson *et al.*, 1983). Lead has toxic effects and can cause mortality to aquatic biota (Sorensen, 1991; Heath, 1995; Ciftci-Soydemir *et al.*, 2008).

The highest value for Cd (0.075 mg/L; Table IV) was higher than USEPA water quality criteria (0.002 mg/L; USEPA 2002). The higher level of Cd was due to natural sources of emission to environment: soil particles from weathering of rocks. Furthermore, cadmium is released from anthropogenic sources of emission from commercial uses, burning of fossil fuels, municipal effluents and metal extraction. The excessive use of phosphate fertilizers in agriculture field had shown to increase leaching of Cd^{+2} from soil particles, which ultimately reached the lake water (Mason, 2002).

Chromium oxidizes from trivalent to hexavalent state. Cr^{+3} ion is an essential nutrient, but Cr^{6+} ion is toxic and can damage adrenals, lungs and livers (Pechova and Pavlata, 2007). The concentration of Cr^{+3} in lake water was 0.0169 mg/L which was around its standard value (0.016 mg/L) set by USEPA (2002). The metal could end up in lake water in the dissolved form through domestic sewage.

There were almost no signs of heavy metals in Uchalli lake in 1994. Water analysis for surface water was carried out and a few metals (Fe^{+2}, Cu^{+2}, Zn^{+2} and Mn) were detected in trace amounts. Heavy metals like Cd^{+2} and Pb^{+2} were not present in lake water (Afzal *et al.*, 1998). Sulphates, nitrates, chlorides, phosphorous, calcium and magnesium were already present in lake due to domestic sewage inputs and runoff from agricultural fields and because of its situation in salt range. But the concentration of these parameters in the current study has increased to a considerable level showing that the continuous addition of domestic waste and fertilizers is causing further degradation of the lake.

Sediments act as reservoir for all contaminants and dead organic matter which descends from the surface water to the bottom of the lake (Hamed, 1998; Nguyen *et al*., 2005). So it is quite probable that these heavy metals would be present in larger amounts in sediments as compared to the surface water.

High salinity of water and presence of various toxic heavy metals make the water of Uchalli lake unfit for human consumption. This was supported by another study performed on Uchalli lake where a high concentration of fecal *coliforms* and *Halophiles* was found in lake water (Imran Ullah *et al.*, 2012). The values of various parameters are far higher than the WHO limits for drinking purposes. This all could be attributed to unsustainable human activities like agriculture, laundry, household use and direct discharge from settlements. Metal toxicity could also be hazardous for the avifauna, both resident and migratory, and other animal life depending on the lake. Phytoplanktons actively absorb metals from water and are a diet of birds. This metal concentration could build up in the tissues of animals eating them and thus alter their physiology. Bio magnification of these metals could be lethal. Thus aquatic life could come under stress and these contaminants might build up in quite a high concentration if immediate actions are not taken to control the discharge of these toxic entities into the lake. Decrease in number of migrants could also be accredited to the extent of contamination in the lake.

Sudden rise in bird population in 2011 due to heavy rainfall in monsoon was like the revival of this Ramsar site. Before this the wetland was facing long spells of dry seasons due to which bird population had declined drastically. The main identified threats to this wetland were agricultural practices, poaching, climate change, and usage of lake water for domestic purposes. The information is put forward with a hope that it will help out the policy makers to sustain, conserve and safeguard this natural and national asset to maintain its ecological balance. On the other hand, high bird populations at the lake meant that this Ramsar site is still capable of supporting these species that had once abandoned the lake due to its degradation and water loss. If the climatic conditions remain favourable and the water extent of the lake keeps on increasing these species would become the regular visitors and take pleasure in staying at this wintering site.

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